The Variation of Animals and Plants under Domestication

by Charles Darwin
M.A., F.R.S., ETC.

VOLUMES ONE AND TWO

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LIST OF ILLUSTRATIONS

FOREWORD

Harriet Ritvo

Charles Darwin wrote *On the Origin of Species* in a hurry. He had, it was true, been formulating his ideas and arguments for several decades—since his round-the-world *Beagle* voyage of 1831-1836. These ideas and arguments had been slow to take definitive shape; Darwin had nurtured and reworked them, amassing evidence for what he projected to be a weighty magnum opus. Although he had shared his developing evolutionary speculations with his closest professional colleagues, Darwin was reluctant to publish them on several grounds. He was aware that his theory of evolution by natural selection (or descent with modification) was complex, that it rested on vast but not incontrovertible evidence, and that the chain of his reasoning was not uniformly strong. Further, his conclusions challenged not only the scientific assumptions of many fellow specialists but also the theological convictions of a much wider circle of fellow citizens.

In 1859, Darwin did not feel quite ready to expose his cherished theory to the harsh light of public scrutiny. In the introduction to the *Origin* he confessed that although his work on evolution by natural selection was "nearly finished," he would need "two or three more years to complete it." The *Origin* was, he suggested, merely a stopgap, a schematic "abstract" of a much longer and more fully supported treatise yet to come. He had been moved to preview his labors in this way, he explained, because his health was "far from strong" and, perhaps more importantly, because Alfred Russel Wallace, a younger naturalist working in isolation in southeast Asia, had sent a paper to the Linnean Society of London in which he "arrived at almost exactly the same general conclusions that I have on the origin of species." If Darwin had not gone public with his theory at this point, he would have risked losing credit for the work of many years.

As its reception showed immediately and has continued to show, the *Origin* benefited from the succinctness imposed by circumstances. Darwin himself may have appreciated this point; at any rate, he never produced the massive treatise, although he repeatedly issued revised editions of the *Origin*. But he did not abandon his intention to buttress his initial schematic presentation with additional evidence. In the course of the next two decades he published several full-length elaborations of topics summarily discussed in the *Origin: The Variation of Animals and Plants under Domestication; The Descent of Man, and Selection in Relation to Sex;* and *The Expression of the Emotions in Man and Animals*. In addition to fleshing out the *Origin,* these subsequent studies bolstered its arguments and responded to questions raised by critical readers, especially pragmatic questions about the way that descent with modification actually operated.

In *The Variation of Animals and Plants under Domestication,* which appeared first in 1868 and in a revised edition in 1875, Darwin developed a theme to which he had accorded great rhetorical and evidentiary significance. He had begun the *Origin* with a description of artificial selection as practiced by farmers, stock breeders, and pet fanciers, thus using a reassuringly homely example—one recognizable by the general public as well as by members of the scientific community—to introduce the most innovative component of his evolutionary theory. In addition, domesticated animals and plants, because they were numerous and available for constant observation, provided a readily available body of evidence.

Reassuring as it was, the analogy between natural and artificial selection was far from perfect. The point of Darwin's analogy was to make the idea of natural selection seem plausible by characterizing it as a grander version of a well-known process while emphasizing its efficiency and shaping power. He noted, for example, that some of the prize birds bred by London pigeon fanciers diverged so strikingly in size, plumage, beak shape, flying technique, vocalizations. bone structure, and many other attributes, that if they had been presented to an ornithologist as wild specimens, they would unquestionably have been considered to represent distinct species, perhaps even distinct genera. Darwin argued that if the relatively brief and constrained selective efforts of human breeders had produced such impressive results, it was likely that the more protracted and thorough-going efforts of nature would work still more efficaciously.

But as Darwin acknowledged, there were some fairly obvious reasons why the two processes might diverge. The superior power of natural selection—"Man can act only on external and visible characters: nature . . . can act on . . . the whole machinery of life. Man selects only for his own good; Nature only for that of the being which she tends" (*Origin,* chap. 5)—might constitute a difference of kind rather than of degree, as might the much greater stretches of time available for natural selection. Further, although the mechanism of the two processes appeared superficially similar, their outcomes tended to be rather different. Natural selection produced a constantly increasing and diversifying variety of forms; it never reversed or exactly repeated itself. Anyone familiar with artificial selection would have realized that, although new breeds were constantly being developed and although neither improved wheat nor improved cattle showed any tendency to revert to the condition of their aboriginal wild ancestors, the strains produced by human selection were neither as prolific nor as durable as those produced by nature. Indeed, the animals and plants celebrated as the noblest achievements of the breeder's art were especially liable to delicacy and infertility. Highly bred strains, long isolated from others of their species to preserve their genealogical purity, far from serving as a springboard for further variation, often had to be revivified with infusions of less-rarefied blood. Yet any relaxation of reproductive boundaries threatened subsidence into the common run of conspecifics.

Darwin firmly connected *Variation* to the *Origin* by devoting its introduction to an overview of his theory of evolution by natural selection. In particular, the two volumes of *Variation,* cumbersomely organized and packed with zoological and botanical detail, addressed some of the difficulties inherent in the attractive but paradoxical analogy between natural selection and artificial selection. For selection of any sort to operate, diversity already had to exist. With wild populations living under natural conditions, however, diversity was difficult to discern. It was widely believed that a heightened propensity to vary (at least in ways obvious to human observers) was one of the few general characteristics that differentiated domestic animals as a group from their wild relatives. This point was conventionally illustrated with reference to coat color and design. American bison, for example, were, on the whole, brown, and all Burchell's zebras shared similar black and white stripes. A single herd of either *Bos tauras* or *Equus caballus* (domestic cattle or horses), on the other hand, could display colors ranging from white through yellow, red, and brown to black, as well as a variety of spotted and blotched patterns.

In order to demonstrate that such populations spontaneously produced sufficient variation to support artificial selection, Darwin devoted most of the first volume of *Variation* to a species-by-species survey of domesticated plants and animals. He began with the dog, the breeds of which differed so greatly in size, shape, disposition, talents, and every other characteristic that Darwin attributed its exemplary plasticity to its derivation from several different species of wild canines. Domestic cats, on the other hand, differed relatively little from one another, at least, their variation tended to be individual, rather than consolidated into breeds. Darwin attributed this to the minimal influence exerted by cat owners over the mating behavior of their animals, so that, alone among fully domesticated animals, cats could not be said to have undergone a genuine process of artificial selection.

Farmyard ungulates, however, had all proved more susceptible to human manipulation, whether through the gradual enhancement of inherent tendencies, such as the relatively early maturation that distinguished shorthorn cattle, or through the preservation of spontaneously arising monstrosities, such as the short, broad foreheads and protruding lower jaws of the niata cattle of South America, the bulldogs of the bovine world. Among animals, fancy pigeons, with their short generations, devoted breeders, and lack of any pragmatic constraints on their extravagant deformations, provided Darwin with his most abundant material. He allotted less space to his survey of domesticated plants, although, with the exception of trees, they tended to he much shorter lived and more variable even than pigeons. For example, as Darwin pointed out, a single long-cultivated species—*Brassica oleracea*, the ordinary cabbage—had given rise to strains as distinctive as Brussels sprouts, cauliflower, broccoli, and kohl-rabi.

Darwin crammed in so much information of this sort that, in order to confine *Variation* to two volumes of manageable size, less crucial evidence was relegated to a smaller typeface. And so compendious was his survey of domesticates that he felt constrained to deny that it was intended to he an exhaustive catalog. After all, many such catalogs, devoted merely to the accumulation of species- or breed-specific data, existed already; Darwin cited them generously in his footnotes. The material included in *Variation* had been chosen to fulfill a more focused argumentative purpose. Darwin's theory of descent with modification required something further than the simple demonstration that abundant variation existed among domesticated animals and plants. The accumulated experience of naturalists and breeders offered no clear explanation of the causes of variation; indeed, no consensus existed on this issue. Variation under domestication was frequently attributed to accidental external influences, especially climate and food. But environmentally induced variation was not of much use to Darwin. Instead, he sought evidence not only that the tendency to vary was inherent in domesticated animals and plants but also that specific variations were inherited.

As a result, Darwin's wealth of detail in *Variation* disproportionately featured strong—as well as puzzling, problematic, or even questionable—versions of inheritance, in addition to the unsurprising, if still not completely understood, likelihood that children would resemble their parents. For example, he devoted an entire chapter to what he termed "atavism" or "reversion"—that is, the tendency for offspring to manifest traits apparently derived from their grandparents, collateral relations, or even remote ancestors, rather than from their mothers or their fathers. The existence of this tendency in the lineages of individuals, he argued, incontrovertibly demonstrated the fact of heritability; and in an extended or exaggerated version it also demonstrated evolutionary relations between species. Thus, many breeds of domesticated chickens revealed their ultimate ancestry by producing occasional sports with the red and orange plumage of the original *Callus bankiva*, or jungle fowl.

Like many other naturalists of his time, Darwin was receptive to the idea of telegony, also known as "the influence of the previous sire." He retailed the famous story of Lord Morton's mare, a chestnut of seven-eighths Arabian blood, whose first foal had been sired by a quagga (a now-extinct relative of the zebra) her owner was attempting to domesticate. It was not surprising that the young hybrid faintly echoed his father's stripes, but the fact that her next two foals, both sired by a black Arabian horse, also seemed to resemble the quagga in this regard, was more remarkable. Darwin pointed out that atavism offered one possible explanation of this phenomenon—infant horses and donkeys often showed evanescent striping, which might indicate the pattern of their ancient shared progenitor—but he was also drawn to the notion that the first male to impregnate a female left some permanent, heritable trace of himself behind. He offered analogous examples from the vegetable kingdom, where the pollen of related varieties of apples, corn, or orchids, could not only produce hybrid offspring but occasionally also physically alter the reproductive tract of the female. Plants also, and more regularly, demonstrated a kind of variability that could arise independently of sexual reproduction, such as "bud variation," whereby what Darwin called a "monstrosity" might appear on a single branch or flower and then be transmitted, sexually or asexually, to future generations.

As he documented the profusion of variation among domesticated animals and plants, and the tendency of organisms to transmit these variations down the generations, Darwin did more than demonstrate that there was ample grist for the mill of natural selection. He also addressed the most serious weakness in the argument of the *Origin*. Despite the incompleteness of the fossil record, plenty of evidence suggested that evolution had taken place; indeed the idea of evolution had been current in one form or another for a century before 1859. Darwin's explanation of the way that natural selection should operate was also widely persuasive. The competitive metaphors with which he characterized it, especially the "struggle for life" prominently featured in the *Origin*'s subtitle, fit well with Victorian understandings about how things worked in the human arenas of industry, commerce, and geopolitics. There was, however, a problem that troubled those inclined to sympathize with Darwin's reasoning as well as those inclined to reject it. The efficacy of natural selection, like that of artificial selection, depended on the inheritance of particular traits. But before the modern understanding of genetics became available, no satisfactory mechanism had been adduced to explain this phenomenon. No consensus yet existed about the way that sexual reproduction worked, so there was also disagreement about which characteristics were inherited and which were the result of environment, and what could he contributed by the male as opposed to the female parent, let alone why offspring sometimes resembled a grandparent or some more distant relative rather than their parents. The special difficulty of accounting for the sudden emergence of monstrosities, or even less dramatically novel traits, led Darwin, in later editions of the *Origin* as well as in *Variation,* to become increasingly receptive to the notion that characteristics acquired by one generation might he inherited by the next.

In the penultimate chapter of *Variation,* Darwin attempted to strengthen the weak link in his chain of argument by proposing a mechanism for inheritance. He called his theory "pangenesis," and he claimed that it explained not only ordinary inheritance—the influence of parents on their children—but also reversion, telegony, the regeneration of amputated limbs in some kinds of animals, the inheritance of acquired characteristics, and the relationship between sexual and asexual modes of reproduction and inheritance. The operation of pangenesis depended on the posited existence of unobservable units that Darwin called "gemmules," tiny granules that were thrown off by individual cells and then circulated through the body. They had, however, an affinity for each other, which led to their aggregation in the reproductive organs or in parthenogenetic buds. They could remain latent for years, until an organism reached a certain stage of development, or for generations, until they encountered other gemmules to which they bore some special relationship. In this way a long-dormant greatgrandparental gemmule might suddenly manifest itself in a child. Since gemmules could he altered by environmental influences, they could convert acquired characteristics into the stuff of heredity. And since they were vulnerable to error, they could occasionally make mistakes, causing organs, such as limbs or tails or even heads, to develop in inappropriate numbers or in the wrong places.

It has doubtless been fortunate for Darwin's reputation that his theory of pangenesis is not as well remembered as his theory of evolution by natural selection. As vague in detail as it was ambitious and comprehensive in scope, it was unpersuasive at the time and has since been proven completely wrong. But like *Variation* as a whole, which similarly illustrated the limitations of its author as well as his strengths, pangenesis does not therefore lack interest or significance. Despite recent excellent and well-appreciated studies of his entire life and extended *oeuvre* (Janet Browne, *Charles Darwin: Voyaging* [New York: Knopf, 1995] and Adrian Desmond and James Moore, *Darwin* [London: Michael Joseph, 1991], Darwin is known primarily as the author of the *Origin,* which is unrepresentative in its economy of structure, argument, and evidence, as well as on account of its historical notoriety. Its enforced streamlining has helped to preserve the *Origin*'s accessibility, but its relative paucity of examples was particularly uncharacteristic of Darwin. *Variation,* with its accumulation of evidence about everything from the webbing between dogs' toes to the weight of gooseberries, was much more typical; in addition, it placed Darwin firmly—indeed, irretrievably—within his time, rather than in an achronological limbo reserved for intellectual heroes. As a graduate student from the People's Republic of China told me several years ago, after having participated in a seminar that read excerpts from *Variation* and *The Expression of the Emotions*, if the leaders of his government knew that Darwin had written such books, he would not be officially admired.

In science as in politics the victors tend to write the history books. As a result, the record of the past is edited, intentionally or unintentionally, so that it focuses mainly on the precursors of contemporary orthodoxy. Such a focus may accurately represent the genealogy of modem ideas, but it almost inevitably misrepresents the historical experience of their progenitors. Viewed without the benefit of hindsight, the marketplace of Victorian ideas seemed much more competitive than it does to us. Even the powerful, persuasive, and ultimately triumphant theory of evolution by natural selection required not only defense, but repeated buttressing and revision. *Variation* showed Darwin hard at work on this rearguard action, using the materials he had at hand—for the most part, homely details about the domesticated animals and plants with which his audience was most familiar. His information was gleaned from the observations of fanciers, breeders, and amateur naturalists, as well as from the treatises of those on the cutting edge of zoology and botany. As hindsight narrows the historical spotlight, it imposes its own sense of hierarchy on the preoccupations of the past. But Darwin was interested in all of these topics, valued all of these sources, and belonged, to a greater or lesser extent, to all of these communities.

The author of *Variation* was a Victorian country gentleman, a lover of dogs and horses, a breeder of pigeons and peas. He was also, and equally, the author of *On the Origin of Species.*

PREFACE TO THE SECOND EDITION

During the seven years which have elapsed since the publication in 1868 of the first edition of this Work, I have continued to attend to the same subjects, as far as lay in my power; and I have thus accumulated a large body of additional facts, chiefly through the kindness of many correspondents. Of these facts I have been able here to use only those which seemed to me the more important. I have omitted some statements, and corrected some errors, the discovery of which I owe to my reviewers. Many additional references have been given. The eleventh chapter, and that on Pangenesis, are those which have been most altered, parts having been remodelled; but I will give a list of the more important alterations for the sake of those who may possess the first edition of this book.

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INTRODUCTION

The object of this work is not to describe all the many races of animals which have been domesticated by man, and of the plants which have been cultivated by him; even if I possessed the requisite knowledge, so gigantic an undertaking would be here superfluous. It is my intention to give under the head of each species only such facts as I have been able to collect or observe, showing the amount and nature of the changes which animals and plants have undergone whilst under man's dominion, or which bear on the general principles of variation. In one case alone, namely in that of the domestic pigeon, I will describe fully all the chief races, their history, the amount and nature of their differences, and the probable steps by which they have been formed. I have selected this case, because, as we shall hereafter see, the materials are better than in any other; and one case fully described will in fact illustrate all others. But I shall also describe domesticated rabbits, fowls, and ducks, with considerable fulness.

The subjects discussed in this volume are so connected that it is not a little difficult to decide how they can be best arranged. I have determined in the first part to give, under the heads of the various animals and plants, a large body of facts, some of which may at first appear but little related to our subject, and to devote the latter part to general discussions. Whenever I have found it necessary to give numerous details, in support of any proposition or conclusion, small type has been used. The reader will, I think, find this plan a convenience, for, if he does not doubt the conclusion or care about the details, he can easily pass them over; yet I may be permitted to say that some of the discussions thus printed deserve attention, at least from the professed naturalist.

It may be useful to those who have read nothing about Natural Selection, if I here give a brief sketch of the whole subject and of its bearing on the origin of species.[1] This is the more desirable, as it is impossible in the present work to avoid many allusions to questions which will be fully discussed in future volumes.

From a remote period, in all parts of the world, man has subjected many animals and plants to domestication or culture. Man has no power of altering the absolute conditions of life; he cannot change the climate of any country; he adds no new element to the soil; but he can remove an animal or plant from one climate or soil to another, and give it food on which it did not subsist in its natural state. It is an error to speak of man "tampering with nature" and causing variability. If a man drops a piece of iron into sulphuric acid, it cannot be said strictly that he makes the sulphate of iron, he only allows their elective affinities to come into play. If organic beings had not possessed an inherent tendency to vary, man could have done nothing.[2] He unintentionally exposes his animals and plants to various conditions of life, and variability supervenes, which he cannot even prevent or check. Consider the simple case of a plant which has been cultivated during a long time in its native country, and which consequently has not been subjected to any change of climate. It has been protected to a certain extent from the competing roots of plants of other kinds; it has generally been grown in manured soil; but probably not richer than that of many an alluvial flat; and lastly, it has been exposed to changes in its conditions, being grown sometimes in one district and sometimes in another, in different soils. Under such circumstances, scarcely a plant can be named, though cultivated in the rudest manner, which has not given birth to several varieties. It can hardly be maintained that during the many changes which this earth has undergone, and during the natural migrations of plants from one land or island to another, tenanted by different species, that such plants will not often have been subjected to changes in their conditions analogous to those which almost inevitably cause cultivated plants to vary. No doubt man selects varying individuals, sows their seeds, and again selects their varying offspring. But the initial variation on which man works, and without which he can do nothing, is caused by slight changes in the conditions of life, which must often have occurred under nature. Man, therefore, may be said to have been trying an experiment on a gigantic scale; and it is an experiment which nature during the long lapse of time has incessantly tried. Hence it follows that the principles of domestication are important for us. The main result is that organic beings thus treated have varied largely, and the variations have been inherited. This has apparently been one chief cause of the belief long held by some few naturalists that species in a state of nature undergo change.

I shall in this volume treat, as fully as my materials permit, the whole subject of variation under domestication. We may thus hope to obtain some light, little though it be, on the causes of variability,—on the laws which govern it, such as the direct action of climate and food, the effects of use and disuse, and of correlation of growth,—and on the amount of change to which domesticated organisms are liable. We shall learn something of the laws of inheritance, of the effects of crossing different breeds, and on that sterility which often supervenes when organic beings are removed from their natural conditions of life, and likewise when they are too closely interbred. During this investigation we shall see that the principle of Selection is highly important. Although man does not cause variability and cannot even prevent it, he can select, preserve, and accumulate the variations given to him by the hand of nature almost in any way which he chooses; and thus he can certainly produce a great result. Selection may be followed either methodically and intentionally, or unconsciously and unintentionally. Man may select and preserve each successive variation, with the distinct intention of improving and altering a breed, in accordance with a preconceived idea; and by thus adding up variations, often so slight as to be imperceptible by an uneducated eye, he has effected wonderful changes and improvements. It can, also, be clearly shown that man, without any intention or thought of improving the breed, by preserving in each successive generation the individuals which he prizes most, and by destroying the worthless individuals, slowly, though surely, induces great changes. As the will of man thus comes into play, we can understand how it is that domesticated breeds show adaptation to his wants and pleasures. We can further understand how it is that domestic races of animals and cultivated races of plants often exhibit an abnormal character, as compared with natural species; for they have been modified not for their own benefit, but for that of man.

In another work I shall discuss, if time and health permit, the variability of organic beings in a state of nature; namely, the individual differences presented by animals and plants, and those slightly greater and generally inherited differences which are ranked by naturalists as varieties or geographical races. We shall see how difficult, or rather how impossible it often is, to distinguish between races and sub-species, as the less well-marked forms have sometimes been denominated; and again between sub-species and true species. I shall further attempt to show that it is the common and widely ranging, or, as they may be called, the dominant species, which most frequently vary; and that it is the large and flourishing genera which include the greatest number of varying species. Varieties, as we shall see, may justly be called incipient species.

But it may be urged, granting that organic beings in a state of nature present some varieties,—that their organisation is in some slight degree plastic; granting that many animals and plants have varied greatly under domestication, and that man by his power of selection has gone on accumulating such variations until he has made strongly marked and firmly inherited races; granting all this, how, it may be asked, have species arisen in a state of nature? The differences between natural varieties are slight; whereas the differences are considerable between the species of the same genus, and great between the species of distinct genera. How do these lesser differences become augmented into the greater difference? How do varieties, or as I have called them incipient species, become converted into true and well-defined species? How has each new species been adapted to the surrounding physical conditions, and to the other forms of life on which it in any way depends? We see on every side of us innumerable adaptations and contrivances, which have justly excited the highest admiration of every observer. There is, for instance, a fly (Cecidomyia)[3] which deposits its eggs within the stamens of a Scrophularia, and secretes a poison which produces a gall, on which the larva feeds; but there is another insect (Misocampus) which deposits its eggs within the body of the larva within the gall, and is thus nourished by its living prey; so that here a hymenopterous insect depends on a dipterous insect, and this depends on its power of producing a monstrous growth in a particular organ of a particular plant. So it is, in a more or less plainly marked manner, in thousands and tens of thousands of cases, with the lowest as well as with the highest productions of nature.

This problem of the conversion of varieties into species,—that is, the augmentation of the slight differences characteristic of varieties into the greater differences characteristic of species and genera, including the admirable adaptations of each being to its complex organic and inorganic conditions of life,—has been briefly treated in my 'Origin of Species.' It was there shown that all organic beings, without exception, tend to increase at so high a ratio, that no district, no station, not even the whole surface of the land or the whole ocean, would hold the progeny of a single pair after a certain number of generations. The inevitable result is an ever-recurrent Struggle for Existence. It has truly been said that all nature is at war; the strongest ultimately prevail, the weakest fail; and we well know that myriads of forms have disappeared from the face of the earth. If then organic beings in a state of nature vary even in a slight degree, owing to changes in the surrounding conditions, of which we have abundant geological evidence, or from any other cause; if, in the long course of ages, inheritable variations ever arise in any way advantageous to any being under its excessively complex and changing relations of life; and it would be a strange fact if beneficial variations did never arise, seeing how many have arisen which man has taken advantage of for his own profit or pleasure; if then these contingencies ever occur, and I do not see how the probability of their occurrence can be doubted, then the severe and often-recurrent struggle for existence will determine that those variations, however slight, which are favourable shall be preserved or selected, and those which are unfavourable shall be destroyed.

This preservation, during the battle for life, of varieties which possess any advantage in structure, constitution, or instinct, I have called Natural Selection; and Mr. Herbert Spencer has well expressed the same idea by the Survival of the Fittest. The term "natural selection" is in some respects a bad one, as it seems to imply conscious choice; but this will be disregarded after a little familiarity. No one objects to chemists speaking of "elective affinity;" and certainly an acid has no more choice in combining with a base, than the conditions of life have in determining whether or not a new form be selected or preserved. The term is so far a good one as it brings into connection the production of domestic races by man's power of selection, and the natural preservation of varieties and species in a state of nature. For brevity sake I sometimes speak of natural selection as an intelligent power;—in the same way as astronomers speak of the attraction of gravity as ruling the movements of the planets, or as agriculturists speak of man making domestic races by his power of selection. In the one case, as in the other, selection does nothing without variability, and this depends in some manner on the action of the surrounding circumstances on the organism. I have, also, often personified the word Nature; for I have found it difficult to avoid this ambiguity; but I mean by nature only the aggregate action and product of many natural laws,—and by laws only the ascertained sequence of events.

It has been shown from many facts that the largest amount of life can be supported on each area, by great diversification or divergence in the structure and constitution of its inhabitants. We have, also, seen that the continued production of new forms through natural selection, which implies that each new variety has some advantage over others, inevitably leads to the extermination of the older and less improved forms. These latter are almost necessarily intermediate in structure, as well as in descent, between the last-produced forms and their original parent-species. Now, if we suppose a species to produce two or more varieties, and these in the course of time to produce other varieties, the principal of good being derived from diversification of structure will generally lead to the preservation of the most divergent varieties; thus the lesser differences characteristic of varieties come to be augmented into the greater differences characteristic of species, and, by the extermination of the older intermediate forms, new species end by being distinctly defined objects. Thus, also, we shall see how it is that organic beings can be classed by what is called a natural method in distinct groups—species under genera, and genera under families.

As all the inhabitants of each country may be said, owing to their high rate of reproduction, to be striving to increase in numbers; as each form comes into competition with many other forms in the struggle for life,—for destroy any one and its place will be seized by others; as every part of the organisation occasionally varies in some slight degree, and as natural selection acts exclusively by the preservation of variations which are advantageous under the excessively complex conditions to which each being is exposed, no limit exists to the number, singularity, and perfection of the contrivances and co-adaptations which may thus be produced. An animal or a plant may thus slowly become related in its structure and habits in the most intricate manner to many other animals and plants, and to the physical conditions of its home. Variations in the organisation will in some cases be aided by habit, or by the use and disuse of parts, and they will be governed by the direct action of the surrounding physical conditions and by correlation of growth.

On the principles here briefly sketched out, there is no innate or necessary tendency in each being to its own advancement in the scale of organisation. We are almost compelled to look at the specialisation or differentiation of parts or organs for different functions as the best or even sole standard of advancement; for by such division of labour each function of body and mind is better performed. And as natural selection acts exclusively through the preservation of profitable modifications of structure, and as the conditions of life in each area generally become more and more complex from the increasing number of different forms which inhabit it and from most of these forms acquiring a more and more perfect structure, we may confidently believe, that, on the whole, organisation advances. Nevertheless a very simple form fitted for very simple conditions of life might remain for indefinite ages unaltered or unimproved; for what would it profit an infusorial animalcule, for instance, or an intestinal worm, to become highly organised? Members of a high group might even become, and this apparently has often occurred, fitted for simpler conditions of life; and in this case natural selection would tend to simplify or degrade the organisation, for complicated mechanism for simple actions would be useless or even disadvantageous.

The arguments opposed to the theory of Natural Selection, have been discussed in my ‘Origin of Species,’ as far as the size of that work permitted, under the following heads: the difficulty in understanding how very simple organs have been converted by small and graduated steps into highly perfect and complex organs; the marvellous facts of Instinct; the whole question of Hybridity; and, lastly, the absence in our known geological formations of innumerable links connecting all allied species. Although some of these difficulties are of great weight, we shall see that many of them are explicable on the theory of natural selection, and are otherwise inexplicable.

In scientific investigations it is permitted to invent any hypothesis, and if it explains various large and independent classes of facts it rises to the rank of a well-grounded theory. The undulations of the ether and even its existence are hypothetical, yet every one now admits the undulatory theory of light. The principle of natural selection may be looked at as a mere hypothesis, but rendered in some degree probable by what we positively know of the variability of organic beings in a state of nature,—by what we positively know of the struggle for existence, and the consequent almost inevitable preservation of favourable variations,—and from the analogical formation of domestic races. Now this hypothesis may be tested,—and this seems to me the only fair and legitimate manner of considering the whole question,—by trying whether it explains several large and independent classes of facts; such as the geological succession of organic beings, their distribution in past and present times, and their mutual affinities and homologies. If the principle of natural selection does explain these and other large bodies of facts, it ought to be received. On the ordinary view of each species having been independently created, we gain no scientific explanation of any one of these facts. We can only say that it has so pleased the Creator to command that the past and present inhabitants of the world should appear in a certain order and in certain areas; that He has impressed on them the most extraordinary resemblances, and has classed them in groups subordinate to groups. But by such statements we gain no new knowledge; we do not connect together facts and laws; we explain nothing.

It was the consideration of such large groups of facts as these which first led me to take up the present subject. When I visited during the voyage of H.M.S. *Beagle*, the Galapagos Archipelago, situated in the Pacific Ocean about 500 miles from South America, I found myself surrounded by peculiar species of birds, reptiles, and plants, existing nowhere else in the world. Yet they nearly all bore an American stamp. In the song of the mocking-thrush, in the harsh cry of the carrion-hawk, in the great candlestick-like opuntias, I clearly perceived the neighbourhood of America, though the islands were separated by so many miles of ocean from the mainland, and differed much in their geological constitution and climate. Still more surprising was the fact that most of the inhabitants of each separate island in this small archipelago were specifically different, though most closely related to each other. The archipelago, with its innumerable craters and bare streams of lava, appeared to be of recent origin; and thus I fancied myself brought near to the very act of creation. I often asked myself how these many peculiar animals and plants had been produced: the simplest answer seemed to be that the inhabitants of the several islands had descended from each other, undergoing modification in the course of their descent; and that all the inhabitants of the archipelago were descended from those of the nearest land, namely America, whence colonists would naturally have been derived. But it long remained to me an inexplicable problem how the necessary degree of modification could have been effected, and it would have thus remained for ever, had I not studied domestic productions, and thus acquired a just idea of the power of Selection. As soon as I had fully realised this idea, I saw, on reading Malthus on Population, that Natural Selection was the inevitable result of the rapid increase of all organic beings; for I was prepared to appreciate the struggle for existence by having long studied the habits of animals.

Before visiting the Galapagos I had collected many animals whilst travelling from north to south on both sides of America, and everywhere, under conditions of life as different as it is possible to conceive, American forms were met with—species replacing species of the same peculiar genera. Thus it was when the Cordilleras were ascended, or the thick tropical forests penetrated, or the fresh waters of America searched. Subsequently I visited other countries, which in all their conditions of life were incomparably more like parts of South America, than the different parts of that continent are to each other; yet in these countries, as in Australia or Southern Africa, the traveller cannot fail to be struck with the entire difference of their productions. Again the reflection was forced on me that community of descent from the early inhabitants of South America would alone explain the wide prevalence of American types throughout that immense area.

To exhume with one’s own hands the bones of extinct and gigantic quadrupeds brings the whole question of the succession of species vividly before one’s mind; and I found in South America great pieces of tesselated armour exactly like, but on a magnificent scale, that covering the pigmy armadillo; I had found great teeth like those of the living sloth, and bones like those of the cavy. An analogous succession of allied forms had been previously observed in Australia. Here then we see the prevalence, as if by descent, in time as in space, of the same types in the same areas; and in neither the case does the similarity of the conditions by any means seem sufficient to account for the similarity of the forms of life. It is notorious that the fossil remains of closely consecutive formations are closely allied in structure, and we can at once understand the fact if they are closely allied by descent. The succession of the many distinct species of the same genus throughout the long series of geological formations seems to have been unbroken or continuous. New species come in gradually one by one. Ancient and extinct forms of life are often intermediate in character, like the words of a dead language with respect to its several offshoots or living tongues. All these facts seemed to me to point to descent with modification as the means of production of new species.

The innumerable past and present inhabitants of the world are connected together by the most singular and complex affinities, and can be classed in groups under groups, in the same manner as varieties can be classed under species and sub-varieties under varieties, but with much higher grades of difference. These complex affinities and the rules for classification, receive a rational explanation on the theory of descent, combined with the principle of natural selection, which entails divergence of character and the extinction of intermediate forms. How inexplicable is the similar pattern of the hand of a man, the foot of a dog, the wing of a bat, the flipper of a seal, on the doctrine of independent acts of creation! how simply explained on the principle of the natural selection of successive slight variations in the diverging descendants from a single progenitor! So it is with certain parts or organs in the same individual animal or plant, for instance, the jaws and legs of a crab, or the petals, stamens, and pistils of a flower. During the many changes to which in the course of time organic beings have been subjected, certain organs or parts have occasionally become at first of little use and ultimately superfluous; and the retention of such parts in a rudimentary and useless condition is intelligible on the theory of descent. It can be shown that modifications of structure are generally inherited by the offspring at the same age at which each successive variation appeared in the parents; it can further be shown that variations do not commonly supervene at a very early period of embryonic growth, and on these two principles we can understand that most wonderful fact in the whole circuit of natural history, namely, the close similarity of the embryos within the same great class—for instance, those of mammals, birds, reptiles, and fish.

It is the consideration and explanation of such facts as these which has convinced me that the theory of descent with modification by means of natural selection is in the main true. These facts have as yet received no explanation on the theory of independent Creation; they cannot be grouped together under one point of view, but each has to be considered as an ultimate fact. As the first origin of life on this earth, as well as the continued life of each individual, is at present quite beyond the scope of science, I do not wish to lay much stress on the greater simplicity of the view of a few forms or of only one form having been originally created, instead of innumerable miraculous creations having been necessary at innumerable periods; though this more simple view accords well with Maupertuis's philosophical axiom of "least action."

In considering how far the theory of natural selection may be extended, —that is, in determining from how many progenitors the inhabitants of the world have descended,—we may conclude that at least all the members of the same class have descended from a single ancestor. A number of organic beings are included in the same class, because they present, independently of their habits of life, the same fundamental type of structure, and because they graduate into each other. Moreover, members of the same class can in most cases be shown to be closely alike at an early embryonic age. These facts can be explained on the belief of their descent from a common form; therefore it may be safely admitted that all the members of the same class are descended from one progenitor. But as the members of quite distinct classes have something in common in structure and much in common in constitution, analogy would lead us one step further, and to infer as probable that all living creatures are descended from a single prototype.

I hope that the reader will pause before coming to any final and hostile conclusion on the theory of natural selection. The reader may consult my 'Origin of Species' for a general sketch of the whole subject; but in that work he has to take many statements on trust. In considering the theory of natural selection, he will assuredly meet with weighty difficulties, but these difficulties relate chiefly to subjects—such as the degree of perfection of the geological record, the means of distribution, the possibility of transitions in organs, etc.—on which we are confessedly ignorant; nor do we know how ignorant we are. If we are much more ignorant than is generally supposed, most of these difficulties wholly disappear. Let the reader reflect on the difficulty of looking at whole classes of facts from a new point of view. Let him observe how slowly, but surely, the noble views of Lyell on the gradual changes now in progress on the earth's surface have been accepted as sufficient to account for all that we see in its past history. The present action of natural selection may seem more or less probable; but I believe in the truth of the theory, because it collects, under one point of view, and gives a rational explanation of, many apparently independent classes of facts.[4]

REFERENCES

[1] To any one who has attentively read my 'Origin of Species' this Introduction will be superfluous. As I stated in that work that I should soon publish the facts on which the conclusions given in it were founded, I here beg permission to remark that the great delay in publishing this first work has been caused by continued ill-health.

[2] M. Pouchet has recently ('Plurality of Races,' Eng. Translat., 1864, p. 83, etc.) insisted that variation under domestication throws no light on the natural modification of species. I cannot perceive the force of his arguments, or, to speak more accurately, of his assertions to this effect.

[3] Léon Dufour in 'Annales des Science. Nat.' (3rd series, Zoolog.), tom. v. p. 6.

[4] In treating the several subjects included in the present and my other works I have continually been led to ask for information from many zoologists, botanists, geologists, breeders of animals, and horticulturists, and I have invariably received from them the most generous assistance. Without such aid I could have effected little. I have repeatedly applied for information and specimens to foreigners, and to British merchants and officers of the Government residing in distant lands, and, with the rarest exceptions, I have received prompt, open-handed, and valuable assistance. I cannot express too strongly my obligations to the many persons who have assisted me, and who, I am convinced, would be equally willing to assist others in any scientific investigation.

CHAPTER I.
DOMESTIC DOGS AND CATS.

ANCIENT VARIETIES OF THE DOG—RESEMBLANCE OF DOMESTIC DOGS IN VARIOUS COUNTRIES TO NATIVE CANINE SPECIES—ANIMALS NOT ACQUAINTED WITH MAN AT FIRST FEARLESS—DOGS RESEMBLING WOLVES AND JACKALS—HABIT OF BARKING ACQUIRED AND LOST—FERAL DOGS—TAN-COLOURED EYE-SPOTS—PERIOD OF GESTATION—OFFENSIVE ODOUR—FERTILITY OF THE RACES WHEN CROSSED—DIFFERENCES IN THE SEVERAL RACES IN PART DUE TO DESCENT FROM DISTINCT SPECIES—DIFFERENCES IN THE SKULL AND TEETH—DIFFERENCES IN THE BODY, IN CONSTITUTION—FEW IMPORTANT DIFFERENCES HAVE BEEN FIXED BY SELECTION—DIRECT ACTION OF CLIMATE—WATER-DOGS WITH PALMATED FEET—HISTORY OF THE CHANGES WHICH CERTAIN ENGLISH RACES OF THE DOG HAVE GRADUALLY UNDERGONE THROUGH SELECTION—EXTINCTION OF THE LESS IMPROVED SUB-BREEDS.

CATS, CROSSED WITH SEVERAL SPECIES—DIFFERENT BREEDS FOUND ONLY IN SEPARATED COUNTRIES—DIRECT EFFECTS OF THE CONDITIONS OF LIFE—FERAL CATS—INDIVIDUAL VARIABILITY.

The first and chief point of interest in this chapter is, whether the numerous domesticated varieties of the dog have descended from a single wild species, or from several. Some authors believe that all have descended from the wolf, or from the jackal, or from an unknown and extinct species. Others again believe, and this of late has been the favourite tenet, that they have descended from several species, extinct and recent, more or less commingled together. We shall probably never be able to ascertain their origin with certainty. Palæontology[1] does not throw much light on the question, owing, on the one hand, to the close similarity of the skulls of extinct as well as living wolves and jackals, and owing, on the other hand, to the great dissimilarity of the skulls of the several breeds of the domestic dogs. It seems, however, that remains have been found in the later tertiary deposits more like those of a large dog than of a wolf, which favours the belief of De Blainville that our dogs are the descendants of a single extinct species. On the other hand, some authors go so far as to assert that every chief domestic breed must have had its wild prototype. This latter view is extremely improbable: it allows nothing for variation; it passes over the almost monstrous character of some of the breeds; and it almost necessarily assumes that a large number of species have become extinct since man domesticated the dog; whereas we plainly see that wild members of the dog-family are extirpated by human agency with much difficulty; even so recently as 1710 the wolf existed in so small an island as Ireland.

The reasons which have led various authors to infer that our dogs have descended from more than one wild species are as follows.[2] Firstly, the great difference between the several breeds; but this will appear of comparatively little weight, after we shall have seen how great are the differences between the several races of various domesticated animals which certainly have descended from a single parent-form. Secondly, the more important fact, that, at the most anciently known historical periods, several breeds of the dog existed, very unlike each other, and closely resembling or identical with breeds still alive.

We will briefly run back through the historical records. The materials are remarkably deficient between the fourteenth century and the Roman classical period.[3] At this latter period various breeds, namely hounds, house-dogs, lapdogs, etc, existed; but, as Dr. Walther has remarked, it is impossible to recognise the greater number with any certainty. Youatt, however, gives a drawing of a beautiful sculpture of two greyhound puppies from the Villa of Antoninus. On an Assyrian monument, about 640 B.C., an enormous mastiff[4] is figured; and according to Sir H. Rawlinson (as I was informed at the British Museum), similar dogs are still imported into this same country. I have looked through the magnificent works of Lepsius and Rosellini, and on the Egyptian monuments from the fourth to the twelfth dynasties (i.e. from about 3400 B.C. to 2100 B.C.) several varieties of the dog are represented; most of them are allied to greyhounds; at the later of these periods a dog resembling a hound is figured, with drooping ears, but with a longer back and more pointed head than in our hounds. There is, also, a turnspit, with short and crooked legs, closely resembling the existing variety; but this kind of monstrosity is so common with various animals, as with the ancon sheep, and even, according to Rengger, with jaguars in Paraguay, that it would be rash to look at the monumental animal as the parent of all our turnspits: Colonel Sykes[5] also has described an Indian pariah dog as presenting the same monstrous character. The most ancient dog represented on the Egyptian monuments is one of the most singular; it resembles a greyhound, but has long pointed ears and a short curled tail: a closely allied variety still exists in Northern Africa; for Mr. E. Vernon Harcourt[6] states that the Arab boar-hound is "an eccentric hieroglyphic animal, such as Cheops once hunted with, somewhat resembling the rough Scotch deer-hound; their tails are curled tight round on their backs, and their ears stick out at right angles." With this most ancient variety a pariah-like dog coexisted.

We thus see that, at a period between four and five thousand years ago, various breeds, viz. pariah dogs, greyhounds, common hounds, mastiffs, house-dogs, lapdogs, and turnspits, existed, more or less closely resembling our present breeds. But there is not sufficient evidence that any of these ancient dogs belonged to the same identical sub-varieties with our present dogs.[7] As long as man was believed to have existed on this earth only about 6000 years, this fact of the great diversity of the breeds at so early a period was an argument of much weight that they had proceeded from several wild sources, for there would not have been sufficient time for their divergence and modification. But now that we know, from the discovery of flint tools embedded with the remains of extinct animals in districts which have since undergone great geographical changes, that man has existed for an incomparably longer period, and bearing in mind that the most barbarous nations possess domestic dogs, the argument from insufficient time falls away greatly in value.

Long before the period of any historical record the dog was domesticated in Europe. In the Danish Middens of the Neolithic or Newer Stone period, bones of a canine animal are embedded, and Steenstrup ingeniously argues that these belonged to a domestic dog; for a very large proportion of the bones of birds preserved in the refuse consists of long bones, which it was found on trial dogs cannot devour.[8] This ancient dog was succeeded in Denmark during the Bronze period by a larger kind, presenting certain differences, and this again during the Iron period, by a still larger kind. In Switzerland, we hear from Prof. Rütimeyer,[9] that during the Neolithic period a domesticated dog of middle size existed, which in its skull was about equally remote from the wolf and jackal, and partook of the characters of our hounds and setters or spaniels (Jagdhund und Wachtelhund). Rütimeyer insists strongly on the constancy of form during a very long period of time of this the most ancient known dog. During the Bronze period a larger dog appeared, and this closely resembled in its jaw a dog of the same age in Denmark. Remains of two notably distinct varieties of the dog were found by Schmerling in a cave;[10] but their age cannot be positively determined.

The existence of a single race, remarkably constant in form during the whole Neolithic period, is an interesting fact in contrast with what we see of the changes which the races underwent during the period of the successive Egyptian monuments, and in contrast with our existing dogs. The character of this animal during the Neolithic period, as given by Rütimeyer, supports De Blainville's view that our varieties have descended from an unknown and extinct form. But we should not forget that we know nothing with respect to the antiquity of man in the warmer parts of the world. The succession of the different kinds of dogs in Switzerland and Denmark is thought to be due to the immigration of conquering tribes bringing with them their dogs; and this view accords with the belief that different wild canine animals were domesticated in different regions. Independently of the immigration of new races of man, we know from the wide-spread presence of bronze, composed of an alloy of tin, how much commerce there must have been throughout Europe at an extremely remote period, and dogs would then probably have been bartered. At the present time, amongst the savages of the interior of Guiana, the Taruma Indians are considered the best trainers of dogs, and possess a large breed which they barter at a high price with other tribes.[11]

The main argument in favour of the several breeds of the dog being the descendants of distinct wild stocks, is their resemblance in various countries to distinct species still existing there. It must, however, be admitted that the comparison between the wild and domesticated animal has been made but in few cases with sufficient exactness. Before entering on details, it will be well to show that there is no a priori difficulty in the belief that several canine species have been domesticated. Members of the dog family inhabit nearly the whole world; and several species agree pretty closely in habits and structure with our several domesticated dogs. Mr. Galton has shown[12] how fond savages are of keeping and taming animals of all kinds. Social animals are the most easily subjugated by man, and several species of Canidæ hunt in packs. It deserves notice, as bearing on other animals as well as on the dog, that at an extremely ancient period, when man first entered any country, the animals living there would have felt no instinctive or inherited fear of him, and would consequently have been tamed far more easily than at present. For instance, when the Falkland Islands were first visited by man, the large wolf-like dog (*Canis antarcticus*) fearlessly came to meet Byron's sailors, who, mistaking this ignorant curiosity for ferocity, ran into the water to avoid them: even recently a man, by holding a piece of meat in one hand and a knife in the other, could sometimes stick them at night. On a island in the Sea of Aral, when first discovered by Butakoff, the saigak antelopes, which are "generally very timid and watchful, did not fly from us, but on the contrary looked at us with a sort of curiosity." So, again, on the shores of the Mauritius, the manatee was not at first in the least afraid of man, and thus it has been in several quarters of the world with seals and the morse. I have elsewhere shown[13] how slowly the native birds of several islands have acquired and inherited a salutary dread of man: at the Galapagos Archipelago I pushed with the muzzle of my gun hawks from a branch, and held out a pitcher of water for other birds to alight on and drink. Quadrupeds and birds which have seldom been disturbed by man, dread him no more than do our English birds, the cows, or horses grazing in the fields.

It is a more important consideration that several canine species evince (as will be shown in a future chapter) no strong repugnance or inability to breed under confinement; and the incapacity to breed under confinement is one of the commonest bars to domestication. Lastly, savages set the highest value, as we shall see in the chapter on Selection, on dogs: even half-tamed animals are highly useful to them: the Indians of North America cross their half-wild dogs with wolves, and thus render them even wilder than before, but bolder: the savages of Guiana catch and partially tame and use the whelps of two wild species of *Canis*, as do the savages of Australia those of the wild Dingo. Mr. Philip King informs me that he once trained a wild Dingo puppy to drive cattle, and found it very useful. From these several considerations we see that there is no difficulty in believing that man might have domesticated various canine species in different countries. It would indeed have been a strange fact if one species alone had been domesticated throughout the world.

We will now enter into details. The accurate and sagacious Richardson says, “The resemblance between the Northern American wolves (*Canis lupus,* var. *occidentalis*) and the domestic dogs of the Indians is so great that the size and strength of the wolf seems to be the only difference. I have more than once mistaken a band of wolves for the dogs of a party of Indians; and the howl of the animals of both species is prolonged so exactly in the same key that even the practised ear of the Indian fails at times to discriminate them.” He adds that the more northern Esquimaux dogs are not only extremely like the grey wolves of the Arctic circle in form and colour, but also nearly equal them in size. Dr. Kane has often seen in his teams of sledge-dogs the oblique eye (a character on which some naturalists lay great stress), the drooping tail, and scared look of the wolf. In disposition the Esquimaux dogs differ little from wolves, and, according to Dr. Hayes, they are capable of no attachment to man, and are so savage that when hungry they will attack even their masters. According to Kane they readily become feral. Their affinity is so close with wolves that they frequently cross with them, and the Indians take the whelps of wolves “to improve the breed of their dogs.” The half-bred wolves sometimes (Lamare-Picquot) cannot be tamed, “though this case is rare;” but they do not become thoroughly well broken in till the second or third generation. These facts show that there can be but little, if any, sterility between the Esquimaux dog and the wolf, for otherwise they would not be used to improve the breed. As Dr. Hayes says of these dogs, “reclaimed wolves they doubtless are.”[14]

North America is inhabited by a second kind of wolf, the prairie-wolf (*Canis latrans*), which is now looked at by all naturalists as specifically distinct from the common wolf; and is, according to Mr. J.K. Lord, in some respects intermediate in habits between a wolf and a fox. Sir J. Richardson, after describing the Hare Indian dog, which differs in many respects from the Esquimaux dog, says, “It bears the same relation to the prairie-wolf that the Esquimaux dog does to the great grey wolf.” He could, in fact, detect no marked difference between them; and Messrs. Nott and Gliddon give additional details showing their close resemblance. The dogs derived from the above two aboriginal sources cross together and with the wild wolves, at least with the *C. occidentalis,* and with European dogs. In Florida, according to Bartram, the black wolf-dog of the Indians differs in nothing from the wolves of that country except in barking.[15]

Turning to the southern parts of the new world, Columbus found two kinds of dogs in the West Indies; and Fernandez[16] describes three in Mexico: some of these native dogs were dumb—that is, did not bark. In Guiana it has been known since the time of Buffon that the natives cross their dogs with an aboriginal species, apparently the *Canis cancrivorus.* Sir R. Schomburgk, who has so carefully explored these regions, writes to me, “I have been repeatedly told by the Arawaak Indians, who reside near the coast, that they cross their dogs with a wild species to improve the breed, and individual dogs have been shown to me which certainly resembled the *C. cancrivorus* much more than the common breed. It is but seldom that the Indians keep the *C. cancrivorus* for domestic purposes, nor is the Ai, another species of wild dog, and which I consider to be identical with the *Dusicyon silvestris* of H. Smith, now much used by the Arecunas for the purpose of hunting. The dogs of the Taruma Indians are quite distinct, and resemble Buffon's St. Domingo greyhound." It thus appears that the natives of Guiana have partially domesticated two aboriginal species, and still cross their dogs with them; these two species belong to a quite different type from the North American and European wolves. A careful observer, Rengger,[17] gives reasons for believing that a hairless dog was domesticated when America was first visited by Europeans: some of these dogs in Paraguay are still dumb, and Tschudi[18] states that they suffer from cold in the Cordillera. This naked dog is, however quite distinct from that found preserved in the ancient Peruvian burial-places, and described by Tschudi, under the name of *Canis ingæ*, as withstanding cold well and as barking. It is not known whether these two distinct kinds of dog are the descendants of native species, and it might be argued that when man first migrated into America he brought with him from the Asiatic continent dogs which had not learned to bark; but this view does not seem probable, as the natives along the line of their march from the north reclaimed, as we have seen, at least two N. American species of Canidæ.

Turning to the Old World, some European dogs closely resemble the wolf; thus the shepherd dog of the plains of Hungary is white or reddish-brown, has a sharp nose, short, erect ears, shaggy coat, and bushy tail, and so much resembles a wolf that Mr. p.t, who gives this description, says he has known a Hungarian mistake a wolf for one of his own dogs. Jeitteles, also, remarks on the close similarity of the Hungarian dog and wolf. Shepherd dogs in Italy must anciently have closely resembled wolves, for Columella (vii. 12) advises that white dogs be kept, adding, "pastor album probat, ne pro lupo canem feriat." Several accounts have been given of dogs and wolves crossing naturally; and Pliny asserts that the Gauls tied their female dogs in the woods that they might cross with wolves.[19] The European wolf differs slightly from that of North America, and has been ranked by many naturalists as a distinct species. The common wolf of India is also by some esteemed as a third species, and here again we find a marked resemblance between the pariah dogs of certain districts of India and the Indian wolf.[20]

With respect to Jackals, Isidore Geoffroy Saint-Hilaire[21] says that not one constant difference can be pointed out between their structure and that of the smaller races of dogs. They agree closely in habits: jackals, when tamed and called by their master, wag their tails, lick his hands, crouch, and throw themselves on their backs; they smell at the tails of other dogs, and void their urine sideways; they roll on carrion or on animals which they have killed; and, lastly, when in high spirits, they run round in circles or in a figure of eight, with their tails between their legs.[22] A number of excellent naturalists, from the time of Güldenstädt to that of Ehrenberg, Hemprich, and Cretzschmar, have expressed themselves in the strongest terms with respect to the resemblance of the half-domestic dogs of Asia and Egypt to jackals. M. Nordmann, for instance, says, “Les chiens d’Awhasie ressemblent étonnamment à des chacals.” Ehrenberg[23] asserts that the domestic dogs of Lower Egypt, and certain mummied dogs, have for their wild type a species of wolf (*C. lupaster*) of the country; whereas the domestic dogs of Nubia and certain other mummied dogs have the closest relation to a wild species of the same country, viz. *C. sabbar*, which is only a form of the common jackal. Pallas asserts that jackals and dogs sometimes naturally cross in the East; and a case is on record in Algeria.[24] The greater number of naturalists divide the jackals of Asia and Africa into several species, but some few rank them all as one.

I may add that the domestic dogs on the coast of Guinea are fox-like animals, and are dumb.[25] On the east coast of Africa, between latitude 4° and 6° south, and about ten days’ journey in the interior, a semi-domestic dog, as the Rev. S. Erhardt informs me, is kept, which the natives assert is derived from a similar wild animal. Lichtenstein[26] says that the dogs of the Bosjemans present a striking resemblance even in colour (excepting the black stripe down the back) with the *C. mesomelas* of South Africa. Mr. E. Layard informs me that he has seen a Caffre dog which closely resembled an Esquimaux dog. In Australia the Dingo is both domesticated and wild; though this animal may have been introduced aboriginally by man, yet it must be considered as almost an endemic form, for its remains have been found in a similar state of preservation and associated with extinct mammals, so that its introduction must have been ancient.[27]

From this resemblance of the half-domesticated dogs in several countries to the wild species still living there,—from the facility with which they can often be crossed together,—from even half-tamed animals being so much valued by savages,—and from the other circumstances previously remarked on which favour their domestication, it is highly probable that the domestic dogs of the world are descended from two well-defined species of wolf (viz. *C. lupus* and *C. latrans),* and from two or three other doubtful species (namely, the European, Indian, and North African wolves); from at least one or two South American canine species; from several races or species of jackal; and perhaps from one or more extinct species. Although it is possible or even probable that domesticated dogs, introduced into any country and bred there for many generations, might acquire some of the characters proper to the aboriginal Canidæ of the country, we can hardly thus account for introduced dogs having given rise to two breeds in the same country, resembling two of its aboriginal species, as in the above-given cases of Guiana and of North America.[28]

It cannot be objected to the view of several canine species having been anciently domesticated, that these animals are tamed with difficulty: facts have been already given on this head, but I may add that the young of the *Canis primævus* of India were tamed by Mr. Hodgson,[29] and became as sensible of caresses, and manifested as much intelligence, as any sporting dog of the same age. There is not much difference, as we have already shown and shall further see, in habits between the domestic dogs of the

North American Indians and the wolves of that country, or between the Eastern pariah dogs and jackals, or between the dogs which have run wild in various countries and the several natural species of the family. The habit of barking, however, which is almost universal with domesticated dogs, forms an exception, as it does not characterise a single natural species of the family, though I am assured that the *Canis latrans* of North America utters a noise which closely approaches a bark. But this habit is soon lost by dogs when they become feral and is soon reacquired when they are again domesticated. The case of the wild dogs on the island of Juan Fernandez having become dumb has often been quoted, and there is reason to believe[30] that the dumbness ensued in the course of thirty-three years; on the other hand, dogs taken from this island by Ulloa slowly reacquired the habit of barking. The Mackenzie-river dogs, of the *Canis latrans* type, when brought to England, never learned to bark properly; but one born in the Zoological Gardens[31] "made his voice sound as loudly as any other dog of the same age and size." According to Professor Nillson,[32] a wolf-whelp reared by a bitch barks. I. Geoffroy Saint-Hilaire exhibited a jackal which barked with the same tone as any common dog.[33] An interesting account has been given by Mr. G. Clarke[34] of some dogs run wild on Juan de Nova, in the Indian Ocean; "they had entirely lost the faculty of barking; they had no inclination for the company of other dogs, nor did they acquire their voice" during a captivity of several months. On the island they "congregate in vast packs, and catch sea-birds with as much address as foxes could display." The feral dogs of La Plata have not become dumb; they are of large size, hunt singly or in packs, and burrow holes for their young.[35] In these habits the feral dogs of La Plata resemble wolves and jackals; both of which hunt either singly or in packs, and burrow holes.[36] These feral dogs have not become uniform in colour on Juan Fernandez, Juan de Nova, or La Plata.[37] In Cuba the feral dogs are described by Poeppig as nearly all mouse-coloured, with short ears and light-blue eyes. In St. Domingo, Col. Ham. Smith says[38] that the feral dogs are very large, like greyhounds, of a uniform pale blue-ash, with small ears, and large light-brown eyes. Even the wild Dingo, though so anciently naturalised in Australia, "varies considerably in colour," as I am informed by Mr. P.P. King: a half-bred Dingo reared in England[39] showed signs of wishing to burrow.

From the several foregoing facts we see that reversion in the feral state gives no indication of the colour or size of the aboriginal parent-species. One fact, however, with respect to the colouring of domestic dogs, I at one time hoped might have thrown some light on their origin; and it is worth giving, as showing how colouring follows laws, even in so anciently and thoroughly domesticated an animal as the dog. Black dogs with tan-coloured feet, whatever breed they may belong to, almost invariably have a tan-coloured spot on the upper and inner corners of each eye, and their lips are generally thus coloured. I have seen only two exceptions to this rule, namely, in a spaniel and terrier. Dogs of a light-brown colour often have a lighter, yellowish-brown spot over the eyes; sometimes the spot is white, and in a mongrel terrier the spot was black. Mr. Waring kindly examined for me a stud of fifteen greyhounds in Suffolk: eleven of them were black, or black and white, or brindled, and these had no eye-spots; but three were red and one slaty-blue, and these four had dark-coloured spots over their eyes. Although the spots thus sometimes differ in colour, they strongly tend to be tan-coloured; this is proved by my having seen four spaniels, a setter, two Yorkshire shepherd dogs, a large mongrel, and some fox-hounds, coloured black and white, with not a trace of tan-colour, excepting the spots over the eyes, and sometimes a little on the feet. These latter cases, and many others, show plainly that the colour of the feet and the eye-spots are in some way correlated. I have noticed, in various breeds, every gradation, from the whole face being tan-coloured, to a complete ring round the eyes, to a minute spot over the inner and upper corners. The spots occur in various sub-breeds of terriers and spaniels; in setters; in hounds of various kinds, including the turnspit-like German badger-hound; in shepherd dogs; in a mongrel, of which neither parent had the spots; in one pure bulldog, though the spots were in this case almost white; and in greyhounds,—but true black-and-tan greyhounds are excessively rare; nevertheless I have been assured by Mr. Warwick, that one ran at the Caledonian Champion meeting of April 1860, and was "marked precisely like a black-and-tan terrier." This dog, or another exactly the same colour, ran at the Scottish National Club on the 21st of March, 1865; and I hear from Mr. C. M. Browne, that "there was no reason either on the sire or dam side for the appearance of this unusual colour." Mr. Swinhoe at my request looked at the dogs in China, at Amoy, and he soon noticed a brown dog with yellow spots over the eyes. Colonel H. Smith[40] figures the magnificent black mastiff of Thibet with a tan-coloured stripe over the eyes, feet, and chaps; and what is more singular, he figures the Alco, or native domestic dog of Mexico, as black and white, with narrow tan-coloured rings round the eyes; at the Exhibition of dogs in London, May 1863, a so-called forest dog from North-West Mexico was shown, which had pale tan-coloured spots over the eyes. The occurrence of these tan-coloured spots in dogs of such extremely different breeds, living in various parts of the world, makes the fact highly remarkable.

We shall hereafter see, especially in the chapter on Pigeons, that coloured marks are strongly inherited, and that they often aid us in discovering the primitive forms of our domestic races. Hence, if any wild canine species had distinctly exhibited the tan-coloured spots over the eyes, it might have been argued that this was the parent-form of nearly all our domestic races. But after looking at many coloured plates, and through the whole collection of skins in the British Museum, I can find no species thus marked. It is no doubt possible that some extinct species was thus coloured. On the other hand, in looking at the various species, there seems to be a tolerably plain correlation between tan-coloured legs and face; and less frequently between black legs and a black face; and this general rule of colouring explains to a certain extent the above-given cases of correlation between the eye-spots and the colour of the feet. Moreover, some jackals and foxes have a trace of a white ring round their eyes, as in *C. mesomelas, C. aureus,* and (judging from Colonel H. Smith's drawing) in *C. alopex,* and *C. thaleb*. Other species have a trace of a black line over the corners of the eyes, as in *C.*

variegatus, cinereo-variegatus, and *fulvus,* and the wild Dingo. Hence I am inclined to conclude that a tendency for tan-coloured spots to appear over the eyes in the various breeds of dogs, is analogous to the case observed by Desmarest, namely, that when any white appears on a dog the tip of the tail is always white, "de manière à rappeler la tache terminale de même couleur, qui caractérise la plupart des Canidés sauvages."[41] This rule, however, as I am assured by Mr. Jesse, does not invariably hold good.

It has been objected that our domestic dogs cannot be descended from wolves or jackals, because their periods of gestation are different. The supposed difference rests on statements made by Buffon, Gilibert, Bechstein, and others; but these are now known to be erroneous; and the period is found to agree in the wolf, jackal, and dog, as closely as could be expected, for it is often in some degree variable.[42] Tessier, who has closely attended to this subject, allows a difference of four days in the gestation of the dog. The Rev. W. D. Fox has given me three carefully recorded cases of retrievers, in which the bitch was put only once to the dog; and not counting this day, but counting that of parturition, the periods were fifty-nine, sixty-two, and sixty-seven days. The average period is sixty-three days; but Bellingeri states that this applies only to large dogs; and that for small races it is from sixty to sixty-three days; Mr. Eyton of Eyton, who has had much experience with dogs, also informs me that the time is apt to be longer with large than with small dogs.

F. Cuvier has objected that the jackal would not have been domesticated on account of its offensive smell; but savages are not sensitive in this respect. The degree of odour, also, differs in the different kinds of jackal;[43] and Colonel H. Smith makes a sectional division of the group with one character dependent on not being offensive. On the other hand, dogs— for instance, rough and smooth terriers—differ much in this respect; and M. Godron states that the hairless so-called Turkish dog is more odoriferous than other dogs. Isidore Geoffroy[44] gave to a dog the same odour as that from a jackal by feeding it on raw flesh.

The belief that our dogs are descended from wolves, jackals, South American Canidæ, and other species, suggests a far more important difficulty. These animals in their undomesticated state, judging from a widely-spread analogy, would have been in some degree sterile if intercrossed; and such sterility will be admitted as almost certain by all those who believe that the lessened fertility of crossed forms is an infallible criterion of specific distinctness. Anyhow these animals keep distinct in the countries which they inhabit in common. On the other hand, all domestic dogs, which are here supposed to be descended from several distinct species, are, as far as is known, mutually fertile together. But, as Broca has well remarked,[45] the fertility of successive generations of mongrel dogs has never been scrutinised with that care which is thought indispensable when species are crossed. The few facts leading to the conclusion that the sexual feelings and reproductive powers differ in the several races of the dog when crossed are (passing over mere size as rendering propagation difficult) as follows: the Mexican Alco[46] apparently dislikes dogs of other kinds, but this perhaps is not strictly a sexual feeling; the hairless endemic dog of Paraguay, according to Rengger, mixes less with the European races than these do with each other; the Spitz dog in Germany is said to receive the fox more readily than do other breeds; and Dr. Hodgkin states that a female Dingo in England attracted the male wild foxes. If these latter statements can be trusted, they prove some degree of sexual difference in the breeds of the dog. But the fact remains that our domestic dogs, differing so widely as they do in external structure, are far more fertile together than we have reason to believe their supposed wild parents would have been. Pallas assumes[47] that a long course of domestication eliminates that sterility which the parent-species would have exhibited if only lately captured; no distinct facts are recorded in support of this hypothesis; but the evidence seems to me so strong (independently of the evidence derived from other domesticated animals) in favour of our domestic dogs having descended from several wild stocks, that I am inclined to admit the truth of this hypothesis.

There is another and closely allied difficulty consequent on the doctrine of the descent of our domestic dogs from several wild species, namely, that they do not seem to be perfectly fertile with their supposed parents. But the experiment has not been quite fairly tried; the Hungarian dog, for instance, which in external appearance so closely resembles the European wolf, ought to be crossed with this wolf: and the pariah dogs of India with Indian wolves and jackals; and so in other cases. That the sterility is very slight between certain dogs and wolves and other Canidæ is shown by savages taking the trouble to cross them. Buffon got four successive generations from the wolf and dog, and the mongrels were perfectly fertile together.[48] But more lately M. Flourens states positively as the result of his numerous experiments that hybrids from the wolf and dog, crossed *inter se,* become sterile at the third generation, and those from the jackal and dog at the fourth generation.[49] But these animals were closely confined; and many wild animals, as we shall see in a future chapter, are rendered by confinement in some degree or even utterly sterile. The Dingo, which breeds freely in Australia with our imported dogs, would not breed though repeatedly crossed in the Jardin des Plantes.[50] Some hounds from Central Africa, brought home by Major Denham, never bred in the Town of London;[51] and a similar tendency to sterility might be transmitted to the hybrid offspring of a wild animal. Moreover, it appears that in M. Flourens' experiments the hybrids were closely bred in and in for three or four generations; and this circumstance would most certainly increase the tendency to sterility. Several years ago I saw confined in the Zoological Gardens of London a female hybrid from an English dog and jackal, which even in this the first generation was so sterile that, as I was assured by her keeper, she did not fully exhibit her proper periods; but this case was certainly exceptional, as numerous instances have occurred of fertile hybrids from these two animals. In almost all experiments on the crossing of animals there are so many causes of doubt, that it is extremely difficult to come to any positive conclusion. It would, however, appear, that those who believe that our dogs are descended from several species will have not only to admit that their offspring after a long course of domestication generally lose all tendency to sterility when crossed together; but that between certain breeds of dogs and some of their supposed aboriginal parents a certain degree of sterility has been retained or possibly even acquired.

Notwithstanding the difficulties in regard to fertility given in the last two paragraphs, when we reflect on the inherent improbability of man having domesticated throughout the world one single species alone of so widely distributed, so easily tamed, and so useful a group as the Canidæ; when we reflect on the extreme antiquity of the different breeds; and especially when we reflect on the close similarity, both in external structure and habits, between the domestic dogs of various countries and the wild species still inhabiting these same countries, the balance of evidence is strongly in favour of the multiple origin of our dogs.

Differences between the several Breeds of the Dog.—If the several breeds have descended from several wild stocks, their difference can obviously in part be explained by that of their parent species. For instance, the form of the greyhound may be partly accounted for by descent from some such animal as the slim Abyssinian *Canis simensis,*[52] with its elongated muzzle; that of the larger dogs from the larger wolves, and the smaller and slighter dogs from the jackals: and thus perhaps we may account for certain constitutional and climatal differences. But it would be a great error to suppose that there has not been in addition[53] a large amount of variation. The intercrossing of the several aboriginal wild stocks, and of the subsequently formed races, has probably increased the total number of breeds, and, as we shall presently see, has greatly modified some of them. But we cannot explain by crossing the origin of such extreme forms as thoroughbred greyhounds, bloodhounds, bulldogs, Blenheim spaniels, terriers, pugs, etc., unless we believe that forms equally or more strongly characterised in these different respects once existed in nature. But hardly any one has been bold enough to suppose that such unnatural forms ever did or could exist in a wild state. When compared with all known members of the family of Canidæ they betray a distinct and abnormal origin. No instance is on record of such dogs as bloodhounds, spaniels, true greyhounds having been kept by savages: they are the product of long-continued civilisation.

The number of breeds and sub-breeds of the dog is great; Youatt for instance, describes twelve kinds of greyhounds. I will not attempt to enumerate or describe the varieties, for we cannot discriminate how much of their difference is due to variation, and how much to descent from different aboriginal stocks. But it may be worth while briefly to mention some points. Commencing with the skull, Cuvier has admitted[54] that in form the differences are “plus fortes que celles d’aucunes espèces sauvages d’un même genre naturel.” The proportions of the different bones; the curvature of the lower jaw, the position of the condyles with respect to the plane of the teeth (on which F. Cuvier founded his classification), and in mastiffs the shape of its posterior branch; the shape of the zygomatic arch, and of the temporal fossae; the position of the occiput—all vary considerably.[55] The difference in size between the brains of dogs belonging to large and small breeds "is something prodigious." "Some dogs' brains are high and rounded, while others are low, long, and narrow in front." In the latter, "the olfactory lobes are visible for about half their extent, when the brain is seen from above, but they are wholly concealed by the hemispheres in other breeds."[56] The dog has properly six pairs of molar teeth in the upper jaw, and seven in the lower; but several naturalists have seen not rarely an additional pair in the upper jaw;[57] and Professor Gervais says that there are dogs "qui ont sept paires de dents supérieures et huit inférieures." De Blainville[58] has given full particulars on the frequency of these deviations in the number of the teeth, and has shown that it is not always the same tooth which is supernumerary. In short-muzzled races, according to H. Müller,[59] the molar teeth stand obliquely, whilst in long-muzzled races they are placed longitudinally, with open spaces between them. The naked, so-called Egyptian or Turkish dog is extremely deficient in its teeth,[60] — sometimes having none except one molar on each side; but this, though characteristic of the breed, must be considered as a monstrosity. M. Girard,[61] who seems to have attended closely to the subject, says that the period of the appearance of the permanent teeth differs in different dogs, being earlier in large dogs; thus the mastiff assumes its adult teeth in four or five months, whilst in the spaniel the period is sometimes more than seven or eight months. On the other hand small dogs are mature, and the females have arrived at the best age for breeding, when one year old, whereas large dogs "are still in their puppyhood at this time, and take fully twice as long to develop their proportions."[62]

With respect to minor differences little need be said. Isidore Geoffroy has shown[63] that in size some dogs are six times as long (the tail being excluded) as others; and that the height relatively to the length of the body varies from between one to two, and one to nearly four. In the Scotch deer-hound there is a striking and remarkable difference in the size of the male and female.[64] Every one knows how the ears vary in size in different breeds, and with their great development their muscles become atrophied. Certain breeds of dogs are described as having a deep furrow between the nostrils and lips. The caudal vertebrae, according to F. Cuvier, on whose authority the two last statements rest, vary in number; and the tail in English cattle and some shepherd dogs is almost absent. The mammae vary from seven to ten in number; Daubenton, having examined twenty-one dogs, found eight with five mammae on each side; eight with four on each side; and the others with an unequal number on the two sides.[65] Dogs have properly five toes in front and four behind, but a fifth toe is often added; and F. Cuvier states that, when a fifth toe is present, a fourth cuneiform bone is developed; and, in this case, sometimes the great cuneiform bone is raised, and gives on its inner side a large articular surface to the astragalus; so that even the relative connection of the bones, the most constant of all characters, varies. These modifications, however, in the feet of dogs are not important, because they ought to be ranked, as De Blainville has shown[66] as monstrosities. Nevertheless they are interesting from being correlated with the size of the body, for they occur much more frequently with mastiffs and other large breeds than with small dogs. Closely allied varieties, however, sometimes differ in this respect; thus Mr. Hodgson states that the black-and-tan Lassa variety of the Thibet mastiff has the fifth digit, whilst the Mustang sub-variety is not thus characterised. The extent to which the skin is developed between the toes varies much; but we shall return to this point. The degree to which the various breeds differ in the perfection of their senses, dispositions, and inherited habits is notorious to every one. The breeds present some constitutional differences: the pulse, says Youatt[67] "varies materially according to the breed, as well as to the size of the animal." Different breeds of dogs are subject in different degrees to various diseases. They certainly become adapted to different climates under which they have long existed. It is notorious that most of our best European breeds deteriorate in India.[68] The Rev R. Everest[69] believes that no one has succeeded in keeping the Newfoundland dog long alive in India; so it is, according to Lichtenstein,[70] even at the Cape of Good Hope. The Thibet mastiff degenerates on the plains of India, and can live only on the mountains.[71] Lloyd[72] asserts that our bloodhounds and bulldogs have been tried, and cannot withstand the cold of the northern European forests.

Seeing in how many characters the races of the dog differ from each other, and remembering Cuvier's admission that their skulls differ more than do those of the species of any natural genus, and bearing in mind how closely the bones of wolves, jackals, foxes, and other Canidæ agree, it is remarkable that we meet with the statement, repeated over and over again, that the races of the dog differ in no important characters. A highly competent judge, Prof. Gervais,[73] admits "si l'on prenait sans contrôle les alterations dont chacun de ces organes est susceptible, on pourrait croire qu'il y a entre les chiens domestiques des différences plus grandes que celles qui séparent ailleurs les espèces, quelquefois même les genres." Some of the differences above enumerated are in one respect of comparatively little value, for they are not characteristic of distinct breeds: no one pretends that such is the case with the additional molar teeth or with the number of mammae; the additional digit is generally present with mastiffs, and some of the more important differences in the skull and lower jaw are more or less characteristic of various breeds. But we must not forget that the predominant power of selection has not been applied in any of these cases; we have variability in important parts, but the differences have not been fixed by selection. Man cares for the form and fleetness of his greyhounds, for the size of his mastiffs, and formerly for the strength of the jaw in his bulldogs, etc.; but he cares nothing about the number of their molar teeth or mammae or digits; nor do we know that differences in these organs are correlated with, or owe their development to, differences in other parts of the body about which man does care. Those who have attended to the subject of selection will admit that, nature having given variability, man, if he so chose, could fix five toes to the hinder feet of certain breeds of dogs, as certainly as to the feet of his Dorking fowls: he could probably fix, but with much more difficulty, an additional pair of molar teeth in either jaw, in the same way as he has given additional horns to certain breeds of sheep; if he wished to produce a toothless breed of dogs, having the so-called Turkish dog with its imperfect teeth to work on, he could probably do so, for he has succeeded in making hornless breeds of cattle and sheep.

With respect to the precise causes and steps by which the several races of dogs have come to differ so greatly from each other, we are, as in most other cases, profoundly ignorant. We may attribute part of the difference in external form and constitution to inheritance from distinct wild stocks, that is to changes effected under nature before domestication. We must attribute something to the crossing of the several domestic and natural races. I shall, however, soon recur to the crossing of races. We have already seen how often savages cross their dogs with wild native species; and Pennant gives a curious account[74] of the manner in which Fochabers, in Scotland, was stocked "with a multitude of curs of a most wolfish aspect" from a single hybrid-wolf brought into that district.

It would appear that climate to a certain extent directly modifies the forms of dogs. We have lately seen that several of our English breeds cannot live in India, and it is positively asserted that when bred there for a few generations they degenerate not only in their mental faculties, but in form. Captain Williamson,[75] who carefully attended to this subject, states that "hounds are the most rapid in their decline;" "greyhounds and pointers, also, rapidly decline." But spaniels, after eight or nine generations, and without a cross from Europe, are as good as their ancestors. Dr. Falconer informs me that bulldogs, which have been known, when first brought into the country, to pin down even an elephant by its trunk, not only fall off after two or three generations in pluck and ferocity, but lose the under-hung character of their lower jaws; their muzzles become finer and their bodies lighter. English dogs imported into India are so valuable that probably due care has been taken to prevent their crossing with native dogs; so that the deterioration cannot be thus accounted for. The Rev. R. Everest informs me that he obtained a pair of setters, born in India, which perfectly resembled their Scotch parents: he raised several litters from them in Delhi, taking the most stringent precautions to prevent a cross, but he never succeeded, though this was only the second generation in India, in obtaining a single young dog like its parents in size or make; their nostrils were more contracted, their noses more pointed, their size inferior, and their limbs more slender. So again on the coast of Guinea, dogs, according to Bosman, "alter strangely; their ears grow long and stiff like those of foxes, to which colour they also incline, so that in three or four years, they degenerate into very ugly creatures; and in three or four broods their barking turns into a howl."[76] This remarkable tendency to rapid deterioration in European dogs subjected to the climate of India and Africa, may be largely accounted for by reversion to a primordial condition which many animals exhibit, as we shall hereafter see, when their constitutions are in any way disturbed.

Some of the peculiarities characteristic of the several breeds of the dog have probably arisen suddenly, and, though strictly inherited, may be called monstrosities; for instance, the shape of the legs and body in the turnspit of Europe and India; the shape of the head and the under-hanging jaw in the bull-and pug-dog, so alike in this one respect and so unlike in all others. A peculiarity suddenly arising, and therefore in one sense deserving to be called a monstrosity, may, however, be increased and fixed by man's selection. We can hardly doubt that long-continued training, as with the greyhound in coursing hares, as with water-dogs in swimming—and the want of exercise, in the case of lapdogs—must have produced some direct effect on their structure and instincts. But we shall immediately see that the most potent cause of change has probably been the selection, both methodical and unconscious, of slight individual differences,—the latter kind of selection resulting from the occasional preservation, during hundreds of generations, of those individual dogs which were the most useful to man for certain purposes and under certain conditions of life. In a future chapter on Selection I shall show that even barbarians attend closely to the qualities of their dogs. This unconscious selection by man would be aided by a kind of natural selection; for the dogs of savages have partly to gain their own subsistence: for instance, in Australia, as we hear from Mr. Nind,[77] the dogs are sometimes compelled by want to leave their masters and provide for themselves; but in a few days they generally return. And we may infer that dogs of different shapes, sizes, and habits, would have the best chance of surviving under different circumstances,—on open sterile plains, where they have to run down their own prey,—on rocky coasts, where they have to feed on crabs and fish left in the tidal pools, as in the case of New Guinea and Tierra del Fuego. In this latter country, as I am informed by Mr. Bridges, the Catechist to the Mission, the dogs turn over the stones on the shore to catch the crustaceans which lie beneath, and they "are clever enough to knock off the shell-fish at a first blow;" for if this be not done, shell-fish are well-known to have an almost invincible power of adhesion.

It has already been remarked that dogs differ in the degree to which their feet are webbed. In dogs of the Newfoundland breed, which are eminently aquatic in their habits, the skin, according to Isidore Geoffroy,[78] extends to the third phalanges whilst in ordinary dogs it extends only to the second. In two Newfoundland dogs which I examined, when the toes were stretched apart and viewed on the under side, the skin extended in a nearly straight line between the outer margins of the balls of the toes; whereas, in two terriers of distinct sub-breeds, the skin viewed in the same manner was deeply scooped out. In Canada there is a dog which is peculiar to the country and common there, and this has "half-webbed feet and is fond of the water."[79] English otter-hounds are said to have webbed feet: a friend examined for me the feet of two, in comparison with the feet of some harriers and bloodhounds; he found the skin variable in extent in all, but more developed in the otter-hounds than in the others.[80] As aquatic animals which belong to quite different orders have webbed feet, there can be no doubt that this structure would be serviceable to dogs that frequent the water. We may confidently infer that no man ever selected his water-dogs by the extent to which the skin was developed between their toes; but what he does, is to preserve and breed from those individuals which hunt best in the water, or best retrieve wounded game, and thus he unconsciously selects dogs with feet slightly better webbed. The effects of use from the frequent stretching apart of the toes will likewise aid in the result. Man thus closely imitates Natural Selection. We have an excellent illustration of this same process in North America, where, according to Sir J. Richardson,[81] all the wolves, foxes, and aboriginal domestic dogs have their feet broader than in the corresponding species of the Old World, and "well calculated for running on the snow" Now, in these Arctic regions, the life or death of every animal will often depend on its success in hunting over the snow when soft; and this will in part depend on the feet being broad; yet they must not be so broad as to interfere with the activity of the animal when the ground is sticky, or with its power of burrowing holes, or with other necessary habits of life.

As changes in domestic breeds which take place so slowly are not to be noticed at any one period, whether due to the selection of individual variations or of differences resulting from crosses, are most important in understanding the origin of our domestic productions, and likewise in throwing indirect light on the changes effected under nature, I will give in detail such cases as I have been able to collect. Lawrence,[82] who paid particular attention to the history of the foxhound, writing in 1829, says that between eighty and ninety years before "an entirely new foxhound was raised through the breeder's art," the ears of the old southern hound being reduced, the bone and bulk lightened, the waist increased in length, and the stature somewhat added to. It is believed that this was effected by a cross with a greyhound. With respect to this latter dog, Youatt,[83] who is generally cautious in his statements, says that the greyhound within the last fifty years, that is before the commencement of the present century, "assumed a somewhat different character from that which he once possessed. He is now distinguished by a beautiful symmetry of form, of which he could not once boast, and he has even superior speed to that which he formerly exhibited. He is no longer used to struggle with deer, but contends with his fellows over a shorter and speedier course." An able writer[84] believes that our English greyhounds are the descendants, *progressively improved*, of the large rough greyhounds which existed in Scotland so early as the third century. A cross at some former period with the Italian greyhound has been suspected; but this seems hardly probable, considering the feebleness of this latter breed. Lord Orford, as is well-known, crossed his famous greyhounds, which failed in courage, with a bulldog—this breed being chosen from being erroneously supposed to be deficient in the power of scent; "after the sixth or seventh generation," says Youatt, "there was not a vestige left of the form of the bulldog, but his courage and indomitable perseverance remained."

Youatt infers, from a comparison of an old picture of King Charles's spaniels with the living dog, that "the breed of the present day is materially altered for the worse:" the muzzle has become shorter, the forehead more prominent, and the eyes larger; the changes in this case have probably been due to simple selection. The setter, as this author remarks in another place, "is evidently the large spaniel improved to his present peculiar size and beauty, and taught another way of marking his game. If the form of the dog were not sufficiently satisfactory on this point, we might have recourse to history:" he then refers to a document dated 1685 bearing on this subject, and adds that the pure Irish setter shows no signs of a cross with the pointer, which some authors suspect has been the case with the English setter. The bulldog is an English breed, and as I hear from Mr. G. R. Jesse,[85] seems to have originated from the mastiff since the time of Shakspeare; but certainly existed in 1631, as shown by Prestwick Eaton's letters. There can be no doubt that the fancy bulldogs of the present day, now that they are not used for bull-baiting, have become greatly reduced in size, without any express intention on the part of the breeder. Our pointers are certainly descended from a Spanish breed, as even their present names, Don, Ponto, Carlos, etc., show; it is said that they were not known in England before the Revolution in 1688;[86] but the breed since its introduction has been much modified, for Mr. Borrow, who is a sportsman and knows Spain intimately well, informs me that he has not seen in that country any breed "corresponding in figure with the English pointer; but there are genuine pointers near Xeres which have been imported by English gentlemen." A nearly parallel case is offered by the Newfoundland dog, which was certainly brought into England from that country, but which has since been so much modified that, as several writers have observed, it does not now closely resemble any existing native dog in Newfoundland.[87]

These several cases of slow and gradual changes in our English dogs possess some interest; for though the changes have generally, but not invariably, been caused by one or two crosses with a distinct breed, yet we may feel sure, from the well-known extreme variability of crossed breeds, that rigorous and long-continued selection must have been practised, in order to improve them in a definite manner. As soon as any strain or family became slightly improved or better adapted to alter circumstances, it would tend to supplant the older and less improved strains. For instance, as soon as the old foxhound was improved by a cross with the greyhound, or by simple selection, and assumed its present character—and the change was probably desired owing to the increased fleetness of our hunters—it rapidly spread throughout the country, and is now everywhere nearly uniform. But the process of improvement is still going on for every one tries to improve his strain by occasionally procuring dogs from the best kennels. Through this process of gradual substitution the old English hound has been lost; and so it has been with the Irish wolf-dog, the old English bulldog, and several other breeds, such as the alaunt, as I am informed by Mr. Jesse. But the extinction of former breeds is apparently aided by another cause; for whenever a breed is kept in scanty numbers, as at present with the bloodhound, it is reared with some difficulty, apparently from the evil effects of long-continued close interbreeding. As several breeds of the dog have been slightly but sensibly modified within so short a period as the last one or two centuries, by the selection of the best individuals, modified in many cases by crosses with other breeds; and as we shall hereafter see that the breeding of dogs was attended to in ancient times, as it still is by savages, we may conclude that we have in selection, even if only occasionally practised, a potent means of modification.

DOMESTIC CATS.

Cats have been domesticated in the East from an ancient period; Mr. Blyth informs me that they are mentioned in a Sanskrit writing 2000 years old, and in Egypt their antiquity is known to be even greater, as shown by monumental drawings and their mummied bodies. These mummies, according to De Blainville,[88] who has particularly studied the subject, belong to no less than three species, namely, *F. caligulata*, bubastes, and *chaus*. The two former species are said to be still found, both wild and domesticated, in parts of Egypt. *F. caligulata* presents a difference in the first inferior milk molar tooth, as compared with the domestic cats of Europe, which makes De Blainville conclude that it is not one of the parent-forms of our cats. Several naturalists, as Pallas, Temminck, Blyth, believe that domestic cats are the descendants of several species commingled: it is certain that cats cross readily with various wild species, and it would appear that the character of the domestic breeds has, at least in some cases, been thus affected. Sir W. Jardine has no doubt that, "in the north of Scotland, there has been occasional crossing with our native species (*F. sylvestris*), and that the result of these crosses has been kept in our houses. I have seen," he adds, "many cats very closely resembling the wild cat, and one or two that could scarcely be distinguished from it." Mr. Blyth[89] remarks on this passage, "but such cats are never seen in the southern parts of England; still, as compared with any Indian tame cat, the affinity of the ordinary British cat to *F. sylvestris* is manifest; and due I suspect to frequent intermixture at a time when the tame cat was first introduced into Britain and continued rare, while the wild species was far more abundant than at present." In Hungary, Jeitteles[90] was assured on trustworthy authority that a wild male cat crossed with a female domestic cat, and that the hybrids long lived in a domesticated state. In Algiers the domestic cat has crossed with the wild cat (*F. lybica*) of that country.[91] In South Africa as Mr. E. Layard informs me, the domestic cat intermingles freely with the wild *F. caffra*; he has seen a pair of hybrids which were quite tame and particularly attached to the lady who brought them up; and Mr. Fry has found that these hybrids are fertile. In India the domestic cat, according to Mr. Blyth, has crossed with four Indian species. With respect to one of these species, *F. chaus*, an excellent observer, Sir W. Elliot, informs me that he once killed, near Madras, a wild brood, which were evidently hybrids from the domestic cat; these young animals had a thick lynx-like tail and the broad brown bar on the inside of the forearm characteristic of *F. chaus*. Sir W. Elliot adds that he has often observed this same mark on the forearms of domestic cats in India. Mr. Blyth states that domestic cats coloured nearly like *F. chaus*, but not resembling that species in shape, abound in Bengal; he adds, "such a colouration is utterly unknown in European cats, and the proper tabby markings (pale streaks on a black ground, peculiarly and symmetrically disposed), so common in English cats, are never seen in those of India." Dr. D. Short has assured Mr. Blyth[92] that, at Hansi, hybrids between the common cat and *F. ornata* (or *torquata*) occur, "and that many of the domestic cats of that part of India were undistinguishable from the wild *F. ornata*." Azara states, but only on the authority of the inhabitants, that in Paraguay the cat has crossed with two native species. From these several cases we see that in Europe, Asia, Africa, and America, the common cat, which lives a freer life than most other domesticated animals, has crossed with various wild species; and that in some instances the crossing has been sufficiently frequent to affect the character of the breed.

Whether domestic cats have descended from several distinct species, or have only been modified by occasional crosses, their fertility, as far as is known, is unimpaired. The large Angora or Persian cat is the most distinct in structure and habits of all the domestic breeds; and is believed by Pallas, but on no distinct evidence, to be descended from the *F. manul* of middle Asia; and I am assured by Mr. Blyth that the Angora cat breeds freely with Indian cats, which, as we have already seen, have apparently been much crossed with *F. chaus.* In England half-bred Angora cats are perfectly fertile with one another.

Within the same country we do not meet with distinct races of the cat, as we do of dogs and of most other domestic animals; though the cats of the same country present a considerable amount of fluctuating variability. The explanation obviously is that, from their nocturnal and rambling habits, indiscriminate crossing cannot without much trouble be prevented. Selection cannot be brought into play to produce distinct breeds, or to keep those distinct which have been imported from foreign lands. On the other hand, in islands and in countries completely separated from each other, we meet with breeds more or less distinct; and these cases are worth giving, showing that the scarcity of distinct races in the same country is not caused by a deficiency of variability in the animal. The tailless cats of the Isle of Man are said to differ from common cats not only in the want of a tail, but in the greater length of their hind legs, in the size of their heads, and in habits. The Creole cat of Antigua, as I am informed by Mr. Nicholson, is smaller, and has a more elongated head, than the British cat. In Ceylon, as Mr. Thwaites writes to me, every one at first notices the different appearance of the native cat from the English animal; it is of small size, with closely lying hairs; its head is small, with a receding forehead; but the ears are large and sharp; altogether it has what is there called a "low-caste" appearance. Rengger[93] says that the domestic cat, which has been bred for 300 years in Paraguay, presents a striking difference from the European cat; it is smaller by a fourth, has a more lanky body, its hair is short, shining, scanty and lies close, especially on the tail: he adds that the change has been less at Ascension, the capital of Paraguay, owing to the continual crossing with newly imported cats; and this fact well illustrates the importance of separation. The conditions of life in Paraguay appear not to be highly favourable to the cat, for, though they have run half-wild, they do not become thoroughly feral, like so many other European animals. In another part of South America, according to Roulin,[94] the introduced cat has lost the habit of uttering its hideous nocturnal howl. The Rev. W.D. Fox purchased a cat in Portsmouth, which he was told came from the coast of Guinea; its skin was black and wrinkled, fur bluish-grey and short, its ears rather bare, legs long, and whole aspect peculiar. This "negro" cat was fertile with common cats. On the opposite coast of Africa, at Mombas, Captain Owen, R.N.,[95] states that all the cats are covered with short stiff hair instead of fur: he gives a curious account of a cat from Algoa Bay, which had been kept for some time on board and could be identified with certainty; this animal was left for only eight weeks at Mombas, but during that short period it "underwent a complete metamorphosis, having parted with its sandy-coloured fur." A cat from the Cape of Good Hope has been described by Desmarest as remarkable from a red stripe extending along the whole length of its back. Throughout an immense area, namely, the Malayan archipelago, Siam, Pegu, and Burmah, all the cats have truncated tails about half the proper length,[96] often with a sort of knot at the end. In the Caroline archipelago the cats have very long legs, and are of a reddish-yellow colour.[97] In China a breed has drooping ears. At Tobolsk, according to Gmelin, there is a red-coloured breed. In Asia, also, we find the well-known Angora or Persian breed.

The domestic cat has run wild in several countries, and everywhere assumes, as far as can be judged by the short recorded descriptions, a uniform character. Near Maldonado, in La Plata, I shot one which seemed perfectly wild; it was carefully examined by Mr. Waterhouse,[98] who found nothing remarkable in it, excepting its great size. In New Zealand according to Dieffenbach, the feral cats assume a streaky grey colour like that of wild cats; and this is the case with the half-wild cats of the Scotch Highlands.

We have seen that distant countries possess distinct domestic races of the cat. The differences may be in part due to descent from several aboriginal species, or at least to crosses with them. In some cases, as in Paraguay, Mombas, and Antigua, the differences seem due to the direct action of different conditions of life. In other cases some slight effect may possibly be attributed to natural selection, as cats in many cases have largely to support themselves and to escape diverse dangers. But man, owing to the difficulty of pairing cats, has done nothing by methodical selection; and probably very little by unintentional selection; though in each litter he generally saves the prettiest, and values most a good breed of mouse- or rat-catchers. Those cats which have a strong tendency to prowl after game, generally get destroyed by traps. As cats are so much petted, a breed bearing the same relation to other cats, that lapdogs bear to larger dogs, would have been much valued; and if selection could have been applied, we should certainly have had many breeds in each long-civilised country, for there is plenty of variability to work upon.

We see in this country considerable diversity in size, some in the proportions of the body, and extreme variability in colouring. I have only lately attended to this subject, but have already heard of some singular cases of variation; one of a cat born in the West Indies toothless, and remaining so all its life. Mr. Tegetmeier has shown me the skull of a female cat with its canines so much developed that they protruded uncovered beyond the lips; the tooth with the fang being .95, and the part projecting from the gum

.6 of an inch in length. I have heard of several families of six-toed cats, in one of which the peculiarity had been transmitted for at least three generations. The tail varies greatly in length; I have seen a cat which always carried its tail flat on its back when pleased. The ears vary in shape, and certain strains, in England, inherit a pencil-like tuft of hairs, above a quarter of an inch in length, on the tips of their ears; and this same peculiarity, according to Mr. Blyth, characterises some cats in India. The great variability in the length of the tail and the lynx-like tufts of hairs on the ears are apparently analogous to differences in certain wild species of the genus. A much more important difference, according to Daubenton,[99] is that the intestines of domestic cats are wider, and a third longer, than in wild cats of the same size; and this apparently has been by their less strictly carnivorous diet.

REFERENCES

[1] Owen 'British Fossil Mammals,' pp. 123 to 133. Pictet's 'Traité de Pal.,' 1853, tom. i. p. 202. De Blainville in his 'Ostéographie, Canidæ,' p. 142, has largely discussed the whole subject, and concludes that the extinct parent of all domesticated dogs came nearest to the wolf in organisation, and to the jackal in habits. *See also* Boyd Dawkins, 'Cave Hunting,' 1874, p. 131, etc., and his other publications. Jeitteles has discussed in great detail the character of the breeds of pre-historic dogs: 'Die vorgeschichtlichen Alterthümer der Stadt Olmütz,' II. Theil, 1872, p. 44 to end.

[2] Pallas, I believe, originated this doctrine in 'Act. Acad. St. Petersburgh,' 1780, Part ii. Ehrenberg has advocated it, as may be seen in De Blainville's 'Ostéographie,' p. 79. It has been carried to an extreme extent by Col. Hamilton Smith in the 'Naturalist Library,' vols ix and x. Mr. W. C. Martin adopts it in his excellent 'History of the Dog,' 1845; as does Dr. Morton, as well as Nott and Gliddon, in the United States. Prof. Low, in his 'Domesticated Animals,' 1845, p. 666, comes to this same conclusion. No one has argued on this side with more clearness and force than the late James Wilson, of Edinburgh, in various papers read before the Highland Agricultural and Wernerian Societies. Isidore Geoffroy Saint-Hilaire ('Hist. Nat. Gén.,' 1860, tom. iii. p. 107), though he believes that most dogs have descended from the jackal, yet inclines to the belief that some are descended from the wolf. Prof. Gervais ('Hist. Nat. Mamm.' 1855, tom. ii. p. 69, referring to the view that all the domestic races are the modified descendants of a single species, after a long discussion, says, "Cette opinion est, suivant nous du moins, la moins probable."

[3] Berjeau, 'The Varieties of the Dog; in old Sculptures and Pictures,' 1863. 'Der Hund,' von Dr. F. L. Walther, Giessen, 1817, s. 48: this author seems carefully to have studied all classical works on the subject. *See also* Volz, 'Beiträge zur Kulturgeschichte,' Leipzig, 1852, s. 115, 'Youatt on the Dog,' 1845, p. 6. A very full history is given by De Blainville in his 'Ostéographie, Canidæ.'

[4] I have seen drawings of this dog from the tomb of the son of Esar Haddon, and clay models in the British Museum. Nott and Gliddon, in their ‘Types of Mankind,’ 1854, p. 393, give a copy of these drawings. This dog has been called a Thibetan mastiff, but Mr. H. A. Oldfield, who is familiar with the so-called Thibet mastiff, and has examined the drawings in the British Museum, informs me that he considers them different.

[5] ‘Proc. Zoolog. Soc.,’ July 12th, 1831.

[6] ‘Sporting in Algeria,’ p. 51.

[7] Berjeau gives facsimiles of the Egyptian drawings. Mr. C. L. Martin in his ‘History of the Dog,’ 1845, copies several figures from the Egyptian monuments, and speaks with much confidence with respect to their identity with still living dogs. Messrs. Nott and Gliddon (‘Types of Mankind,’ 1854, p. 388) give still more numerous figures. Mr. Gliddon asserts that a curl-tailed greyhound, like that represented on the most ancient monuments, is common in Borneo; but the Rajah, Sir J. Brooke, informs me that no such dog exists there.

[8] These, and the following facts on the Danish remains, are taken from M. Morlot’s most interesting memoir in ‘Soc. Vaudoise des Sc. Nat.’ tom. vi., 1860, pp. 281, 299, 320.

[9] ‘Die Fauna der Pfahlbauten,’ 1861, s. 117, 162.

[10] De Blainville ‘Ostéographie, Canidæ.’

[11] Sir R. Schomburgk has given me information on this head. *See also* ‘Journal of R. Geographical Soc.’ vol. xiii. 1843, p. 65.

[12] ‘Domestication of Animals:’ Ethnological Soc., Dec. 22nd, 1863.

[13] ‘Journal of Researches,’ etc., 1845, p. 393. With respect to *Canis antarcticus, see* p. 193. For the case of the antelope, *see* ‘Journal Royal Geograph. Soc.,’ vol. xxiii. p. 94.

[14] The authorities for the foregoing statements are as follow:—Richardson in ‘Fauna Boreali-Americana,’ 1829, pp. 64, 75; Dr. Kane ‘Arctic Explorations,’ 1856, vol. i. pp. 398, 455; Dr. Hayes ‘Arctic Boat Journey,’ 1860, p. 167. Franklin’s ‘Narrative,’ vol. i. p. 269, gives the case of three whelps of a black wolf being carried away by the Indians. Parry, Richardson, and others, give accounts of wolves and dogs naturally crossing in the eastern parts of North America. Seeman in his ‘Voyage of H.M.S. *Herald*,’ 1853, vol. ii. p. 26, says the wolf is often caught by the Esquimaux for the purpose of crossing with their dogs, and thus adding to their size and strength. M. Lamare-Picquot in ‘Bull. de la Soc. d’Acclimat,’ tom. vii., 1860, p. 148, gives a good account of the half-bred Esquimaux dogs.

[15] ‘Fauna Boreali-Americana,’ 1829, pp. 73, 78, 80. Nott and Gliddon, ‘Types of Mankind,’ p. 383. The naturalist and traveller Bartram is quoted by Hamilton Smith, in ‘Naturalist Lib.,’ vol. x. p. 156. A Mexican domestic dog seems also to resemble a wild dog of the same country; but this may be the prairie-wolf. Another capable judge, Mr. J. K. Lord (‘The Naturalist in Vancouver Island,’ 1866, vol. ii. p. 218), says that the Indian dog of the Spokans, near the Rocky Mountains, “is beyond all question nothing more than a tamed Cayote or prairie-wolf,” or *Canis latrans.*)

[16] I quote this from Mr. R. Hill’s excellent account of the Alco or domestic dog of Mexico, in Gosse’s ‘Naturalist’s Sojourn in Jamaica,’ 1851, p. 329.

[17] ‘Naturgeschichte der Säugethiere von Paraguay,’ 1830, s. 151.

[18] Quoted in Humboldt’s ‘Aspects of Nature’ (Eng. trans.), vol. i. p. 108.

[19] p.t’s ‘Travels in Hungary and Transylvania,’ vol. i. p. 501. Jeitteles ‘Fauna Hungariæ Superioris,’ 1862, s. 13. *See* Pliny ‘Hist. of the World’ (Eng. trans.), 8th book, ch. xl., about the Gauls crossing their dogs. *See also* Aristotle ‘Hist. Animal.’lib. viii. c. 28. For good evidence about wolves and dogs naturally crossing near the Pyrenees, *see* M. Mauduyt ‘Du Loup et de ses Races,’ Poitiers, 1851; also Pallas in ‘Acta Acad. St. Petersburgh,’ 1780, part ii. p. 94.

[20] I give this on excellent authority, namely Mr. Blyth (under the signature of Zoophilus), in the ‘Indian Sporting Review,’ Oct. 1856, p. 134. Mr. Blyth states that he was struck with the resemblance between a brush-tailed race of pariah-dogs, north-west of Cawnpore, and the Indian wolf. He gives corroborative evidence with respect to the dogs of the valley of the Nerbudda.

[21] For numerous and interesting details on the resemblance of dogs and jackals *see* Isid. Geoffroy St.-Hilaire ‘Hist. Nat. Gén.,’ 1860, tom. iii. p. 101. *See also* ‘Hist. Nat. des Mammifères,’ par Prof. Gervais, 1855, tom. ii. p. 60.

[22] Also Güldenstädt ‘Nov. Comment. Acad. Petrop.,’ tom. xx., pro anno 1775, p. 449. Also Salvin in ‘Land and Water,’ Oct. 1869.

[23] Quoted by De Blainville in his ‘Ostéographie, Canidæ,’ pp. 79, 98.

[24] *See* Pallas in ‘Act. Acad. St. Petersburgh,’ 1780, part ii. p. 91. For Algeria, *see* Isid. Geoffroy St.-Hilaire ‘Hist. Nat. Gén.,’ tom. iii. p. 177. In both countries it is the male jackal which pairs with female domestic dogs.

[25] John Barbut’s ‘Description of the Coast of Guinea in 1746.’

[26] ‘Travels in South Africa,’ vol. ii. p. 272.

[27] Selwyn, Geology of Victoria; 'Journal of Geolog. Soc.,' vol. xiv., 1858, p. 536, and vol. xvi., 1860, p. 148; and Prof. M'Coy, in 'Annals and Mag. of Nat. Hist.' (3rd series) vol. ix., 1862, p. 147. The Dingo differs from the dogs of the central Polynesian islands. Dieffenbach remarks ('Travels,' vol. ii. p. 45) that the native New Zealand dog also differs from the Dingo.

[28] These latter remarks afford, I think, a sufficient answer to some criticisms by Mr. Wallace, on the multiple origin of dogs, given in Lyell's 'Principles of Geology,' 1872, vol. ii. p. 295.

[29] 'Proceedings Zoolog. Soc.,' 1833, p. 112. *See also,* on the taming of the common wolf, L. Lloyd, 'Scandinavian Adventures,' 1854, vol. i. p. 460. With respect to the jackal, *see* Prof. Gervais 'Hist. Nat. Mamm.' tom. ii. p. 61. With respect to the aguara of Paraguay *see* Rengger's work.

[30] Roulin, in 'Mém. présent. par divers Savans,' tom. vi. p. 341.

[31] Martin, 'History of the Dog,' p. 14.

[32] Quoted by L. Lloyd in 'Field Sports of North of Europe,' vol. i. p. 387.

[33] Quatrefages, 'Soc. d'Acclimat.,' May 11th, 1863, p. 7.

[34] 'Annals and Mag. of Nat. Hist.' vol. xv., 1845, p. 140.

[35] Azara, 'Voyages dans l'Amér. Mérid.' tom. i. p. 381; his account is fully confirmed by Rengger. Quatrefages gives an account of a bitch brought from Jerusalem to France which burrowed a hole and littered in it. *See* 'Discours, Exposition des Races Canines,' 1865, p. 3.

[36] With respect to wolves burrowing holes *see* Richardson, 'Fauna Boreali-Americana,' p. 64; and Bechstein 'Naturgeschichte Deutschlands,' B. i. s. 617.

[37] *See* Poeppig, 'Reise in Chile,' B. i. s. 290; Mr. G. Clarke, as above; and Rengger, s. 155.

[38] Dogs, 'Nat. Library,' vol. x. p. 121; an endemic South American dog seems also to have become feral in this island. *See* Gosse's 'Jamaica,' p. 340.

[39] Low 'Domesticated Animals,' p. 650.

[40] 'The Naturalist Library,' Dogs, vol. x. pp. 4, 19.

[41] Quoted by Prof. Gervais, 'Hist. Nat. Mamm.,' tom. ii. p. 66.

[42] J. Hunter shows that the long period of seventy-three days given by Buffon is easily explained by the bitch having received the dog many times during a period of sixteen days ('Phil. Transact.,' 1787, p. 353). Hunter found that the gestation of a mongrel from wolf and dog ('Phil. Transact.,'

1789, p. 160) apparently was sixty-three days, for she received the dog more than once. The period of a mongrel dog and jackal was fifty-nine days. Fred. Cuvier found the period of gestation of the wolf to be (‘Dict. Class. d’Hist. Nat.’ tom. iv. p. 8) two months and a few days, which agrees with the dog. Isid G. St.-Hilaire, who has discussed the whole subject, and from whom I quote Bellingeri, states (‘Hist. Nat. Gén.,’ tom. iii. p. 112) that in the Jardin des Plantes the period of the jackal has been found to be from sixty to sixty-three days, exactly as with the dog.

[43] *See* Isid. Geoffroy St.-Hilaire ‘Hist. Nat. Gén.,’ tom. iii. p. 112, on the odour of jackals. Col. Ham. Smith in ‘Nat. Lib.,’ vol. x. p. 289.

[44] Quoted by Quatrefages in ‘Bull. Soc. d’Acclimat.,’ May 11th, 1863.

[45] ‘Journal de la Physiologie,’ tom. ii. p. 385.

[46] *See* Mr. R. Hill’s excellent account of this breed in Gosse’s ‘Jamaica,’ p. 338; Rengger ‘Säugethiere von Paraguay,’ s. 153. With respect to Spitz dogs, *see* Bechstein’s ‘Naturgesch. Deutschlands,’ 1801, B. i. s. 638. With respect to Dr. Hodgkin’s statement made before Brit. Assoc. *see* ‘The Zoologist,’ vol. iv. for 1845-46 p. 1097.

[47] ‘Acta Acad. St. Petersburgh,’ 1780, part ii. pp. 84, 100.

[48] M. Broca has shown (‘Journal de Physiologie,’ tom. ii. p. 353) that Buffon’s experiments have been often misrepresented. Broca has collected (pp. 390-395) many facts on the fertility of crossed dogs, wolves, and jackals.

[49] ‘De la Longévité Humaine,’ par M. Flourens, 1855, p. 143. Mr. Blyth says (‘Indian Sporting Review,’ vol. 2 p. 137) that he has seen in India several hybrids from the pariah-dog and jackal; and between one of these hybrids and a terrier. The experiments of Hunter on the jackal are well-known. *See also* Isid. Geoffroy St.-Hilaire, ‘Hist. Nat. Gén.,’ tom. iii. p. 217, who speaks of the hybrid offspring of the jackal as perfectly fertile for three generations.

[50] On authority of F. Cuvier quoted in Bronn’s ‘Geschichte der Natur,’ B ii. s. 164.

[51] W. C. L. Martin ‘History of the Dog,’ 1845, p. 203. Mr. Philip P. King, after ample opportunities of observation, informs me that the Dingo and European dogs often cross in Australia.

[52] Rüppel ‘Neue Wirbelthiere von Abyssinien,’ 1835-40 ‘Mammif.,’ s. 39 pl. xiv. There is a specimen of this fine animal in the British Museum.

[53] Even Pallas admits this; *see* ‘Act. Acad. St. Petersburgh,’ 1780, p. 93.

[54] Quoted by I. Geoffroy, ‘Hist. Nat. Gén.,’ tom. iii. p. 453.

[55] F. Cuvier in ‘Annales du Muséum,’ tom. xviii. p. 337; Godron ‘De l’Espèce,’ tom. i. p. 342; and Col. H. Smith in ‘Nat. Library,’ vol. ix. p. 101. *See also* some observations on the degeneracy of the skull in certain breeds, by Prof. Bianconi, ‘La Theorie Darwinienne,’ 1874, p. 279.

[56] Dr. Burt Wilder, ‘American Assoc. Advancement of Science,’ 1873, pp. 236, 239.

[57] Isid. Geoffroy Saint-Hilaire ‘Hist. des Anomalies,’ 1832, tom. i. p. 660, Gervais ‘Hist. Nat. des Mammifères,’ tom. ii., 1855, p. 66. De Blainville (‘Ostéographie, Canidæ,’ p. 137) has also seen an extra molar on both sides.

[58] ‘Ostéographie, Canidæ,’ p. 137.

[59] Würzburger ‘Medecin. Zeitschrift,’ 1860, B. i. s. 265.

[60] Mr. Yarrell in ‘Proc. Zoolog. Soc.,’ Oct. 8th, 1833. Mr. Waterhouse showed me a skull of one of these dogs, which had only a single molar on each side and some imperfect incisors.

[61] Quoted in ‘The Veterinary,’ London, vol. viii. p. 415.

[62] This is quoted from Stonehenge, a great authority, ‘The Dog,’ 1867, p. 187.

[63] ‘Hist. Nat. Général,’ tom. iii. p. 448.

[64] W. Scrope ‘Art of Deer-Stalking,’ p. 354.

[65] Quoted by Col. Ham. Smith in ‘Nat. Lib.,’ vol. x. p. 79.

[66] De Blainville ‘Ostéographie, Canidæ,’ p. 134. F. Cuvier ‘Annales du Muséum,’ tom. xviii. p. 342. In regard to mastiffs, *see* Col. H. Smith ‘Nat. Lib.’ vol. x. p. 218. For the Thibet mastiff, *see* Mr. Hodgson in ‘Journal of As. Soc. of Bengal,’ vol. i., 1832, p. 342.

[67] ‘The Dog,’ 1845, p. 186. With respect to diseases Youatt asserts (p. 167) that the Italian greyhound is “strongly subject” to polypi in the matrix or vagina. The spaniel and pug (p. 182) are most liable to bronchocele. The liability to distemper (p. 232) is extremely different in different breeds. On the distemper, *see also* Col. Hutchinson on ‘Dog Breaking,’ 1850, p. 279.

[68] *See* Youatt on the Dog, p. 15; ‘The Veterinary,’ London, vol. xi. p. 235.

[69] ‘Journal of As. Soc. of Bengal,’ vol. iii. p. 19.

[70] ‘Travels,’ vol. ii. p. 15.

[71] Hodgson in ‘Journal of As. Soc. of Bengal,’ vol. i. p. 342.

[72] ‘Field Sports of the North of Europe,’ vol. ii. p. 165.

[73] ‘Hist. Nat. des Mammif.,’ 1855, tom. ii. pp. 66, 67.

[74] ‘History of Quadrupeds,’ 1793, vol. i. p. 238.

[75] ‘Oriental Field Sports,’ quoted by Youatt, ‘The Dog,’ p. 15.

[76] A. Murray gives this passage in his ‘Geographical Distribution of Mammals,’ 4to, 1866, p. 8.

[77] Quoted by Mr. Galton, ‘Domestication of Animals,’ p. 13.

[78] ‘Hist. Nat. Gén.,’ tom. iii. p. 450.

[79] Mr. Greenhow on the Canadian Dog in Loudon’s ‘Mag. of Nat. Hist.,’ vol. vi., 1833, p. 511.

[80] *See* Mr. C. O. Groom-Napier on the webbing of the hind feet of Otterhounds in ‘Land and Water,’ Oct. 13, 1866, p. 270.

[81] ‘Fauna Boreali-Americana,’ 1829, p. 62.

[82] ‘The Horse in all his Varieties,’ etc., 1829, pp. 230, 234.

[83] ‘The Dog,’ 1845, pp. 31, 35; with respect to King Charles’s spaniel, p. 45; for the setter, p. 90.

[84] In the ‘Encyclop. of Rural Sports,’ p. 557.

[85] Author of ‘Researches into the History of the British Dog.’

[86] *See* Col. Hamilton Smith on the antiquity of the Pointer, in ‘Nat. Lib.’ vol. x. p. 196.

[87] The Newfoundland dog is believed to have originated from a cross between the Esquimaux dog and a large French hound. *See* Dr. Hodgkin ‘British Assoc.,’ 1844; Bechstein ‘Naturgesch. Deutschland,’ B. i. s. 574; ‘Nat. Lib.,’ vol. x. p. 132; also Mr. Jukes’ ‘Excursion in and about Newfoundland.’

[88] De Blainville ‘Ostéographie, Felis,’ p. 65, on the character of *F. caligulata*; pp. 85, 89, 90, 175, on the other mummied species. He quotes Ehrenberg on *F. maniculata* being mummied.

[89] Asiatic Soc. of Calcutta; Curator’s Report, Aug. 1856. The passage from Sir W. Jardine is quoted from this Report. Mr. Blyth, who has especially attended to the wild and domestic cats of India, has given in this Report a very interesting discussion on their origin.

[90] ‘Fauna Hungariæ Sup.,’ 1862, s. 12.

[91] Isid. Geoffroy Saint-Hilaire, ‘Hist. Nat. Gén.,’ tom. iii. p. 177.

[92] 'Proc. Zoolog. Soc.,' 1863, p. 184.

[93] 'Säugethiere von Paraguay,' 1830, s. 212.

[94] 'Mem. présentés par divers Savans: Acad. Roy. des Sciences,' tom. vi. p. 346. Gomara first noticed this fact in 1554.

[95] 'Narrative of Voyages,' vol. ii. p. 180.

[96] J. Crawfurd 'Descript. Dict. of the Indian Islands,' p. 255. The Madagascar cat is said to have a twisted tail; *see* Desmarest in 'Encyclop. Nat. Mamm.,' 1820, p. 233, for some of the other breeds.

[97] Admiral Lutké's Voyage, vol. iii. p. 308.

[98] 'Zoology of the Voyage of the Beagle, Mammalia,' p. 20. Dieffenbach 'Travels in New Zealand,' vol. ii. p. 185. Ch. St. John 'Wild Sports of the Highlands,' 1846, p. 40.

[99] Quoted by Isid. Geoffroy 'Hist. Nat. Gén.,' tom. iii. p. 427.

CHAPTER II.
HORSES AND ASSES.

HORSE. DIFFERENCES IN THE BREEDS—INDIVIDUAL VARIABILITY OF—DIRECT EFFECTS OF THE CONDITIONS OF LIFE—CAN WITHSTAND MUCH COLD—BREEDS MUCH MODIFIED BY SELECTION—COLOURS OF THE HORSE—DAPPLING—DARK STRIPES ON THE SPINE, LEGS, SHOULDERS, AND FOREHEAD—DUN-COLOURED HORSES MOST FREQUENTLY STRIPED—STRIPES PROBABLY DUE TO REVERSION TO THE PRIMITIVE STATE OF THE HORSE.

ASSES. BREEDS OF—COLOUR OF—LEG- AND SHOULDER-STRIPES—SHOULDER-STRIPES SOMETIMES ABSENT, SOMETIMES FORKED.

The history of the Horse is lost in antiquity. Remains of this animal in a domesticated condition have been found in the Swiss lake-dwellings, belonging to the Neolithic period.[1] At the present time the number of breeds is great, as may be seen by consulting any treatise on the Horse.[2] Looking only to the native ponies of Great Britain, those of the Shetland Isles, Wales, the New Forest, and Devonshire are distinguishable; and so it is, amongst other instances, with each separate island in the great Malay archipelago.[3] Some of the breeds present great differences in size, shape of ears, length of mane, proportions of the body, form of the withers and hind quarters, and especially in the head. Compare the race-horse, dray-horse, and a Shetland pony in size, configuration, and disposition; and see how much greater the difference is than between the seven or eight other living species of the genus Equus.

Of individual variations not known to characterise particular breeds, and not great or injurious enough to be called monstrosities, I have not collected many cases. Mr. G. Brown, of the Cirencester Agricultural College, who has particularly attended to the dentition of our domestic animals, writes to me that he has "several times noticed eight permanent incisors instead of six in the jaw." Male horses only should have canines, but they are occasionally found in the mare, though a small size.[4] The number of ribs on each side is properly eighteen, but Youatt[5] asserts that not unfrequently there are nineteen, the additional one being always the posterior rib. It is a remarkable fact that the ancient Indian horse is said in the Rig-Vêda to have only seventeen ribs; and M. Piétrement,[6] who has called attention to this subject, gives various reasons for placing full trust in this statement, more especially as during former times the Hindoos carefully counted the bones of animals. I have seen several notices of variations in the bones of the leg; thus Mr. Price[7] speaks of an additional bone in the hock, and of certain abnormal appearances between the tibia and astragalus, as quite common in Irish horses, and not due to disease. Horses have often been observed, according to M. Gaudry,[8] to possess a trapezium and a rudiment of a fifth metacarpal bone, so that "one sees appearing by monstrosity, in the foot of the horse, structures which normally exist in the foot of the Hipparion,"—an allied and extinct animal. In various countries horn-like projections have been observed on the frontal bones of the horse: in one case described by Mr. Percival they arose about two inches above the orbital processes, and were "very like those in a calf from five to six months old," being from half to three-quarters of an inch in length.[9] Azara has described two cases in South America in which the projections were between three and four inches in length: other instances have occurred in Spain.

That there has been much inherited variation in the horse cannot be doubted, when we reflect on the number of the breeds existing throughout the world or even within the same country, and when we know that they have largely increased in number since the earliest known records.[10] Even in so fleeting a character as colour, Hofacker[11] found that, out of 216 cases in which horses of the same colour were paired, only eleven pairs produced foals of a quite different colour. As Professor Low[12] has remarked, the English race-horse offers the best possible evidence of inheritance. The pedigree of a race-horse is of more value in judging of its probable success than its appearance: "King Herod" gained in prizes 201,505 pounds sterling, and begot 497 winners; "Eclipse" begot 334 winners.

Whether the whole amount of difference between the various breeds has arisen under domestication is doubtful. From the fertility of the most distinct breeds[13] when crossed, naturalists have generally looked at all the breeds as having descended from a single species. Few will agree with Colonel H. Smith, who believes that they have descended from no less than five primitive and differently coloured stocks.[14] But as several species and varieties of the horse existed[15] during the later tertiary periods, and as Rutimeyer found differences in the size and form of the skull in the earliest known domesticated horses,[16] we ought not to feel sure that all our breeds are descended from a single species. The savages of North and South America easily reclaim the feral horses, so that there is no improbability in savages in various quarters of the world having domesticated more than one native species or natural race. M. Sanson[17] thinks that he has proved that two distinct species have been domesticated, one in the East, and one in North Africa; and that these differed in the number of their lumbar vertebra and in various other parts; but M. Sanson seems to believe that osteological characters are subject to very little variation, which is certainly a mistake. At present no aboriginal or truly wild horse is positively known to exist; for it is commonly believed that the wild horses of the East are escaped domestic animals.[18] If therefore our domestic breeds are descended from several species or natural races, all have become extinct in the wild state.

With respect to the causes of the modifications which horses have undergone, the conditions of life seem to produce a considerable direct effect. Mr. D. Forbes, who has had excellent opportunities of comparing the horses of Spain with those of South America, informs me that the horses of Chile, which have lived under nearly the same conditions as their progenitors in Andalusia, remain unaltered, whilst the Pampas horses and the Puno horses are considerably modified. There can be no doubt that horses become greatly reduced in size and altered in appearance by living on mountains and islands; and this apparently is due to want of nutritious or varied food. Every one knows how small and rugged the ponies are on the Northern islands and on the mountains of Europe. Corsica and Sardinia have their native ponies; and there were,[19] or still are, on some islands on the coast of Virginia, ponies like those of the Shetland Islands, which are believed to have originated through exposure to unfavourable conditions. The Puno ponies, which inhabit the lofty regions of the Cordillera, are, as I hear from Mr. D. Forbes, strange little creatures, very unlike their Spanish progenitors. Further south, in the Falkland Islands, the offspring of the horses imported in 1764 have already so much deteriorated in size[20] and strength that they are unfitted for catching wild cattle with the lasso; so that fresh horses have to be brought for this purpose from La Plata at a great expense. The reduced size of the horses bred on both southern and northern islands, and on several mountain-chains, can hardly have been caused by the cold, as a similar reduction has occurred on the Virginian and Mediterranean islands. The horse can withstand intense cold, for wild troops live on the plains of Siberia under lat. 56°,[21] and aboriginally the horses must have inhabited countries annually covered with snow, for he long retains the instinct of scraping it away to get at the herbage beneath. The wild tarpans in the East have this instinct; and so it is, as I am informed by Admiral Sulivan, with the horses recently and formerly introduced into the Falkland Islands from La Plata, some of which have run wild; this latter fact is remarkable, as the progenitors of these horses could not have followed this instinct during many generations in La Plata. On the other hand, the wild cattle of the Falklands never scrape away the snow, and perish when the ground is long covered. In the northern parts of America the horses descended from those introduced by the Spanish conquerors of Mexico, have the same habit, as have the native bisons, but not so the cattle introduced from Europe.[22]

The horse can flourish under intense heat as well as under intense cold, for he is known to come to the highest perfection, though not attaining a large size, in Arabia and northern Africa. Much humidity is apparently more injurious to the horse than heat or cold. In the Falkland Islands, horses suffer much from the dampness; and this circumstance may perhaps partly account for the singular fact that to the eastward of the Bay of Bengal,[23] over an enormous and humid area, in Ava, Pegu, Siam, the Malayan archipelago, the Loo Choo Islands, and a large part of China, no full-sized horse is found. When we advance as far eastward as Japan, the horse reacquires his full size.[24]

With most of our domesticated animals, some breeds are kept on account of their curiosity or beauty; but the horse is valued almost solely for its utility. Hence semi-monstrous breeds are not preserved; and probably all the existing breeds have been slowly formed either by the direct action of the conditions of life, or through the selection of individual differences. No doubt semi-monstrous breeds might have been formed: thus Mr. Waterton records[25] the case of a mare which produced successively three foals without tails; so that a tailless race might have been formed like the tailless races of dogs and cats. A Russian breed of horses is said to have curled hair, and Azara[26] relates that in Paraguay horses are occasionally born, but are generally destroyed, with hair like that on the head of a negro; and this peculiarity is transmitted even to half-breeds: it is a curious case of correlation that such horses have short manes and tails, and their hoofs are of a peculiar shape like those of a mule.

It is scarcely possible to doubt that the long-continued selection of qualities serviceable to man has been the chief agent in the formation of the several breeds of the horse. Look at a dray-horse, and see how well adapted he is to draw heavy weights, and how unlike in appearance to any allied wild animal. The English race-horse is known to be derived from the commingled blood of Arabs, Turks, and Barbs; but selection, which was carried on during very early times in England,[27] together with training, have made him a very different animal from his parent-stocks. As a writer in India, who evidently knows the pure Arab well, asks, who now, “looking at our present breed of race-horses, could have conceived that they were the result of the union of the Arab horse and African mare?” The improvement is so marked that in running for the Goodwood Cup the first descendants of Arabian, Turkish, and Persian horses, are allowed a discount of 18 pounds weight; and when both parents are of these countries a discount of 36 pounds.[28] It is notorious that the Arabs have long been as careful about the pedigree of their horses as we are, and this implies great and continued care in breeding. Seeing what has been done in England by careful breeding, can we doubt that the Arabs must likewise have produced during the course of centuries a marked effect on the qualities of their horses? But we may go much farther back in time, for in the Bible we hear of studs carefully kept for breeding, and of horses imported at high prices from various countries.[29] We may therefore conclude that, whether or not the various existing breeds of the horse have proceeded from one or more aboriginal stocks, yet that a great amount of change has resulted from the direct action of the conditions of life, and probably a still greater amount from the long-continued selection by man of slight individual differences.

With several domesticated quadrupeds and birds, certain coloured marks are either strongly inherited or tend to reappear after having been lost for a long time. As this subject will hereafter be seen to be of importance, I will give a full account of the colouring of horses. All English breeds, however unlike in size and appearance, and several of those in India and the Malay archipelago, present a similar range and diversity of colour. The English race-horse, however, is said[30] never to be dun-coloured; but as dun and cream-coloured horses are considered by the Arabs as worthless, "and fit only for Jews to ride,"[31] these tints may have been removed by long-continued selection. Horses of every colour, and of such widely different kinds as dray-horses, cobs, and ponies, are all occasionally dappled,[32] in the same manner as is so conspicuous with grey horses. This fact does not throw any clear light on the colouring of the aboriginal horse, but is a case of analogous variation, for even asses are sometimes dappled, and I have seen, in the British Museum, a hybrid from the ass and zebra dappled on its hinder quarters. By the expression analogous variation (and it is one that I shall often have occasion to use) I mean a variation occurring in a species or variety which resembles a normal character in another and distinct species or variety. Analogous variations may arise, as will be explained in a future chapter, from two or more forms with a similar constitution having been exposed to similar conditions,—or from one of two forms having reacquired through reversion a character inherited by the other form from their common progenitor,—or from both forms having reverted to the same ancestral character. We shall immediately see that horses occasionally exhibit a tendency to become striped over a large part of their bodies; and as we know that in the varieties of the domestic cat and in several feline species stripes readily pass into spots and cloudy marks—even the cubs of the uniformly-coloured lion being spotted with dark marks on a lighter ground—we may suspect that the dappling of the horse, which has been noticed by some authors with surprise, is a modification or vestige of a tendency to become striped.

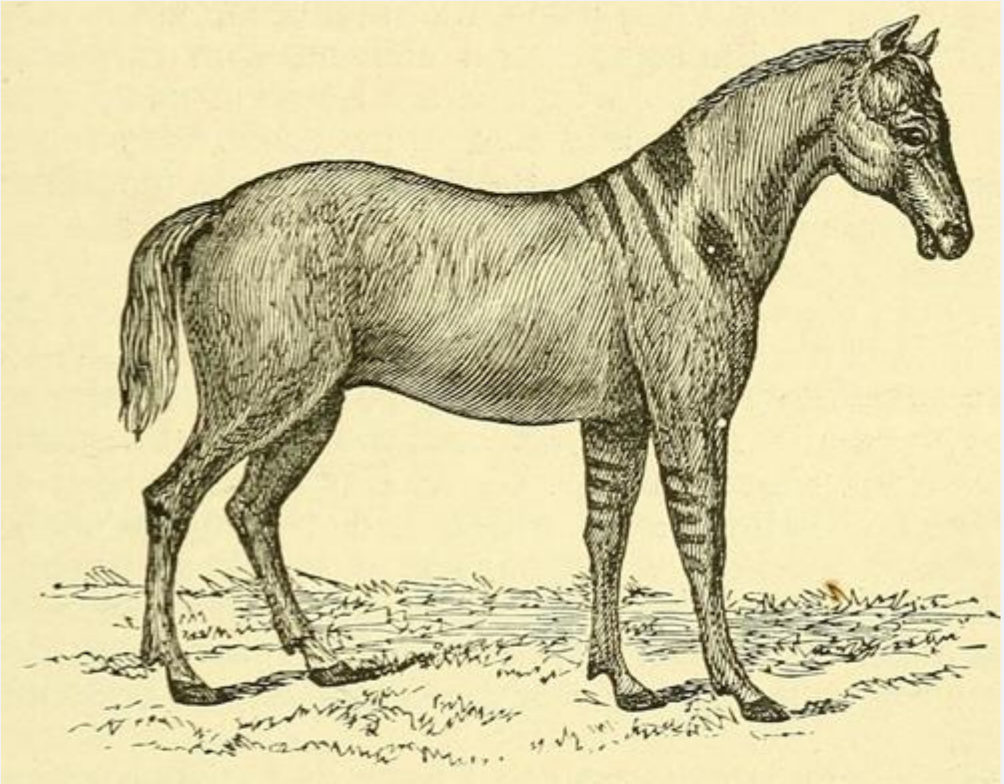


Fig. 1.—Dun Devonshire Pony, with shoulder, spinal, and leg stripes.

This tendency in the horse to become striped is in several respects an interesting fact. Horses of all colours, of the most diverse breeds, in various parts of the world, often have a dark stripe extending along the spine, from the mane to the tail; but this is so common that I need enter into no particulars.[33] Occasionally horses are transversely barred on the legs, chiefly on the under side; and more rarely they have a distinct stripe on the shoulder, like that on the shoulder of the ass, or a broad dark patch representing a stripe. Before entering on any details I must premise that the term dun-coloured is vague, and includes three groups of colours, viz., that between cream-colour and reddish-brown, which graduates into light-bay or light-chestnut—this, I believe is often called fallow-dun; secondly, leaden or slate-colour or mouse-dun, which graduates into an ash-colour; and, lastly, dark-dun, between brown and black. In England I have examined a rather large, lightly-built, fallow-dun Devonshire pony (Figure 1), with a conspicuous stripe along the back, with light transverse stripes on the under sides of its front legs, and with four parallel stripes on each shoulder. Of these four stripes the posterior one was very minute and faint; the anterior one, on the other hand, was long and broad, but interrupted in the middle, and truncated at its lower extremity, with the anterior angle produced into a long tapering point. I mention this latter fact because the shoulder-stripe of the ass occasionally presents exactly the same appearance. I have had an outline and description sent to me of a small, purely-bred, light fallow-dun Welch pony, with a spinal stripe, a single transverse stripe on each leg, and three shoulder-stripes; the posterior stripe corresponding with that on the shoulder of the ass was the longest, whilst the two anterior parallel stripes, arising from the mane, decreased in length, in a reversed manner as compared with the shoulder-stripes on the above-described Devonshire pony. I have seen a bright fallow-dun cob, with its front legs transversely barred on the under sides in the most conspicuous manner; also a dark-leaden mouse-coloured pony with similar leg stripes, but much less conspicuous; also a bright fallow-dun colt, fully three-parts thoroughbred, with very plain transverse stripes on the legs; also a chestnut-dun cart-horse with a conspicuous spinal stripe, with distinct traces of shoulder-stripes, but none on the legs; I could add other cases. My son made a sketch for me of a large, heavy, Belgian cart-horse, of a fallow-dun, with a conspicuous spinal stripe, traces of leg-stripes, and with two parallel (three inches apart) stripes about seven or eight inches in length on both shoulders. I have seen another rather light cart-horse, of a dirty dark cream-colour, with striped legs, and on one shoulder a large ill-defined dark cloudy patch, and on the opposite shoulder two parallel faint stripes. All the cases yet mentioned are duns of various tints; but Mr. W. W. Edwards has seen a nearly thoroughbred chestnut horse which had the spinal stripe, and distinct bars on the legs; and I have seen two bay carriage-horses with black spinal stripes; one of these horses had on each shoulder a light shoulder-stripe, and the other had a broad back ill-defined stripe, running obliquely half-way down each shoulder; neither had leg-stripes.

The most interesting case which I have met with occurred in a colt of my own breeding. A bay mare (descended from a dark-brown Flemish mare by a light grey Turcoman horse) was put to Hercules, a thoroughbred dark bay, whose sire (Kingston) and dam were both bays. The colt ultimately turned out brown; but when only a fortnight old it was a dirty bay, shaded with mouse-grey, and in parts with a yellowish tint: it had only a trace of the spinal stripe, with a few obscure transverse bars on the legs; but almost the whole body was marked with very narrow dark stripes, in most parts so obscure as to be visible only in certain lights, like the stripes which may be seen on black kittens. These stripes were distinct on the hind-quarters, where they diverged from the spine, and pointed a little forwards; many of them as they diverged became a little branched, exactly in the same manner as in some zebrine species. The stripes were plainest on the forehead between the ears, where they formed a set of pointed arches, one under the other, decreasing in size downwards towards the muzzle; exactly similar marks may be seen on the forehead of the quagga and Burchell's zebra. When this foal was two or three months old all the stripes entirely disappeared. I have seen similar marks on the forehead of a fully grown, fallow-dun, cob-like horse, having a conspicuous spinal stripe, and with its front legs well barred.

In Norway the colour of the native horse or pony is dun, varying from almost cream-colour to dark-mouse dun; and an animal is not considered purely bred unless it has the spinal and leg-stripes.[34] My son estimated that about a third of the ponies which he saw there had striped legs; he counted seven stripes on the fore-legs and two on the hind-legs of one pony; only a few of them exhibited traces of shoulder stripes; but I have heard of a cob imported from Norway which had the shoulder as well as the other stripes well developed. Colonel H. Smith[35] alludes to dun-horses with the spinal stripe in the Sierras of Spain; and the horses originally derived from Spain, in some parts of South America, are now duns. Sir W. Elliot informs me that he inspected a herd of 300 South American horses imported into Madras, and many of these had transverse stripes on the legs and short shoulder-stripes; the most strongly marked individual, of which a coloured drawing was sent me, was a mouse-dun, with the shoulder-stripes slightly forked.

In the North-Western parts of India striped horses of more than one breed are apparently commoner than in any other part of the world; and I have received information respecting them from several officers, especially from Colonel Poole, Colonel Curtis, Major Campbell, Brigadier St. John, and others. The Kattywar horses are often fifteen or sixteen hands in height, and are well but lightly built. They are of all colours, but the several kinds of duns prevail; and these are so generally striped, that a horse without stripes is not considered pure. Colonel Poole believes that all the duns have the spinal stripe, the leg-stripes are generally present, and he thinks that about half the horses have the shoulder-stripe; this stripe is sometimes double or treble on both shoulders. Colonel Poole has often seen stripes on the cheeks and sides of the nose. He has seen stripes on the grey and bay Kattywars when first foaled, but they soon faded away. I have received other accounts of cream-coloured, bay, brown, and grey Kattywar horses being striped. Eastward of India, the Shan (north of Burmah) ponies, as I am informed by Mr. Blyth, have spinal, leg, and shoulder stripes. Sir W. Elliot informs me that he saw two bay Pegu ponies with leg-stripes. Burmese and Javanese ponies are frequently dun-coloured, and have the three kinds of stripes, "in the same degree as in England."[36] Mr. Swinhoe informs me that he examined two light-dun ponies of two Chinese breeds, viz., those of Shanghai and Amoy; both had the spinal stripe, and the latter an indistinct shoulder-stripe.

We thus see that in all parts of the world breeds of the horse as different as possible, when of a dun-colour (including under this term a wide range of tint from cream to dusty black), and rarely when almost white tinged with yellow, grey, bay, and chestnut, have the several above-specified stripes. Horses which are of a yellow colour with white mane and tail, and which are sometimes called duns, I have never seen with stripes.[37]

From reasons which will be apparent in the chapter on Reversion, I have endeavoured, but with poor success, to discover whether duns, which are so much oftener striped than other coloured horses, are ever produced from the crossing of two horses, neither of which are duns. Most persons to whom I have applied believe that one parent must be dun; and it is generally asserted that, when this is the case, the dun-colour and the stripes are strongly inherited.[38] One case, however, has fallen under my own observation of a foal from a black mare by a bay horse, which when fully grown was a dark fallow-dun and had a narrow but plain spinal stripe. Hofacker[39] gives two instances of mouse-duns (Mausrapp) being produced from two parents of different colours and neither duns.

The stripes of all kinds are generally plainer in the foal than in the adult horse, being commonly lost at the first shedding of the hair.[40] Colonel Poole believes that “the stripes in the Kattywar breed are plainest when the colt is first foaled; they then become less and less distinct till after the first coat is shed, when they come out as strongly as before; but certainly often fade away as the age of the horse increases.” Two other accounts confirm this fading of the stripes in old horses in India. One writer, on the other hand, states that colts are often born without stripes, but that they appear as the colt grows older. Three authorities affirm that in Norway the stripes are less plain in the foal than in the adult. In the case described by me of the young foal which was narrowly striped over nearly all its body, there was no doubt about the early and complete disappearance of the stripes. Mr. W. W. Edwards examined for me twenty-two foals of race-horses, and twelve had the spinal stripe more or less plain; this fact, and some other accounts which I have received, lead me to believe that the spinal stripe often disappears in the English race-horse when old. With natural species, the young often exhibit characters which disappear at maturity.

The stripes are variable in colour, but are always darker than the rest of the body. They do not by any means always coexist on the different parts of the body: the legs may be striped without any shoulder-stripe, or the converse case, which is rarer, may occur; but I have never heard of either shoulder or leg-stripes without the spinal stripe. The latter is by far the commonest of all the stripes, as might have been expected, as it characterises the other seven or eight species of the genus. It is remarkable that so trifling a character as the shoulder-stripe being double or triple should occur in such different breeds as Welch and Devonshire ponies, the Shan pony, heavy cart-horses, light South American horses, and the lanky Kattywar breed. Colonel Hamilton Smith believes that one of his five supposed primitive stocks was dun-coloured and striped; and that the stripes in all the other breeds result from ancient crosses with this one primitive dun; but it is extremely improbable that different breeds living in such distant quarters of the world should all have been crossed with any one aboriginally distinct stock. Nor have we any reason to believe that the effects of a cross at a very remote period would be propagated for so many generations as is implied on this view.

With respect to the primitive colour of the horse having been dun, Colonel Hamilton Smith[41] has collected a large body of evidence showing that this tint was common in the East as far back as the time of Alexander, and that the wild horses of Western Asia and Eastern Europe now are, or recently were, of various shades of dun. It seems that not very long ago a wild breed of dun-coloured horses with a spinal stripe was preserved in the royal parks in Prussia. I hear from Hungary that the inhabitants of that country look at the duns with a spinal stripe as the aboriginal stock, and so it is in Norway. Dun-coloured ponies are not rare in the mountainous parts of Devonshire, Wales, and Scotland, where the aboriginal breed would have the best chance of being preserved. In

South America in the time of Azara, when the horse had been feral for about 250 years, 90 out of 100 horses were "bai-châtains," and the remaining ten were "zains," that is brown; not more than one in 2000 being black. In North America the feral horses show a strong tendency to become roans of various shades; but in certain parts, as I hear from Dr. Canfield, they are mostly duns and striped.[42]

In the following chapters on the Pigeon we shall see that a blue bird is occasionally produced by pure breeds of various colours and that when this occurs certain black marks invariably appear on the wings and tail; so again, when variously coloured breeds are crossed, blue birds with the same black marks are frequently produced. We shall further see that these facts are explained by, and afford strong evidence in favour of, the view that all the breeds are descended from the rock-pigeon, or *Columba livia*, which is thus coloured and marked. But the appearance of the stripes on the various breeds of the horse, when of a dun colour, does not afford nearly such good evidence of their descent from a single primitive stock as in the case of the pigeon: because no horse certainly wild is known as a standard of comparison; because the stripes when they appear are variable in character; because there is far from sufficient evidence that the crossing of distinct breeds produces stripes, and lastly, because all the species of the genus Equus have the spinal stripe, and several species have shoulder and leg stripes. Nevertheless the similarity in the most distinct breeds in their general range of colour, in their dappling, and in the occasional appearance, especially in duns, of leg-stripes and of double or triple shoulder-stripes, taken together, indicate the probability of the descent of all the existing races from a single, dun-coloured, more or less striped, primitive stock, to which our horses occasionally revert.

THE ASS.

Four species of Asses, besides three zebras, have been described by naturalists. There is now little doubt that our domesticated animal is descended from the *Equus tæniopus* of Abyssinia.[43] The ass is sometimes advanced as an instance of an animal domesticated, as we know by the Old Testament, from an ancient period, which has varied only in a very slight degree. But this is by no means strictly true; for in Syria alone there are four breeds;[44] first, a light and graceful animal, with an agreeable gait, used by ladies; secondly, an Arab breed reserved exclusively for the saddle; thirdly, a stouter animal used for ploughing and various purposes; and lastly, the large Damascus breed, with a peculiarly long body and ears. In the South of France also there are several breeds, and one of extraordinary size, some individuals being as tall as full-sized horses. Although the ass in England is by no means uniform in appearance, distinct breeds have not been formed. This may probably be accounted for by the animal being kept chiefly by poor persons, who do not rear large numbers, nor carefully match and select the young. For, as we shall see in a future chapter, the ass can with ease be greatly improved in size and strength by careful selection, combined no doubt with good food; and we may infer that all its other characters would be equally amenable to selection. The small size of the ass in England and Northern Europe is apparently due far more to want of care in breeding than to cold; for in Western India, where the ass is used as a beast of burden by some of the lower castes, it is not much larger than a Newfoundland dog, "being generally not more than from twenty to thirty inches high."[45]

The ass varies greatly in colour; and its legs, especially the fore-legs, both in England and other countries—for instance, in China—are occasionally barred more plainly than those of dun-coloured horses. Thirteen or fourteen transverse stripes have been counted on both the fore and hind legs. With the horse the occasional appearance of leg-stripes was accounted for by reversion to a supposed parent-form, and in the case of the ass we may confidently believe in this explanation, as *E. tæniopus* is known to be barred, though only in a slight degree, and not quite invariably. The stripes are believed to occur most frequently and to be plainest on the legs of the domestic ass during early youth,[46] as likewise occurs with the horse. The shoulder-stripe, which is so eminently characteristic of the species, is nevertheless variable in breadth, length, and manner of termination. I have measured one four times as broad as another, and some more than twice as long as others. In one light-grey ass the shoulder-stripe was only six inches in length, and as thin as a piece of string; and in another animal of the same colour there was only a dusky shade representing a stripe. I have heard of three white asses, not albinoes, with no trace of shoulder or spinal stripes;[47] and I have seen nine other asses with no shoulder-stripe, and some of them had no spinal stripe. Three of the nine were light-greys, one a dark-grey, another grey passing into reddish-roan, and the others were brown, two being tinted on parts of their bodies with a reddish or bay shade. If therefore grey and reddish-brown asses had been steadily selected and bred from, the shoulder stripe would probably have been lost almost as generally and completely as in the case of the horse.

The shoulder stripe on the ass is sometimes double, and Mr. Blyth has seen even three or four parallel stripes.[48] I have observed in ten cases shoulder-stripes abruptly truncated at the lower end, with the anterior angle produced into a tapering point, precisely as in the above dun Devonshire pony. I have seen three cases of the terminal portion abruptly and angularly bent; and have seen and heard of four cases of a distinct though slight forking of the stripe. In Syria, Dr. Hooker and his party observed for me no less than five similar instances of the shoulder-stripe plainly bifurcating over the fore leg. In the common mule it likewise sometimes bifurcates. When I first noticed the forking and angular bending of the shoulder-stripe, I had seen enough of the stripes in the various equine species to feel convinced that even a character so unimportant as this had a distinct meaning, and was thus led to attend to the subject. I now find that in the *E. burchellii* and *quagga*, the stripe which corresponds with the shoulder-stripe of the ass, as well as some of the stripes on the neck, bifurcate, and that some of those near the shoulder have their extremities bent angularly backwards. The bifurcation and angular bending of the stripes on the shoulders apparently are connected with the nearly upright stripes on the sides of the body and neck changing their direction and becoming transverse on the legs. Finally, we see that the presence of shoulder, leg, and spinal stripes in the horse,— their occasional absence in the ass,—the occurrence of double and triple shoulder-stripes in both animals, and the similar manner in which these stripes terminate downwards,—are all cases of analogous variation in the horse and ass. These cases are probably not due to similar conditions acting on similar constitutions, but to a partial reversion in colour to the common progenitor of the genus. We shall hereafter return to this subject, and discuss it more fully.

REFERENCES

[1] Rütimeyer 'Fauna der Pfahlbauten,' 1861, s. 122.

[2] *See* 'Youatt on the Horse': J. Lawrence on the Horse, 1829; W. C. L. Martin, 'History of the Horse,' 1845: Col. H. Smith, in 'Nat. Library, Horses,' 1841, vol. xii.: Prof. Veith, 'Die naturgesch. Haussäugethiere,' 1856.

[3] Crawfurd, 'Descript. Dict. of Indian Islands,' 1856, p. 153. "There are many different breeds, every island having at least one peculiar to it." Thus in Sumatra there are at least two breeds; in Achin and Batubara one; in Java several breeds; one in Bali, Lomboc, Sumbawa (one of the best breeds), Tambora, Bima, Gunung-api, Celebes, Sumba, and Philippines. Other breeds are specified by Zollinger in the 'Journal of the Indian Archipelago,' vol. v, p. 343, etc.

[4] 'The Horse,' etc. by John Lawrence, 1829, p. 14.

[5] 'The Veterinary,' London, vol. v, p. 543.

[6] 'Mémoire sur les chevaux à trente-quatre côtes,' 1871.

[7] Proc. Veterinary Assoc., in 'The Veterinary,' vol. xiii. p. 42.

[8] 'Bulletin de la Soc. Géolog.,' tom. xxii., 1866, p. 22.

[9] Mr. Percival of the Enniskillen Dragoons, in 'The Veterinary,' vol. i. p. 224: *see* Azara, 'Des Quadrupèdes du Paraguay,' tom. ii. p. 313. The French translator of Azara refers to other cases mentioned by Huzard as having occurred in Spain.

[10] Godron, 'De l'Espèce' tom. i. p. 378.

[11] 'Ueber die Eigenschaften,' etc., 1828, s. 10.

[12] 'Domesticated Animals of the British Islands,' pp. 527, 532. In all the veterinary treatises and papers which I have read, the writers insist in the strongest terms on the inheritance by the horse of all good and bad tendencies and qualities. Perhaps the principle of inheritance is not really

stronger in the horse than in any other animal; but, from its value, the tendency has been more carefully observed.

[13] Andrew Knight crossed breeds so different in size as a dray-horse and Norwegian pony: *see* A. Walker on ‘Intermarriage,’ 1838, p. 205.

[14] ‘Nat. Library, Horses,’ vol. xii. p. 208.

[15] Gervais, ‘Hist. Nat. Mamm.,’ tom. ii. p. 143. Owen, ‘British Fossil Mammals,’ p. 383.

[16] ‘Kenntniss der fossilen Pferde,’ 1863, s. 131.

[17] ‘Comptes rendus,’ 1866, p. 485, and ‘Journal de l’Anat. et de la Phys.,’ Mai 1868.

[18] Mr. W. C. L. Martin, (‘The Horse,’ 1845, p. 34), in arguing against the belief that the wild Eastern horses are merely feral, has remarked on the improbability of man in ancient times having extirpated a species in a region where it can now exist in numbers.

[19] ‘Transact. Maryland Academy,’ vol. i. part i. p. 28.

[20] Mr. Mackinnon ‘The Falkland Islands,’ p. 25. The average height of the Falkland horses is said to be 14 hands 2 inches. *See* also my ‘Journal of Researches.’

[21] Pallas, ‘Act. Acad. St. Petersburgh,’ 1777, part ii. p. 265. With respect to the tarpans scraping away the snow *see* Col. Hamilton Smith in ‘Nat. Lib.,’ vol. xii. p. 165.

[22] Franklin’s ‘Narrative,’ vol. i. p. 87; note by Sir J. Richardson.

[23] Mr. J. H. Moor, ‘Notices of the Indian Archipelago;’ Singapore, 1837, p. 189. A pony from Java was sent (‘Athenæum,’ 1842, p. 718) to the Queen only 28 inches in height. For the Loo Choo Islands, *see* Beechey’s ‘Voyage,’ 4th. edit., vol. i. p. 499.

[24] J. Crawford, ‘History of the Horse;’ ‘Journal of Royal United Service Institution,’ vol. iv.

[25] ‘Essays on Natural History,’ 2nd series, p. 161.

[26] ‘Quadrupédes du Paraguay,’ tom. ii. p. 333. Dr. Canfield informs me that a breed with curly hair was formed by selection at Los Angeles in North America.

[27] See the evidence on this head in ‘Land and Water,’ May 2nd, 1868.

[28] Prof. Low, ‘Domesticated Animals,’ p. 546. With respect to the writer in India *see* ‘India Sporting Review,’ vol. ii. p. 181. As Lawrence has remarked (‘The Horse,’ p. 9), “perhaps no instance has ever occurred of a

three-part bred horse (*i.e.* a horse, one of whose grandparents was of impure blood) saving his distance in running two miles with thoroughbred racers." Some few instances are on record of seven-eights racers having been successful.

[29] Prof. Gervais (in his 'Hist. Nat. Mamm.,' tom. ii. p. 144) has collected many facts on this head. For instance Solomon (Kings, B. i. ch. x. v. 28) bought horses in Egypt at a high price.

[30] 'The Field,' July 13th, 1861, p. 42.

[31] E. Vernon Harcourt, 'Sporting in Algeria,' p. 26.

[32] I state this from my own observations made during several years on the colours of horses. I have seen cream-coloured, light-dun and mouse-dun horses dappled, which I mention because it has been stated (Martin, 'History of the Horse,' p. 134) that duns are never dappled. Martin (p. 205) refers to dappled asses. In the 'Farrier' (London, 1828, pp. 453, 455) there are some good remarks on the dappling of horses; and likewise in Col. Hamilton Smith on 'The Horse.'

[33] Some details are given in 'The Farrier,' 1828, pp. 452, 455. One of the smallest ponies I ever saw, of the colour of a mouse, had a conspicuous spinal stripe. A small Indian chestnut pony had the same stripe, as had a remarkably heavy chestnut cart-horse. Race-horses often have the spinal stripe.

[34] I have received information, through the kindness of the Consul-General, Mr. J. R. Crowe, from Prof. Boeck, Rasck, and Esmarck, on the colours of the Norwegian ponies. *See also* 'The Field,' 1861, p. 431.

[35] Col. Hamilton Smith, 'Nat. Lib.,' vol. xii. p. 275.

[36] Mr. G. Clark, in 'Annal and Mag. of Nat. History,' 2nd series, vol. ii. 1848, p. 363. Mr. Wallace informs me that he saw in Java a dun and clay-coloured horse with spinal and leg stripes.

[37] *See also* on this point, 'The Field,' July 27th, 1861, p. 91.

[38] 'The Field,' 1861, pp. 431, 493, 545.

[39] 'Ueber die Eigenschaften,' etc., 1828, s. 13, 14.

[40] Von Nathusius, 'Vorträge über Viehzucht,' 1872, 135.

[41] 'Nat. Library,' vol. xii. (1841), pp. 109, 156 to 163, 280, 281. Cream-colour, passing into Isabella (*i.e.* the colour of the dirty linen of Queen Isabella), seems to have been common in ancient times. *See also* Pallas's account of the wild horses of the East, who speaks of dun and brown as the prevalent colours. In the Icelandic sagas, which were committed to writing

in the twelfth century, dun-coloured horses with a black spinal stripe are mentioned; *see* Dasent's translation, vol. i. p. 169.

[42] Azara, 'Quadrupèdes du Paraguay,' tom. ii. p. 307. In North America, Catlin (vol. ii. p. 57) describes the wild horses, believed to have descended from the Spanish horses of Mexico, as of all colours, black, grey, roan, and roan pied with sorrel. F. Michaux ('Travels in North America,' Eng. translat., p. 235) describes two wild horses from Mexico as roan. In the Falkland Islands, where the horse has been feral only between 60 and 70 years, I was told that roans and iron-greys were the prevalent colours. These several facts show that horses do not soon revert to any uniform colour.

[43] Dr. Sclater, in 'Proc. Zoolog. Soc.,' 1862, p. 164. Dr. Hartmann says ('Annalen der Landw.' B. xliv. p. 222) that this animal in its wild state is not always striped across the legs.

[44] W. C. Martin, 'History of the Horse,' 1845, p. 207.

[45] Col. Sykes' Cat. of Mammalia, 'Proc. Zoolog. Soc.' July 12th, 1831. Williamson 'Oriental Field Sports,' vol. ii., quoted by Martin, p. 206.

[46] Blyth, in 'Charlesworth's Mag. of Nat. Hist.,' vol. iv., 1840, p. 83. I have also been assured by a breeder that this is the case.

[47] (One case is given by Martin, 'The Horse,' p. 205.

[48] 'Journal As. Soc. of Bengal,' vol. xxviii. 1860, p. 231. Martin on the Horse, p. 205.

CHAPTER III.
PIGS—CATTLE—SHEEP—GOATS

PIGS BELONG TO TWO DISTINCT TYPES, SUS SCROFA AND INDICUS—TORFSCHWEIN—JAPAN PIGS—FERTILITY OF CROSSED PIGS—CHANGES IN THE SKULL OF THE HIGHLY CULTIVATED RACES—CONVERGENCE OF CHARACTER—GESTATION—SOLID-HOOFED SWINE—CURIOUS APPENDAGES TO THE JAWS—DECREASE IN SIZE OF THE TUSKS—YOUNG PIGS LONGITUDINALLY STRIPED—FERAL PIGS—CROSSED BREEDS.

CATTLE—ZEBU A DISTINCT SPECIES—EUROPEAN CATTLE PROBABLY DESCENDED FROM THREE WILD FORMS—ALL THE RACES NOW FERTILE TOGETHER—BRITISH PARK CATTLE—ON THE

COLOUR OF THE ABORIGINAL SPECIES—CONSTITUTIONAL DIFFERENCES—SOUTH AFRICAN RACES—SOUTH AMERICAN RACES—NIATA CATTLE—ORIGIN OF THE VARIOUS RACES OF CATTLE.

SHEEP —REMARKABLE RACES OF—VARIATIONS ATTACHED TO THE MALE SEX—ADAPTATIONS TO VARIOUS CONDITIONS—GESTATION OF—CHANGES IN THE WOOL—SEMI-MONSTROUS BREEDS.

GOATS —REMARKABLE VARIATIONS OF.

The breeds of the pig have recently been more closely studied, though much still remains to be done, than those of almost any other domesticated animal. This has been effected by Hermann von Nathusius in two admirable works, especially in the later one on the Skulls of the several races, and by Rütimeyer in his celebrated Fauna of the ancient Swiss lake-dwellings.[1] Nathusius has shown that all the known breeds may be divided into two great groups: one resembling in all important respects and no doubt descended from the common wild boar; so that this may be called the *Sus scrofa* group. The other group differs in several important and constant osteological characters; its wild parent-form is unknown; the name given to it by Nathusius, according to the law of priority, is *Sus indicus*, of Pallas. This name must now be followed, though an unfortunate one, as the wild aboriginal does not inhabit India, and the best-known domesticated breeds have been imported from Siam and China.

First for the *Sus scrofa* breeds, or those resembling the common wild boar. These still exist, according to Nathusius (‘Schweineschädel’ s. 75), in various parts of central and northern Europe; formerly every kingdom,[2] and almost every province in Britain, possessed its own native breed; but these are now everywhere rapidly disappearing, being replaced by improved breeds crossed with the *S. indicus* form. The skull in the breeds of the *S. scrofa* type resembles, in all important respects, that of the European wild boar; but it has become (‘Schweineschädel’ s. 63-68) higher and broader relatively to its length; and the hinder part is more upright. The differences, however, are all variable in degree. The breeds which thus resemble *S. scrofa* in their essential skull characters differ conspicuously from each other in other respects, as in the length of the ears and legs, curvature of the ribs, colour, hairiness, size and proportions of the body.

The wild *Sus scrofa* has a wide range, namely, Europe, North Africa, as identified by osteological characters by Rütimeyer, and Hindostan, as similarly identified by Nathusius. But the wild boars inhabiting these several countries differ so much from each other in external characters, that they have been ranked by some naturalists as specifically distinct. Even within Hindostan these animals, according to Mr. Blyth, form very distinct races in the different districts; in the N. Western provinces, as I am informed by the Rev. R. Everest, the boar never exceeds 36 inches in height, whilst in Bengal one has been measured 44 inches in height. In Europe, Northern Africa, and Hindostan, domestic pigs have been known to cross with the wild native species;[3] and in Hindostan an accurate observer,[4] Sir Walter Elliot, after describing the differences between wild Indian and wild German boars, remarks that "the same differences are perceptible in the domesticated individuals of the two countries." We may therefore conclude that the breeds of the *Sus scrofa* type are descended from, or have been modified by crossing with, forms which may be ranked as geographical races, but which, according to some naturalists, ought to be ranked as distinct species.

Pigs of the *Sus indicus* type are best known to Englishmen under the form of the Chinese breed. The skull of *S. indicus*, as described by Nathusius, differs from that of *S. scrofa* in several minor respects, as in its greater breadth and in some details in the teeth; but chiefly in the shortness of the lachrymal bones, in the greater width of the fore part of the palate-bones, and in the divergence of the premolar teeth. It deserves especial notice that these latter characters are not gained, even in the least degree, by the domesticated forms of *S. scrofa*. After reading the remarks and descriptions given by Nathusius, it seems to me to be merely playing with words to doubt whether *S. indicus* ought to be ranked as a species; for the above-specified differences are more strongly marked than any that can be pointed out between, for instance, the fox and the wolf, or the ass and the horse. As already stated, *S. indicus* is not known in a wild state; but its domesticated forms, according to Nathusius, come near to *S. vittatus* of Java and some allied species. A pig found wild in the Aru islands ('Schweineschädel' s. 169) is apparently identical with *S. indicus*; but it is doubtful whether this is a truly native animal. The domesticated breeds of China, Cochin-China, and Siam belong to this type. The Roman or Neapolitan breed, the Andalusian, the Hungarian, and the "Krause" swine of Nathusius, inhabiting south-eastern Europe and Turkey, and having fine curly hair, and the small Swiss "Bündtnerschwein" of Rütimeyer, all agree in their more important skull-characters with *S. indicus*, and, as is supposed, have all been largely crossed with this form. Pigs of this type have existed during a long period on the shores of the Mediterranean, for a figure ('Schweineschädel' s. 142) closely resembling the existing Neapolitan pig was found in the buried city of Herculaneum.

Rütimeyer has made the remarkable discovery that there lived contemporaneously in Switzerland, during the Neolithic period, two domesticated forms, the *S. scrofa*, and the *S. scrofa palustris* or Torfschwein. Rütimeyer perceived that the latter approached the Eastern breeds, and, according to Nathusius, it certainly belongs to the *S. indicus* group; but Rütimeyer has subsequently shown that it differs in some well-marked characters. This author was formerly convinced that his Torfschwein existed as a wild animal during the first part of the Stone period, and was domesticated during a later part of the same period.[5] Nathusius, whilst he fully admits the curious fact first observed by Rütimeyer, that the bones of domesticated and wild animals can be distinguished by their different aspect, yet, from special difficulties in the case of the bones of the pig (‘Schweineschädel’ s. 147), is not convinced of the truth of the above conclusion; and Rütimeyer himself seems now to feel some doubt. Other naturalists have also argued strongly on the same side as Nathusius.[6]

Several breeds, differing in the proportions of the body, in the length of the ears, in the nature of the hair, in colour, etc., come under the *S. indicus* type. Nor is this surprising, considering how ancient the domestication of this form has been both in Europe and in China. In this latter country the date is believed by an eminent Chinese scholar[7] to go back at least 4900 years from the present time. This same scholar alludes to the existence of many local varieties of the pig in China; and at the present time the Chinese take extraordinary pains in feeding and tending their pigs, not even allowing them to walk from place to place.[8] Hence these pigs, as Nathusius has remarked,[9] display in an eminent degree the characters of a highly-cultivated race, and hence, no doubt, their high value in the improvement of our European breeds. Nathusius makes a remarkable statement (‘Schweineschädel’ s. 138), that the infusion of the 1/32nd, or even of the 1/64th, part of the blood of *S. indicus* into a breed of *S. scrofa*, is sufficient plainly to modify the skull of the latter species. This singular fact may perhaps be accounted for by several of the chief distinctive characters of *S. indicus*, such as the shortness of the lachrymal bones, etc., being common to several species of the genus; for in crosses characters which are common to many species apparently tend to be prepotent over those appertaining to only a few species.

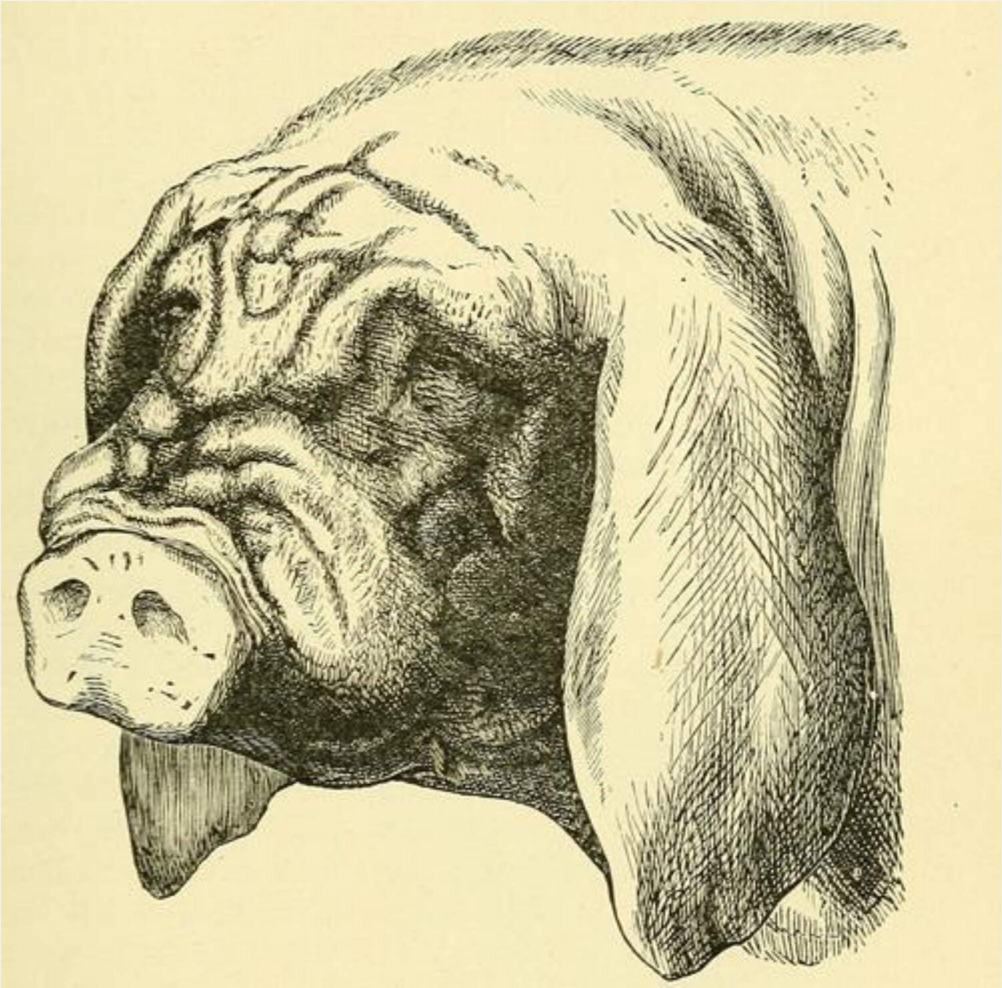


Fig. 2.—Head of Japan or Masked Pig.

The Japan pig (*S. pliciceps* of Gray), which was formerly exhibited in the Zoological Gardens, has an extraordinary appearance from its short head, broad forehead and nose, great fleshy ears, and deeply furrowed skin. Figure 2 is copied from that given by Mr. Bartlett.[10] Not only is the face furrowed, but thick folds of skin, which are harder than the other parts, almost like the plates on the Indian rhinoceros, hang about the shoulders and rump. It is coloured black, with white feet, and breeds true. That it has long been domesticated there can be little doubt; and this might have been inferred even from the fact that its young are not longitudinally striped; for this is a character common to all the species included within the genus *Sus* and the allied genera whilst in their natural state.[11] Dr. Gray[12] has described the skull of this animal, which he ranks not only as a distinct species, but places it in a distinct section of the genus. Nathusius, however, after his careful study of the whole group, states positively ('Schweineschädel' s. 153-158). that the skull in all essential characters closely resembles that of the short-eared Chinese breed of the *S. indicus* type. Hence Nathusius considers the Japan pig as only a domesticated variety of *S. indicus*: if this really be the case, it is a wonderful instance of the amount of modification which can be effected under domestication.

Formerly there existed in the central islands of the Pacific Ocean a singular breed of pigs. These are described by the Rev. D. Tyerman and G. Bennett[13] as of small size, hump-backed, with a disproportionately long head, with short ears turned backwards, with a bushy tail not more than two inches in length, placed as if it grew from the back. Within half a century after the introduction of European and Chinese pigs into these islands, the native breed, according to the above authors, became almost completely lost by being repeatedly crossed with them. Secluded islands, as might have been expected, seem favourable for the production or retention of peculiar breeds; thus, in the Orkney Islands, the hogs have been described as very small, with erect and sharp ears, and “with an appearance altogether different from the hogs brought from the south.”[14]

Seeing how different the Chinese pigs, belonging to the *Sus indicus* type, are in their osteological characters and in external appearance from the pigs of the *S. scrofa* type, so that they must be considered specifically distinct, it is a fact well deserving attention, that Chinese and common pigs have been repeatedly crossed in various manners, with unimpaired fertility. One great breeder who had used pure Chinese pigs assured me that the fertility of the half-breeds *inter se* and of their recrossed progeny was actually increased; and this is the general belief of agriculturists. Again, the Japan pig or *S. pliciceps* of Gray is so distinct in appearance from all common pigs, that it stretches one’s belief to the utmost to admit that it is simply a domestic variety; yet this breed has been found perfectly fertile with the Berkshire breed; and Mr. Eyton informs me that he paired a half-bred brother and sister and found them quite fertile together.

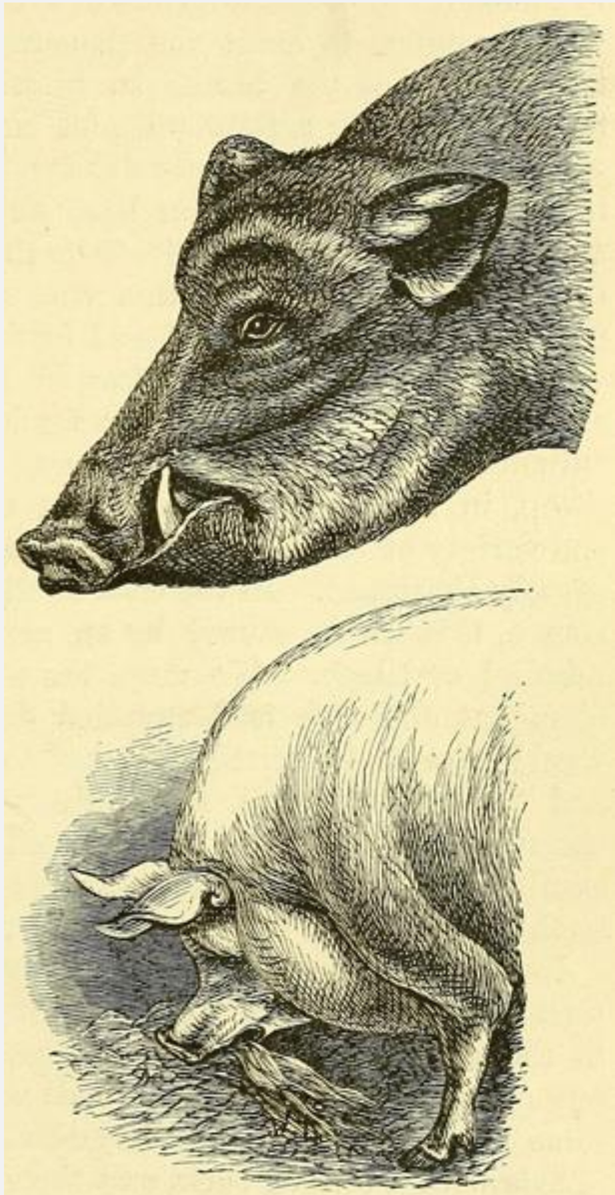


Fig. 3—Head of Wild Boar, and of "Golden Days," a pig of the Yorkshire Large Breed

The modification of the skull in the most highly cultivated races is wonderful. To appreciate the amount of change, Nathusius' work, with its excellent figures, should be studied. The whole of the exterior in all its parts has been altered: the hinder surface, instead of sloping backwards, is directed forwards, entailing many changes in other parts; the front of the head is deeply concave; the orbits have a different shape; the auditory meatus has a different direction and shape; the incisors of the upper and lower jaws do not touch each other, and they stand in both jaws beyond the plane of the molars; the canines of the upper jaw stand in front of those of the lower jaw, and this is a remarkable anomaly: the articular surfaces of the occipital condyles are so greatly changed in shape, that, as Nathusius remarks (s. 133), no naturalist, seeing this important part of the skull by itself, would suppose that it belonged to the genus Sus. These and various other modifications, as Nathusius observes, can hardly be considered as monstrosities, for they are not injurious, and are strictly inherited. The whole head is much shortened; thus, whilst in common breeds its length to that of the body is as 1 to 6, in the "cultur-racen" the proportion is as 1 to 9, and even recently as 1 to 11.[15] The following woodcut[16] of the head of a wild boar and of a sow from a photograph of the Yorkshire Large Breed, may aid in showing how greatly the head in a highly cultivated race has been modified and shortened.

Nathusius has well discussed the causes of the remarkable changes in the skull and shape of the body which the highly cultivated races have undergone. These modifications occur chiefly in the pure and crossed races of the *S. indicus* type; but their commencement may be clearly detected in the slightly improved breeds of the *S. scrofa* type.[17] Nathusius states positively (s. 99, 103), as the result of common experience and of his experiments, that rich and abundant food, given during youth, tends by some direct action to make the head broader and shorter; and that poor food works a contrary result. He lays much stress on the fact that all wild and semi-domesticated pigs, in ploughing up the ground with their muzzles, have, whilst young, to exert the powerful muscles fixed to the hinder part of the head. In highly cultivated races this habit is no longer followed, and consequently the back of the skull becomes modified in shape, entailing other changes in other parts. There can hardly be a doubt that so great a change in habits would affect the skull; but it seems rather doubtful how far this will account for the greatly reduced length of the skull and for its concave front. It is well known (Nathusius himself advancing many cases, s. 104) that there is a strong tendency in many domestic animals—in bull- and pug-dogs, in the niata cattle, in sheep, in Polish fowls, short-faced tumbler pigeons, and in one variety of the carp—for the bones of the face to become greatly shortened. In the case of the dog, as H. Müller has shown, this seems caused by an abnormal state of the primordial cartilage. We may, however, readily admit that abundant and rich food supplied during many generations would give an inherited tendency to increased size of body, and that, from disuse, the limbs would become finer and shorter.[18] We shall in a future chapter see also that the skull and limbs are apparently in some manner correlated, so that any change in the one tends to affect the other.

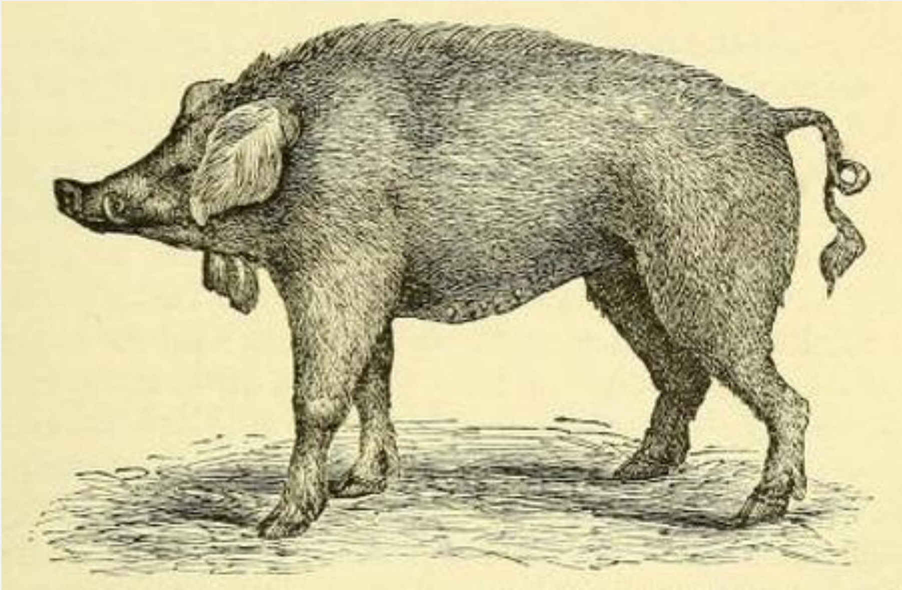
Nathusius has remarked, and the observation is an interesting one, that the peculiar form of the skull and body in the most highly cultivated races is not characteristic of any one race, but is common to all when improved up to the same standard. Thus the large-bodied, long-eared, English breeds with a convex back, and the small-bodied, short-eared, Chinese breeds with a concave back, when bred to the same state of perfection, nearly resemble each other in the form of the head and body. This result, it appears, is partly due to similar causes of change acting on the several races, and partly to man breeding the pig for one sole purpose, namely, for the greatest amount of flesh and fat; so that selection has always tended towards one and the same end. With most domestic animals the result of selection has been divergence of character, here it has been convergence.[19]

The nature of the food supplied during many generations has apparently affected the length of the intestines; for, according to Cuvier,[20] their length to that of the body in the wild boar is as 9 to 1,—in the common domestic boar as 13·5 to 1,—and in the Siam breed as 16 to 1. In this latter breed the greater length may be due either to descent from a distinct species or to more ancient domestication. The number of mammæ vary, as does the period of gestation. The latest authority says[21] that "the period averages from 17 to 20 weeks," but I think there must be some error in this statement: in M. Tessier's observations on 25 sows it varied from 109 to 123 days. The Rev. W. D. Fox has given me ten carefully recorded cases with well-bred pigs, in which the period varied from 101 to 116 days. According to Nathusius the period is shortest in the races which come early to maturity; but the course of their development does not appear to be actually shortened, for the young animal is born, judging from the state of the skull, less fully developed, or in a more embryonic condition,[22] than in the case of common swine. In the highly cultivated and early matured races the teeth, also, are developed earlier.

The difference in the number of the vertebræ and ribs in different kinds of pigs, as observed by Mr. Eyton,[23] and as given in the following table, has often been quoted. The African sow probably belongs to the *S. scrofa* type; and Mr. Eyton informs me that, since the publication of this paper, cross-bred animals from the African and English races were found by Lord Hill to be perfectly fertile.

	English Long-legged Male.	African Female.	Chinese Male.	Wild Boar from Cuvier.	French Domestic Boar, from Cuvier.
Dorsal vertebræ	15	13	15	14	14
Lumbar	6	6	4	5	5
Dorsal and lumbar together	21	19	19	19	19
Sacral	5	5	4	4	4
Total number of vertebræ	26	24	23	23	23

Some semi-monstrous breeds deserve notice. From the time of Aristotle to the present time solid-hoofed swine have occasionally been observed in various parts of the world. Although this peculiarity is strongly inherited, it is hardly probable that all the animals with solid hoofs have descended from the same parents; it is more probable that the same peculiarity has reappeared at various times and places. Dr. Struthers has lately described and figured[24] the structure of the feet; in both front and hind feet the distal phalanges of the two greater toes are represented by a single, great, hoof-bearing phalanx; and in the front feet, the middle phalanges are represented by a bone which is single towards the lower end, but bears two separate articulations towards the upper end. From other accounts it appears that an intermediate toe is likewise sometimes superadded.



Old Irish Pig, with jaw-appendages.

Another curious anomaly is offered by the appendages, described by M. Eudes-Deslongchamps as often characterizing the Normandy pigs. These appendages are always attached to the same spot, to the corners of the jaw; they are cylindrical, about three inches in length, covered with bristles, and with a pencil of bristles rising out of a sinus on one side: they have a cartilaginous centre, with two small longitudinal muscles they occur either symmetrically on both sides of the face or on one side alone. Richardson figures them on the gaunt old "Irish Greyhound pig;" and Nathusius states that they occasionally appear in all the long eared races, but are not strictly inherited, for they occur or fail in animals of the same litter.[25] As no wild pigs are known to have analogous appendages, we have at present no reason to suppose that their appearance is due to reversion; and if this be so, we are forced to admit that a somewhat complex, though apparently useless, structure may be suddenly developed without the aid of selection.

It is a remarkable fact that the boars of all domesticated breeds have much shorter tusks than wild boars. Many facts show that with many animals the state of the hair is much affected by exposure to, or protection from, climate; and as we see that the state of the hair and teeth are correlated in Turkish dogs (other analogous facts will be hereafter given), may we not venture to surmise that the reduction of the tusks in the domestic boar is related to his coat of bristles being diminished from living under shelter? On the other hand, as we shall immediately see, the tusks and bristles reappear with feral boars, which are no longer protected from the weather. It is not surprising that the tusks should be more affected than the other teeth; as parts developed to serve as secondary sexual characters are always liable to much variation.

It is a well-known fact that the young of wild European and Indian pigs,[26] for the first six months, are longitudinally banded with light-coloured stripes. This character generally disappears under domestication. The Turkish domestic pigs, however, have striped young, as have those of Westphalia, "whatever may be their hue;"[27] whether these latter pigs belong to the same curly-haired race as the Turkish swine, I do not know. The pigs which have run wild in Jamaica and the semi-feral pigs of New Granada, both those which are black and those which are black with a white band across the stomach, often extending over the back, have resumed this aboriginal character and produce longitudinally-striped young. This is likewise the case, at least occasionally, with the neglected pigs in the Zambesi settlement on the coast of Africa.[28]

The common belief that all domesticated animals, when they run wild, revert completely to the character of their parent-stock, is chiefly founded, as far as I can discover, on feral pigs. But even in this case the belief is not grounded on sufficient evidence; for the two main types, namely, *S. scrofa* and *indicus*, have not been distinguished. The young, as we have just seen, reacquire their longitudinal stripes, and the boars invariably reassume their tusks. They revert also in the general shape of their bodies, and in the length of their legs and muzzles, to the state of the wild animal, as might have been expected from the amount of exercise which they are compelled to take in search of food. In Jamaica the feral pigs do not acquire the full size of the European wild boar, "never attaining a greater height than 20 inches at the shoulder." In various countries they reassume their original bristly covering, but in different degrees, dependent on the climate; thus, according to Roulin, the semi-feral pigs in the hot valleys of New Granada are very scantily clothed; whereas, on the Paramos, at the height of 7000 to 8000 feet, they acquire a thick covering of wool lying under the bristles, like that on the truly wild pigs of France. These pigs on the Paramos are small and stunted. The wild boar of India is said to have the bristles at the end of its tail arranged like the plumes of an arrow, whilst the European boar has a simple tuft; and it is a curious fact that many, but not all, of the feral pigs in Jamaica, derived from a Spanish stock, have a plumed tail.[29] With respect to colour, feral pigs generally revert to that of the wild boar; but in certain parts of S. America, as we have seen, some of the semi-feral pigs have a curious white band across their stomachs; and in certain other hot places the pigs are red, and this colour has likewise occasionally been observed in the feral pigs of Jamaica. From these several facts we see that with pigs when feral there is a strong tendency to revert to the wild type; but that this tendency is largely governed by the nature of the climate, amount of exercise, and other causes of change to which they have been subjected.

The last point worth notice is that we have unusually good evidence of breeds of pigs now keeping perfectly true, which have been formed by the crossing of several distinct breeds. The Improved Essex pigs, for instance, breed very true; but there is no doubt that they largely owe their present excellent qualities to crosses originally made by Lord Western with the Neapolitan race, and to subsequent crosses with the Berkshire breed (this also having been improved by Neapolitan crosses), and likewise, probably, with the Sussex breed.[30] In breeds thus formed by complex crosses, the most careful and unremitting selection during many generations has been found to be indispensable. Chiefly in consequence of so much crossing, some well-known breeds have undergone rapid changes; thus, according to Nathusius,[31] the Berkshire breed of 1780 is quite different from that of 1810; and, since this latter period, at least two distinct forms have borne the same name.

CATTLE.

Domestic cattle are certainly the descendants of more than one wild form, in the same manner as has been shown to be the case with our dogs and pigs. Naturalists have generally made two main divisions of cattle: the humped kinds inhabiting tropical countries, called in India Zebus, to which the specific name of *Bos indicus* has been given; and the common non-humped cattle, generally included under the name of *Bos taurus*. The humped cattle were domesticated, as may be seen on the Egyptian monuments, at least as early as the twelfth dynasty, that is 2100 B.C. They differ from common cattle in various osteological characters, even in a greater degree, according to Rütimeyer,[32] than do the fossil and prehistoric European species, namely, *Bos primigenius* and *longifrons*, from each other. They differ, also, as Mr. Blyth,[33] who has particularly attended to this subject, remarks, in general configuration, in the shape of their ears, in the point where the dewlap commences, in the typical curvature of their horns, in their manner of carrying their heads when at rest, in their ordinary variations of colour, especially in the frequent presence of "nilgau-like markings on their feet," and "in the one being born with teeth protruding through the jaws, and the other not so." They have different habits, and their voice is entirely different. The humped cattle in India "seldom seek shade, and never go into the water and there stand knee-deep, like the cattle of Europe." They have run wild in parts of Oude and Rohilcund, and can maintain themselves in a region infested by tigers. They have given rise to many races differing greatly in size, in the presence of one or two humps, in length of horns, and other respects. Mr. Blyth sums up emphatically that the humped and humpless cattle must be considered as distinct species. When we consider the number of points in external structure and habits, independently of important osteological differences, in which they differ from each other; and that many of these points are not likely to have been affected by domestication, there can hardly be a doubt, notwithstanding the adverse opinion of some naturalists, that the humped and non-humped cattle must be ranked as specifically distinct.

The European breeds of humpless cattle are numerous. Professor Low enumerates 19 British breeds, only a few of which are identical with those on the Continent. Even the small Channel islands of Guernsey, Jersey, and Alderney possess their own sub-breeds;[34] and these again differ from the cattle of the other British islands, such as Anglesea, and the western isles of Scotland. Desmarest, who paid attention to the subject, describes 15 French races, excluding sub-varieties and those imported from other countries. In other parts of Europe there are several distinct races, such as the pale-coloured Hungarian cattle, with their light and free step, and enormous horns sometimes measuring above five feet from tip to tip:[35] the Podolian cattle also are remarkable from the height of their fore-quarters. In the most recent work on Cattle,[36] engravings are given of fifty-five European breeds; it is, however, probable that several of these differ very little from each other, or are merely synonyms. It must not be supposed that numerous breeds of cattle exist only in long-civilised countries, for we shall presently see that several kinds are kept by the savages of Southern Africa.

With respect to the parentage of the several European breeds, we already know much from Nilsson’s Memoir,[37] and more especially from Rütimeyer’s works and those of Boyd Dawkins. Two or three species or forms of Bos, closely allied to still living domestic races, have been found in the more recent tertiary deposits or amongst prehistoric remains in Europe. Following Rütimeyer, we have:—

*Bos primigenius.*This magnificent, well known species was domesticated in Switzerland during the Neolithic period; even at this early period it varied a little, having apparently been crossed with other races. Some of the larger races on the Continent, as the Friesland, etc., and the Pembroke race in England, closely resemble in essential structure *B. primigenius*, and no doubt are its descendants. This is likewise the opinion of Nilsson. *Bos primigenius* existed as a wild animal in Cæsar’s time, and is now semi-wild, though much degenerated in size, in the park of Chillingham; for I am informed by Professor Rütimeyer, to whom Lord Tankerville sent a skull, that the Chillingham cattle are less altered from the true primigenius type than any other known breed.[38]

Bos trochoceros. This form is not included in the three species above mentioned, for it is now considered by Rütimeyer to be the female of an early domesticated form of *B. primigenius*, and as the progenitor of his *frontosus* race. I may add that specific names have been given to four other fossil oxen, now believed to be identical with *B. primigenius*.[39]

Bos longifrons (or *brachyceros*) of Owen.—This very distinct species was of small size, and had a short body with fine legs. According to Boyd Dawkins[40] it was introduced as a domesticated animal into Britain at a very early period, and supplied food to the Roman legionaries.[41] Some remains have been found in Ireland in certain crannoges, of which the dates are believed to be from 843-933 A.D.[42] It was also the commonest form in a domesticated condition in Switzerland during the earliest part of the Neolithic period. Professor Owen[43] thinks it probable that the Welsh and Highland cattle are descended from this form; as likewise is the case, according to Rütimeyer, with some of the existing Swiss breeds. These latter are of different shades of colour from light-grey to blackish-brown, with a lighter stripe along the spine, but they have no pure white marks. The cattle of North Wales and the Highlands, on the other hand, are generally black or dark-coloured.

Bos frontosus of Nilsson.—This species is allied to *B. longifrons*, and, according to the high authority of Mr. Boyd Dawkins, is identical with it, but in the opinion of some judges is distinct. Both co-existed in Scania during the same late geological period,[44] and both have been found in the Irish crannoges.[45] Nilsson believes that his *B. frontosus* may be the parent of the mountain cattle of Norway, which have a high protuberance on the skull between the base of the horns. As Professor Owen and others believe that the Scotch Highland cattle are descended from his *B. longifrons*, it is worth notice that a capable judge[46] has remarked that he saw no cattle in Norway like the Highland breed, but that they more nearly resembled the Devonshire breed.

On the whole we may conclude, more especially from the researches of Boyd Dawkins, that European cattle are descended from two species; and there is no improbability in this fact, for the genus Bos readily yields to domestication. Besides these two species and the zebu, the yak, the gayal, and the arni[47] (not to mention the buffalo or genus Bubalus) have been domesticated; making altogether six species of Bos. The zebu and the two European species are now extinct in a wild state. Although certain races of cattle were domesticated at a very ancient period in Europe, it does not follow that they were first domesticated here. Those who place much reliance on philology argue that they were imported from the East.[48] It is probable that they originally inhabited a temperate or cold climate, but not a land long covered with snow; for our cattle, as we have seen in the chapter on Horses, have not the instinct of scraping away the snow to get at the herbage beneath. No one could behold the magnificent wild bulls on the bleak Falkland Islands in the southern hemisphere, and doubt about the climate being admirably suited to them. Azara has remarked that in the temperate regions of La Plata the cows conceive when two years old, whilst in the much hotter country of Paraguay they do not conceive till three years old; "from which fact," as he adds, "one may conclude that cattle do not succeed so well in warm countries."[49]

Bos primigenius and *longifrons* have been ranked by nearly all palæontologists as distinct species; and it would not be reasonable to take a different view simply because their domesticated descendants now intercross with the utmost freedom. All the European breeds have so often been crossed both intentionally and unintentionally, that, if any sterility had ensued from such unions, it would certainly have been detected. As zebus inhabit a distant and much hotter region, and as they differ in so many characters from our European cattle, I have taken pains to ascertain whether the two forms are fertile when crossed. The late Lord Powis imported some zebus and crossed them with common cattle in Shropshire; and I was assured by his steward that the cross-bred animals were perfectly fertile with both parent-stocks. Mr. Blyth informs me that in India hybrids, with various proportions of either blood, are quite fertile; and this can hardly fail to be known, for in some districts[50] the two species are allowed to breed freely together. Most of the cattle which were first introduced into Tasmania were humped, so that at one time thousands of crossed animals existed there; and Mr. B. O'Neile Wilson, M.A., writes to me from Tasmania that he has never heard of any sterility having been observed. He himself formerly possessed a herd of such crossed cattle, and all were perfectly fertile; so much so, that he cannot remember even a single cow failing to calve. These several facts afford an important confirmation of the Pallasian doctrine that the descendants of species which when first domesticated would if crossed have been in all probability in some degree sterile, become perfectly fertile after a long course of domestication. In a future chapter we shall see that this doctrine throws some light on the difficult subject of Hybridism.

I have alluded to the cattle in Chillingham Park, which, according to Rütimeyer, have been very little changed from the *Bos primigenius* type. This park is so ancient that it is referred to in a record of the year 1220. The cattle in their instincts and habits are truly wild. They are white, with the inside of the ears reddish-brown, eyes rimmed with black, muzzles brown, hoofs black, and horns white tipped with black. Within a period of thirty-three years about a dozen calves were born with "brown and blue spots upon the cheeks or necks; but these, together with any defective animals, were always destroyed." According to Bewick, about the year 1770 some calves appeared with black ears; but these were also destroyed by the keeper, and black ears have not since reappeared. The wild white cattle in the Duke of Hamilton's park, where I have heard of the birth of a black calf, are said by Lord Tankerville to be inferior to those at Chillingham. The cattle kept until the year 1780 by the Duke of Queensberry, but now extinct, had their ears, muzzle, and orbits of the eyes black. Those which have existed from time immemorial at Chartley, closely resemble the cattle at Chillingham, but are larger, "with some small difference in the colour of the ears." "They frequently tend to become entirely black; and a singular superstition prevails in the vicinity that, when a black calf is born, some calamity impends over the noble house of Ferrers. All the black calves are destroyed." The cattle at Burton Constable in Yorkshire, now extinct, had ears, muzzle, and the tip of the tail black. Those at Gisburne, also in Yorkshire, are said by Bewick to have been sometimes without dark muzzles, with the inside alone of the ears brown; and they are elsewhere said to have been low in stature and hornless.[51]

The several above-specified differences in the park-cattle, slight though they be, are worth recording, as they show that animals living nearly in a state of nature, and exposed to nearly uniform conditions, if not allowed to roam freely and to cross with other herds, do not keep as uniform as truly wild animals. For the preservation of a uniform character, even within the same park, a certain degree of selection—that is, the destruction of the dark-coloured calves—is apparently necessary.

Boyd Dawkins believes that the park-cattle are descended from anciently domesticated, and not truly wild animals; and from the occasional appearance of dark-coloured calves, it is improbable that the aboriginal *Bos primigenius* was white. It is curious what a strong, though not invariable, tendency there is in wild or escaped cattle to become white with coloured ears, under widely different conditions of life. If the old writers Boethius and Leslie[52] can be trusted, the wild cattle of Scotland were white and furnished with a great mane; but the colour of their ears is not mentioned. In Wales,[53] during the tenth century, some of the cattle are described as being white with red ears. Four hundred cattle thus coloured were sent to King John; and an early record speaks of a hundred cattle with red ears having been demanded as a compensation for some offence, but, if the cattle were of a dark or black colour, 150 were to be presented. The black cattle of North Wales apparently belong, as we have seen, to the small *longifrons* type: and as the alternative was offered of either 150 dark cattle, or 100 white cattle with red ears, we may presume that the latter were the larger beasts, and probably belonged to the *primigenius* type. Youatt has remarked that at the present day, whenever cattle of the shorthorn breed are white, the extremities of their ears are more or less tinged with red.

The cattle which have run wild on the Pampas, in Texas, and in two parts of Africa, have become of a nearly uniform dark brownish-red.[54] On the Ladrone Islands, in the Pacific Ocean, immense herds of cattle, which were wild in the year 1741, are described as "milk-white, except their ears, which are generally black."[55] The Falkland Islands, situated far south, with all the conditions of life as different as it is possible to conceive from those of the Ladrones, offer a more interesting case. Cattle have run wild there during eighty or ninety years; and in the southern districts the animals are mostly white, with their feet, or whole heads, or only their ears black; but my informant, Admiral Sulivan,[56] who long resided on these islands, does not believe that they are ever purely white. So that in these two archipelagos we see that the cattle tend to become white with coloured ears. In other parts of the Falkland Islands other colours prevail: near Port Pleasant brown is the common tint; round Mount Usborn, about half the animals in some of the herds were lead- or mouse-coloured, which elsewhere is an unusual tint. These latter cattle, though generally inhabiting high land, breed about a month earlier than the other cattle; and this circumstance would aid in keeping them distinct and in perpetuating a peculiar colour. It is worth recalling to mind that blue or lead-coloured marks have occasionally appeared on the white cattle of Chillingham. So plainly different were the colours of the wild herds in different parts of the Falkland Islands, that in hunting them, as Admiral Sulivan informs me, white spots in one district, and dark spots in another district, were always looked out for on the distant hills. In the intermediate districts, intermediate colours prevailed. Whatever the cause may be, this tendency in the wild cattle of the Falkland Islands, which are all descended from a few brought from La Plata, to break up into herds of three different colours, is an interesting fact.

Returning to the several British breeds, the conspicuous difference in general appearance between Shorthorns, Longhorns (now rarely seen), Herefords, Highland cattle, Alderneys, etc., must be familiar to every one. A part of this difference may be attributed to descent from primordially distinct species; but we may feel sure that there has been a considerable amount of variation. Even during the Neolithic period, the domestic cattle were to a certain extent variable. Within recent times most of the breeds have been modified by careful and methodical selection. How strongly the characters thus acquired are inherited, may be inferred from the prices realised by the improved breeds; even at the first sale of Colling's Shorthorns, eleven bulls reached an average of 214 pounds, and lately Shorthorn bulls have been sold for a thousand guineas, and have been exported to all quarters of the world.

Some constitutional differences may be here noticed. The Shorthorns arrive at maturity far earlier than the wilder breeds, such as those of Wales or the Highlands. This fact has been shown in an interesting manner by Mr. Simonds,[57] who has given a table of the average period of their dentition, which proves that there is a difference of no less than six months in the appearance of the permanent incisors. The period of gestation, from observations made by Tessier on 1131 cows, varies to the extent of eighty-one days; and what is more interesting, M. Lefour affirms "that the period of gestation is longer in the large German cattle than in the smaller breeds."[58] With respect to the period of conception, it seems certain that Alderney and Zetland cows often become pregnant earlier than other breeds.[59] Lastly, as four fully developed mammæ is a generic character in the genus Bos,[60] it is worth notice that with our domestic cows the two rudimentary mammæ often become fairly well developed and yield milk.

As numerous breeds are generally found only in long-civilised countries, it may be well to show that in some countries inhabited by barbarous races, who are frequently at war with each other, and therefore have little free communication, several distinct breeds of cattle now exist or formerly existed. At the Cape of Good Hope Leguat observed, in the year 1720, three kinds.[61] At the present day various travellers have noticed the differences in the breeds in Southern Africa. Sir Andrew Smith several years ago remarked to me that the cattle possessed by the different tribes of Caffres, though living near each other under the same latitude and in the same kind of country, yet differed, and he expressed much surprise at the fact. Mr. Andersson has described[62] the Damara, Bechuana, and Namaqua cattle; and he informs me in a letter that the cattle north of Lake Ngami are likewise different, as Mr. Galton has heard is also the case with the cattle of Benguela. The Namaqua cattle in size and shape nearly resemble European cattle, and have short stout horns and large hoofs. The Damara cattle are very peculiar, being big-boned, with slender legs, and small hard feet; their tails are adorned with a tuft of long bushy hair nearly touching the ground, and their horns are extraordinarily large. The Bechuana cattle have even larger horns, and there is now a skull in London with the two horns 8 ft. 8-1/4 in. long, as measured in a straight line from tip to tip, and no less than 13 ft. 5 in. as measured along their curvature! Mr. Andersson in his letter to me says that, though he will not venture to describe the differences between the breeds belonging to the many different sub-tribes, yet such certainly exist, as shown by the wonderful facility with which the natives discriminate them.

That many breeds of cattle have originated through variation, independently of descent from distinct species, we may infer from what we see in South America, where the genus Bos was not endemic, and where the cattle which now exist in such vast numbers are the descendants of a few imported from Spain and Portugal. In Columbia, Roulin[63] describes two peculiar breeds, namely, *pelones*, with extremely thin and fine hair, and *calongos*, absolutely naked. According to Castelnau there are two races in Brazil, one like European cattle, the other different, with remarkable horns. In Paraguay, Azara describes a breed which certainly originated in S. America, called *chivos*, "because they have straight vertical horns, conical, and very large at the base." He likewise describes a dwarf race in Corrientes, with short legs and a body larger than usual. Cattle without horns, and others with reversed hair, have also originated in Paraguay.

Another monstrous breed, called niatas or natas, of which I saw two small herds on the northern bank of the Plata, is so remarkable as to deserve a fuller description. This breed bears the same relation to other breeds, as bull or pug dogs do to other dogs, or as improved pigs, according to H. von Nathusius, do to common pigs.[64] Rütimeyer believes that these cattle belong to the primigenius type.[65] The forehead is very short and broad, with the nasal end of the skull, together with the whole plane of the upper molar-teeth, curved upwards. The lower jaw projects beyond the upper, and has a corresponding upward curvature. It is an interesting fact that an almost similar confirmation characterizes, as I am informed by Dr. Falconer, the extinct and gigantic Sivatherium of India, and is not known in any other ruminant. The upper lip is much drawn back, the nostrils are seated high up and are widely open, the eyes project outwards, and the horns are large. In walking the head is carried low, and the neck is short. The hind legs appear to be longer, compared with the front legs, than is usual. The exposed incisor teeth, the short head and upturned nostrils, give these cattle the most ludicrous, self-confident air of defiance. The skull which I presented to the College of Surgeons has been thus described by Professor Owen:[66] "It is remarkable from the stunted development of the nasals, premaxillaries, and fore-part of the lower jaw, which is unusually curved upwards to come into contact with the premaxillaries. The nasal bones are about one-third the ordinary length, but retain almost their normal breadth. The triangular vacuity is left between them, the frontal and lachrymal, which latter bone articulates with the premaxillary, and thus excludes the maxillary from any junction with the nasal." So that even the connexion of some of the bones is changed. Other differences might be added: thus the plane of the condyles is somewhat modified, and the terminal edge of the premaxillaries forms an arch. In fact, on comparison with the skull of a common ox, scarcely a single bone presents the same exact shape, and the whole skull has a wonderfully different appearance.

The first brief published notice of this race was by Azara, between the years 1783-96; but Don F. Muniz, of Luxan, who has kindly collected information for me, states that about 1760 these cattle were kept as curiosities near Buenos Ayres. Their origin is not positively known, but they must have originated subsequently to the year 1552, when cattle were first introduced. Senor Muniz informs me that the breed is believed to have originated with the Indians southward of the Plata. Even to this day those reared near the Plata show their less civilised nature in being fiercer than common cattle, and in the cow, if visited too often, easily deserting her first calf. The breed is very true, and a niata bull and cow invariably produce niata calves. The breed has already lasted at least a century. A niata bull crossed with a common cow, and the reverse cross, yield offspring having an intermediate character, but with the niata character strongly displayed. According to Senor Muniz, there is the clearest evidence, contrary to the common belief of agriculturists in analogous cases, that the niata cow when crossed with a common bull transmits her peculiarities more strongly than does the niata bull when crossed with a common cow. When the pasture is tolerably long, these cattle feed as well as common cattle with their tongue and palate; but during the great droughts, when so many animals perish on the Pampas, the niata breed lies under a great disadvantage, and would, if not attended to, become extinct; for the common cattle, like horses, are able to keep alive by browsing with their lips on the twigs of trees and on reeds: this the niatas cannot so well do, as their lips do not join, and hence they are found to perish before the common cattle. This strikes me as a good illustration of how little we are able to judge from the ordinary habits of an animal, on what circumstances, occurring only at long intervals of time, its rarity or extinction may depend. It shows us, also, how natural selection would have determined the rejection of the niata modification had it arisen in a state of nature.

Having described the semi-monstrous niata breed, I may allude to a white bull, said to have been brought from Africa, which was exhibited in London in 1829, and which has been well figured by Mr. Harvey.[67] It had a hump, and was furnished with a mane. The dewlap was peculiar, being divided between its fore-legs into parallel divisions. Its lateral hoofs were annually shed, and grew to the length of five or six inches. The eye was very peculiar, being remarkably prominent, and "resembled a cup and ball, thus enabling the animal to see on all sides with equal ease; the pupil was small and oval, or rather a parallelogram with the ends cut off, and lying transversely across the ball." A new and strange breed might probably have been formed by careful breeding and selection from this animal.

I have often speculated on the probable causes through which each separate district in Great Britain came to possess in former times its own peculiar breed of cattle; and the question is, perhaps, even more perplexing in the case of Southern Africa. We now know that the differences may be in part attributed to descent from distinct species; but this cause is far from sufficient. Have the slight differences in climate and in the nature of the pasture, in the different districts of Britain, directly induced corresponding differences in the cattle? We have seen that the semi-wild cattle in the several British parks are not identical in colouring or size, and that some degree of selection has been requisite to keep them true. It is almost certain that abundant food given during many generations directly affects the size of a breed.[68] That climate directly affects the thickness of the skin and the hair is likewise certain: thus Roulin asserts[69] that the hides of the feral cattle on the hot Llanos "are always much less heavy than those of the cattle raised on the high platform of Bogota; and that these hides yield in weight and in thickness of hair to those of the cattle which have run wild on the lofty Paramos." The same difference has been observed in the hides of the cattle reared on the bleak Falkland Islands and on the temperate Pampas. Low has remarked[70] that the cattle which inhabit the more humid parts of Britain have longer hair and thicker skins than other British cattle. When we compare highly improved stall-fed cattle with the wilder breeds, or compare mountain and lowland breeds, we cannot doubt that an active life, leading to the free use of the limbs and lungs, affects the shape and proportions of the whole body. It is probable that some breeds, such as the semi-monstrous niata cattle, and some peculiarities, such as being hornless, etc., have appeared suddenly owing to what we may call in our ignorance spontaneous variation; but even in this case a rude kind of selection is necessary, and the animals thus characterised must be at least partially separated from others. This degree of care, however, has sometimes been taken even in little-civilised districts, where we should least have expected it, as in the case of the niata, chivo, and hornless cattle in S. America.

That methodical selection has done wonders within a recent period in modifying our cattle, no one doubts. During the process of methodical selection it has occasionally happened that deviations of structure, more strongly pronounced than mere individual differences, yet by no means deserving to be called monstrosities, have been taken advantage of: thus the famous Longhorn Bull, Shakespeare, though of the pure Canley stock, scarcely inherited a single point of the long-horned breed, his horns excepted;[71] yet in the hands of Mr. Fowler, this bull greatly improved his race. We have also reason to believe that selection, carried on so far unconsciously that there was at no one time any distinct intention to improve or change the breed, has in the course of time modified most of our cattle; for by this process, aided by more abundant food, all the lowland British breeds have increased greatly in size and in early maturity since the reign of Henry VII.[72] It should never be forgotten that many animals have to be annually slaughtered; so that each owner must determine which shall be killed and which preserved for breeding. In every district, as Youatt has remarked, there is a prejudice in favour of the native breed; so that animals possessing qualities, whatever they may be, which are most valued in each district, will be oftenest preserved; and this unmethodical selection assuredly will in the long run affect the character of the whole breed. But it may be asked, can this rude kind of selection have been practised by barbarians such as those of southern Africa? In a future chapter on Selection we shall see that this has certainly occurred to some extent. Therefore, looking to the origin of the many breeds of cattle which formerly inhabited the several districts of Britain, I conclude that, although slight differences in the nature of the climate, food, etc., as well as changed habits of life, aided by correlation of growth, and the occasional appearance from unknown causes of considerable deviations of structure, have all probably played their parts; yet that the occasional preservation in each district of those individual animals which were most valued by each owner has perhaps been even more effective in the production of the several British breeds. As soon as two or more breeds were formed in any district, or when new breeds descended from distinct species were introduced, their crossing, especially if aided by some selection, will have multiplied the number and modified the characters of the older breeds.

SHEEP.

I shall treat this subject briefly. Most authors look at our domestic sheep as descended from several distinct species. Mr. Blyth, who has carefully attended to the subject, believes that fourteen wild species now exist, but “that not one of them can be identified as the progenitor of any one of the interminable domestic races.” M. Gervais thinks that there are six species of Ovis,[73] but that our domestic sheep form a distinct genus, now completely extinct. A German naturalist[74] believes that our sheep descend from ten aboriginally distinct species, of which only one is still living in a wild state! Another ingenious observer,[75] though not a naturalist, with a bold defiance of everything known on geographical distribution, infers that the sheep of Great Britain alone are the descendants of eleven endemic British forms! Under such a hopeless state of doubt it would be useless for my purpose to give a detailed account of the several breeds; but a few remarks may be added.

Sheep have been domesticated from a very ancient period. Rütimeyer[76] found in the Swiss lake-dwellings the remains of a small breed, with thin tall legs, and horns like those of a goat, thus differing somewhat from any kind now known. Almost every country has its own peculiar breed; and many countries have several breeds differing greatly from each other. One of the most strongly marked races is an Eastern one with a long tail, including, according to Pallas, twenty vertebræ, and so loaded with fat that it is sometimes placed on a truck, which is dragged about by the living animal. These sheep, though ranked by Fitzinger as a distinct aboriginal form, bear in their drooping ears the stamp of long domestication. This is likewise the case with those sheep which have two great masses of fat on the rump, with the tail in a rudimentary condition. The Angola variety of the long-tailed race has curious masses of fat on the back of the head and beneath the jaws.[77] Mr. Hodgson in an admirable paper[78] on the sheep of the

Himalaya infers from the distribution of the several races, "that this caudal augmentation in most of its phases is an instance of degeneracy in these pre-eminently Alpine animals." The horns present an endless diversity in character; being not rarely absent, especially in the female sex, or, on the other hand, amounting to four or even eight in number. The horns, when numerous, arise from a crest on the frontal bone, which is elevated in a peculiar manner. It is remarkable that multiplicity of horns "is generally accompanied by great length and coarseness of the fleece."[79] This correlation, however, is far from being general; for instance, I am informed by Mr. D. Forbes, that the Spanish sheep in Chile resemble, in fleece and in all other characters, their parent merino-race, except that instead of a pair they generally bear four horns. The existence of a pair of mammæ is a generic character in the genus Ovis as well as in several allied forms; nevertheless, as Mr. Hodgson has remarked, "this character is not absolutely constant even among the true and proper sheep: for I have more than once met with Càgias (a sub-Himalayan domestic race) possessed of four teats."[80] This case is the more remarkable as, when any part or organ is present in reduced number in comparison with the same part in allied groups, it usually is subject to little variation. The presence of interdigital pits has likewise been considered as a generic distinction in sheep; but Isidore Geoffroy[81] has shown that these pits or pouches are absent in some breeds.

In sheep there is a strong tendency for characters, which have apparently been acquired under domestication, to become attached either exclusively to the male sex, or to be more highly developed in this than in the other sex. Thus in many breeds the horns are deficient in the ewe, though this likewise occurs occasionally with the female of the wild musmon. In the rams of the Wallachian breed, "the horns spring almost perpendicularly from the frontal bone, and then take a beautiful spiral form; in the ewes they protrude nearly at right angles from the head, and then become twisted in a singular manner."[82] Mr. Hodgson states that the extraordinarily arched nose or chaffron, which is so highly developed in several foreign breeds, is characteristic of the ram alone, and apparently is the result of domestication.[83] I hear from Mr. Blyth that the accumulation of fat in the fat-tailed sheep of the plains of India is greater in the male than in the female; and Fitzinger[84] remarks that the mane in the African maned race is far more developed in the ram than in the ewe.

Different races of sheep, like cattle, present constitutional differences. Thus the improved breeds arrive at maturity at an early age, as has been well shown by Mr. Simonds through their early average period of dentition. The several races have become adapted to different kinds of pasture and climate: for instance, no one can rear Leicester sheep on mountainous regions, where Cheviots flourish. As Youatt has remarked, "In all the different districts of Great Britain we find various breeds of sheep beautifully adapted to the locality which they occupy. No one knows their origin; they are indigenous to the soil, climate, pasturage, and the locality on which they graze; they seem to have been formed for it and by it."[85] Marshall relates[86] that a flock of heavy Lincolnshire and light Norfolk sheep which had been bred together in a large sheep-walk, part of which was low, rich, and moist, and another part high and dry, with benty grass, when turned out, regularly separated from each other; the heavy sheep drawing off to the rich soil, and the lighter sheep to their own soil; so that "whilst there was plenty of grass the two breeds kept themselves as distinct as rooks and pigeons." Numerous sheep from various parts of the world have been brought during a long course of years to the Zoological Gardens of London; but as Youatt, who attended the animals as a veterinary surgeon, remarks, "few or none die of the rot, but they are phthisical; not one of them from a torrid climate lasts out the second year, and when they die their lungs are tuberculated."[87] There is very good evidence that English breeds of sheep will not succeed in France.[88] Even in certain parts of England it has been found impossible to keep certain breeds of sheep; thus on a farm on the banks of the Ouse, the Leicester sheep were so rapidly destroyed by pleuritis[89] that the owner could not keep them; the coarser-skinned sheep never being affected.

The period of gestation was formerly thought to be of so unalterable a character, that a supposed difference of this kind between the wolf and the dog was esteemed a sure sign of specific distinction; but we have seen that the period is shorter in the improved breeds of the pig, and in the larger breeds of the ox, than in other breeds of these two animals. And now we know, on the excellent authority of Hermann von Nathusius,[90] that Merino and Southdown sheep, when both have long been kept under exactly the same conditions, differ in their average period of gestation, as is seen in the following Table:—

Merinos	150·3 days.
Southdowns	144·2 days.
Half-bred Merinos and Southdowns	146·3 days.
3/4 blood of Southdown	145·5 days.
7/8 blood of Southdown	144·2 days.

In this graduated difference in cross-bred animals having different proportions of Southdown blood, we see how strictly the two periods of gestation have been transmitted. Nathusius remarks that, as Southdowns grow with remarkable rapidity after birth, it is not surprising that their foetal development should have been shortened. It is of course possible that the difference in these two breeds may be due to their descent from distinct parent-species; but as the early maturity of the Southdowns has long been carefully attended to by breeders, the difference is more probably the result of such attention. Lastly, the fecundity of the several breeds differs much; some generally producing twins or even triplets at a birth, of which fact the curious Shangai sheep (with their truncated and rudimentary ears, and great Roman noses), lately exhibited in the Zoological Gardens, offer a remarkable instance.

Sheep are perhaps more readily affected by the direct action of the conditions of life to which they have been exposed than almost any other domestic animal. According to Pallas, and more recently according to Erman, the fat-tailed Kirghisian sheep, when bred for a few generations in Russia, degenerate, and the mass of fat dwindles away, “the scanty and bitter herbage of the steppes seems so essential to their development.” Pallas makes an analogous statement with respect to one of the Crimean breeds. Burnes states that the Karakool breed, which produces a fine, curled, black, and valuable fleece, when removed from its own canton near Bokhara to Persia or to other quarters, loses its peculiar fleece.[91] In all such cases, however, it may be that a change of any kind in the conditions of life causes variability and consequent loss of character, and not that certain conditions are necessary for the development of certain characters.

Great heat, however, seems to act directly on the fleece: several accounts have been published of the change which sheep imported from Europe undergo in the West Indies. Dr. Nicholson of Antigua informs me that, after the third generation, the wool disappears from the whole body, except over the loins; and the animal then appears like a goat with a dirty door-mat on its back. A similar change is said to take place on the west coast of Africa.[92] On the other hand, many wool-bearing sheep live on the hot plains of India. Roulin asserts that in the lower and heated valleys of the Cordillera, if the lambs are sheared as soon as the wool has grown to a certain thickness, all goes on afterwards as usual; but if not sheared, the wool detaches itself in flakes, and short shining hair like that on a goat is produced ever afterwards. This curious result seems merely to be an exaggerated tendency natural to the Merino breed, for as a great authority, namely, Lord Somerville, remarks, “the wool of our Merino sheep after shear-time is hard and coarse to such a degree as to render it almost impossible to suppose that the same animal could bear wool so opposite in quality, compared to that which has been clipped from it: as the cold weather advances, the fleeces recover their soft quality.” As in sheep of all breeds the fleece naturally consists of longer and coarser hair covering shorter and softer wool, the change which it often undergoes in hot climates is probably merely a case of unequal development; for even with those sheep which like goats are covered with hair, a small quantity of underlying wool may always be found.[93] In the wild mountain-sheep (*0vis montana*) of North America there is an analogous annual change of coat; “the wool begins to drop out in early spring, leaving in its place a coat of hair resembling that of the elk, a change of pelage quite different in character from the ordinary thickening of the coat or hair, common to all furred animals in winter,—for instance, in the horse, the cow, etc., which shed their winter coat in the spring.”[94]

A slight difference in climate or pasture sometimes slightly affects the fleece, as has been observed even in different districts in England, and is well shown by the great softness of the wool brought from Southern Australia. But it should be observed, as Youatt repeatedly insists, that the tendency to change may generally be counteracted by careful selection. M. Lasterye, after discussing this subject, sums up as follows: “The preservation of the Merino race in its utmost purity at the Cape of Good Hope, in the marshes of Holland, and under the rigorous climate of Sweden, furnishes an additional support of this my unalterable principle, that fine-woolled sheep may be kept wherever industrious men and intelligent breeders exist."

That methodical selection has effected great changes in several breeds of sheep no one who knows anything on the subject, entertains a doubt. The case of the Southdowns, as improved by Ellman, offers perhaps the most striking instance. Unconscious or occasional selection has likewise slowly produced a great effect, as we shall see in the chapters on Selection. That crossing has largely modified some breeds, no one who will study what has been written on this subject—for instance, Mr. Spooner's paper—will dispute; but to produce uniformity in a crossed breed, careful selection and "rigorous weeding," as this author expresses it, are indispensable.[95]

In some few instances new breeds have suddenly originated; thus, in 1791, a ram-lamb was born in Massachusetts, having short crooked legs and a long back, like a turnspit-dog. From this one lamb the *otter* or *ancon* semi-monstrous breed was raised; as these sheep could not leap over the fences, it was thought that they would be valuable; but they have been supplanted by merinos, and thus exterminated. The sheep are remarkable from transmitting their character so truly that Colonel Humphreys[96] never heard of "but one questionable case" of an ancon ram and ewe not producing ancon offspring. When they are crossed with other breeds the offspring, with rare exceptions, instead of being intermediate in character, perfectly resemble either parent; even one of twins has resembled one parent and the second the other. Lastly, "the ancons have been observed to keep together, separating themselves from the rest of the flock when put into enclosures with other sheep."

A more interesting case has been recorded in the Report of the Juries for the Great Exhibition (1851), namely, the production of a merino ram-lamb on the Mauchamp farm, in 1828, which was remarkable for its long, smooth, straight, and silky wool. By the year 1833 M. Graux had raised rams enough to serve his whole flock, and after a few more years he was able to sell stock of his new breed. So peculiar and valuable is the wool, that it sells at 25 per cent above the best merino wool: even the fleeces of half-bred animals are valuable, and are known in France as the "Mauchamp-merino." It is interesting, as showing how generally any marked deviation of structure is accompanied by other deviations, that the first ram and his immediate offspring were of small size, with large heads, long necks, narrow chests, and long flanks; but these blemishes were removed by judicious crosses and selection. The long smooth wool was also correlated with smooth horns; and as horns and hair are homologous structures, we can understand the meaning of this correlation. If the Mauchamp and ancon breeds had originated a century or two ago, we should have had no record of their birth; and many a naturalist would no doubt have insisted, especially in the case of the Mauchamp race, that they had each descended from, or been crossed with, some unknown aboriginal form.

GOATS.

From the recent researches of M. Brandt, most naturalists now believe that all our goats are descended from the *Capra ægagrus* of the mountains of Asia, possibly mingled with the allied Indian species *C. falconeri* of India.[97] In Switzerland, during the neolithic period, the domestic goat was commoner than the sheep; and this very ancient race differed in no respect from that now common in Switzerland.[98] At the present time, the many races found in several parts of the world differ greatly from each other; nevertheless, as far as they have been tried,[99] they are all quite fertile when crossed. So numerous are the breeds, that Mr. G. Clark[100] has described eight distinct kinds imported into the one island of Mauritius. The ears of one kind were enormously developed, being, as measured by Mr. Clark, no less than 19 inches in length and 4-3/4 inches in breadth. As with cattle, the mammæ of those breeds which are regularly milked become greatly developed; and, as Mr. Clark remarks, "it is not rare to see their teats touching the ground." The following cases are worth notice as presenting unusual points of variation. According to Godron,[101] the mammæ differ greatly in shape in different breeds, being elongated in the common goat, hemispherical in the Angora race, and bilobed and divergent in the goats of Syria and Nubia. According to this same author, the males of certain breeds have lost their usual offensive odour. In one of the Indian breeds the males and females have horns of widely-different shapes;[102] and in some breeds the females are destitute of horns.[103] M. Ramu of Nancy informs me that many of the goats there bear on the upper part of the throat a pair of hairy appendages, 70 mm. in length and about 10 mm. in diameter, which in external appearance resemble those above described on the jaws of pigs. The presence of inter-digital pits or glands on all four feet has been thought to characterise the genus Ovis, and their absence to be characteristic of the genus Capra; but Mr. Hodgson has found that they exist in the front feet of the majority of Himalayan goats.[104] Mr. Hodgson measured the intestines in two goats of the Dúgú race, and he found that the proportional length of the great and small intestines differed considerably. In one of these goats the cæcum was thirteen inches, and in the other no less than thirty-six inches in length!

REFERENCES

[1] Hermann von Nathusius 'Die Racen des Schweines,' Berlin, 1860; and 'Vorstudien für Geschichte,' etc., 'Schweineschädel,' Berlin, 1864. Rütimeyer, 'Die Fauna der Pfahlbauten,' Basel, 1861.

[2] Nathusius, 'Die Racen des Schweines,' Berlin, 1860. An excellent appendix is given with references to published and trustworthy drawings of the breeds of each country.

[3] For Europe *see* Bechstein, 'Naturgesch. Deutschlands,' 1801, B. i., s. 505. Several accounts have been published on the fertility of the offspring from wild and tame swine. *See* Burdach's 'Physiology,' and Godron 'De

l'Espèce,' tom. i. p. 370. For Africa, 'Bull. de la Soc. d'Acclimat.' tom. iv. p. 389. For India, *see* Nathusius, 'Schweineschädel,' s. 148.

[4] Sir W. Elliot, Catalogue of Mammalia, 'Madras Journal of Lit. and Science,' vol. x. p. 219.

[5] 'Pfahlbauten,' s. 163 *et passim.*

[6] *See* J. W. Schütz' interesting essay, 'Zur Kenntniss des Torfschweins,' 1868. This author believes that the Torfschwein is descended from a distinct species, the *S. sennariensis* of Central Africa.

[7] Stan. Julien quoted by de Blainville, 'Ostéographie,' p. 163.

[8] Richardson, 'Pigs, their Origin,' etc., p. 26.

[9] 'Die Racen des Schweines' s. 47, 64.

[10] 'Proc. Zoolog. Soc.,' 1861, p. 263.

[11] Sclater, in 'Proc. Zoolog. Soc.,' Feb. 26, 1861.

[12] 'Proc. Zoolog. Soc.,' 1862, p. 13. The skull has since been described much more fully by Professor Lucae in a very interesting essay, 'Der Schädel des Maskenschweines,' 1870. He confirms the conclusion of von Nathusius on the relationship of this kind of pig.

[13] 'Journal of Voyages and Travels from 1821 to 1829,' vol. i. p. 300.

[14] Rev. G. Low 'Fauna Orcadensis,' p. 10. *See also* Dr. Hibbert's account of the pig of the Shetland Islands.

[15] 'Die Racen des Schweines' s. 70.

[16] These woodcuts are copied from engravings given in Mr. S. Sidney's excellent edition of 'The Pig,' by Youatt, 1860. *See* pp. 1, 16, 19.

[17] 'Schweineschädel' s. 74, 135.

[18] Nathusius, 'Die Racen des Schweines,' s. 71.

[19] 'Die Racen des Schweines,' s. 47. 'Schweineschädel' s. 104. Compare, also, the figures of the old Irish and the improved Irish breeds in Richardson on 'The Pig,' 1847.

[20] Quoted by Isid. Geoffroy, 'Hist. Nat. Gén.,' tom. iii. p. 441.

[21] S. Sidney, 'The Pig,' p. 61.

[22] 'Schweineschädel,' s. 2, 20.

[23] ‘Proc. Zoolog. Soc.,’ 1837, p. 23. I have not given the caudal vertebræ, as Mr. Eyton says some might possibly have been lost. I have added together the dorsal and lumbar vertebræ, owing to Prof. Owen’s remarks (‘Journal Linn. Soc.,’ vol. ii. p. 28) on the difference between dorsal and lumbar vertebræ depending only on the development of the ribs. Nevertheless the difference in the number of the ribs in pigs deserves notice. M. Sanson gives the number of lumbar vertebræ in various pigs; ‘Comptes Rendus,’ lxiii. p. 843.

[24] ‘Edinburgh New Philosoph. Journal,’ April, 1863. *See also* De Blainville’s ‘Ostéographie,’ p. 128, for various authorities on this subject.

[25] Eudes-Deslongchamps, ‘Mémoires de la Soc. Linn. de Normandie,’ vol. vii., 1842, p. 41. Richardson, ‘Pigs, their Origin, etc.,’ 1847, p. 30. Nathusius, ‘Die Racen des Schweines,’ 1863, s. 54.

[26] D. Johnson’s ‘Sketches of Indian Field Sports,’ p. 272. Mr. Crawfurd informs me that the same fact holds good with the wild pigs of the Malay peninsula.

[27] For Turkish pigs *see* Desmarest, ‘Mammalogie,’ 1820, p. 391. For those of Westphalia *see* Richardson’s ‘Pigs, their Origin, etc.,’ 1847, p. 41.

[28] With respect to the several foregoing and following statements on feral pigs, *see* Roulin, in ‘Mém. présentés par divers Savans a l’Acad.,’ etc., Paris, tom. vi. 1835, p. 326. It should be observed that his account does not apply to truly feral pigs; but to pigs long introduced into the country and living in a half-wild state. For the truly feral pigs of Jamaica, *see* Gosse’s ‘Sojourn in Jamaica,’ 1851, p. 386; and Col. Hamilton Smith, in ‘Nat. Library,’ vol. ix. p. 93. With respect to Africa *see* Livingstone’s ‘Expedition to the Zambesi,’ 1865, p. 153. The most precise statement with respect to the tusks of the West Indian feral boars is by P. Labat (quoted by Roulin); but this author attributes the state of these pigs to descent from a domestic stock which he saw in Spain. Admiral Sulivan, R.N., had ample opportunities of observing the wild pigs on Eagle Islet in the Falklands; and he informs me that they resembled wild boars with bristly ridged backs and large tusks. The pigs which have run wild in the province of Buenos Ayres (Rengger ‘Säugethiere,’ s. 331) have not reverted to the wild type. De Blainville (‘Ostéographie,’ p. 132) refers to two skulls of domestic pigs sent from Patagonia by Al. d’Orbigny, and he states that they have the occipital elevation of the wild European boar, but that the head altogether is “plus courte et plus ramassée.” He refers, also, to the skin of a feral pig from North America, and says “il ressemble tout à fait à un petit sanglier, mais il est presque tout noir, et peut-être un peu plus ramassé dans ses formes.”

[29] Gosse’s ‘Jamaica,’ p. 386, with a quotation from Williamson’s ‘Oriental Field Sports.’ Also Col. Hamilton Smith, in ‘Naturalist Library,’ vol. ix. p. 94.

[30] S. Sidney’s edition of ‘Youatt on the Pig,’ 1860, pp. 7, 26, 27, 29, 30.

[31] ‘Schweineschädel’ s. 140.

[32] ‘Die Fauna der Pfahlbauten,’ 1861, s. 109, 149, 222. *See also* Geoffroy Saint-Hilaire in ‘Mém. du Mus. d’Hist. Nat.,’ tom. x. p. 172; and his son Isidore in ‘Hist. Nat. Gen.’ tom. iii. p. 69. Vasey, in his ‘Delineations of the Ox Tribe,’ 1851, p. 127, says the zebu has four, and common ox five, sacral vertebræ. Mr. Hodgson found the ribs either thirteen or fourteen in number; *see* a note in ‘Indian Field,’ 1858, p. 62.

[33] ‘The Indian Field,’ 1858, p. 74, where Mr. Blyth gives his authorities with respect to the feral humped cattle. Pickering, also, in his ‘Races of Man,’ 1850, p. 274, notices the peculiar grunt-like character of the voice of the humped cattle.

[34] Mr. H. E. Marquand, in ‘The Times,’ June 23rd, 1856.

[35] Vasey, ‘Delineations of the Ox-Tribe,’ p. 124. Brace’s ‘Hungary,’ 1851, p. 94. The Hungarian cattle descend, according to Rütimeyer ‘Zahmen Europ. Rindes,’ 1866, s. 13 from *Bos primigenius.*

[36] Moll and Gayot, ‘La Connaissance Gén. du Bœuf,’ Paris, 1860. Fig. 82 is that of the Podolian breed.

[37] A translation appeared in three parts in the ‘Annals and Mag. of Nat. Hist.,’ 2nd series, vol. iv., 1849.

[38] *See also* Rütimeyer’s ‘Beiträge pal. Gesch. der Wiederkäuer Basel,’ 1865, s. 54.

[39] Pictet ‘Paléontologie,’ tom. i. p. 365 (2nd edit.). With respect to *B. trochoceros, see* Rütimeyer ‘Zahmen Europ. Rindes,’ 1866, s. 26.

[40] W. Boyd Dawkins on the British Fossil Oxen, ‘Journal of the Geolog. Soc.,’ Aug. 1867, p. 182. Also ‘Proc. Phil. Soc. of Manchester,’ Nov. 14th, 1871, and ‘Cave Hunting,’ 1875, p. 27, 138.

[41] ‘British Pleistocene Mammalia,’ by W. B. Dawkins and W. A. Sandford, 1866, p. 15.

[42] W. R. Wilde, ‘An Essay on the Animal Remains, etc. Royal Irish Academy,’ 1860, p. 29. Also ‘Proc. of R. Irish Academy,’ 1858, p. 48.

[43] ‘Lecture: Royal Institution of G. Britain,’ May 2nd, 1856, p. 4. ‘British Fossil Mammals,’ p. 513.

[44] Nilsson, in ‘Annals and Mag. of Nat. Hist.,’ 1849, vol. iv. p. 354.

[45] *See* W. R. Wilde, ut supra; and Mr. Blyth, in ‘Proc. Irish Academy,’ March 5th, 1864.

[46] Laing’s ‘Tour in Norway,’ p. 110.

[47] Isid. Geoffroy Saint-Hilaire, 'Hist. Nat. Gén.,' tom. iii. 96.

[48] Idem, tom. iii. pp. 82, 91.

[49] 'Quadrupèdes du Paraguay,' tom. ii. p. 360.

[50] Walther 'Das Rindvieh,' 1817, s. 30.

[51] I am much indebted to the present Earl of Tankerville for information about his wild cattle; and for the skull which was sent to Prof. Rütimeyer. The fullest account of the Chillingham cattle is given by Mr. Hindmarsh, together with a letter by the late Lord Tankerville, in 'Annals and Mag. of Nat. Hist.,' vol. ii., 1839, p. 274. *See* Bewick, 'Quadrupeds,' 2nd edit., 1791, p. 35, note. With respect to those of the Duke of Queensberry, *see* Pennant's 'Tour in Scotland,' p. 109. For those of Chartley, *see* Low's 'Domesticated Animals of Britain,' 1845, p. 238. For those of Gisburne, *see* Bewick 'Quadrupeds,' and 'Encyclop. of Rural Sports,' p. 101.

[52] Boethius was born in 1470; 'Annals and Mag. of Nat. Hist.,' vol. ii., 1839, p. 281; and vol. iv., 1849, p. 424.

[53] n'Youatt on Cattle,' 1834, p. 48: *See also* p. 242, on short-horn cattle. Bell, in his 'British Quadrupeds,' p. 423, states that, after long attending to the subject, he has found that white cattle invariably have coloured ears.ote

[54] Azara, 'Quadrupèdes du Paraguay,' tom. ii. p. 361. Azara quotes Buffon for the feral cattle of Africa. For Texas *see* 'Times,' Feb. 18th, 1846.

[55] Anson's Voyage. *See* Kerr and Porter's 'Collection,' vol. xii. p. 103.

[56] *See also* Mr. Mackinnon's pamphlet on the Falkland Islands, p. 24.

[57] 'The Age of the Ox, Sheep, Pig,' etc., by Prof. James Simonds, published by order of the Royal Agricult. Soc.

[58] 'Ann. Agricult. France,' April, 1837, as quoted in 'The Veterinary,' vol. xii. p. 725. I quote Tessier's observations from 'Youatt on Cattle,' p. 527.

[59] 'The Veterinary,' vol. viii. p. 681 and vol. x. p. 268. Low's 'Domest. Animals, etc.' p. 297.

[60] Mr. Ogleby in 'Proc. Zoolog. Soc.,' 1836, p. 138, and 1840, p. 4. Quatrefages quotes Philippi ('Revue des Cours Scientifiques,' Feb. 12, 1688, p. 657), that the cattle of Piacentino have thirteen dorsal vertebræ and ribs in the place of the ordinary number of twelve.

[61] Leguat's Voyage, quoted by Vasey in his 'Delineations of the Ox-tribe,' p. 132.

[62] 'Travels in South Africa,' pp. 317, 336.

[63] ‘Mem. de l’Institut présent. par divers Savans,’ tom. vi., 1835, p. 333. For Brazil, *see* ‘Comptes Rendus,’ June 15, 1846. *See* Azara ‘Quadrupèdes du Paraguay,’ tom. ii. pp. 359, 361.

[64] ‘Schweineschädel,’ 1864, s. 104. Nathusius states that the form of skull characteristic in the niata cattle occasionally appears in European cattle; but he is mistaken, as we shall hereafter see, in supposing that these cattle do not form a distinct race. Prof. Wyman, of Cambridge, United States, informs me that the common cod-fish presents a similar monstrosity, called by the fishermen “bull-dog cod.” Prof. Wyman also concluded, after making numerous inquiries in La Plata, that the niata cattle transmit their peculiarities or form a race.

[65] ‘Ueber Art des zahmen Europ. Rindes,’ 1866, s. 28.

[66] ‘Descriptive Cat. of Ost. Collect. of College of Surgeons,’ 1853, p. 624. Vasey in his ‘Delineations of the Ox-tribe’ has given a figure of this skull; and I sent a photograph of it to Prof. Rütimeyer.

[67] Loudon’s ‘Magazine of Nat. Hist.,’ vol. i. 1829, p. 113. Separate figures are given of the animal, its hoofs, eye, and dewlap.

[68] Low, ‘Domesticated Animals of the British Isles,’ p. 264.

[69] ‘Mém. de l’Institut présent. Par divers Savans,’ tom. vi., 1835, p. 332.

[70] Idem, pp. 304, 368, etc.

[71] ‘Youatt on Cattle,’ p. 193. A full account of this bull is taken from Marshall.

[72] ‘Youatt on Cattle,’ p. 116. Lord Spencer has written on this same subject.

[73] Blyth, on the genus Ovis, in ‘Annals and Mag. of Nat. History,’ vol. vii., 1841, p. 261. With respect to the parentage of the breeds *see* Mr. Blyth’s excellent articles in ‘Land and Water,’ 1867, pp. 134, 156. Gervais, ‘Hist. Nat. des Mammifères,’ 1855, tom. ii. p. 191.

[74] Dr. L. Fitzinger, ‘Ueber die Racen des Zahmen Schafes,’ 1860, s. 86.

[75] J. Anderson, ‘Recreations in Agriculture and Natural History,’ vol. ii. p. 264.

[76] ‘Pfahlbauten’ s. 127, 193.

[77] ‘Youatt on Sheep,’ p. 120.

[78] ‘Journal of the Asiatic Soc. of Bengal,’ vol.xvi. pp. 1007, 1016.

[79] ‘Youatt on Sheep,’ pp. 142-169.

[80] ‘Journal Asiat. Soc. of Bengal,’ vol. xvi., 1847, p. 1015.

[81] ‘Hist. Nat. Gén.,’ tom. iii. p. 435.

[82] ‘Youatt on Sheep,’ p. 138.

[83] ‘Journal Asiat. Soc. of Bengal,’ vol. xvi., 1847, pp. 1015, 1016.

[84] ‘Racen des Zahmen Schafes,’ s. 77.

[85] ‘Rural Economy of Norfolk,’ vol. ii. p. 136.

[86] ‘Youatt on Sheep,’ p. 312. On same subject, *see* excellent remarks in ‘Gardener’s Chronicle,’ 1858, p. 868. For experiments in crossing Cheviot sheep with Leicesters *see* Youatt, p. 325.

[87] ‘Youatt on Sheep,’ note, p. 491.

[88] M. Malingié-Nouel, ‘Journal R. Agricult. Soc.,’ vol. xiv. 1853, p. 214. Translated and therefore approved by a great authority, Mr. Pusey.

[89] ‘The Veterinary,’ vol. x. p. 217.

[90] A translation of his paper is given in ‘Bull. Soc. Imp. d’Acclimat.,’ tom. ix., 1862, p. 723.

[91] Erman’s ‘Travels in Siberia,’ (Eng. trans.) vol. i. p. 228. For Pallas on the fat-tailed sheep I quote from Anderson’s account of the ‘Sheep of Russia,’ 1794, p. 34. With respect to the Crimean sheep *see* Pallas’ ‘Travels’ (Eng. trans.) vol. ii. p. 454. For the Karakool sheep *see* Burnes’ ‘Travels in Bokhara,’ vol. iii. p. 151.

[92] *See* Report of the Directors of the Sierra Leone Company, as quoted in White’s ‘Gradation of Man,’ p. 95. With respect to the change which sheep undergo in the West Indies *see also* Dr. Davy, in ‘Edin. New. Phil. Journal,’ Jan. 1852. For the statement made by Roulin, *see* ‘Mém. de l’Institut présent. par divers Savans,’ tom. vi., 1835, p. 347.

[93] ‘Youatt on Sheep,’ p. 69, where Lord Somerville is quoted. *See* p. 117 on the presence of wool under the hair. With respect to the fleeces of Australian sheep, p. 185. On selection counteracting any tendency to change, *see* pp. 70, 117, 120, 168.

[94] Audubon and Bachman, ‘The Quadrupeds of North America,’ 1846, vol. v. p. 365.

[95] ‘Journal of R. Agricult. Soc. of England,’ vol. xx., part ii., W. C. Spooner on cross-Breeding.

[96] ‘Philosoph. Transactions,’ London, 1813, p. 88.

[97] Isidore Geoffroy St. Hilaire, 'Hist. Nat. Générale,' tom. iii. p. 87. Mr. Blyth, ('Land and Water,' 1867, p. 37) has arrived at a similar conclusion, but he thinks that certain Eastern races may perhaps be in part descended from the Asiatic markhor.

[98] Rütimeyer 'Pfahlbauten,' s. 127.

[99] Godron 'De l'Espèce,' tom. i. p. 402.

[100] 'Annals and Mag. of Nat. History,' vol ii. (2nd series), 1848, p. 363.

[101] 'De l'Espèce,' tom. i. p. 406. Mr. Clark also refers to differences in the shape of the mammæ. Godron states that in the Nubian race the scrotum is divided into two lobes; and Mr. Clark gives a ludicrous proof of this fact, for he saw in the Mauritius a male goat of the Muscat breed purchased at a high price for a female in full milk. These differences in the scrotum are probably not due to descent from distinct species: for Mr. Clark states that this part varies much in form.

[102] Mr. Clark, 'Annals and Mag. of Nat. Hist.,' vol. ii. (2nd series), 1848, p. 361.

[103] Desmarest, 'Encyclop. Méthod. Mammalogie,' p. 480.

[104] 'Journal of Asiatic Soc. of Bengal,' vol. xvi., 1847, pp. 1020, 1025.

CHAPTER IV.
DOMESTIC RABBITS.

DOMESTIC RABBITS DESCENDED FROM THE COMMON WILD RABBIT—ANCIENT DOMESTICATION—ANCIENT SELECTION—LARGE LOP-EARED RABBITS—VARIOUS BREEDS—FLUCTUATING CHARACTERS—ORIGIN OF THE HIMALAYAN BREED—CURIOUS CASE OF INHERITANCE—FERAL RABBITS IN JAMAICA AND THE FALKLAND ISLANDS—PORTO SANTO FERAL RABBITS—OSTEOLOGICAL CHARACTERS—SKULL—SKULL OF HALF-LOP RABBITS—VARIATIONS IN THE SKULL ANALOGOUS TO DIFFERENCES IN DIFFERENT SPECIES OF HARES—VERtebræ—STERNUM—SCAPULA—EFFECTS OF USE AND DISUSE ON THE PROPORTIONS OF THE LIMBS AND BODY—CAPACITY OF THE SKULL AND

REDUCED SIZE OF THE BRAIN—SUMMARY ON THE MODIFICATIONS OF DOMESTICATED RABBITS.

All naturalists, with, as far as I know, a single exception, believe that the several domestic breeds of the rabbit are descended from the common wild species; I shall therefore describe them more carefully than in the previous cases. Professor Gervais[1] states "that the true wild rabbit is smaller than the domestic; its proportions are not absolutely the same; its tail is smaller; its ears are shorter and more thickly clothed with hair; and these characters, without speaking of colour, are so many indications opposed to the opinion which unites these animals under the same specific denomination." Few naturalists will agree with this author that such slight differences are sufficient to separate as distinct species the wild and domestic rabbit. How extraordinary it would be, if close confinement, perfect tameness, unnatural food, and careful breeding, all prolonged during many generations, had not produced at least some effect! The tame rabbit has been domesticated from an ancient period. Confucius ranges rabbits among animals worthy to be sacrificed to the gods, and, as he prescribes their multiplication, they were probably at this early period domesticated in China. They are mentioned by several of the classical writers. In 1631 Gervaise Markham writes, "You shall not, as in other cattell, looke to their shape, but to their richnesse, onely elect your buckes, the largest and goodliest conies you can get; and for the richnesse of the skin, that is accounted the richest which hath the equallest mixture of blacke and white haire together, yet the blacke rather shadowing the white; the furre should be thicke, deepe, smooth, and shining; ... they are of body much fatter and larger, and, when another skin is worth two or three pence, they are worth two shillings." From this full description we see that silver-grey rabbits existed in England at this period; and what is far more important, we see that the breeding or selection of rabbits was then carefully attended to. Aldrovandi, in 1637, describes, on the authority of several old writers (as Scaliger, in 1557), rabbits of various colours, some "like a hare," and he adds that P. Valerianus (who died a very old man in 1558) saw at Verona rabbits four times bigger than ours.[2]

From the fact of the rabbit having been domesticated at an ancient period, we must look to the northern hemisphere of the Old World, and to the warmer temperate regions alone, for the aboriginal parent-form; for the rabbit cannot live without protection in countries as cold as Sweden, and, though it has run wild in the tropical island of Jamaica, it has never greatly multiplied there. It now exists, and has long existed, in the warmer temperate parts of Europe, for fossil remains have been found in several countries.[3] The domestic rabbit readily becomes feral in these same countries, and when variously coloured kinds are turned out they generally revert to the ordinary grey colour.[4] Wild rabbits, if taken young, can be domesticated, though the process is generally very troublesome.[5] The various domestic races are often crossed, and are believed to be quite fertile together, and a perfect gradation can be shown to exist from the largest domestic kinds, having enormously developed ears, to the common wild kind. The parent-form must have been a burrowing animal, a habit not common, as far as I can discover, to any other species in the large genus Lepus. Only one wild species is known with certainty to exist in Europe; but the rabbit (if it be a true rabbit) from Mount Sinai, and likewise that from Algeria, present slight differences; and these forms have been considered by some authors as specifically distinct.[6] But such slight differences would aid us little in explaining the more considerable differences characteristic of the several domestic races. If the latter are the descendants of two or more closely allied species, these, with the exception of the common rabbit, have been exterminated in a wild state; and this is very improbable, seeing with what pertinacity this animal holds its ground. From these several reasons we may infer with safety that all the domestic breeds are the descendants of the common wild species. But from what we hear of the marvellous success in France in rearing hybrids between the hare and rabbit,[7] it is possible, though not probable, from the great difficulty in making the first cross, that some of the larger races, which are coloured like the hare, may have been modified by crosses with this animal. Nevertheless, the chief differences in the skeletons of the several domestic breeds cannot, as we shall presently see, have been derived from a cross with the hare.

There are many breeds which transmit their characters more or less truly. Every one has seen the enormous lop-eared rabbits exhibited at our shows; various allied sub-breeds are reared on the Continent, such as the so-called Andalusian, which is said to have a large head with a round forehead, and to attain a greater size than any other kind; another large Paris breed is named the Rouennais, and has a square head; the so-called Patagonian rabbit has remarkably short ears and a large round head. Although I have not seen all these breeds, I feel some doubt about there being any marked difference in the shape of their skulls.[8] English lop-eared rabbits often weigh 8 pounds or 10 pounds, and one has been exhibited weighing 18 pounds; whereas a full-sized wild rabbit weighs only about 3-1/4 pounds. The head or skull in all the large lop-eared rabbits examined by me is much longer relatively to its breadth than in the wild rabbit. Many of them have loose transverse folds of skin or dewlaps beneath the throat, which can be pulled out so as to reach nearly to the ends of the jaws. Their ears are prodigiously developed, and hang down on each side of their faces. A rabbit was exhibited in 1867 with its two ears, measured from the tip of one to the tip of the other, 22 inches in length, and each ear 5-3/8 inches in breadth. In 1869 one was exhibited with ears, measured in the same manner, 23-1/8 in length and 5-1/2 in breadth; “thus exceeding any rabbit ever exhibited at a prize show.” In a common wild rabbit I found that the length of two ears, from tip to tip, was 7-5/8 inches, and the breadth only 1-7/8 inch. The weight of body in the larger rabbits, and the development of their ears, are the qualities which win prizes, and have been carefully selected.

The hare-coloured, or, as it is sometimes called, the Belgian rabbit, differs in nothing except colour from the other large breeds; but Mr. J. Young, of Southampton, a great breeder of this kind, informs me that the females, in all the specimens examined by him, had only six mammæ and this certainly was the case with two females which came into my possession. Mr. B. P. Brent, however, assures me that the number is variable with other domestic rabbits. The common wild rabbit always has ten mammæ. The Angora rabbit is remarkable from the length and fineness of its fur, which even on the soles of the feet is of considerable length. This breed is the only one which differs in its mental qualities, for it is said to be much more sociable than other rabbits, and the male shows no wish to destroy its young.[9] Two live rabbits were brought to me from Moscow, of about the size of the wild species, but with long soft fur, different from that of the Angora. These Moscow rabbits had pink eyes and were snow-white, excepting the ears, two spots near the nose, the upper and under surface of the tail, and the hinder tarsi, which were blackish-brown. In short, they were coloured nearly like the so-called Himalayan rabbits, presently to be described, and differed from them only in the character of their fur. There are two other breeds which come true to colour, but differ in no other respect, namely silver-greys and chinchillas. Lastly, the Nicard or Dutch rabbit may be mentioned, which varies in colour, and is remarkable from its small size, some specimens weighing only 1-1/4 pounds; rabbits of this breed make excellent nurses for other and more delicate kinds.[10]

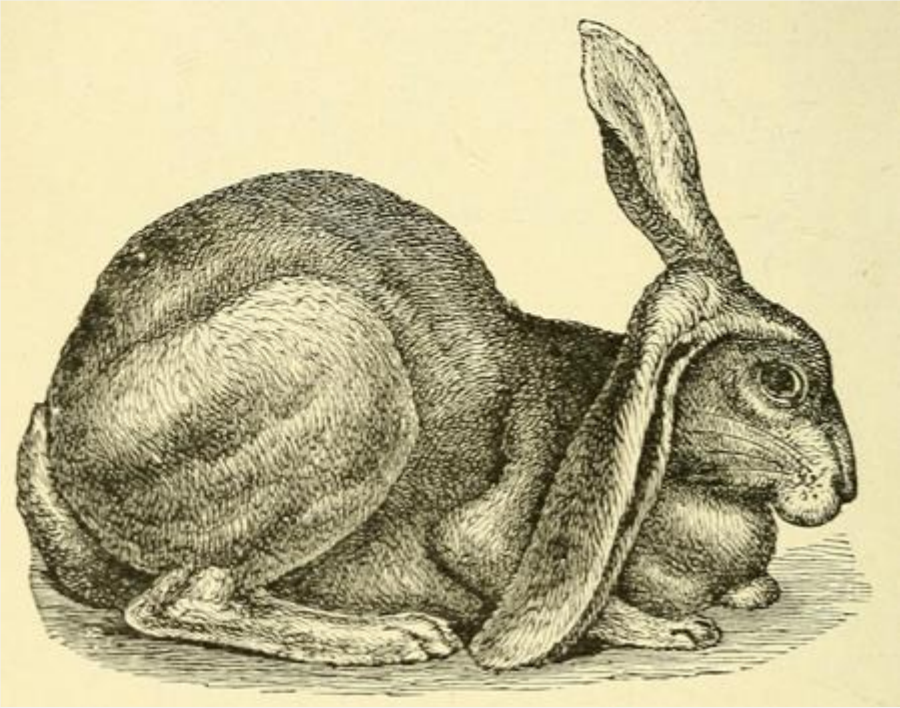


Fig. 5—Half-lop Rabbit.

Certain characters are remarkably fluctuating, or are very feebly transmitted by domestic rabbits: thus, one breeder tells me that with the smaller kinds he has hardly ever raised a whole litter of the same colour: with the large lop-eared breeds "it is impossible," says a great judge,[11] "to breed true to colour, but by judicious crossing a great deal may be done towards it. The fancier should know how his does are bred, that is, the colour of their parents." Nevertheless, certain colours, as we shall presently see, are transmitted truly. The dewlap is not strictly inherited. Lop-eared rabbits, with their ears hanging down flat on each side of the face, do not transmit this character at all truly. Mr. Delamer remarks that, "with fancy rabbits, when both the parents are perfectly formed, have model ears, and are handsomely marked, their progeny do not invariably turn out the same." When one parent, or even both, are oar-laps, that is, have their ears sticking out at right angles, or when one parent or both are half-lops, that is, have only one ear dependent, there is nearly as good a chance of the progeny having both ears full-lop, as if both parents had been thus characterised. But I am informed, if both parents have upright ears, there is hardly a chance of a full-lop. In some half-lops the ear that hangs down is broader and longer than the upright ear;[12] so that we have the unusual case of a want of symmetry on the two sides. This difference in the position and size of the two ears probably indicates that the lopping results from the great length and weight of the ear, favoured no doubt by the weakness of the muscles consequent on disuse. Anderson[13] mentions a breed having only a single ear; and Professor Gervais another breed destitute of ears.

We come now to the Himalayan breed, which is sometimes called Chinese, Polish, or Russian. These pretty rabbits are white, or occasionally yellow, excepting their ears, nose, feet, and the upper side of the tail, which are all brownish-black; but as they have red eyes, they may be considered as albinoes. I have received several accounts of their breeding perfectly true. From their symmetrical marks, they were at first ranked as specifically distinct, and were provisionally named *L. nigripes*.[14] Some good observers thought that they could detect a difference in their habits, and stoutly maintained that they formed a new species. The origin of this breed is so curious, both in itself and as throwing some light on the complex laws of inheritance that it is worth giving in detail. But it is first necessary briefly to describe two other breeds: silver-greys or silver-sprigs generally have black heads and legs, and their fine grey fur is interspersed with numerous black and white long hairs. They breed perfectly true, and have long been kept in warrens. When they escape and cross with common rabbits, the product, as I hear from Mr. Wyrley Birch, of Wretham Hall, is not a mixture of the two colours, but about half take after the one parent, and the other half after the other parent. Secondly, chinchillas or tame silver-greys (I will use the former name) have short, paler, mouse or slate-coloured fur, interspersed with long, blackish, slate-coloured, and white hairs.[15] These rabbits breed perfectly true. A writer stated in 1857[16] that he had produced Himalayan rabbits in the following manner. He had a breed of chinchillas which had been crossed with the common black rabbit, and their offspring were either blacks or chinchillas. These latter were again crossed with other chinchillas (which had also been crossed with silver-greys), and from this complicated cross Himalayan rabbits were raised. From these and other similar statements, Mr. Bartlett[17] was led to make a careful trial in the Zoological Gardens, and he found that by simply crossing silver-greys with chinchillas he could always produce some few Himalayans; and the latter, notwithstanding their sudden origin, if kept separate, bred perfectly true. But I have recently been assured the pure silver-greys of any sub-breed occasionally produce Himalayans.

The Himalayans, when first born, are quite white, and are then true albinoes; but in the course of a few months they gradually assume their dark ears, nose, feet, and tail. Occasionally, however, as I am informed by Mr. W. A. Wooler and the Rev. W. D. Fox, the young are born of a very pale grey colour, and specimens of such fur were sent me by the former gentleman. The grey tint, however, disappears as the animal comes to maturity. So that with these Himalayans there is a tendency, strictly confined to early youth, to revert to the colour of the adult silver-grey parent-stock. Silver-greys and chinchillas, on the other hand, present a remarkable contrast with the Himalayans in their colour whilst quite young, for they are born perfectly black, but soon assume their characteristic grey or silver tints. The same thing occurs with grey horses, which, as long as they are foals, are generally of a nearly black colour, but soon become grey, and get whiter and whiter as they grow older. Hence the usual rule is that Himalayans are born white and afterwards become in certain parts of their bodies dark-coloured; whilst silver-greys are born black and afterwards become sprinkled with white. Exceptions, however, and of a directly opposite nature, occasionally occur in both cases. For young silver-greys are sometimes born in warrens, as I hear from Mr. W. Birch, of a cream-colour, but these young animals ultimately become black. The Himalayans, on the other hand, sometimes produce, as is stated by an experienced amateur,[18] a single black young one in a litter; and this, before two months elapse, becomes perfectly white.

To sum up the whole curious case: wild silver-greys may be considered as black rabbits which become grey at an early period of life. When they are crossed with common rabbits, the offspring are said not to have blended colours, but to take after either parent; and in this respect they resemble black and albino varieties of most quadrupeds, which often transmit their colours in this same manner. When they are crossed with chinchillas, that is, with a paler sub-variety, the young are at first pure albinoes, but soon become dark-coloured in certain parts of their bodies, and are then called Himalayans. The young Himalayans, however, are sometimes at first either pale grey or completely black, in either case changing after a time to white. In a future chapter I shall advance a large body of facts showing that, when two varieties are crossed both of which differ in colour from their parent-stock, there is a strong tendency in the young to revert to the aboriginal colour; and what is very remarkable, this reversion occasionally supervenes, not before birth, but during the growth of the animal. Hence, if it could be shown that silver-greys and chinchillas were the offspring of a cross between a black and albino variety with the colours intimately blended—a supposition in itself not improbable, and supported by the circumstance of silver-greys in warrens sometimes producing creamy-white young, which ultimately become black—then all the above given paradoxical facts on the changes of colour in silver-greys and in their descendants the Himalayans would come under the law of reversion, supervening at different periods of growth and in different degrees, either to the original black or to the original albino parent-variety.

It is, also, remarkable that Himalayans, though produced so suddenly; breed true. But as, whilst young, they are albinoes, the case falls under a very general rule; albinism being well known to be strongly inherited, for instance with white mice and many other quadrupeds, and even white flowers. But why, it may be asked, do the ears, tail, nose, and feet, and no other part of the body, revert to a black colour? This apparently depends on a law, which generally holds good, namely, that characters common to many species of a genus—and this, in fact, implies long inheritance from the ancient progenitor of the genus—are found to resist variation, or to reappear if lost, more persistently than the characters which are confined to the separate species. Now, in the genus Lepus, a large majority of the species have their ears and the upper surface of the tail tinted black; but the persistence of these marks is best seen in those species which in winter become white: thus, in Scotland the *L. variabilis*[19] in its winter dress has a shade of colour on its nose, and the tips of its ears are black: in the *L. tibetanus* the ears are black, the upper surface of the tail greyish-black, and the soles of the feet brown: in *L. glacialis* the winter fur is pure white, except the soles of the feet and the points of the ears. Even in the variously-coloured fancy rabbits we may often observe a tendency in these same parts to be more darkly tinted than the rest of the body. Thus the several coloured marks on the Himalayan rabbits, as they grow old, are rendered intelligible. I may add a nearly analogous case: fancy rabbits very often have a white star on their foreheads; and the common English hare, whilst young, generally has, as I have myself observed, a similar white star on its forehead.

When variously coloured rabbits are set free in Europe, and are thus placed under their natural conditions, they generally revert to the aboriginal grey colour; this may be in part due to the tendency in all crossed animals, as lately observed, to revert to their primordial state. But this tendency does not always prevail; thus silver-grey rabbits are kept in warrens, and remain true though living almost in a state of nature; but a warren must not be stocked with both silver-greys and common rabbits; otherwise "in a few years there will be none but common greys surviving."[20] When rabbits run wild in foreign countries under new conditions of life, they by no means always revert to their aboriginal colour. In Jamaica the feral rabbits are described as having been "slate-coloured, deeply tinted with sprinklings of white on the neck, on the shoulders, and on the back; softening off to blue-white under the breast and belly."[21] But in this tropical island the conditions were not favourable to their increase, and they never spread widely, and are now extinct, as I hear from Mr. R. Hill, owing to a great fire which occurred in the woods. Rabbits during many years have run wild in the Falkland Islands; they are abundant in certain parts, but do not spread extensively. Most of them are of the common grey colour; a few, as I am informed by Admiral Sulivan, are hare-coloured, and many are black, often with nearly symmetrical white marks on their faces. Hence, M. Lesson described the black variety as a distinct species, under the name of *Lepus magellanicus*, but this, as I have elsewhere shown, is an error.[22] Within recent times the sealers have stocked some of the small outlying islets in the Falkland group with rabbits; and on Pebble Islet, as I hear from Admiral Sulivan, a large proportion are hare-coloured, whereas on Rabbit Islet a large proportion are of a bluish colour, which is not elsewhere seen. How the rabbits were coloured which were turned out of these islets is not known.

The rabbits which have become feral on the island of Porto Santo, near Madeira, deserve a fuller account. In 1418 or 1419, J. Gonzales Zarco[23] happened to have a female rabbit on board which had produced young during the voyage, and he turned them all out on the island. These animals soon increased so rapidly, that they became a nuisance, and actually caused the abandonment of the settlement. Thirty-seven years subsequently, Cada Mosto describes them as innumerable; nor is this surprising, as the island was not inhabited by any beast of prey or by any terrestrial mammal. We do not know the character of the mother-rabbit; but it was probably the common domesticated kind. The Spanish peninsula, whence Zarco sailed, is known to have abounded with the common wild species at the most remote historical period; and as these rabbits were taken on board for food, it is improbable that they should have been of any peculiar breed. That the breed was well domesticated is shown by the doe having littered during the voyage. Mr. Wollaston, at my request, brought home two of these feral rabbits in spirits of wine; and, subsequently, Mr. W. Haywood sent to me three more specimens in brine, and two alive. These seven specimens, though caught at different periods, closely resembled each other. They were full grown, as shown by the state of their bones. Although the conditions of life in Porto Santo are evidently highly favourable to rabbits, as proved by their extraordinarily rapid increase, yet they differ conspicuously in their small size from the wild English rabbit. Four English rabbits, measured from the incisors to the anus, varied between 17 and 17-3/4 inches in length; whilst two of the Porto Santo rabbits were only 14-1/2 and 15 inches in length. But the decrease in size is best shown by weight; four wild English rabbits averaged 3 pounds 5 ounces, whilst one of the Porto Santo rabbits, which had lived for four years in the Zoological Gardens, but had become thin, weighed only 1 pound 9 ounces. A fairer test is afforded by the comparison of the well-cleaned limb-bones of a Porto Santo rabbit killed on the island with the same bones of a wild English rabbit of average size, and they differed in the proportion of rather less than five to nine. So that the Porto Santo rabbits have decreased nearly three inches in length, and almost half in weight of body.[24] The head has not decreased in length proportionally with the body; and the capacity of the brain case is, as we shall hereafter see, singularly variable. I prepared four skulls, and these resembled each other more closely than do generally the skulls of wild English rabbits; but the only difference in structure which they presented was that the supra-orbital processes of the frontal bones were narrower.

In colour the Porto Santo rabbit differs considerably from the common rabbit; the upper surface is redder, and is rarely interspersed with any black or black-tipped hairs.

The throat and certain parts of the under surface, instead of being pure white, are generally pale grey or leaden colour. But the most remarkable difference is in the ears and tail; I have examined many fresh English rabbits, and the large collection of skins in the British Museum from various countries, and all have the upper surface of the tail and the tips of the ears clothed with blackish-grey fur; and this is given in most works as one of the specific characters of the rabbit. Now in the seven Porto Santo rabbits the upper surface of the tail was reddish-brown, and the tips of the ears had no trace of the black edging. But here we meet with a singular circumstance: in June, 1861 I examined two of these rabbits recently sent to the Zoological Gardens, and their tails and ears were coloured as just described; but when one of their dead bodies was sent to me in February, 1865, the ears were plainly edged, and the upper surface of the tail was covered with blackish-grey fur, and the whole body was much less red; so that under the English climate this individual rabbit had recovered the proper colour of its fur in rather less than four years!

The two little Porto Santo rabbits, whilst alive in the Zoological Gardens, had a remarkably different appearance from the common kind. They were extraordinarily wild and active, so that many persons exclaimed on seeing them that they were more like large rats than rabbits. They were nocturnal to an unusual degree in their habits, and their wildness was never in the least subdued; so that the superintendent, Mr. Bartlett, assured me that he had never had a wilder animal under his charge. This is a singular fact, considering that they are descended from a domesticated breed. I was so much surprised at it, that I requested Mr. Haywood to make inquiries on the spot, whether they were much hunted by the inhabitants, or persecuted by hawks, or cats, or other animals; but this is not the case, and no cause can be assigned for their wildness. They live both on the central, higher rocky land and near the sea-cliffs, and, from being exceedingly shy and timid, seldom appear in the lower and cultivated districts. They are said to produce from four to six young at a birth, and their breeding season is in July and August. Lastly, and this is a highly remarkable fact, Mr. Bartlett could never succeed in getting these two rabbits, which were both males, to associate or breed with the females of several breeds which were repeatedly placed with them.

If the history of these Porto Santo rabbits had not been known, most naturalists, on observing their much reduced size, their colour, reddish above and grey beneath, their tails and ears not tipped with black, would have ranked them as a distinct species. They would have been strongly confirmed in this view by seeing them alive in the Zoological Gardens, and hearing that they refused to couple with other rabbits. Yet this rabbit, which there can be little doubt would thus have been ranked as a distinct species, as certainly originated since the year 1420. Finally, from the three cases of the rabbits which have run wild in Porto Santo, Jamaica, and the Falkland Islands, we see that these animals do not, under new conditions of life, revert to or retain their aboriginal character, as is so generally asserted to be the case by most authors.

Osteological Characters.

When we remember, on the one hand, how frequently it is stated that important parts of the structure never vary; and, on the other hand, on what small differences in the skeleton fossil species have often been founded, the variability of the skull and of some other bones in the domesticated rabbit well deserves attention. It must not be supposed that the more important differences immediately to be described strictly characterise any one breed; all that can be said is, that they are generally present in certain breeds. We should bear in mind that selection has not been applied to fix any character in the skeleton, and that the animals have not had to support themselves under uniform habits of life. We cannot account for most of the differences in the skeleton; but we shall see that the increased size of the body, due to careful nurture and continued selection, has affected the head in a particular manner. Even the elongation and lopping of the ears have influenced in a small degree the form of the whole skull. The want of exercise has apparently modified the proportional length of the limbs in comparison with that of the body.

As a standard of comparison, I prepared skeletons of two wild rabbits from Kent, one from the Shetland Islands, and one from Antrim in Ireland. As all the bones in these four specimens from such distant localities closely resembled each other, presenting scarcely any appreciable difference, it may be concluded that the bones of the wild rabbit are generally uniform in character.

Skull.—I have carefully examined skulls of ten large lop-eared rabbits, and of five common domestic rabbits, which latter differ from the lop-eared only in not having such large bodies or ears, yet both larger than in the wild rabbit. First for the ten lop-eared rabbits: in all these the skull is remarkably elongated in comparison with its breadth. In a wild rabbit the length was 3·15 inches, in a large fancy rabbit 4·3; whilst the breadth of the cranium enclosing the brain was in both almost exactly the same. Even by taking as the standard of comparison the widest part of the zygomatic arch, the skulls of the lop-eared are proportionally to their breadth three-quarters of an inch too long. The depth of the head has increased almost in the same proportion with the length; it is the breadth alone which has not increased. The parietal and occipital bones enclosing the brain are less arched, both in a longitudinal and transverse line, than in the wild rabbit, so that the shape of the cranium is somewhat different. The surface is rougher, less cleanly sculptured, and the lines of sutures are more prominent.

Although the skulls of the large lop-eared rabbits in comparison with those of the wild rabbit are much elongated relatively to their breadth, yet, relatively to the size of body, they are far from elongated. The lop-eared rabbits which I examined were, though not fat, more than twice as heavy as the wild specimens; but the skull was very far from being twice as long. Even if we take the fairer standard of the length of body, from the nose to the anus, the skull is not on an average as long as it ought to be by a third of an inch. In the small feral Porto Santo rabbit, on the other hand, the head relatively to the length of body is about a quarter of an inch too long.

This elongation of the skull relatively to its breadth, I find a universal character, not only with the large lop-eared rabbits, but in all the artificial breeds; as is well seen in the skull of the Angora. I was at first much surprised at the fact, and could not imagine why domestication could produce this uniform result; but the explanation seems to lie in the circumstance that during a number of generations the artificial races have been closely confined, and have had little occasion to exert either their senses, or intellect, or voluntary muscles; consequently the brain, as we shall presently more fully see, has not increased relatively with the size of body. As the brain has not increased, the bony case enclosing it has not increased, and this has evidently affected through correlation the breadth of the entire skull from end to end.

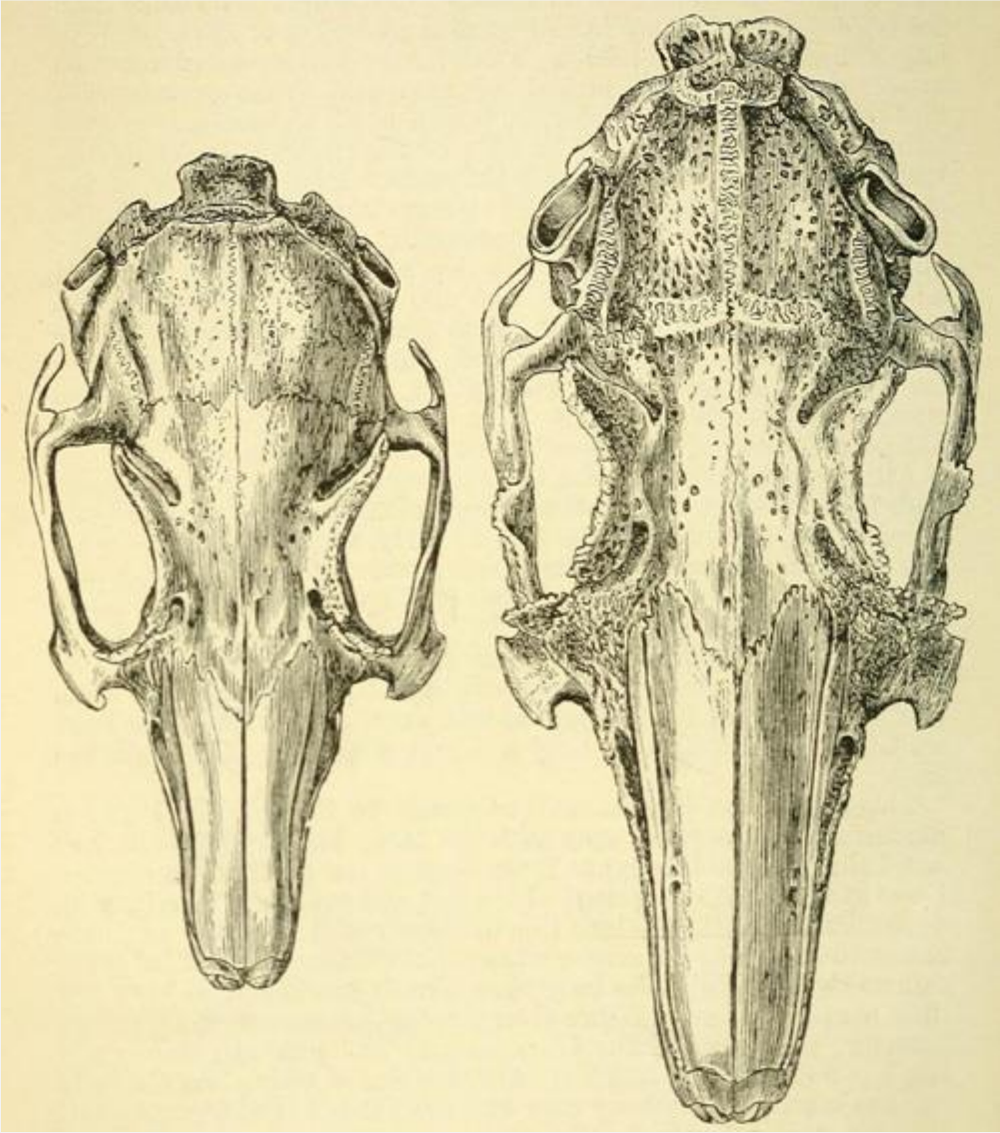


Fig. 6—Skull of Wild Rabbit. Fig. 7—Skull of large Lop-eared Rabbit.

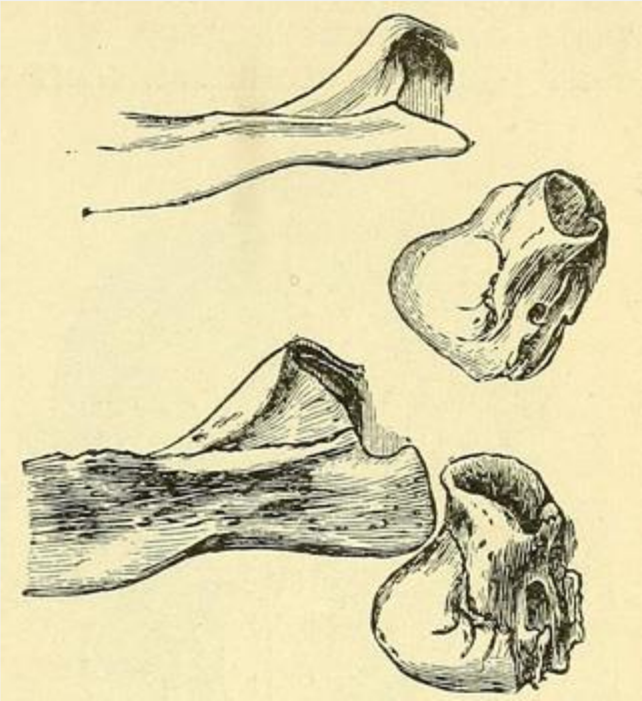


Fig. 8—Part of Zygomatic Arch.

In all the skulls of the large lop-eared rabbits, the supra-orbital plates or processes of the frontal bones are much broader than in the wild rabbit, and they generally project more upwards. In the zygomatic arch the posterior or projecting point of the malar-bone is broader and blunter; and in the specimen, fig. 8, it is so in a remarkable degree. This point approaches nearer to the auditory meatus than in the wild rabbit, as may be best seen in fig. 8; but this circumstance mainly depends on the changed direction of the meatus. The inter-parietal bone (see fig. 9) differs much in shape in the several skulls; generally it is more oval, that is more extended in the line of the longitudinal axis of the skull, than in the wild rabbit. The posterior margin of "the square raised platform"[25] of the occiput, instead of being truncated, or projecting slightly as in the wild rabbit, is in most lop-eared rabbits pointed, as in fig. 9, C. The paramastoids relatively to the size of the skull are generally much thicker than in the wild rabbit.

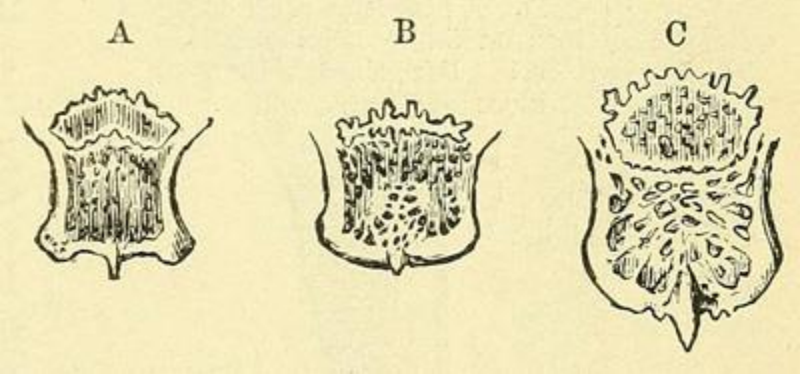


Fig. 9—Posterior end of skull of Rabbits.

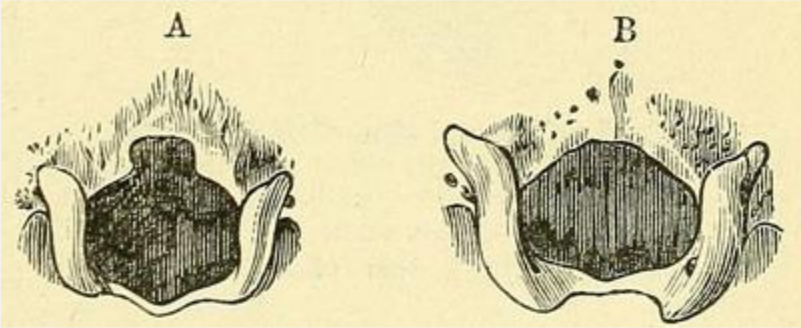


Fig. 10—Occipital Foramen of Rabbits.

The occipital foramen (fig. 10) presents some remarkable differences: in the wild rabbit, the lower edge between the condyles is considerably and almost angularly hollowed out, and the upper edge is deeply and squarely notched; hence the longitudinal axis exceeds the transverse axis. In the skulls of the lop-eared rabbits the transverse axis exceeds the longitudinal; for in none of these skulls was the lower edge between the condyles so deeply hollowed out; in five of them there was no upper square notch, in three there was a trace of the notch, and in two alone it was well developed. These differences in the shape of the foramen are remarkable, considering that it gives passage to so important a structure as the spinal marrow, though apparently the outline of the latter is not affected by the shape of the passage.

In all the skulls of the large lop-eared rabbits, the bony auditory meatus is conspicuously larger than in the wild rabbit. In a skull 4·3 inches in length, and which barely exceeded in breadth the skull of a wild rabbit (which was 3·15 inches in length), the longer diameter of the meatus was exactly twice as great. The orifice is more compressed, and its margin on the side nearest the skull stands up higher than the outer side. The whole meatus is directed more forwards. As in breeding lop-eared rabbits the length of the ears, and their consequent lopping and lying flat on the face, are the chief points of excellence, there can hardly be a doubt that the great change in the size, form, and direction of the bony meatus, relatively to this same part in the wild rabbit, is due to the continued selection of individuals having larger and larger ears. The influence of the external ear on the bony meatus is well shown in the skulls (I have examined three) of half-lops (see fig. 5), in which one ear stands upright, and the other and longer ear hangs down; for in these skulls there was a plain difference in the form and direction of the bony meatus on the two sides. But it is a much more interesting fact, that the changed direction and increased size of the bony meatus have slightly affected on the same side the structure of the whole skull. I here give a drawing (fig. 11) of the skull of a half-lop; and it may be observed that the suture between the parietal and frontal bones does not run strictly at right angles to the longitudinal axis of the skull; the left frontal bone projects beyond the right one; both the posterior and anterior margins of the left zygomatic arch on the side of the lopping ear stand a little in advance of the corresponding bones on the opposite side. Even the lower jaw is affected, and the condyles are not quite symmetrical, that on the left standing a little in advance of that on the right. This seems to me a remarkable case of correlation of growth. Who would have surmised that by keeping an animal during many generations under confinement, and so leading to the disuse of the muscles of the ears, and by continually selecting individuals with the longest and largest ears, he would thus indirectly have affected almost every suture in the skull and the form of the lower jaw!

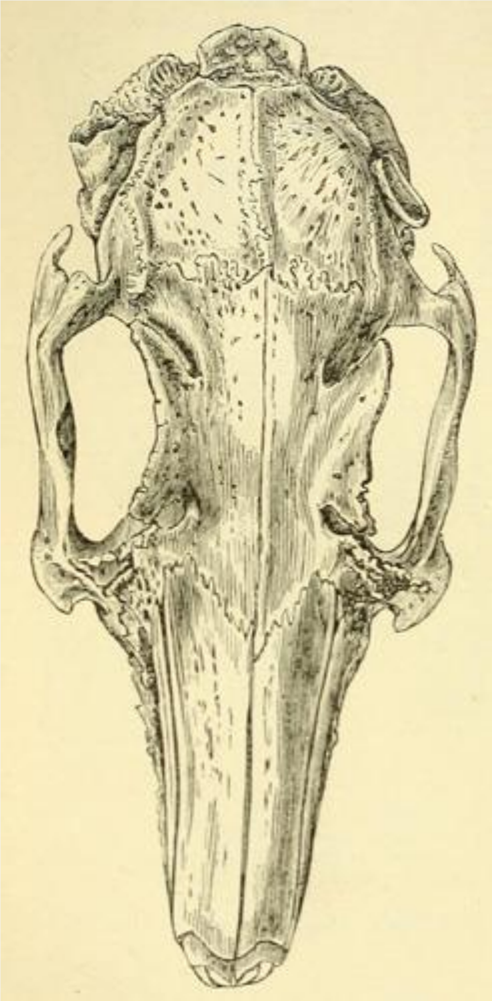


Fig. 11—Skull of Half-lop Rabbit.

In the large lop-eared rabbits the only difference in the lower jaw, in comparison with that of the wild rabbit, is that the posterior margin of the ascending ramus is broader and more inflected. The teeth in neither jaw present any difference, except that the small incisors, beneath the large ones, are proportionately a little longer. The molar teeth have increased in size proportionately with the increased width of the skull, measured across the zygomatic arch, and not proportionally with its increased length. The inner line of the sockets of the molar teeth in the upper jaw of the wild rabbit forms a perfectly straight line; but in some of the largest skulls of the lop-eared this line was plainly bowed inwards. In one specimen there was an additional molar tooth on each side of the upper jaw, between the molars and premolars; but these two teeth did not correspond in size; and as no rodent has seven molars, this is merely a monstrosity, though a curious one.

The five other skulls of common domestic rabbits, some of which approach in size the above-described largest skulls, whilst the others exceed but little those of the wild rabbit, are only worth notice as presenting a perfect gradation in all the above-specified differences between the skulls of the largest lop-eared and wild rabbits. In all, however, the supra-orbital plates are rather larger, and in all the auditory meatus is larger, in conformity with the increased size of the external ears, than in the wild rabbit. The lower notch in the occipital foramen in some was not so deep as in the wild rabbit, but in all five skulls the upper notch was well developed.

The skull of the *Angora* rabbit, like the latter five skulls, is intermediate in general proportions, and in most other characters, between those of the largest lop-eared and wild rabbits. It presents only one singular character: though considerably longer than the skull of the wild rabbit, the breadth measured within the posterior supra-orbital fissures is nearly a third less than in the wild. The skulls of the *silver-grey,* and *chinchilla* and *Himalayan* rabbits are more elongated than in the wild, with broader supra-orbital plates, but differ little in any other respect, excepting that the upper and lower notches of the occipital foramen are not so deep or so well developed. The skull of the *Moscow rabbit* scarcely differs at all from that of the wild rabbit. In the Porto Santo feral rabbits the supra-orbital plates are generally narrower and more pointed than in our wild rabbits.

As some of the largest lop-eared rabbits of which I prepared skeletons were coloured almost like hares, and as these latter animals and rabbits have, as it is affirmed, been recently crossed in France, it might be thought that some of the above-described characters had been derived from a cross at a remote period with the hare. Consequently I examined skulls of the hare, but no light could thus be thrown on the peculiarities of the skulls of the larger rabbits. It is, however, an interesting fact, as illustrating the law that varieties of one species often assume the characters of other species of the same genus, that I found, on comparing the skulls of ten species of hares in the British Museum, that they differed from each other chiefly in the very same points in which domestic rabbits vary,—namely, in general proportions, in the form and size of the supra-orbital plates, in the form of the free end of the malar bone, and in the line of suture separating the occipital and frontal bones. Moreover two eminently variable characters in the domestic rabbit, namely, the outline of the occipital foramen and the shape of the "raised platform" of the occiput, were likewise variable in two instances in the same species of hare.

Vertebræ.—The number is uniform in all the skeletons which I have examined, with two exceptions, namely, in one of the small feral Porto Santo rabbits and in one of the largest lop-eared kinds; both of these had as usual seven cervical, twelve dorsal with ribs, but, instead of seven lumbar, both had eight lumbar vertebræ. This is remarkable, as Gervais gives seven as the number for the whole genus Lepus. The caudal vertebræ apparently differ by two or three, but I did not attend to them, and they are difficult to count with certainty.

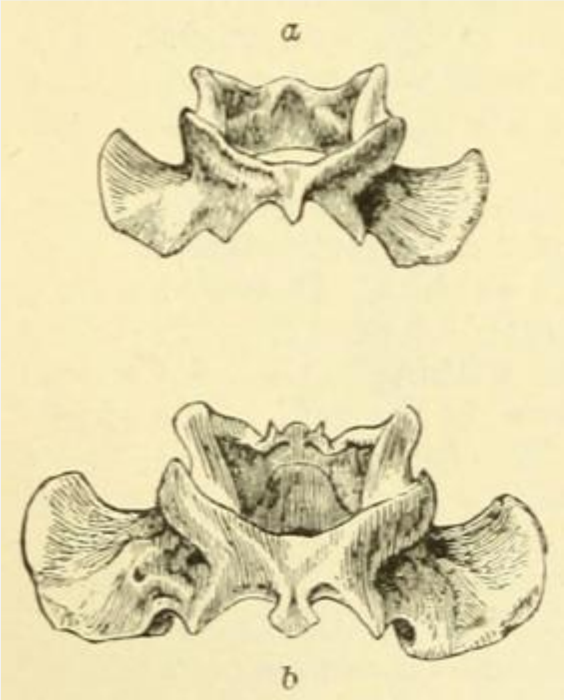


Fig. 12—Atlas Vertebræ of Rabbits.

In the first cervical vertebra, or atlas, the anterior margin of the neural arch varies a little in wild specimens, being either nearly smooth, or furnished with a small supra-median atlantoid process; I have figured a specimen with the largest process (*a*) which I have seen; but it will be observed how inferior this is in size and different in shape to that in a large lop-eared rabbit. In the latter, the infra-median process (*b*) is also proportionally much thicker and longer. The alæ are a little squarer in outline.

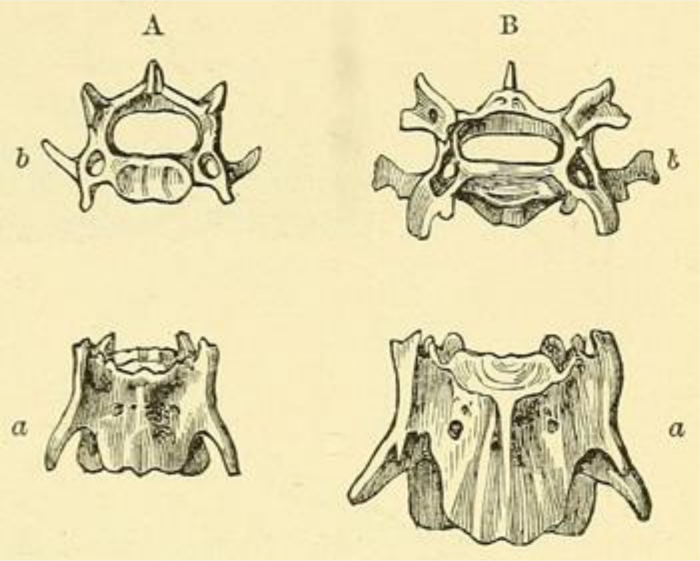


Fig. 13—Third Cervical Vertebræ, of natural size, of—A. Wild Rabbit; B. Hare-coloured, large, Lop-eared Rabbit.

Third cervical vertebra.—In the wild rabbit (fig. 13, A *a*) this vertebra, viewed on the inferior surface, has a transverse process, which is directed obliquely backwards, and consists of a single pointed bar; in the fourth vertebra this process is slightly forked in the middle. In the large lop-eared rabbits this process (B *a*) is forked in the third vertebra, as in the fourth of the wild rabbit. But the third cervical vertebræ of the wild and lop-eared (A *b*, B *b*) rabbits differ more conspicuously when their anterior articular surfaces are compared; for the extremities of the antero-dorsal processes in the wild rabbit are simply rounded, whilst in the lop-eared they are trifid, with a deep central pit. The canal for the spinal marrow in the lop-eared (B *b*) is more elongated in a transverse direction than in the wild rabbit; and the passages for the arteries are of a slightly different shape. These several differences in this vertebra seem to me well deserving attention.

First dorsal vertebra.—Its neural spine varies in length in the wild rabbit; being sometimes very short, but generally more than half as long as that of the second dorsal; but I have seen it in two large lop-eared rabbits three-fourths of the length of that of the second dorsal vertebra.

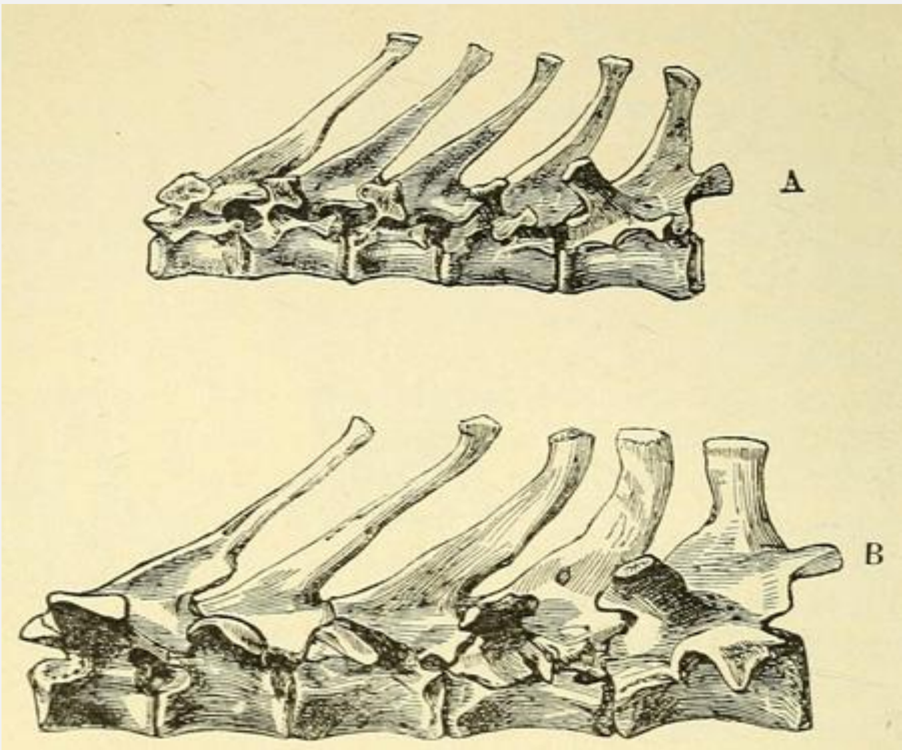


Fig. 14—Dorsal Vertebræ, from sixth to tenth inclusive, of natural size, viewed laterally. A. Wild Rabbit. B. Large, Hare-coloured, so-called Spanish Rabbit.

Ninth and tenth dorsal vertebræ.—In the wild rabbit the neural spine of the ninth vertebra is just perceptibly thicker than that of the eighth; and the neural spine of the tenth is plainly thicker and shorter than those of all the anterior vertebræ. In the large lop-eared rabbits the neural spines of the tenth, ninth, and eighth vertebræ, and even in a slight degree that of the seventh, are very much thicker, and of somewhat different shape, in comparison with those of the wild rabbit. So that this part of the vertebral column differs considerably in appearance from the same part in the wild rabbit, and closely resembles in an interesting manner these same vertebræ in some species of hares. In the Angora, Chinchilla, and Himalayan rabbits, the neural spines of the eighth and ninth vertebræ are in a slight degree thicker than in the wild. On the other hand, in one of the feral Porto Santo rabbits, which in most of its characters deviates from the common wild rabbit, in a direction exactly opposite to that assumed by the large lop-eared rabbits, the neural spines of the ninth and tenth vertebræ were not at all larger than those of the several anterior vertebra. In this same Porto Santo specimen there was no trace in the ninth vertebra of the anterior lateral processes (see fig. 14), which are plainly developed in all British wild rabbits, and still more plainly developed in the large lop-eared rabbits. In a half-wild rabbit from Sandon Park,[26] a haemal spine was moderately well developed on the under side of the twelfth dorsal vertebra, and I have seen this in no other specimen.

Lumbar vertebræ.—I have stated that in two cases there were eight instead of seven lumbar vertebræ. The third lumbar vertebræ in one skeleton of a wild British rabbit, and in one of the Porto Santo feral rabbits, had a haemal spine; whilst in four skeletons of large lop-eared rabbits, and in the Himalayan rabbit, this same vertebra had a well developed hæmal spine.

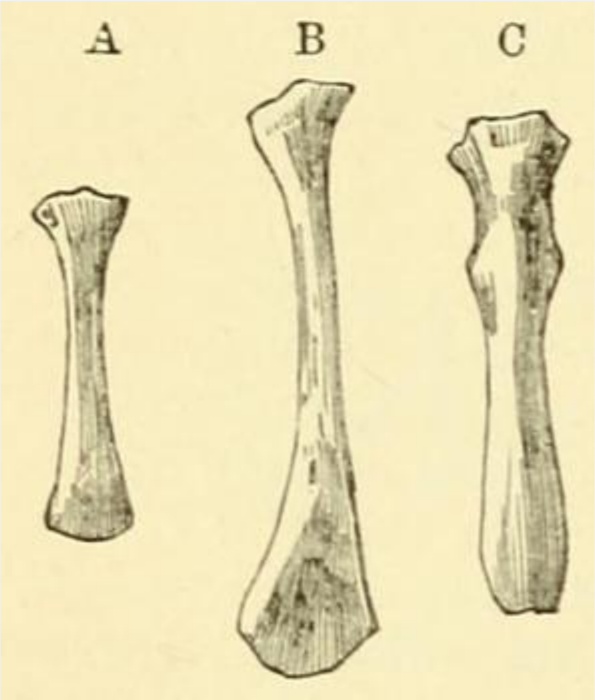


Fig. 15—Terminal bone of Sternum of Rabbits.

Pelvis.—In four wild specimens this bone was almost absolutely identical in shape; but in several domesticated breeds shades of differences could be distinguished. In the large lop-eared rabbits, the whole upper part of the ilium is straighter, or less splayed outwards, than in the wild rabbit; and the tuberosity on the inner lip of the anterior and upper part of the ilium is proportionally more prominent.

Sternum.—The posterior end of the posterior sternal bone in the wild rabbit (fig. 15, A) is thin and slightly enlarged; in some of the large lop-eared rabbits (B) it is much more enlarged towards the extremity; whilst in other specimens (C) it keeps nearly of the same breadth from end to end, but is much thicker at the extremity.

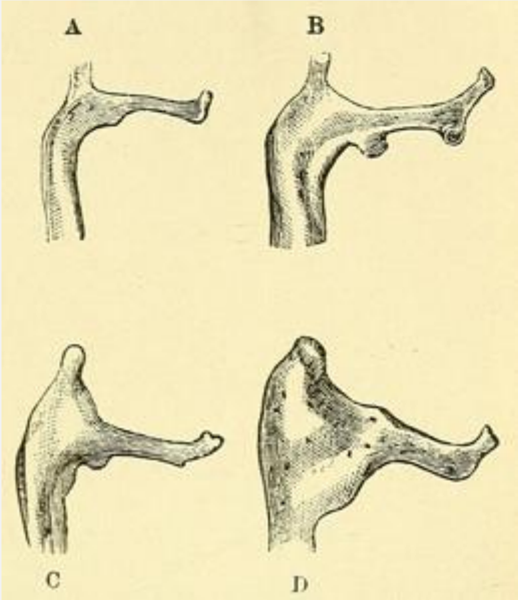


Fig. 16—Acromion of Scapula, of natural size. A. Wild Rabbit. B, C, D, Large, Lop-eared Rabbits.

Scapula.—The acromion sends out a rectangular bar, ending in an oblique knob, which latter in the wild rabbit (fig. 16, A) varies a little in shape and size, as does the apex of the acromion in sharpness, and the part just below the rectangular bar in breadth. But the variations in these respects in the wild rabbit are very slight: whilst in the large lop-eared rabbits they are considerable. Thus in some specimens (B) the oblique terminal knob is developed into a short bar, forming an obtuse angle with the rectangular bar. In another specimen (C) these two unequal bars form nearly a straight line. The apex of the acromion varies much in breadth and sharpness, as may be seen by comparing figures B, C, and D.

Limbs.—In these I could detect no variation; but the bones of the feet were too troublesome to compare with much care.

I have now described all the differences in the skeletons which I have observed. It is impossible not to be struck with the high degree of variability or plasticity of many of the bones. We see how erroneous the often-repeated statement is, that only the crests of the bones which give attachment to muscles vary in shape, and that only parts of slight importance become modified under domestication. No one will say, for instance, that the occipital foramen, or the atlas, or the third cervical vertebra is a part of slight importance. If the several vertebræ of the wild and lop-eared rabbits, of which figures have been given, had been found fossil, palæontologists would have declared without hesitation that they had belonged to distinct species.

The effects of the use and disuse of parts.—In the large lop-eared rabbits the relative proportional length of the bones of the same leg, and of the front and hind legs compared with each other, have remained nearly the same as in the wild rabbit; but in weight, the bones of the hind legs apparently have not increased in due proportion with the front legs. The weight of the whole body in the large rabbits examined by me was from twice to twice and a half as great as that of the wild rabbit; and the weight of the bones of the front and hind limbs taken together (excluding the feet, on account of the difficulty of cleaning so many small bones) has increased in the large lop-eared rabbits in nearly the same proportion; consequently in due proportion to the weight of body which they have to support. If we take the length of the body as the standard of comparison, the limbs of the large rabbits have not increased in length in due proportion by one inch and a half. Again, if we take as the standard of comparison the length of the skull, which, as we have before seen, has not increased in length in due proportion to the length of body, the limbs will be found to be, proportionally with those of the wild rabbit, from half to three-quarters of an inch too short. Hence, whatever standard of comparison be taken, the limb-bones of the large lop-eared rabbits have not increased in length, though they have in weight, in full proportion to the other parts of the frame; and this, I presume, may be accounted for by the inactive life which during many generations they have spent. Nor has the scapula increased in length in due proportion to the increased length of the body.

The capacity of the osseous case of the brain is a more interesting point, to which I was led to attend by finding, as previously stated, that with all domesticated rabbits the length of the skull relatively to its breadth has greatly increased in comparison with that of the wild rabbits. If we had possessed a large number of domesticated rabbits of nearly the same size with the wild rabbits, it would have been a simple task to have measured and compared the capacities of their skulls. But this is not the case: almost all the domestic breeds have larger bodies than wild rabbits, and the lop-eared kinds are more than double their weight. As a small animal has to exert its senses, intellect, and instincts equally with a large animal, we ought not by any means to expect an animal twice or thrice as large as another to have a brain of double or treble the size.[27] Now, after weighing the bodies of four wild rabbits, and of four large but not fattened lop-eared rabbits, I find that on an average the wild are to the lop-eared in weight as 1 to 2·17; in average length of body as 1 to 1·41; whilst in capacity of skull they are as 1 to 1·15. Hence we see that the capacity of the skull, and consequently the size of the brain, has increased but little, relatively to the increased size of the body; and this fact explains the narrowness of the skull relatively to its length in all domestic rabbits.

	I	II	III	IV
Name of Breed WILD AND SEMI-WILD RABBITS.	Length of Skull.	Length of Body from Incisors to Anus.	Weight of whole Body.	Capacity of Skull measured by Small Shot.

		inches	inches	lbs ozs	grains
1	Wild Rabbit, Kent	3·15	17·4	3 5	972
2	Wild Rabbit, Shetland Islands	3·15	—	—	979
3	Wild Rabbit, Ireland	3·15	—	—	992
4	Domestic rabbit, run wild, Sandon	3·15	18·5	—	997
5	Wild, common variety, small specimen, Kent	2·96	17·0	2 14	875
6	Wild, fawn-coloured variety, Scotland	3·10	—	—	918
7	Silver-grey, small specimen, Thetford warren	2·95	15·5	2 11	938
8	Feral rabbit, Porto Santo	2·83	—	—	893
9	Feral rabbit, Porto Santo	2·85	—	—	756
10	Feral Rabbit, Porto Santo	2·95	—	—	835
	Average of the three Porto Santo rabbits	2·88	—	—	828

DOMESTIC RABBITS.

11	Himalayan	3·50	20·5	—	963
12	Moscow	3·25	17·0	3 8	803
13	Angora	3·50	19·5	3 1	697
14	Chinchilla	3·65	22·0	—	995
15	Large lop-eared	4·10	24·5	7 0	1065
16	Large lop-eared	4·10	25·0	7 13	1153
17	Large lop-eared	4·07	—	—	1037

18	Large lop-eared	4·10	25·0	7 4	1208
19	Large lop-eared	4·30	—	—	1232
20	Large lop-eared	4·25	—	—	1124
21	Large hare-coloured	3·86	24·0	6 14	1131
22	Average of above seven large lop-eared rabbits	4·11	24·62	7 4	1136
23	Hare (*L. timidus*) English specimen	3·61	—	7 0	1315
24	Hare (*L. timidus*) German specimen	3·82	—	7 0	1415

	Name of Breed	V	VI	VII
	WILD AND SEMI-WILD RABBITS.	Capacity calculated according to Length of Skull relatively to that of No. 1.	Difference between actual and calculated capacities of Skulls.	Showing how much per cent. the Brain, by calculation according to the length of the Skull is too light or too heavy, relatively to the Brain of the Wild Rabbit No. 1.
		grains	grains	
1	Wild Rabbit, Kent	—	—	
2	Wild Rabbit, Shetland Islands	—	—	2 per cent. too heavy in comparison with No. 1
3	Wild Rabbit, Ireland	—	—	
4	Domestic rabbit, run wild, Sandon			
5	Wild, common variety, small specimen, Kent	913	38	4 per cent. too light.
6	Wild, fawn-coloured variety, Scotland	950	32	3 per cent. too light.

7	Silver-grey, small specimen, Thetford warren	910	28	3 per cent. too heavy.
8	Feral rabbit, Porto Santo	873	20	2 per cent. too heavy.
9	Feral rabbit, Porto Santo	879	123	16 per cent. too light.
10	Feral Rabbit, Porto Santo	910	75	9 per cent. too light.
	Average of the three Porto Santo rabbits	888	60	7 per cent. too light.
	DOMESTIC RABBITS.			
11	Himalayan	1080	117	12 per cent. too light.
12	Moscow	1002	199	24 per cent. too light.
13	Angora	1080	383	54 per cent. too light.
14	Chinchilla	1126	131	13 per cent. too light.
15	Large lop-eared	1265	200	18 per cent. too light.
16	Large lop-eared	1265	112	9 per cent. too light.
17	Large lop-eared	1255	218	21 per cent. too light.
18	Large lop-eared	1265	57	4 per cent. too light.
19	Large lop-eared	1326	94	7 per cent. too light.
20	Large lop-eared	1311	187	16 per cent. too light.
21	Large hare-coloured	1191	60	5 per cent. too light.
22	Average of above seven large lop-eared rabbits	1268	132	11 per cent. too light.

In the upper half of Table 3 I have given the measurements of the skull of ten wild rabbits; and in the lower half, of eleven thoroughly domesticated kinds. As these rabbits differ so greatly in size, it is necessary to have some standard by which to compare the capacities of their skulls. I have selected the length of skull as the best standard, for in the larger rabbits it has not, as already stated, increased in length so much as the body; but as the skull, like every other part, varies in length, neither it nor any other part affords a perfect standard.

In the first column of figures the extreme length of the skull is given in inches and decimals. I am aware that these measurements pretend to greater accuracy than is possible; but I have found it the least trouble to record the exact length which the compass gave. The second and third columns give the length and weight of body, whenever these observations were made. The fourth column gives the capacity of the skull by the weight of small shot with which the skulls were filled; but it is not pretended that these weights are accurate within a few grains. In the fifth column the capacity is given which the skull ought to have had by calculation, according to the length of skull, in comparison with that of the wild rabbit No. 1; in the sixth column the difference between the actual and calculated capacities, and in the seventh the percentage of increase or decrease, are given. For instance, as the wild rabbit No. 5 has a shorter and lighter body than the wild rabbit No. 1, we might have expected that its skull would have had less capacity; the actual capacity, as expressed by the weight of shot, is 875 grains, which is 97 grains less than that of the first rabbit. But comparing these two rabbits by the length of their skulls, we see that in No. 1 the skull is 3·15 inches in length, and in No. 5 2·96 inches in length; according to this ratio, the brain of No. 5 ought to have had a capacity of 913 grains of shot, which is above the actual capacity, but only by 38 grains. Or, to put the case in another way (as in column vii), the brain of this small rabbit, No. 5, for every 100 grains of weight is only 4 grains too light,—that is, it ought, according to the standard rabbit No. 1, to have been 4 per cent heavier. I have taken the rabbit No. 1 as the standard of comparison because, of the skulls having a full average length, this has the least capacity; so that it is the least favourable to the result which I wish to show, namely, that the brain in all long-domesticated rabbits has decreased in size, either actually, or relatively to the length of the head and body, in comparison with the brain of the wild rabbit. Had I taken the Irish rabbit, No. 3, as the standard, the following results would have been somewhat more striking.

Turning to Table 3: the first four wild rabbits have skulls of the same length, and these differ but little in capacity. The Sandon rabbit (No. 4) is interesting, as, though now wild, it is known to be descended from a domesticated breed, as is still shown by its peculiar colouring and longer body; nevertheless the skull has recovered its normal length and full capacity. The next three rabbits are wild, but of small size, and they all have skulls with slightly lessened capacities. The three Porto Santo feral rabbits (Nos. 8 to 10) offer a perplexing case; their bodies are greatly reduced in size, as in a lesser degree are their skulls in length and in actual capacity, in comparison with the skulls of wild English rabbits. But when we compare the capacities of the skull in the three Porto Santo rabbits, we observe a surprising difference, which does not stand in any relation to the slight difference in the length of their skulls, nor, as I believe, to any difference in the size of their bodies; but I neglected weighing separately their bodies. I can hardly suppose that the medullary matter of the brain in these three rabbits, living under similar conditions, can differ as much as is indicated by the proportional difference of capacity in their skulls; nor do I know whether it is possible that one brain may contain considerably more fluid than another. Hence I can throw no light on this case.

Looking to the lower half of Table 3, which gives the measurements of domesticated rabbits, we see that in all the capacity of the skull is less, but in very various degrees, than might have been anticipated according to the length of their skulls, relatively to that of the wild rabbit No. 1. In line 22 the average measurements of seven large lop-eared rabbits are given. Now the question arises, has the average capacity of the skull in these seven large rabbits increased as much as might have been expected from the greatly increased size of body. We may endeavour to answer this question in two ways: in the upper half of the Table we have measurements of the skulls of six small wild rabbits (Nos. 5 to 10), and we find that on an average the skulls are ·18 of an inch shorter, and in capacity 91 grains less, than the average length and capacity of the three first wild rabbits on the list. The seven large lop-eared rabbits, on an average, have skulls 4·11 inches in length, and 1136 grains in capacity; so that these skulls have increased in length more than five times as much as the skulls of the six small wild rabbits have decreased in length; hence we might have expected that the skulls of the large lop-eared rabbits would have increased in capacity five times as much as the skulls of the six small rabbits have decreased in capacity; and this would have given an average increased capacity of 455 grains, whilst the real average increase is only 155 grains. Again, the large lop-eared rabbits have bodies of nearly the same weight and size as the common hare, but their heads are longer; consequently, if the lop-eared rabbits had been wild, it might have been expected that their skulls would have had nearly the same capacity as that of the skull of the hare. But this is far from being the case; for the average capacity of the two hare-skulls (Nos. 23, 24) is so much larger than the average capacity of the seven lop-eared skulls, that the latter would have to be increased 21 per cent to come up to the standard of the hare.[28]

I have previously remarked that, if we had possessed many domestic rabbits of the same average size with the wild rabbit, it would have been easy to compare the capacity of their skulls. Now the Himalayan, Moscow, and Angora rabbits (Nos. 11, 12, 13 of Table 3) are only a little larger in body and have skulls only a little longer, than the wild animal, and we see that the actual capacity of their skulls is less than in the wild animal, and considerably less by calculation (column 7), according to the difference in the length of their skulls. The narrowness of the brain-case in these three rabbits could be plainly seen and proved by external measurement. The Chinchilla rabbit (No. 14) is a considerably larger animal than the wild rabbit, yet the capacity of its skull only slightly exceeds that of the wild rabbit. The Angora rabbit, No. 13, offers the most remarkable case; this animal in its pure white colour and length of silky fur bears the stamp of long domesticity. It has a considerably longer head and body than the wild rabbit, but the actual capacity of its skull is less than that of even the little wild Porto Santo rabbits. By the standard of the length of skull the capacity (see column 7) is only half of what it ought to have been! I kept this individual animal alive, and it was not unhealthy nor idiotic. This case of the Angora rabbit so much surprised me, that I repeated all the measurements and found them correct. I have also compared the capacity of the skull of the Angora with that of the wild rabbit by other standards, namely, by the length and weight of the body, and by the weight of the limb-bones; but by all these standards the brain appears to be much too small, though in a less degree when the standard of the limb-bones was used; and this latter circumstance may probably be accounted for by the limbs of this anciently domesticated breed having become much reduced in weight, from its long-continued inactive life. Hence I infer that in the Angora breed, which is said to differ from other breeds in being quieter and more social, the capacity of the skull has really undergone a remarkable amount of reduction.

From the several facts above given,—namely, firstly, that the actual capacity of the skull in the Himalayan, Moscow, and Angora breeds, is less than in the wild rabbit, though they are in all their dimensions rather larger animals; secondly, that the capacity of the skull of the large lop-eared rabbits has not been increased in nearly the same ratio as the capacity of the skull of the smaller wild rabbits has been decreased; and thirdly, that the capacity of the skull in these same large lop-eared rabbits is very inferior to that of the hare, an animal of nearly the same size,—I conclude, notwithstanding the remarkable differences in capacity in the skulls of the small Porto Santo rabbits, and likewise in the large lop-eared kinds, that in all long-domesticated rabbits the brain has either by no means increased in due proportion with the increased length of the head and increased size of the body, or that it has actually decreased in size, relatively to what would have occurred had these animals lived in a state of nature. When we remember that rabbits, from having been domesticated and closely confined during many generations, cannot have exerted their intellect, instincts, senses, and voluntary movements, either in escaping from various dangers or in searching for food, we may conclude that their brains will have been feebly exercised, and consequently have suffered in development. We thus see that the most important and complicated organ in the whole organisation is subject to the law of decrease in size from disuse.

Finally, let us sum up the more important modifications which domestic rabbits have undergone, together with their causes as far as we can obscurely see them. By the supply of abundant and nutritious food, together with little exercise, and by the continued selection of the heaviest individuals, the weight of the larger breeds has been more than doubled. The bones of the limbs taken together have increased in weight, in due proportion with the increased weight of body, but the hind legs have increased less than the front legs; but in length they have not increased in due proportion, and this may have been caused by the want of proper exercise. With the increased size of the body the third cervical has assumed characters proper to the fourth cervical vertebra; and the eighth and ninth dorsal vertebræ have similarly assumed characters proper to the tenth and posterior vertebræ. The skull in the larger breeds has increased in length, but not in due proportion with the increased length of body; the brain has not duly increased in dimensions, or has even actually decreased, and consequently the bony case for the brain has remained narrow, and by correlation has affected the bones of the face and the entire length of the skull. The skull has thus acquired its characteristic narrowness. From unknown causes the supra-orbital process of the frontal bones and the free end of the malar bones have increased in breadth; and in the larger breeds the occipital foramen is generally much less deeply notched than in wild rabbits. Certain parts of the scapula and the terminal sternal bones have become highly variable in shape. The ears have been increased enormously in length and breadth through continued selection; their weight, conjoined probably with the disuse of their muscles, has caused them to lop downwards; and this has affected the position and form of the bony auditory meatus; and this again, by correlation, the position in a slight degree of almost every bone in the upper part of the skull, and even the position of the condyles of the lower jaw.

REFERENCES

[1] M. P. Gervais, 'Hist. Nat. des Mammifères,' 1854, tom. i., p. 288.

[2] U. Aldrovandi 'De Quadrupedibus digitatis,' 1637, p. 383. For Confucius and G. Markham *see* a writer who has studied the subject in 'Cottage Gardener,' Jan. 22, 1861, p. 250.

[3] Owen, 'British Fossil Mammals,' p. 212.

[4] Bechstein, 'Naturgesch. Deutschlands,' 1801, B. i. p. 1133. I have received similar accounts with respect to England and Scotland.

[5] 'Pigeons and Rabbits,' by E. S. Delamer, 1854, p. 133. Sir J. Sebright ('Observations on Instinct,' 1836, p. 10.) speaks most strongly on the difficulty. But this difficulty is not invariable, as I have received two accounts of perfect success in taming and breeding from the wild rabbit. *See also* Dr. P. Broca in 'Journal de la Physiologie,' tom. ii. p. 368.

[6] Gervais, 'Hist. Nat. des Mammifères,' tom. i. p. 292.

[7] *See* Dr. P. Broca's interesting memoir on this subject in Brown-Séquard's 'Journ. de. Phys.,' vol. ii. p. 367.

[8] The skulls of these breeds are briefly described in the 'Journal of Horticulture,' May 7, 1861, p. 108.

[9] 'Journal of Horticulture,' 1861, p. 380.

[10] 'Journal of Horticulture,' May 28, 1861, p. 169.

[11] 'Journal of Horticulture,' 1861, p. 327. With respect to the ears *see* Delamer on 'Pigeons and Rabbits,' 1854, p. 141; also 'Poultry Chronicle,' vol. ii. p. 499, and ditto for 1854, p. 586.

[12] Delamer, 'Pigeons and Rabbits,' p. 136. *See also* 'Journal of Horticulture,' 1861, p. 375.

[13] ‘An Account of the different Kinds of Sheep in the Russian Dominions,’ 1794, p. 39.

[14] ‘Proc. Zoolog. Soc.,’ June 23, 1857, p. 159.

[15] ‘Journal of Horticulture,’ April 9, 1861, p. 35.

[16] ‘Cottage Gardener,’ 1857, p. 141.

[17] Mr. Bartlett, in ‘Proc. Zoolog Soc.,’ 1861, p. 40.

[18] ‘Phenomenon in Himalayan Rabbits,’ in ‘Journal of Horticulture,’ Jan. 27, 1865, p. 102.

[19] G. R. Waterhouse, ‘Natural History of Mammalia: Rodents,’ 1846, pp. 52, 60, 105.

[20] Delamer on ‘Pigeons and Rabbits,’ p. 114.

[21] Gosse’s ‘Sojourn in Jamaica,’ 1851, p. 441, as described by an excellent observer, Mr. R. Hill. This is the only known case in which rabbits have become feral in a hot country. They can be kept, however, at Loanda (*see* Livingstone’s ‘Travels,’ p. 407). In parts of India, as I am informed by Mr. Blyth, they breed well.

[22] Darwin’s ‘Journal of Researches,’ p. 193; and ‘Zoology of the Voyage of the Beagle: Mammalia,’ p. 92.

[23] Kerr’s ‘Collection of Voyages,’ vol. ii. p. 177: p. 205 for Cada Mosto. According to a work published in Lisbon in 1717 entitled ‘Historia Insulana,’ written by a Jesuit, the rabbits were turned out in 1420. Some authors believe that the island was discovered in 1413.

[24] Something of the same kind has occurred on the island of Lipari, where, according to Spallanzani (‘Voyage dans les deux Siciles,’ quoted by Godron, ‘De l’Espèce,’ p. 364), a countryman turned out some rabbits which multiplied prodigiously, but, says Spallanzani, “les lapins de l’ile de Lipari sont plus petits que ceux qu’on élève en domesticité.”

[25] Waterhouse, ‘Nat. Hist. Mammalia,’ vol. ii. p. 36.

[26] These rabbits have run wild for a considerable time in Sandon Park, and in other places in Staffordshire and Shropshire. They originated, as I have been informed by the gamekeeper, from variously-coloured domestic rabbits which had been turned out. They vary in colour; but many are symmetrically coloured, being white with a streak along the spine, and with the ears and certain marks about the head of a blackish-grey tint. They have rather longer bodies than common rabbits.

[27] *See* Prof. Owen’s remarks on this subject in his paper on the ‘Zoological Significance of the Brain, etc., of Man, etc.,’ read before Brit.

Association 1862: with respect to Birds, *see* ‘Proc. Zoolog. Soc.,’ Jan. 11, 1848, p. 8.

[28] This standard is apparently considerably too low, for Dr. Crisp (‘Proc. Zoolog. Soc.,’ 1861, p. 86) gives 210 grains as the actual weight of the brain of a hare which weighed 7 pounds, and 125 grains as the weight of the brain of a rabbit which weighed 3 pounds 5 ounces, that is, the same weight as the rabbit No. 1 in my list. Now the contents of the skull of rabbit No. 1 in shot is in my table 972 grains; and according to Dr. Crisp’s ratio of 125 to 210, the skull of the hare ought to have contained 1632 grains of shot, instead of only (in the largest hare in my table) 1455 grains.

CHAPTER V.
DOMESTIC PIGEONS.

ENUMERATION AND DESCRIPTION OF THE SEVERAL BREEDS—INDIVIDUAL VARIABILITY—VARIATIONS OF A REMARKABLE NATURE—OSTEOLOGICAL CHARACTERS: SKULL, LOWER JAW, NUMBER OF vertebræ—CORRELATION OF GROWTH: TONGUE WITH BEAK; EYELIDS AND NOSTRILS WITH WATTLED SKIN—NUMBER OF WING-FEATHERS, AND LENGTH OF WING—COLOUR AND DOWN—WEBBED AND FEATHERED FEET—ON THE EFFECTS OF DISUSE—LENGTH OF FEET IN CORRELATION WITH LENGTH OF BEAK—LENGTH OF STERNUM, SCAPULA, AND FURCULUM—LENGTH OF WINGS—SUMMARY ON THE POINTS OF DIFFERENCE IN THE SEVERAL BREEDS.

I have been led to study domestic pigeons with particular care, because the evidence that all the domestic races are descended from one known source is far clearer than with any other anciently domesticated animal. Secondly, because many treatises in several languages, some of them old, have been written on the pigeon, so that we are enabled to trace the history of several breeds. And lastly, because, from causes which we can partly understand, the amount of variation has been extraordinarily great. The details will often be tediously minute; but no one who really wants to understand the progress of change in domestic animals, and especially no one who has kept pigeons and has marked the great difference between the breeds and the trueness with which most of them propagate their kind, will doubt that this minuteness is worth while. Notwithstanding the clear evidence that all the breeds are the descendants of a single species, I could not persuade myself until some years had passed that the whole amount of difference between them, had arisen since man first domesticated the wild rock-pigeon.

I have kept alive all the most distinct breeds, which I could procure in England or from the Continent; and have prepared skeletons of all. I have received skins from Persia, and a large number from India and other quarters of the world.[1] Since my admission into two of the London pigeon-clubs, I have received the kindest assistance from many of the most eminent amateurs.[2]

The races of the Pigeon which can be distinguished, and which breed true, are very numerous. MM. Boitard and Corbié[3] describe in detail 122 kinds; and I could add several European kinds not known to them. In India, judging from the skins sent me, there are many breeds unknown here; and Sir W. Elliot informs me that a collection imported by an Indian merchant into Madras from Cairo and Constantinople included several kinds unknown in India. I have no doubt that there exist considerably above 150 kinds which breed true and have been separately named. But of these the far greater number differ from each other only in unimportant characters. Such differences will be here entirely passed over, and I shall confine myself to the more important points of structure. That many important differences exist we shall presently see. I have looked through the magnificent collection of the Columbidæ in the British Museum, and, with the exception of a few forms (such as the Didunculus, Calænas, Goura, etc.), I do not hesitate to affirm that some domestic races of the rock-pigeon differ fully as much from each other in external characters as do the most distinct natural genera. We may look in vain through the 288 known species[4] for a beak so small and conical as that of the short-faced tumbler; for one so broad and short as that of the barb; for one so long, straight, and narrow, with its enormous wattles, as that of the English carrier; for an expanded upraised tail like that of the fantail; or for an œsophagus like that of the pouter. I do not for a moment pretend that the domestic races differ from each other in their whole organisation as much as the more distinct natural genera. I refer only to external characters, on which, however, it must be confessed that most genera of birds have been founded. When, in a future chapter, we discuss the principle of selection as followed by man, we shall clearly see why the differences between the domestic races are almost always confined to external, or at least to externally visible, characters.

Owing to the amount and gradations of difference between the several breeds, I have found it indispensable in the following classification to rank them under Groups, Races, and Sub-races; to which varieties and sub-varieties, all strictly inheriting their proper characters, must often be added. Even with the individuals of the same sub-variety, when long kept by different fanciers, different strains can sometimes be recognised. There can be no doubt that, if well-characterised forms of the several races had been found wild, all would have been ranked as distinct species, and several of them would certainly have been placed by ornithologists in distinct genera. A good classification of the various domestic breeds is extremely difficult, owing to the manner in which many of the forms graduate into each other; but it is curious how exactly the same difficulties are encountered, and the same rules have to be followed, as in the classification of any natural but difficult group of organic beings. An “artificial classification” might be followed which would present fewer difficulties than a “natural classification;” but then it would interrupt many plain affinities. Extreme forms can readily be defined; but intermediate and troublesome forms often destroy our definitions. Forms which may be called “aberrant” must sometimes be included within groups to which they do not accurately belong. Characters of all kinds must be used; but as with birds in a state of nature, those afforded by the beak are the best and most readily appreciated. It is not possible to weigh the importance of all the characters which have to be used so as to make the groups and sub-groups of equal value. Lastly, a group may contain only one race, and another and less distinctly defined group may contain several races and sub-races, and in this case it is difficult, as in the classification of natural species, to avoid placing too high a value on the number of forms which a group may contain.

In my measurements I have never trusted to the eye; and when speaking of a part being large or small, I always refer to the wild rock-pigeon (*Columba livia*) as the standard of comparison. The measurements are given in decimals of an inch.[5]

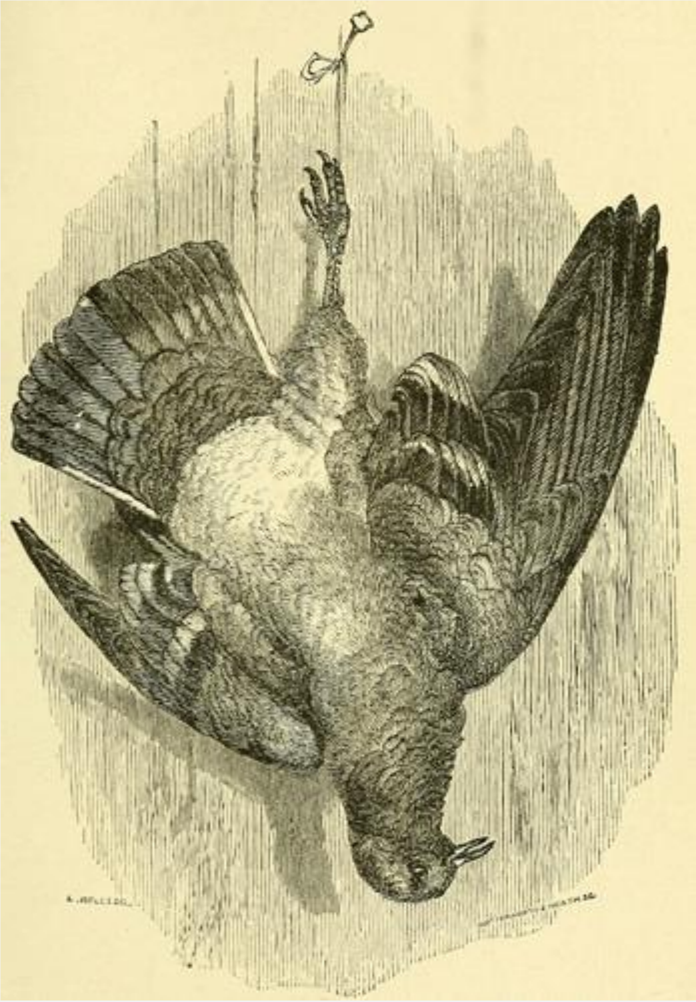
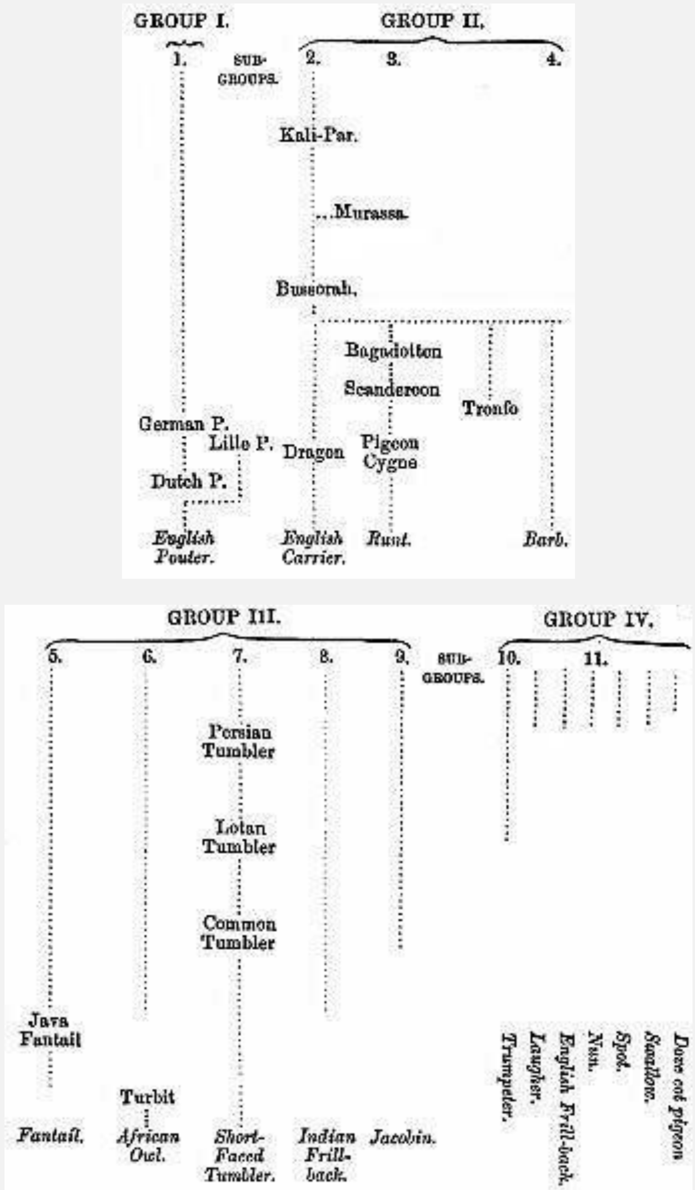


Fig. 17—The Rock-Pigeon, or Columba livia.[6] The parent-form of all domesticated pigeons.

***COLUMBA LIVIA* or ROCK-PIGEON.**



I will now give a brief description of all the principal breeds. The diagram above may aid the reader in learning their names and seeing their affinities. The rock-pigeon, or *Columba livia* (including under this name two or three closely-allied sub-species or geographical races, hereafter to be described), may be confidently viewed, as we shall see in the next chapter, as the common parent-form. The names in italics on the right-hand side of the page show us the most distinct breeds, or those which have undergone the greatest amount of modification. The lengths of the dotted lines rudely represent the degree of distinctness of each breed from the parent-stock, and the names placed under each other in the columns show the more or less closely connecting links. The distances of the dotted lines from each other approximately represent the amount of difference between the several breeds.

Fig. 18—English Pouter.

GROUP I.

This group includes a single race, that of the Pouters. If the most strongly marked sub-race be taken, namely, the Improved English Pouter, this is perhaps the most distinct of all domesticated pigeons.

Race I. Pouter Pigeons.
(Kropftauben, German. Grosses-gorges, or Boulans, French.)

Œsophagus of great size, barely separated from the crop, often inflated. Body and legs elongated. Beak of moderate dimensions.

Sub-race I.—The improved English Pouter, when its crop is fully inflated, presents a truly astonishing appearance. The habit of slightly inflating the crop is common to all domestic pigeons, but is carried to an extreme in the Pouter. The crop does not differ, except in size, from that of other pigeons; but is less plainly separated by an oblique constriction from the œsophagus. The diameter of the upper part of the œsophagus is immense, even close up to the head. The beak in one bird which I possessed was almost completely buried when the œsophagus was fully expanded. The males, especially when excited, pout more than the females, and they glory in exercising this power. If a bird will not, to use the technical expression, "play," the fancier, as I have witnessed, by taking the beak into his mouth, blows him up like a balloon; and the bird, then puffed up with wind and pride, struts about, retaining his magnificent size as long as he can. Pouters often take flight with their crops inflated. After one of my birds had swallowed a good meal of peas and water, as he flew up in order to disgorge them and feed his nearly fledged young, I heard the peas rattling in his inflated crop as if in a bladder. When flying, they often strike the backs of their wings together, and thus make a clapping noise.

Pouters stand remarkably upright, and their bodies are thin and elongated. In connexion with this form of body, the ribs are generally broader and the vertebræ more numerous than in other breeds. From their manner of standing their legs appear longer than they really are, though, in proportion with those of *C. livia*, the legs and feet are actually longer. The wings appear much elongated, but by measurement, in relation to the length of body, this is not the case. The beak likewise appears longer, but it is in fact a little shorter (about ·03 of an inch), proportionally with the size of the body, and relatively to the beak of the rock-pigeon. The Pouter, though not bulky, is a large bird; I measured one which was 34½ inches from tip to tip of wing, and 19 inches from tip of beak to end of tail. In a wild rock-pigeon from the Shetland Islands the same measurements gave only 28¼ and 14¾. There are many sub-varieties of the Pouter of different colours, but these I pass over.

Sub-race II. Dutch Pouter.—This seems to be the parent-form of our improved English Pouters. I kept a pair, but I suspect that they were not pure birds. They are smaller than English pouters, and less well developed in all their characters. Neumeister[7] says that the wings are crossed over the tail, and do not reach to its extremity.

Sub-race III. The Lille Pouter.—I know this breed only from description.[8] It approaches in general form the Dutch Pouter, but the inflated œsophagus assumes a spherical form, as if the pigeon had swallowed a large orange, which had stuck close under the beak. This inflated ball is represented as rising to a level with the crown of the head. The middle toe alone is feathered. A variety of this sub-race, called the claquant, is described by MM. Boitard and Corbié; it pouts but little, and is characterised by the habit of violently hitting its wings together over its back,—a habit which the English Pouter has in a slight degree.

Sub-race IV. Common German Pouter.—I know this bird only from the figures and description given by the accurate Neumeister, one of the few writers on pigeons who, as I have found, may always be trusted. This sub-race seems considerably different. The upper part of the œsophagus is much less distended. The bird stands less upright. The feet are not feathered, and the legs and beak are shorter. In these respects there is an approach in form to the common rock-pigeon. The tail-feathers are very long, yet the tips of the closed wings extend beyond the end of the tail; and the length of the wings, from tip to tip, and of the body, is greater than in the English Pouter.

Fig. 19—English Carrier.

GROUP II.

This group includes three Races, namely, Carriers, Runts, and Barbs, which are manifestly allied to each other. Indeed, certain carriers and runts pass into each other by such insensible gradations that an arbitrary line has to be drawn between them. Carriers also graduate through foreign breeds into the rock-pigeon. Yet, if well-characterised Carriers and Barbs (see figs 19 and 20) had existed as wild species, no ornithologist would have placed them in the same genus with each other or with the rock-pigeon. This group may, as a general rule, be recognised by the beak being long, with the skin over the nostrils swollen and often carunculated or wattled, and with that round the eyes bare and likewise carunculated. The mouth is very wide, and the feet are large. Nevertheless the Barb, which must be classed in this same group, has a very short beak, and some runts have very little bare skin round their eyes.

Race II.—Carriers.

(Türkische Tauben; pigeons turcs, dragons.)

Beak elongated, narrow, pointed; eyes surrounded by much naked, generally carunculated, skin; neck and body elongated.

Sub-race I. The English Carrier.—This is a fine bird, of large size, close feathered, generally dark-coloured, with an elongated neck. The beak is attenuated and of wonderful length: in one specimen it was 1·4 inch in length from the feathered base to the tip; therefore nearly twice as long as that of the rock-pigeon, which measured only ·77. Whenever I compare proportionally any part in the carrier and rock-pigeon, I take the length of the body from the base of the beak to the end of the tail as the standard of comparison; and according to this standard, the beak in one Carrier was nearly half an inch longer than in the rock-pigeon. The upper mandible is often slightly arched. The tongue is very long. The development of the carunculated skin or wattle round the eyes, over the nostrils, and on the lower mandible, is prodigious. The eyelids, measured longitudinally, were in some specimens exactly twice as long as in the rock-pigeon. The external orifice or furrow of the nostrils was also twice as long. The open mouth in its widest part was in one case ·75 of an inch in width, whereas in the rock-pigeon it is only about ·4 of an inch. This great width of mouth is shown in the skeleton by the reflexed edges of the ramus of the lower jaw. The head is flat on the summit and narrow between the orbits. The feet are large and coarse; the length, as measured from end of hind toe to end of middle toe (without the claws), was in two specimens 2·6 inches; and this, proportionally with the rock-pigeon, is an excess of nearly a quarter of an inch. One very fine Carrier measured 31½ inches from tip to tip of wing. Birds of this sub-race are too valuable to be flown as carriers.

Sub-race II. Dragons; Persian Carriers.—The English Dragon differs from the improved English Carrier in being smaller in all its dimensions, and in having less wattle round the eyes and over the nostrils, and none on the lower mandible. Sir W. Elliot sent me from Madras a Bagdad Carrier (sometimes called khandesi), the name of which shows its Persian origin: it would be considered here a very poor Dragon; the body was of the size of the rock-pigeon, with the beak a little longer, namely, 1 inch from the tip to the feathered base. The skin round the eyes was only slightly wattled, whilst that over the nostrils was fairly wattled. The Hon. C. Murray, also, sent me two Carriers direct from Persia; these had nearly the same character as the Madras bird, being about as large as the rock-pigeon, but the beak in one specimen was as much as 1·15 in length; the skin over the nostrils was only moderately, and that round the eyes scarcely at all wattled.

Sub-race III. Bagadotten-Tauben of Neumeister (Pavdotten-or Hocker-Tauben).—I owe to the kindness of Mr. Baily, jun., a dead specimen of this singular breed imported from Germany. It is certainly allied to the Runts; nevertheless, from its close affinity with Carriers, it will be convenient here to describe it. The beak is long, and is hooked or bowed downwards in a highly remarkable manner, as will be seen in fig. 24-D when I treat of the skeleton. The eyes are surrounded by a wide space of bright red skin, which, as well as that over the nostrils, is moderately wattled. The breast-bone is remarkably protuberant, being abruptly bowed outwards. The feet and tarsi are of great length, larger than in first-rate English Carriers. The whole bird is of large size, but in proportion to the size of the body the feathers of the wing and tail are short; a wild rock-pigeon, of considerably less size, had tail-feathers 4·6 inches in length, whereas in the large Bagadotten these feathers were scarcely over 4·1 inches in length. Riedel[9] remarks that it is a very silent bird.

Sub-race IV. Bussorah Carrier.—Two specimens were sent me by Sir W. Elliot from Madras, one in spirits and the other skinned. The name shows its Persian origin. It is much valued in India, and is considered as a distinct breed from the Bagdad Carrier, which forms my second sub-race. At first I suspected that these two sub-races might have been recently formed by crosses with other breeds, though the estimation in which they are held renders this improbable; but in a Persian treatise,[10] believed to have been written about 100 years ago, the Bagdad and Bussorah breeds are described as distinct. The Bussorah Carrier is of about the same size as the wild rock-pigeon. The shape of the beak, with some little carunculated skin over the nostrils,— the much elongated eyelids,—the broad mouth measured internally,—the narrow head,—the feet proportionally a little longer than in the rock-pigeon,—and the general appearance, all show that this bird is an undoubted Carrier; yet in one specimen the beak was of exactly the same length as in the rock-pigeon. In the other specimen the beak (as well as the opening of the nostrils) was only a very little longer, viz., by ·08 of an inch. Although there was a considerable space of bare and slightly carunculated skin round the eyes, that over the nostrils was only in a slight degree rugose. Sir W. Elliot informs me that in the living bird the eye seems remarkably large and prominent, and the same fact is noticed in the Persian treatise; but the bony orbit is barely larger than that in the rock-pigeon.

Amongst the several breeds sent to me from Madras by Sir W. Elliot there is a pair of the *Kali Par*, black birds with the beak slightly elongated, with the skin over the nostrils rather full, and with a little naked skin round the eyes. This breed seems more closely allied to the Carrier than to any other breed, being nearly intermediate between the Bussorah Carrier and the rock-pigeon.

The names applied in different parts of Europe and in India to the several kinds of Carriers all point to Persia or the surrounding countries as the source of this Race. And it deserves especial notice that, even if we neglect the Kali Par as of doubtful origin, we get a series broken by very small steps, from the rock-pigeon, through the Bussorah, which sometimes has a beak not at all longer than that of the rock-pigeon and with the naked skin round the eyes and over the nostrils very slightly swollen and carunculated, through the Bagdad sub-race and Dragons, to our improved English Carriers, which present so marvellous a difference from the rock-pigeon or *Columba livia*.

Race III.—Runts.

(Scanderoons: die Florentiner Tauben and Hinkeltauben of Neumeister; pigeon bagadais, pigeon romain.)

Beak long, massive; body of great size.

Inextricable confusion reigns in the classification, affinities, and naming of Runts. Several characters which are generally pretty constant in other pigeons, such as the length of the wings, tail, legs, and neck, and the amount of naked skin round the eyes, are excessively variable in Runts. When the naked skin over the nostrils and round the eyes is considerably developed and wattled, and when the size of body is not very great, Runts graduate in so insensible a manner into Carriers, that the distinction is quite arbitrary. This fact is likewise shown by the names given to them in different parts of Europe. Nevertheless, taking the most distinct forms, at least five sub-races (some of them including well-marked varieties) can be distinguished, which differ in such important points of structure, that they would be considered as good species in a state of nature.

Sub-race I. Scanderoon of English Writers (die Florentiner and Hinkeltauben of Neumeister).—Birds of this sub-race, of which I kept one alive and have since seen two others, differ from the Bagadotten of Neumeister only in not having the beak nearly so much curved downwards, and in the naked skin round the eyes and over the nostrils being hardly at all wattled. Nevertheless I have felt myself compelled to place the Bagadotten in Race II., or that of the Carriers, and the present bird in Race III., or that of the Runts. The Scanderoon has a very short, narrow, and elevated tail; wings extremely short, so that the first primary feathers were not longer than those of a small tumbler pigeon! Neck long, much bowed; breast-bone prominent. Beak long, being 1·15 inch from tip to feathered base; vertically thick; slightly curved downwards. The skin over the nostrils swollen, not wattled; naked skin round the eyes, broad, slightly carunculated. Legs long; feet very large. Skin of neck bright red, often showing a naked medial line, with a naked red patch at the distal end of the radius of the wing. My bird, as measured from the base of the beak to the root of the tail, was fully 2 inches longer than the rock-pigeon; yet the tail itself was only 4 inches in length, whereas in the rock-pigeon, which is a much smaller bird, the tail is 4-5/8 inches in length.

The Hinkel-or Florentiner Taube of Neumeister (Table 13 fig. 1) agrees with the above description in all the specified characters (for the beak is not mentioned), except that Neumeister expressly says that the neck is short, whereas in my Scanderoon it was remarkably long and bowed; so that the Hinkel forms a well-marked variety.

Sub-race II. Pigeon cygne and Pigeon bagadais of Boitard and Corbié (Scanderoon of French writers).—I kept two of these birds alive, imported from France. They differed from the first sub-race or true Scanderoon in the much greater length of the wing and tail, in the beak not being so long, and in the skin about the head being more carunculated. The skin of the neck is red; but the naked patches on the wings are absent. One of my birds measured 38½ inches from tip to tip of wing. By taking the length of the body as the standard of comparison, the two wings were no less than 5 inches longer than those of the rock-pigeon! The tail was 6¼ inches in length, and therefore 2¼ inches longer than that of the Scanderoon,—a bird of nearly the same size. The beak is longer, thicker, and broader than in the rock-pigeon, proportionally with the size of body. The eyelids, nostrils, and internal gape of mouth are all proportionally very large, as in Carriers. The foot, from the end of the middle to end of hind toe, was actually 2·85 inches in length, which is an excess of ·32 of an inch over the foot of the rock-pigeon, proportionally to the relative size of the two birds.

Sub-race III. Spanish and Roman Runts.—I am not sure that I am right in placing these Runts in a distinct sub-race; yet, if we take well-characterised birds, there can be no doubt of the propriety of the separation. They are heavy, massive birds, with shorter necks, legs, and beaks than in the foregoing races. The skin over the nostrils is swollen, but not carunculated; the naked skin round the eyes is not very wide, and only slightly carunculated; and I have seen a fine so-called Spanish Runt with hardly any naked skin round the eyes. Of the two varieties to be seen in England, one, which is the rarer, has very long wings and tail, and agrees pretty closely with the last sub-race; the other, with shorter wings and tail, is apparently the *Pigeon romain ordinaire* of Boitard and Corbié. These Runts are apt to tremble like Fantails. They are bad flyers. A few years ago Mr. Gulliver[11] exhibited a Runt which weighed 1 pound 14 ounces; and, as I am informed by Mr. Tegetmeier, two Runts from the south of France were lately exhibited at the Crystal Palace, each of which weighed 2 pounds 2½ ounces. A very fine rock-pigeon from the Shetland Islands weighed only 14½ ounces.

Sub-race IV. Tronfo of Aldrovandi (Leghorn Runt?).—In Aldrovandi’s work published in 1600 there is a coarse woodcut of a great Italian pigeon, with an elevated tail, short legs, massive body, and with the beak short and thick. I had imagined that this latter character so abnormal in the group, was merely a false representation from bad drawing; but Moore, in his work published in 1735, says that he possessed a Leghorn Runt of which “the beak was very short for so large a bird.” In other respects Moore’s bird resembled the first sub-race or Scanderoon, for it had a long bowed neck, long legs, short beak, and elevated tail, and not much wattle about the head. So that Aldrovandi’s and Moore’s birds must have formed distinct varieties, both of which seem to be now extinct in Europe. Sir W. Elliot, however, informs me that he has seen in Madras a short-beaked Runt imported from Cairo.

Sub-race V. Murassa (adorned Pigeon) of Madras.—Skins of these handsome chequered birds were sent me from Madras by Sir W. Elliot. They are rather larger than the largest rock-pigeon, with longer and more massive beaks. The skin over the nostrils is rather full and very slightly carunculated, and they have some naked skin round the eyes; feet large. This breed is intermediate between the rock-pigeon and a very poor variety of Runt or Carrier.

From these several descriptions we see that with Runts, as with Carriers, we have a fine gradation from the rock-pigeon (with the Tronfo diverging as a distinct branch) to our largest and most massive Runts. But the chain of affinities, and many points of resemblance, between Runts and carriers, make me believe that these two races have not descended by independent lines from the rock-pigeon, but from some common parent, as represented in the Table, which had already acquired a moderately long beak with slightly swollen skin over the nostrils, and with some slightly carunculated naked skin round the eyes.

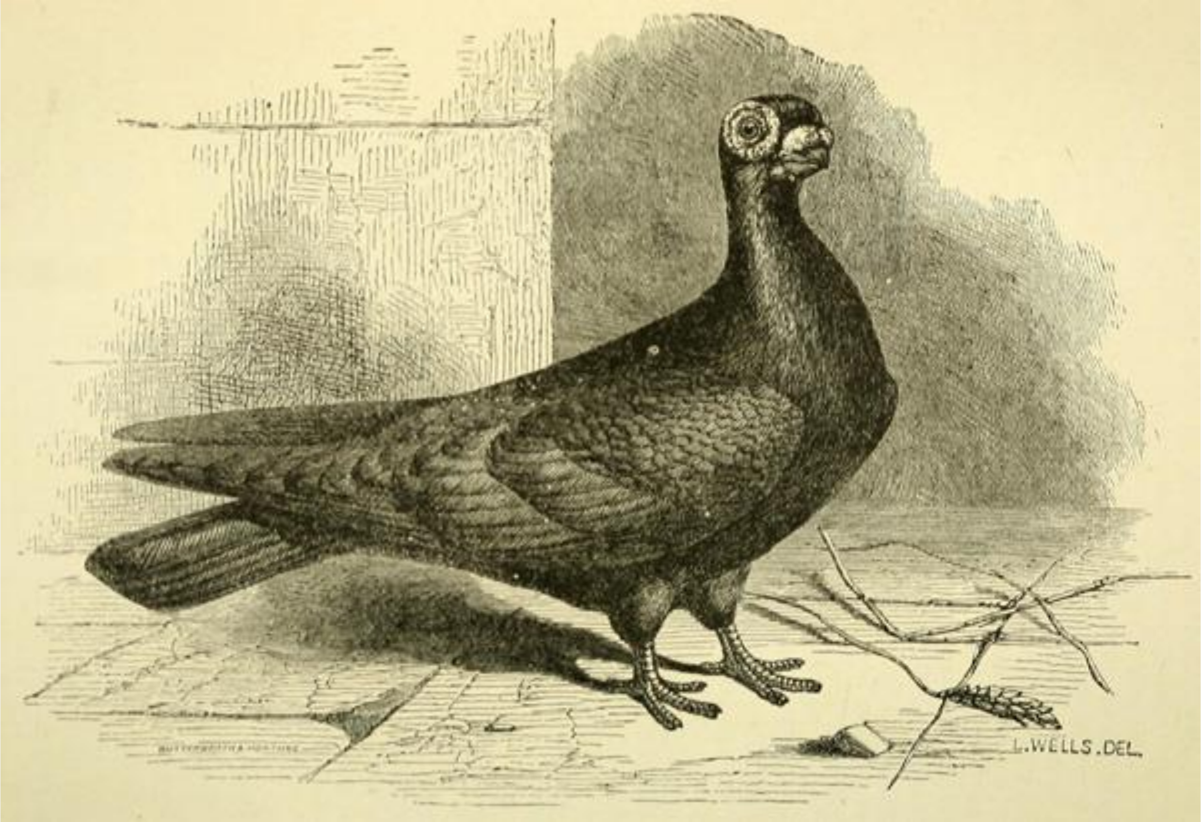


Fig. 20—English Barb.

Race IV.—Barbs.

(Indische Tauben; pigeons polonais.)

Beak short, broad, deep; naked skin round the eyes, broad and carunculated; skin over nostrils slightly swollen.

Misled by the extraordinary shortness and form of the beak, I did not at first perceive the near affinity of this Race to that of Carriers until the fact was pointed out to me by

Mr. Brent. Subsequently, after examining the Bussorah Carrier, I saw that no very great amount of modification would be requisite to convert it into a Barb. This view of the affinity of Barbs to Carriers is supported by the analogical difference between the short and long-beaked Runts; and still more strongly by the fact, that, young Barbs and Dragons, within 24 hours after being hatched, resemble each other much more closely than do young pigeons of other and equally distinct breeds. At this early age, the length of beak, the swollen skin over the rather open nostrils, the gape of the mouth, and the size of the feet, are the same in both; although these parts afterwards become widely different. We thus see that embryology (as the comparison of very young animals may perhaps be called) comes into play in the classification of domestic varieties, as with species in a state of nature.

Fanciers, with some truth, compare the head and beak of the Barb to that of a bullfinch. The Barb, if found in a state of nature would certainly have been placed in a new genus formed for its reception. The body is a little larger than that of the rock-pigeon, but the beak is more than ·2 of an inch shorter; although shorter, it is both vertically and horizontally thicker. From the outward flexure of the rami of the lower jaw, the mouth internally is very broad, in the proportion of ·6 to ·4 to that of the rock-pigeon. The whole head is broad. The skin over the nostril is swollen, but not carunculated, except slightly in first-rate birds when old; whilst the naked skin round the eye is broad and much carunculated. It is sometimes so much developed, that a bird belonging to Mr. Harrison Weir could hardly see to pick up food from the ground. The eyelids in one specimen were nearly twice as long as those of the rock-pigeon. The feet are coarse and strong, but proportionally rather shorter than in the rock-pigeon. The plumage is generally dark and uniform. Barbs, in short, may be called short-beaked Carriers, bearing the same relation to Carriers that the Tronfo of Aldrovandi does to the common Runt.

GROUP III.

This group is artificial, and includes a heterogeneous collection of distinct forms. It may be defined by the beak, in well-characterised specimens of the several races, being shorter than in the rock-pigeon, and by the skin round the eyes not being much developed.

Fig. 21—English Fantail.

Race V.—Fantails.

Sub-race I. European Fantails (Pfauentauben; trembleurs).

Tail expanded, directed upwards, formed of many feathers; oil-gland aborted; body and beak rather short.

The normal number of tail-feathers in the genus Columba is 12; but Fantails have from only 12 (as has been asserted) up to, according to MM. Boitard and Corbié, 42. I have counted in one of my own birds 33, and at Calcutta Mr. Blyth[12] has counted in an *imperfect* tail 34 feathers. In Madras, as I am informed by Sir W. Elliot, 32 is the standard number; but in England number is much less valued than the position and expansion of the tail. The feathers are arranged in an irregular double row; their permanent fanlike expansion and their upward direction are more remarkable characters than their increased number. The tail is capable of the same movements as in other pigeons, and can be depressed so as to sweep the ground. It arises from a more expanded basis than in other pigeons; and in three skeletons there were one or two extra coccygeal vertebræ. I have examined many specimens of various colours from different countries, and there was no trace of the oil-gland; this is a curious case of abortion.[13] The neck is thin and bowed backwards. The breast is broad and protuberant. The feet are small. The carriage of the bird is very different from that of other pigeons; in good birds the head touches the tail-feathers, which consequently often become crumpled. They habitually tremble much: and their necks have an extraordinary, apparently convulsive, backward and forward movement. Good birds walk in a singular manner, as if their small feet were stiff. Owing to their large tails, they fly badly on a windy day. The dark-coloured varieties are generally larger than white Fantails.

Although between the best and common Fantails, now existing in England, there is a vast difference in the position and size of the tail, in the carriage of the head and neck, in the convulsive movements of the neck, in the manner of walking, and in the breadth of the breast, the differences so graduate away, that it is impossible to make more than one sub-race. Moore, however, an excellent old authority[14] says, that in 1735 there were two sorts of broad-tailed shakers (*i.e.* Fantails), "one having a neck much longer and more slender than the other;" and I am informed by Mr. B. P. Brent, that there is an existing German Fantail with a thicker and shorter beak.

Sub-race II. Java Fantail.—Mr. Swinhoe sent me from Amoy, in China, the skin of a Fantail belonging to a breed known to have been imported from Java. It was coloured in a peculiar manner, unlike any European Fantail; and, for a Fantail, had a remarkably short beak. Although a good bird of the kind, it had only 14 tail-feathers; but Mr. Swinhoe has counted in other birds of this breed from 18 to 24 tail-feathers. From a rough sketch sent to me, it is evident that the tail is not so much expanded or so much upraised as in even second-rate European Fantails. The bird shakes its neck like our Fantails. It had a well-developed oil-gland. Fantails were known in India, as We shall hereafter see, before the year 1600; and we may suspect that in the Java Fantail we see the breed in its earlier and less improved condition.

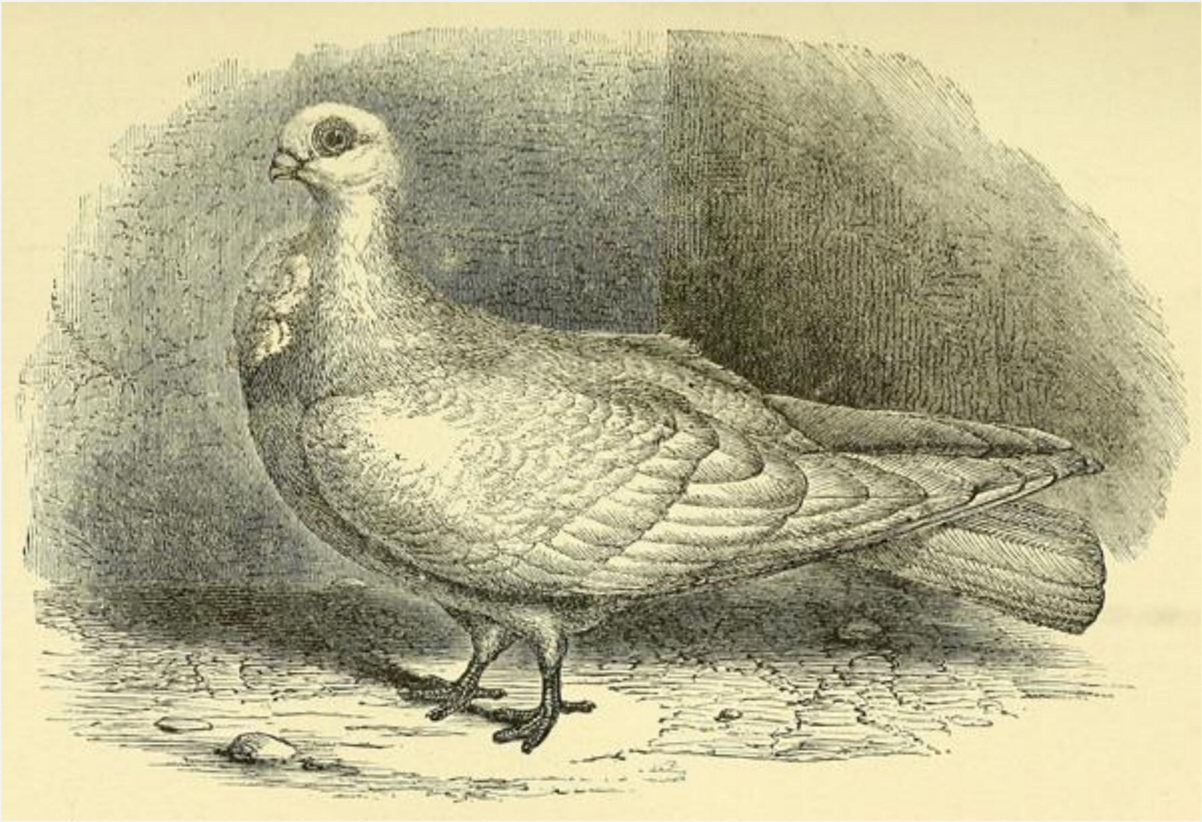


Fig. 22—African Owl.

Race VI.—Turbit and Owl.
(Möventauben; pigeons à cravate.)

Feathers divergent along the front of the neck and breast; beak very short, vertically rather thick; œsophagus somewhat enlarged.

Turbits and Owls differ from each other slightly in the shape of the head; the former have a crest, and the beak is differently curved; but they may be here conveniently grouped together. These pretty birds, some of which are very small, can be recognised at once by the feathers irregularly diverging, like a frill, along the front of the neck, in the same manner, but in a less degree, as along the back of the neck in the Jacobin. They have the remarkable habit of continually and momentarily inflating the upper part of the œsophagus, which causes a movement in the frill. When the œsophagus of a dead bird is inflated, it is seen to be larger than in other breeds, and not so distinctly separated from the crop. The Pouter inflates both its true crop and œsophagus; the Turbit inflates in a much less degree the œsophagus alone. The beak of the Turbit is very short, being ·28 of an inch shorter than that of the rock-pigeon, proportionally with the size of their bodies; and in some owls brought by Mr. E. Vernon Harcourt from Tunis, it was even shorter. The beak is vertically thicker, and perhaps a little broader, in proportion to that of the rock-pigeon.

Race VII.—Tumblers.

(Tümmler, or Burzeltauben; culbutants.)

During flight, tumble backwards; body generally small; beak generally short, sometimes excessively short and conical.

This race may be divided into four sub-races, namely, Persian, Lotan, Common, and short-faced Tumblers. These sub-races include many varieties which breed true. I have examined eight skeletons of various kinds of Tumblers: excepting in one imperfect and doubtful specimen, the ribs are only seven in number, whereas the rock-pigeon has eight ribs.

Sub-race I. Persian Tumblers.—I received a pair direct from Persia, from the Hon. C. Murray. They are rather smaller birds than the wild rock-pigeon, about the size of the common dovecot pigeon, white and mottled, slightly feathered on the feet, with the beak just perceptibly shorter than in the rock-pigeon. H.M. Consul, Mr. Keith Abbott, informs me that the difference in the length of beak is so slight, that only practised Persian fanciers can distinguish these Tumblers from the common pigeon of the country. He informs me that they fly in flocks high up in the air and tumble well. Some of them occasionally appear to become giddy and tumble to the ground, in which respect they resemble some of our Tumblers.

Sub-race II. Lotan, or Lowtun: Indian Ground Tumblers.—These birds present one of the most remarkable inherited habits or instincts ever recorded. The specimens sent to me from Madras by Sir W. Elliot are white, slightly feathered on the feet, with the feathers on the head reversed; and they are rather smaller than the rock or dovecot pigeon. The beak is proportionally only slightly shorter and rather thinner than in the rock-pigeon. These birds when gently shaken and placed on the ground immediately begin tumbling head over heels, and they continue thus to tumble until taken up and soothed,—the ceremony being generally to blow in their faces, as in recovering a person from a state of hypnotism or mesmerism. It is asserted that they will continue to roll over till they die, if not taken up. There is abundant evidence with respect to these remarkable peculiarities; but what makes the case the more worthy of attention is, that the habit has been inherited since before the year 1600, for the breed is distinctly described in the 'Ayeen Akbery.'[15] Mr. Evans kept a pair in London, imported by Captain Vigne; and he assures me that he has seen them tumble in the air, as well as in the manner above described on the ground. Sir W. Elliot, however, writes to me from Madras, that he is informed that they tumble exclusively on the ground, or at a very small height above it. He also mentions birds of another sub-variety, called the Kalmi Lotan, which begin to roll over if only touched on the neck with a rod or wand.

Sub-race III. Common English Tumblers.—These birds have exactly the same habits as the Persian Tumbler, but tumble better. The English bird is rather smaller than the Persian, and the beak is plainly shorter. Compared with the rock-pigeon, and proportionally with the size of body, the beak is from ·15 to nearly ·2 of an inch shorter, but it is not thinner. There are several varieties of the common Tumbler, namely, Baldheads, Beards, and Dutch Rollers. I have kept the latter alive; they have differently shaped heads, longer necks, and are feather-footed. They tumble to an extraordinary degree; as Mr. Brent remarks,[16] "Every few seconds over they go; one, two, or three summersaults at a time. Here and there a bird gives a very quick and rapid spin, revolving like a wheel, though they sometimes lose their balance, and make a rather ungraceful fall, in which they occasionally hurt themselves by striking some object." From Madras I have received several specimens of the common Tumbler of India, differing slightly from each other in the length of their beaks. Mr. Brent sent me a dead specimen of a "House-tumbler,"[17] which is a Scotch variety, not differing in general appearance and form of beak from the common Tumbler. Mr. Brent states that these birds generally begin to tumble "almost as soon as they can well fly; at three months old they tumble well, but still fly strong; at five or six months they tumble excessively; and in the second year they mostly give up flying, on account of their tumbling so much and so close to the ground. Some fly round with the flock, throwing a clean summersault every few yards, till they are obliged to settle from giddiness and exhaustion. These are called Air Tumblers, and they commonly throw from twenty to thirty summersaults in a minute, each clear and clean. I have one red cock that I have on two or three occasions timed by my watch, and counted forty summersaults in the minute. Others tumble differently. At first they throw a single summersault, then it is double, till it becomes a continuous roll, which puts an end to flying, for if they fly a few yards over they go, and roll till they reach the ground. Thus I had one kill herself, and another broke his leg. Many of them turn over only a few inches from the ground, and will tumble two or three times in flying across their loft. These are called House-tumblers, from tumbling in the house. The act of tumbling seems to be one over which they have no control, an involuntary movement which they seem to try to prevent. I have seen a bird sometimes in his struggles fly a yard or two straight upwards, the impulse forcing him backwards while he struggles to go forwards. If suddenly startled, or in a strange place, they seem less able to fly than if quiet in their accustomed loft." These House-tumblers differ from the Lotan or Ground Tumbler of India, in not requiring to be shaken in order to begin tumbling. The breed has probably been formed merely by selecting the best common Tumblers, though it is possible that they may have been crossed at some former period with Lotans.

Fig. 23—Short-faced English Tumbler.

Sub-race IV. Short-faced Tumblers.—These are marvellous birds, and are the glory and pride of many fanciers. In their extremely short, sharp, and conical beaks, with the skin over the nostrils but little developed, they almost depart from the type of the Columbidæ. Their heads are nearly globular and upright in front, so that some fanciers say[18] "the head should resemble a cherry with a barleycorn stuck in it." These are the smallest kind of pigeons. Mr. Esquilant possessed a blue Baldhead, two years old, which when alive weighed, before feeding-time, only 6 ounces 5 drs.; two others, each weighed 7 ounces. We have seen that a wild rock-pigeon weighed 14 ounces 2 drs., and a Runt 34 ounces 4 drs. Short-faced Tumblers have a remarkably erect carriage, with prominent breasts, drooping wings, and very small feet. The length of the beak from the tip to the feathered base was in one good bird only ·4 of an inch; in a wild rock-pigeon it was exactly double this length. As these Tumblers have shorter bodies than the wild rock-pigeon, they ought of course to have shorter beaks; but proportionally with the size of the body, the beak is ·28 of an inch too short. So, again, the feet of this bird were actually ·45 shorter, and proportionally ·21 of an inch shorter, than the feet of the rock-pigeon. The middle toe has only twelve or thirteen, instead of fourteen or fifteen scutellæ. The primary wing-feathers are not rarely nine instead of ten in number. The improved short-faced Tumblers have almost lost the power of tumbling; but there are several authentic accounts of their occasionally tumbling. There are several sub-varieties, such as Bald-heads, Beards, Mottles, and Almonds; the latter are remarkable from not acquiring their perfectly-coloured plumage until they have moulted three or four times. There is good reason to believe that most of these sub-varieties, some of which breed truly, have arisen since the publication of Moore's treatise in 1735.[19]

Finally, in regard to the whole group of Tumblers, it is impossible to conceive a more perfect gradation than I have now lying before me, from the rock-pigeon, through Persian, Lotan, and common Tumblers, up to the marvellous short-faced birds; which latter, no ornithologist, judging from mere external structure, would place in the same genus with the rock-pigeon. The differences between the successive steps in this series are not greater than those which may be observed between common dovecot-pigeons (*C. livia*) brought from different countries.

Race VIII.—Indian Frill-back.

Beak very short; feathers reversed.

A specimen of this bird, in spirits, was sent to me from Madras by Sir W. Elliot. It is wholly different from the Frill-back often exhibited in England. It is a smallish bird, about the size of the common Tumbler, but has a beak in all its proportions like our short-faced Tumblers. The beak, measured from the tip to the feathered base, was only ·46 of an inch in length. The feathers over the whole body are reversed or curl backwards. Had this bird occurred in Europe, I should have thought it only a monstrous variety of our improved Tumbler: but as short-faced Tumblers are not known in India, I think it must rank as a distinct breed. Probably this is the breed seen by Hasselquist in 1757 at Cairo, and said to have been imported from India.

Race IX.—Jacobin.

(Zopf-or Perrückentaube; nonnain.)

Feathers of the neck forming a hood; wings and tail long; beak moderately short.

This pigeon can at once be recognised by its hood, almost enclosing the head and meeting in front of the neck. The hood seems to be merely an exaggeration of the crest of reversed feathers on the back of the head, which is common to many sub-varieties, and which in the Latztaube[20] is in a nearly intermediate state between a hood and a crest. The feathers of the hood are elongated. Both the wings and tail are likewise much elongated; thus the folded wing of the Jacobin, though a somewhat smaller bird, is fully 1¼ inch longer than in the rock-pigeon. Taking the length of the body without the tail as the standard of comparison, the folded wing, proportionally with the wings of the rock-pigeon, is 2¼ inches too long, and the two wings, from tip to tip, 5¼ inches too long. In disposition this bird is singularly quiet, seldom flying or moving about, as Bechstein and Riedel have likewise remarked in Germany.[21] The latter author also notices the length of the wings and tail. The beak is nearly ·2 of an inch shorter in proportion to the size of the body than in the rock-pigeon; but the internal gape of the mouth is considerably wider.

GROUP IV.

The birds of this group may be characterised by their resemblance in all important points of structure, especially in the beak, to the rock-pigeon. The Trumpeter forms the only well-marked race. Of the numerous other sub-races and varieties I shall specify only a few of the most distinct, which I have myself seen and kept alive.

Race X.—Trumpeter.
(Trommeltaube; pigeon tambour, glouglou.)

A tuft of feathers at the base of the beak curling forward; feet much feathered; voice very peculiar; size exceeding that of the rock-pigeon.

This is a well-marked breed, with a peculiar voice, wholly unlike that of any other pigeon. The coo is rapidly repeated, and is continued for several minutes; hence their name of Trumpeters. They are also characterised by a tuft of elongated feathers, which curls forward over the base of the beak, and which is possessed by no other breed. Their feet are so heavily feathered, that they almost appear like little wings. They are larger birds than the rock-pigeon, but their beak is of very nearly the same proportional size. Their feet are rather small. This breed was perfectly characterised in Moore's time, in 1735. Mr. Brent says that two varieties exist, which differ in size.

Race XI.—Scarcely differing in structure from the wild *Columba livia*.

Sub-race I. Laughers.—Size less than the Rock-pigeon; voice very peculiar.—As this bird agrees in nearly all its proportions with the rock-pigeon, though of smaller size, I should not have thought it worthy of mention, had it not been for its peculiar voice—a character supposed seldom to vary with birds. Although the voice of the Laugher is very different from that of the Trumpeter, yet one of my Trumpeters used to utter a single note like that of the Laugher. I have kept two varieties of Laughers, which differed only in one variety being turn-crowned; the smooth-headed kind, for which I am indebted to the kindness of Mr. Brent, besides its peculiar note, used to coo in a singular and pleasing manner, which, independently, struck both Mr. Brent and myself as resembling that of the turtle-dove. Both varieties come from Arabia. This breed was known by Moore in 1735. A pigeon which seems to say Yak-roo is mentioned in 1600 in the 'Ayeen Akbery' and is probably the same breed. Sir W. Elliot has also sent me from Madras a pigeon called Yahui, said to have come from Mecca, which does not differ in appearance from the Laugher; it has "a deep melancholy voice, like Yahu, often repeated." Yahu, yahu, means Oh God, oh God; and Sayzid Mohammed Musari, in the treatise written about 100 years ago, says that these birds "are not flown, because they repeat the name of the most high God." Mr. Keith Abbott, however, informs me that the common pigeon is called Yahoo in Persia.

Sub-race II. Common Frill-back (die Strupptaube).—*Beak rather longer than in the rock-pigeon; feathers reversed.*—This is a considerably larger bird than the rock-pigeon, and with the beak, proportionally with the size of body, a little (viz. by ·04 of an inch) longer. The feathers, especially on the wing-coverts, have their points curled upwards or back-wards.

Sub-race III. Nuns (Pigeons coquilles).—These elegant birds are smaller than the rock-pigeon. The beak is actually 1·7, and proportionally with the size of the body ·1 of an inch shorter than in the rock-pigeons, although of the same thickness. In young birds the scutellæ on the tarsi and toes are generally of a leaden-black colour; and this is a remarkable character (though observed in a lesser degree in some other breeds), as the colour of the legs in the adult state is subject to very little variation in any breed. I have on two or three occasions counted thirteen or fourteen feathers in the tail; this likewise occurs in the barely distinct breed called Helmets. Nuns are symmetrically coloured, with the head, primary wing-feathers, tail, and tail-coverts of the same colour, namely, black or red, and with the rest of the body white. This breed has retained the same character since Aldrovandi wrote in 1600. I have received from Madras almost similarly coloured birds.

Sub-race IV. Spots (die Blasstauben; pigeons heurtés).—These birds are a very little larger than the rock-pigeon, with the beak a trace smaller in all its dimensions, and with the feet decidedly smaller. They are symmetrically coloured, with a spot on the forehead, with the tail and tail-coverts of the same colour, the rest of the body being white. This breed existed in 1676;[22] and in 1735 Moore remarks that they breed truly, as is the case at the present day.

Sub-race V. Swallows.—These birds, as measured from tip to tip of wing, or from the end of the beak to the end of the tail, exceed in size the rock-pigeon; but their bodies are much less bulky; their feet and legs are likewise smaller. The beak is of about the same length, but rather slighter. Altogether their general appearance is considerably different from that of the rock-pigeon. Their heads and wings are of the same colour, the rest of the body being white. Their flight is said to be peculiar. This seems to be a modern breed, which, however, originated before the year 1795 in Germany, for it is described by Bechstein.

Besides the several breeds now described, three or four other very distinct kinds existed lately, or perhaps still exist, in Germany and France. Firstly, the Karmeliten, or carme pigeon, which I have not seen; it is described as of small size, with very short legs, and with an extremely short beak. Secondly, the Finnikin, which is now extinct in England. It had, according to Moore's[23] treatise, published in 1735, a tuft of feathers on the hinder part of the head, which ran down its back not unlike a horse's mane. "When it is salacious it rises over the hen and turns round three or four times, flapping its wings, then reverses and turns as many times the other way." The Turner, on the other hand, when it "plays to the female, turns only one way." Whether these extraordinary statements may be trusted I know not; but the inheritance of any habit may be believed, after what we have seen with respect to the Ground-tumbler of India. MM. Boitard and Corbié describe a pigeon[24] which has the singular habit of sailing for a considerable time through the air, without flapping its wings, like a bird of prey. The confusion is inextricable, from the time of Aldrovandi in 1600 to the present day, in the accounts published of the Draijers, Smiters, Finnikins, Turners, Claquers, etc., which are all remarkable from their manner of flight. Mr. Brent informs me that he has seen one of these breeds in Germany with its wing-feathers injured from having been so often struck together but he did not see it flying. An old stuffed specimen of a Finnikin in the British Museum presents no well-marked character. Thirdly, a singular pigeon with a forked tail is mentioned in some treatises; and as Bechstein[25] briefly describes and figures this bird, with a tail "having completely the structure of that of the house-swallow," it must once have existed, for Bechstein was far too good a naturalist to have confounded any distinct species with the domestic pigeon. Lastly, an extraordinary pigeon imported from Belgium has lately been exhibited at the Philoperisteron Society in London,[26] which "conjoins the colour of an archangel with the head of an owl or barb, its most striking peculiarity being the extraordinary length of the tail and wing-feathers, the latter crossing beyond the tail, and giving to the bird the appearance of a gigantic swift (Cypselus), or long-winged hawk." Mr. Tegetmeier informs me that this bird weighed only 10 ounces, but in length was 15½ inches from tip to beak to end of tail, and 32½ inches from tip to tip of wing; now the wild rock-pigeon weighs 14½ ounces, and measures from tip to beak to end of tail 15 inches, and from tip to tip of wing only 26¾ inches.

I have now described all the domestic pigeons known to me, and have added a few others on reliable authority. I have classed them under four Groups, in order to mark their affinities and degrees of difference; but the third group is artificial. The kinds examined by me form eleven races, which include several sub-races; and even these latter present differences that would certainly have been thought of specific value if observed in a state of nature. The sub-races likewise include many strictly inherited varieties; so that altogether there must exist, as previously remarked, above 150 kinds which can be distinguished, though generally by characters of extremely slight importance. Many of the genera of the Columbidæ, admitted by ornithologists, do not differ in any great degree from each other; taking this into consideration, there can be no doubt that several of the most strongly characterised domestic forms, if found wild, would have been placed in at least five new genera. Thus a new genus would have been formed for the reception of the improved English Pouter: a second genus for Carriers and Runts; and this would have been a wide or comprehensive genus, for it would have admitted common Spanish Runts without any wattle, short-beaked Runts like the Tronfo, and the improved English Carrier: a third genus would have been formed for the Barb: a fourth for the Fantail: and lastly, a fifth for the short beaked, not-wattled pigeons, such as Turbits and short-faced Tumblers. The remaining domestic forms might have been included, in the same genus with the wild rock-pigeon.

Individual Variability; variations of a remarkable nature.

The differences which we have as yet considered are characteristic of distinct breeds; but there are other differences, either confined to individual birds, or often observed in certain breeds but not characteristic of them. These individual differences are of importance, as they might in most cases be secured and accumulated by man's power of selection and thus an existing breed might be greatly modified or a new one formed. Fanciers notice and select only those slight differences which are externally visible; but the whole organisation is so tied together by correlation of growth, that a change in one part is frequently accompanied by other changes. For our purpose, modifications of all kinds are equally important, and if affecting a part which does not commonly vary, are of more importance than a modification in some conspicuous part. At the present day any visible deviation of character in a well-established breed is rejected as a blemish; but it by no means follows that at an early period, before well-marked breeds had been formed, such deviations would have been rejected; on the contrary, they would have been eagerly preserved as presenting a novelty, and would then have been slowly augmented, as we shall hereafter more clearly see, by the process of unconscious selection.

I have made numerous measurements of the various parts of the body in the several breeds, and have hardly ever found them quite the same in birds of the same breed,—the differences being greater than we commonly meet with in wild species within the same district. To begin with the primary feathers of the wing and tail; but I must first mention, as some readers may not be aware of the fact, that the number of the primary wing and tail-feathers in wild birds is generally constant, and characterises, not only whole genera, but even whole families. When the tail-feathers are unusually numerous, as for instance in the swan, they are apt to be variable in number; but this does not apply to the several species and genera of the Columbidæ, which never (as far as I can hear) have less than twelve or more than sixteen tail-feathers; and these numbers characterise, with rare exception, whole sub-families.[27] The wild rock-pigeon has twelve tail-feathers. With Fantails, as we have seen, the number varies from fourteen to forty-two. In two young birds in the same nest I counted twenty-two and twenty-seven feathers. Pouters are very liable to have additional tail-feathers, and I have seen on several occasions fourteen or fifteen in my own birds. Mr. Bult had a specimen, examined by Mr. Yarrell, with seventeen tail-feathers. I had a Nun with thirteen, and another with fourteen tail-feathers; and in a Helmet, a breed barely distinguishable from the Nun, I have counted fifteen, and have heard of other such instances. On the other hand, Mr. Brent possessed a Dragon, which during its whole life never had more than ten tail-feathers; and one of my Dragons, descended from Mr. Brent's, had only eleven. I have seen a Bald-head Tumbler with only ten; and Mr. Brent had an Air-Tumbler with the same number, but another with fourteen tail-feathers. Two of these latter Tumblers, bred by Mr. Brent, were remarkable,—one from having the two central tail-feathers a little divergent, and the other from having the two outer feathers longer by three-eighths of an inch than the others; so that in both cases the tail exhibited a tendency, but in different ways, to become forked. And this shows us how a swallow-tailed breed, like that described by Bechstein, might have been formed by careful selection.

With respect to the primary wing-feathers, the number in the Columbidæ, as far as I can find out, is always nine or ten. In the rock-pigeon it is ten; but I have seen no less than eight short-faced Tumblers with only nine primaries, and the occurrence of this number has been noticed by fanciers, owing to ten primaries of a white colour being one of the points in Short-faced Bald-head-Tumblers. Mr. Brent, however, had an Air-Tumbler (not short-faced) which had in both wings eleven primaries. Mr. Corker, the eminent breeder of prize Carriers, assures me that some of his birds had eleven primaries in both wings. I have seen eleven in one wing in two Pouters. I have been assured by three fanciers that they have seen twelve in Scanderoons; but as Neumeister asserts that in the allied Florence Runt the middle flight-feather is often double, the number twelve may have been caused by two of the ten primaries having each two shafts to a single feather. The secondary wing-feathers are difficult to count, but the number seems to vary from twelve to fifteen. The length of the wing and tail relatively to the body, and of the wings to the tail, certainly varies; I have especially noticed this in Jacobins. In Mr. Bult's magnificent collection of Pouters, the wings and tail varied greatly in length; and were sometimes so much elongated that the birds could hardly play upright. In the relative length of the few first primaries I have observed only a slight degree of variability. Mr. Brent informs me that he has observed the shape of the first feather to vary very slightly. But the variation in these latter points is extremely slight compared with the differences which may be observed in the natural species of the Columbidæ.

In the beak I have seen very considerable differences in birds of the same breed, as in carefully bred Jacobins and Trumpeters. In Carriers there is often a conspicuous difference in the degree of attenuation and curvature of the beak. So it is indeed in many breeds: thus I had two strains of black Barbs, which evidently differed in the curvature of the upper mandible. In width of mouth I have found a great difference in two Swallows. In Fantails of first-rate merit I have seen some birds with much longer and thinner necks than in others. Other analogous facts could be given. We have seen that the oil-gland is aborted in all Fantails (with the exception of the sub-race from Java), and, I may add, so hereditary is this tendency to abortion, that some, although not all, of the mongrels which I reared from the Fantail and Pouter had no oil-gland; in one Swallow out of many which I have examined, and in two Nuns, there was no oil-gland.

The number of the scutellæ on the toes often varies in the same breed, and sometimes even differs on the two feet of the same individual; the Shetland rock-pigeon has fifteen on the middle, and six on the hinder toe; whereas I have seen a Runt with sixteen on the middle and eight on the hind toe; and a short-faced Tumbler with only twelve and five on these same toes. The rock-pigeon has no sensible amount of skin between its toes; but I possessed a Spot and a Nun with the skin extending for a space of a quarter of an inch from the fork, between the two *inner* toes. On the other hand, as will hereafter be more fully shown, pigeons with feathered feet very generally have the bases of their *outer* toes connected by skin. I had a red Tumbler, which had a coo unlike that of its fellows, approaching in tone to that of the Laugher: this bird had the habit, to a degree which I never saw equalled in any other pigeon, of often walking with its wings raised and arched in an elegant-manner. I need say nothing on the great variability, in almost every breed, in size of body, in colour, in the feathering of the feet, and in the feathers on the back of the head being reversed. But I may mention a remarkable Tumbler[28] exhibited at the Crystal Palace, which had an irregular crest of feathers on its head, somewhat like the tuft on the head of the Polish fowl. Mr. Bult reared a hen Jacobin with the feathers on the thigh so long as to reach the ground, and a cock having, but in a lesser degree, the same peculiarity: from these two birds he bred others similarly characterised, which were exhibited at the Philoperisteron Soc. I bred a mongrel pigeon which had fibrous feathers, and the wing and tail-feathers so short and imperfect that the bird could not fly even a foot in height.

There are many singular and inherited peculiarities in the plumage of pigeons: thus Almond-Tumblers do not acquire their perfect mottled feathers until they have moulted three or four times: the Kite Tumbler is at first brindled black and red with a barred appearance, but when "it throws its nest feathers it becomes almost black, generally with a bluish tail, and a reddish colour on the inner webs of the primary wing-feathers."[29] Neumeister describes a breed of a black colour with white bars on the wing and a white crescent-shaped mark on the breast; these marks are generally rusty-red before the first moult, but after the third or fourth moult they undergo a change; the wing-feathers and the crown of the head likewise then become white or grey.[30]

It is an important fact, and I believe there is hardly an exception to the rule, that the especial characters for which each breed is valued are eminently variable: thus, in the Fantail, the number and direction of the tail-feathers, the carriage of the body, and the degree of trembling are all highly variable points; in Pouters, the degree to which they pout, and the shape of their inflated crops; in the Carrier, the length, narrowness, and curvature of the beak, and the amount of wattle; in Short-faced Tumblers, the shortness of the beak, the prominence of the forehead, and general carriage,[31] and in the Almond-Tumbler the colour of the plumage; in common Tumblers, the manner of tumbling; in the Barb, the breadth and shortness of the beak and the amount of eye-wattle; in Runts, the size of body; in Turbits the frill; and lastly in Trumpeters, the cooing, as well as the size of the tuft of feathers over the nostrils. These, which are the distinctive and selected characters of the several breeds, are all eminently variable.

There is another interesting fact with respect to the characters of the several breeds, namely, that they are often most strongly displayed in the male bird. In Carriers, when the males and females are exhibited in separate pens, the wattle is plainly seen to be much more developed in the males, though I have seen a hen Carrier belonging to Mr. Haynes heavily wattled. Mr. Tegetmeier informs me that, in twenty Barbs in Mr. P. H. Jones's possession, the males had generally the largest eye-wattles; Mr. Esquilant also believes in this rule, but Mr. H. Weir, a first-rate judge, entertains some doubt on the subject. Male Pouters distend their crops to a much greater size than do the females; I have, however, seen a hen in the possession of Mr. Evans which pouted excellently; but this is an unusual circumstance. Mr. Harrison Weir, a successful breeder of prize Fantails, informs me that his male birds often have a greater number of tail-feathers than the females. Mr. Eaton asserts[32] that if a cock and hen Tumbler were of equal merit, the hen would be worth double the money; and as pigeons always pair, so that an equal number of both sexes is necessary for reproduction, this seems to show that high merit is rarer in the female than in the male. In the development of the frill in Turbits, of the hood in Jacobins, of the tuft in Trumpeters, of tumbling in Tumblers, there is no difference between the males and females. I may here add a rather different case, namely, the existence in France[33] of a wine-coloured variety of the Pouter, in which the male is generally chequered with black, whilst the female is never so chequered. Dr. Chapuis also remarks[34] that in certain light-coloured pigeons the males have their feathers striated with black, and these striæ increase in size at each moult, so that the male ultimately becomes spotted with black. With Carriers, the wattle, both on the beak and round the eyes, and with Barbs that round the eyes, goes on increasing with age. This augmentation of character with advancing age, and more especially the difference between the males and females in the above-mentioned several respects, are remarkable facts, for there is no sensible difference at any age between the two sexes in the aboriginal rock-pigeon; and not often any strongly marked difference throughout the family of the Columbidæ.[35]

Osteological Characters.

In the skeletons of the various breeds there is much variability; and though certain differences occur frequently, and others rarely, in certain breeds, yet none can be said to be absolutely characteristic of any breed. Considering that strongly-marked domestic races have been formed chiefly by man's selection, we ought not to expect to find great and constant differences in the skeleton; for fanciers neither see, nor do they care for, modifications of structure in the internal framework. Nor ought we to expect changes in the skeletons from changed habits of life; as every facility is given to the most distinct breeds to follow the same habits, and the much modified races are never allowed to wander abroad and procure their own food in various ways. Moreover, I find, on comparing the skeletons of *Columba livia, oenas, palumbus,* and *turtur*, which are ranked by all systematists in two or three distinct though allied genera, that the differences are extremely slight, certainly less than between the skeletons of some of the most distinct domestic breeds. How far the skeleton of the wild rock-pigeon is constant I have had no means of judging, as I have examined only two.

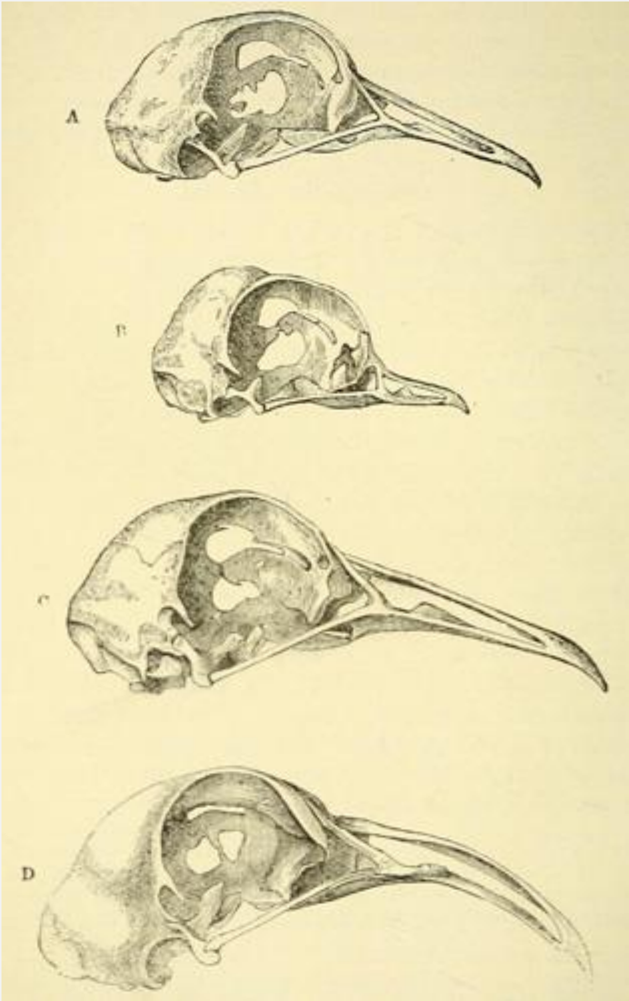


Fig. 24—Skulls of Pigeons, viewed laterally.

Skull.—The individual bones, especially those at the base, do not differ in shape. But the whole skull, in its proportions, outline, and relative direction of the bones, differs greatly in some of the breeds, as may be seen by comparing the figures of (A) the wild rock-pigeon, (B) the Short-faced Tumbler, (C) the English Carrier, and (D) the Bagadotten Carrier (of Neumeister), all drawn of the natural size and viewed laterally. In the Carrier, besides the elongation of the bones of the face, the space between the orbits is proportionally a little narrower than in the rock-pigeon. In the Bagadotten the upper mandible is remarkably arched, and the premaxillary bones are proportionally broader. In the Short-faced Tumbler the skull is more globular: all the bones of the face are much shortened, and the front of the skull and descending nasal bones are almost perpendicular: the maxillo-jugal arch and premaxillary bones form an almost straight line; the space between the prominent edges of the eye-orbits is depressed. In the Barb the premaxillary bones are much shortened, and their anterior portion is thicker than in the rock-pigeon, as is the lower part of the nasal bone. In two Nuns the ascending branches of the premaxillaries, near their tips, were somewhat attenuated, and in these birds, as well as in some others, for instance in the Spot, the occipital crest over the foramen was considerably more prominent than in the rock-pigeon.

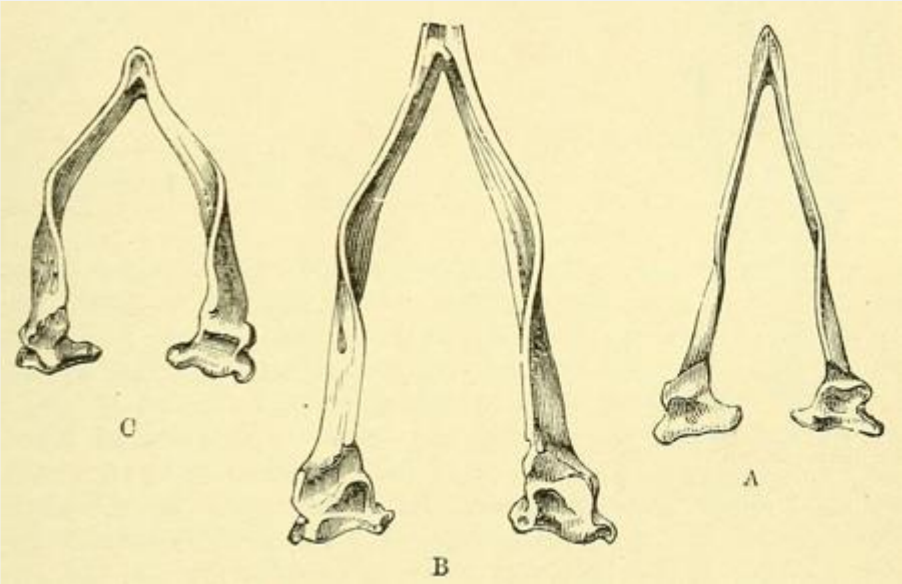


Fig. 25—Lower jaws, seen from above.

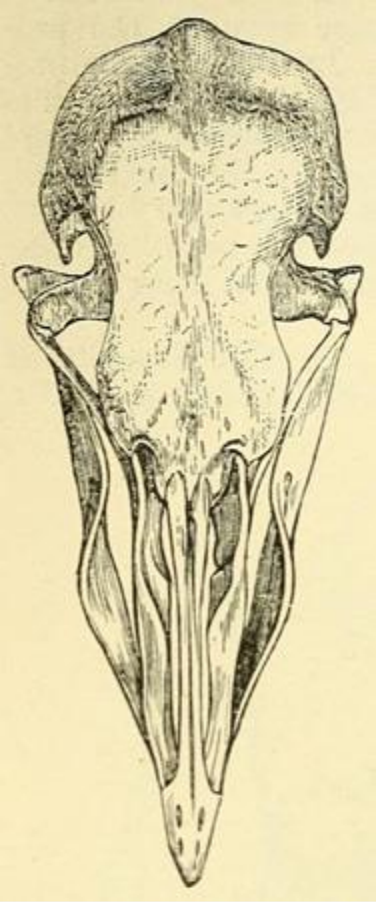


Fig. 26—Skull of Runt.

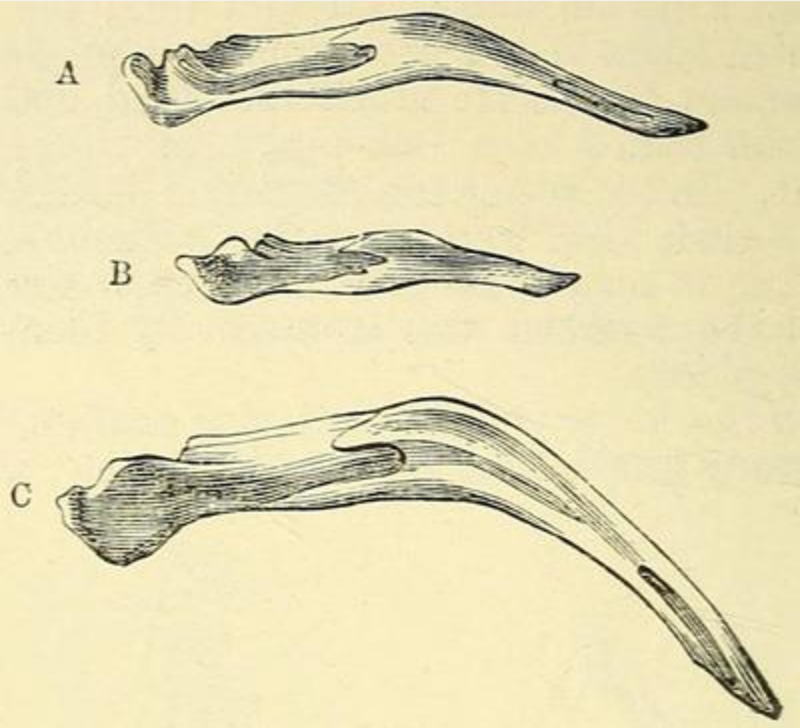


Fig. 27—Lateral view of jaws.

In the lower jaw, the articular surface is proportionably smaller in many breeds than in the rock-pigeon; and the vertical diameter, more especially of the outer part of the articular surface, is considerably shorter. May not this be accounted for by the lessened use of the jaws, owing to nutritious food having been given during a long period to all highly improved pigeons? In Runts, Carriers, and Barbs (and in a lesser degree in several breeds), the whole side of the jaw near the articular end is bent inwards in a highly remarkable manner; and the superior margin of the ramus, beyond the middle, is reflexed in an equally remarkable manner, as may be seen in fig. 25, in comparison with the jaw of the rock-pigeon. This reflection of the upper margin of the lower jaw is plainly connected with the singularly wide gape of the mouth, as has been described in Runts, Carriers, and Barbs. The reflection is well shown in fig. 26 of the head of a Runt seen from above; here a wide open space may be observed on each side, between the edges of the lower jaw and of the premaxillary bones. In the rock-pigeon, and in several domestic breeds, the edges of the lower jaw on each side come close up to the premaxillary bones, so that no open space is left. The degree of downward curvature of the distal half of the lower jaw also differs to an extraordinary degree in some breeds, as may be seen in the drawings (fig. 27 A) of the rock-pigeon, (B) of the Short-faced Tumbler, and (C) of the Bagadotten Carrier of Neumeister. In some Runts the symphysis of the lower jaw is remarkably solid. No one would readily have believed that jaws differing in the several above-specified points so greatly could have belonged to the same species.

Vertebræ.—All the breeds have twelve cervical vertebræ.[36] But in a Bussorah Carrier from India the twelfth vertebra carried a small rib, a quarter of an inch in length, with a perfect double articulation.

The *dorsal vertebræ* are always eight. In the rock-pigeon all eight bear ribs; the eighth rib being very thin, and the seventh having no process. In Pouters all the ribs are extremely broad, eight bear ribs; the eighth rib being very thin and the seventh having no process. In Pouters all the ribs are extremely broad, and, in three out of four skeletons examined by me, the eighth rib was twice or even thrice as broad as in the rock-pigeon; and the seventh pair had distinct processes. In many breeds there are only seven ribs, as in seven out of eight skeletons of various Tumblers, and in several skeletons of Fantails, Turbits and Nuns.>

In all these breeds the seventh pair was very small, and was destitute of processes, in which respect it differed from the same rib in the rock-pigeon. In one Tumbler, and in the Bussorah Carrier, even the sixth pair had no process. The hypapophysis of the second dorsal vertebra varies much in development; being sometimes (as in several, but not all Tumblers) nearly as prominent as that of the third dorsal vertebra; and the two hypapophyses together tend to form an ossified arch. The development of the arch, formed by the hypapophyses of the third and fourth dorsal vertebræ, also varies considerably, as does the size of the hypapophysis of the fifth vertebra.

The rock-pigeon has twelve sacral vertebræ; but these vary in number, relative size, and distinctness, in the different breeds. In Pouters, with their elongated bodies, there are thirteen or even fourteen, and, as we shall immediately see, an additional number of caudal vertebræ. In Runts and Carriers there is generally the proper number, namely twelve; but in one Runt, and in the Bussorah Carrier, there were only eleven. In Tumblers there are either eleven, or twelve, or thirteen sacral vertebræ.

The *caudal vertebræ* are seven in number in the rock-pigeon. In Fantails, which have their tails so largely developed, there are eight or nine, and apparently in one case ten, and they are a little longer than in the rock-pigeon, and their shape varies considerably. Pouters, also, have eight or nine caudal vertebræ. I have seen eight in a Nun and Jacobin. Tumblers, though such small birds, always have the normal number seven; as have Carriers, with one exception, in which there were only six.

The following table will serve as a summary, and will show the most remarkable deviations in the number of the vertebra and ribs which I have observed:—

	Rock Pigeon.	Pouter, from Mr. Bult.	Tumbler, Dutch Roller.	Bussorah Carrier.
Cervical Vertebræ	12	12	12	12 The 12th bore a small rib.

Dorsal Vertebræ	8	8	8	8
Dorsal Ribs	8 The 6th pair with processes, the 7th pair without a process.	8 The 6th and 7th pair with processes.	7 The 6th and 7th pair without processes.	7 The 6th and 7th pair without processes.
Sacral Vertebræ	12	14	11	11
Caudal Vertebræ	7	8 or 9	7	7
Total Vertebræ	39	42 or 43	38	38

The *pelvis* differs very little in any breed. The anterior margin of the ilium, however, is sometimes a little more equally rounded on both sides than in the rock-pigeon. The ischium is also frequently rather more elongated. The obturator-notch is sometimes, as in many Tumblers, less developed than in the rock-pigeon. The ridges on the ilium are very prominent in most Runts.

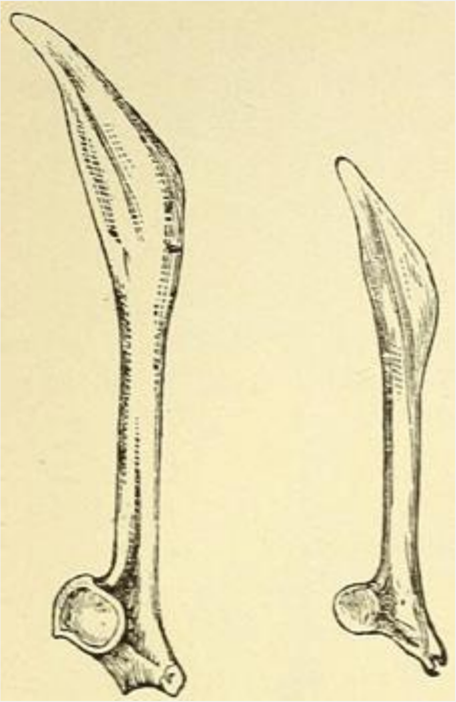


Fig. 28—Scapulæ of Pigeons.

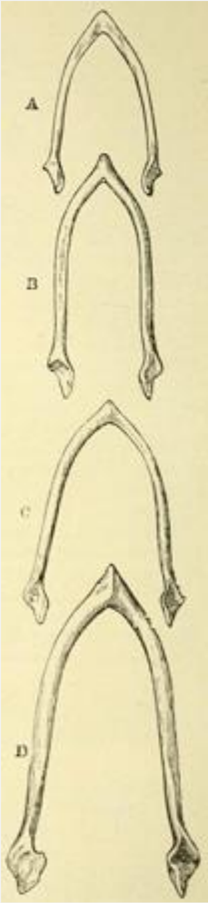


Fig. 29—Furcula of Pigeons.

In the bones of the extremities I could detect no difference, except in their proportional lengths; for instance, the metatarsus in a Pouter was 1·65 inch, and in a Short-faced Tumbler only ·95 in length; and this is a greater difference than would naturally follow from their differently-sized bodies; but long legs in the Pouter, and small feet in the Tumbler, are selected points. In some Pouters the *scapula* is rather straighter, and in some Tumblers it is straighter, with the apex less elongated, than in the rock-pigeon: in fig. 28, the scapula of the rock-pigeon (A), and of a short-faced Tumbler (B), are given. The processes at the summit of the *coracoid*, which receive the extremities of the furculum, form a more perfect cavity in some Tumblers than in the rock-pigeon: in Pouters these processes are larger and differently shaped, and the exterior angle of the extremity of the coracoid, which is articulated to the sternum, is squarer.

The two arms of the *furculum* in Pouters diverge less, proportionally to their length, than in the rock-pigeon; and the symphysis is more solid and pointed. In Fantails the degree of divergence of the two arms varies in a remarkable manner. In fig. 29, B and C represent the furcula of two Fantails; and it will be seen that the divergence in B is rather less even than in the furculum of the short-faced, small-sized Tumbler (A), whereas the divergence in C equals that in a rock-pigeon, or in the Pouter (D), though the latter is a much larger bird. The extremities of the furculum, where articulated to the coracoids, vary considerably in outline.

In the *sternum* the differences in form are slight, except in the size and outline of the perforations, which, both in the larger and lesser sized breeds, are sometimes small. These perforations, also, are sometimes either nearly circular, or elongated as is often the case with Carriers. The posterior perforations occasionally are not complete, being left open posteriorly. The marginal apophyses forming the anterior perforations vary greatly in development. The degree of convexity of the posterior part of the sternum differs much, being sometimes almost perfectly flat. The manubrium is rather more prominent in some individuals than in others, and the pore immediately under it varies greatly in size.

Correlation of Growth.—By this term I mean that the whole organisation is so connected, that when one part varies, other parts vary; but which of two correlated variations ought to be looked at as the cause and which as the effect, or whether both result from some common cause, we can seldom or never tell. The point of interest for us is that, when fanciers, by the continued selection of slight variations, have largely modified one part, they often unintentionally produce other modifications. For instance, the beak is readily acted on by selection, and, with its increased or diminished length, the tongue increases or diminishes, but not in due proportion; for, in a Barb and Short-faced Tumbler, both of which have very short beaks, the tongue, taking the rock-pigeon as the standard of comparison, was proportionally not shortened enough, whilst in two Carriers and in a Runt the tongue, proportionally with the beak, was not lengthened enough, thus, in a first-rate English Carrier, in which the beak from the tip to the feathered base was exactly thrice as long as in a first-rate Short-faced Tumbler, the tongue was only a little more than twice as long. But the tongue varies in length independently of the beak: thus in a Carrier with a beak 1·2 inch in length, the tongue was ·67 in length: whilst in a Runt which equalled the Carrier in length of body and in stretch of wings from tip to tip, the beak was ·92 whilst the tongue was ·73 of an inch in length, so that the tongue was actually longer than in the carrier with its long beak. The tongue of the Runt was also very broad at the root. Of two Runts, one had its beak longer by ·23 of an inch, whilst its tongue was shorter by ·14 than in the other.

With the increased or diminished length of the beak the length of the slit forming the external orifice of the nostrils varies, but not in due proportion, for, taking the rock-pigeon as the standard, the orifice in a Short-faced Tumbler was not shortened in due proportion with its very short beak. On the other hand (and this could not have been anticipated), the orifice in three English Carriers, in the Bagadotten Carrier, and in a Runt (*pigeon cygne*), was longer by above the tenth of an inch than would follow from the length of the beak proportionally with that of the rock-pigeon. In one Carrier the orifice of the nostrils was thrice as long as in the rock-pigeon, though in body and length of beak this bird was not nearly double the size of the rock-pigeon. This greatly increased length of the orifice of the nostrils seems to stand partly in correlation with the enlargement of the wattled skin on the upper mandible and over the nostrils; and this is a character which is selected by fanciers. So again, the broad, naked, and wattled skin round the eyes of Carriers and Barbs is a selected character; and in obvious correlation with this, the eyelids, measured longitudinally, are proportionally more than double the length of those of the rock-pigeon.

The great difference (see fig. 27) in the curvature of the lower jaw in the rock-pigeon, the Tumbler, and Bagadotten Carrier, stands in obvious relation to the curvature of the upper jaw, and more especially to the angle formed by the maxillo-jugal arch with the premaxillary bones. But in Carriers, Runts, and Barbs the singular reflexion of the upper margin of the middle part of the lower jaw (see fig. 25) is not strictly correlated with the width or divergence (as may be clearly seen in fig. 26) of the premaxillary bones, but with the breadth of the horny and soft parts of the upper mandible, which are always overlapped by the edges of the lower mandible.

In Pouters, the elongation of the body is a selected character, and the ribs, as we have seen, have generally become very broad, with the seventh pair furnished with processes; the sacral and caudal vertebræ have been augmented in number; the sternum has likewise increased in length (but not in the depth of the crest) by ·4 of an inch more than would follow from the greater bulk of the body in comparison with that of the rock-pigeon. In Fantails, the length and number of the caudal vertebræ have increased. Hence, during the gradual progress of variation and selection, the internal bony framework and the external shape of the body have been, to a certain extent, modified in a correlated manner.

Although the wings and tail often vary in length independently of each other, it is scarcely possible to doubt that they generally tend to become elongated or shortened in correlation. This is well seen in Jacobins, and still more plainly in Runts, some varieties of which have their wings and tail of great length, whilst others have both very short. With Jacobins, the remarkable length of the tail and wing-feathers is not a character which is intentionally selected by fanciers; but fanciers have been trying for centuries, at least since the year 1600, to increase the length of the reversed feathers on the neck, so that the hood may more completely enclose the head; and it may be suspected that the increased length of the wing and tail-feathers stand in correlation with the increased length of the neck-feathers. Short-faced Tumblers have short wings in nearly due proportion with the reduced size of their bodies; but it is remarkable, seeing that the number of the primary wing-feathers is a constant character in most birds, that these Tumblers generally have only nine instead of ten primaries. I have myself observed this in eight birds; and the Original Columbarian Society[37] reduced the standard for Bald-head Tumblers from ten to nine white flight-feathers, thinking it unfair that a bird which had only nine feathers should be disqualified for a prize because it had not ten *white* flight-feathers. On the other hand, in Carriers and Runts, which have large bodies and long wings, eleven primary feathers have occasionally been observed.

Mr. Tegetmeier has informed me of a curious and inexplicable case of correlation, namely, that young pigeons of all breeds which when mature become white, yellow, silver (*i.e.,* extremely pale blue), or dun-coloured, are born almost naked; whereas pigeons of other colours are born well-clothed with down. Mr. Esquilant, however, has observed that young dun Carriers are not so bare as young dun Barbs and Tumblers. Mr. Tegetmeier has seen two young birds in the same nest, produced from differently coloured parents, which differed greatly in the degree to which they were at first clothed with down.

I have observed another case of correlation which at first sight appears quite inexplicable, but on which, as we shall see in a future chapter, some light can be thrown by the law of homologous parts varying in the same manner. The case is, that, when the feet are much feathered, the roots of the feathers are connected by a web of skin, and apparently in correlation with this the two outer toes become connected for a considerable space by skin. I have observed this in very many specimens of Pouters, Trumpeters, Swallows, Roller-tumblers (likewise observed in this breed by Mr. Brent), and in a lesser degree in other feather-footed pigeons.

The feet of the smaller and larger breeds are of course much smaller or larger than those of the rock-pigeon; but the scutellæ or scales covering the toes and tarsi have not only decreased or increased in size, but likewise in number. To give a single instance, I have counted eight scutellæ on the hind toe of a Runt, and only five on that of a Short-faced Tumbler. With birds in a state of nature the number of the scutellæ on the feet is usually a constant character. The length of the feet and the length of the beak apparently stand in correlation; but as disuse apparently has affected the size of the feet, this case may come under the following discussion.

On the Effects of Disuse.—In the following discussion on the relative proportions of the feet, sternum, furculum, scapulæ, and wings, I may premise, in order to give some confidence to the reader, that all my measurements were made in the same manner, and that they were made without the least intention of applying them to the following purpose.

Table I.

Pigeons with their beaks generally shorter than that of the Rock-pigeon, proportionally to the size of their bodies.

Name of Breed.	Actual length of Feet	Difference between actual and calculated length of feet, in proportion to length of feet and size of body in the Rock-pigeon.

		Too short by	Too long by
Wild rock-pigeon (mean measurement)	2·02		
Short-faced Tumbler, blad-head	1·57	0·11	—
Short-faced Tumbler, almond	1·60	0·16	—
Tumbler, red magpie	1·75	0·19	—
Tumbler, red common (by standard to end of tail)	1·85	0·07	—
Tumbler, common bald-head	1·85	0·18	—
Tumbler, roller	1·80	0·06	—
Turbit	1·75	0·17	—
Turbit	1·80	0·01	—
Turbit	1·84	0·15	—
Jacobin	1·90	0·02	—
Trumpeter, white	2·02	0·06	—
Trumpeter, mottled	1·95	0·18	—
Fantail (by standard to end of tail)	1·85	0·15	—
Fantail (by standard to end of tail)	1·95	0·15	—
Fantail crested va. (by standard to end of tail)	1·95	0·0	0·0
Indian Frill-back (by standard to end of tail)	1·80	0·19	—
English Frill-back	2·10	0·03	—
Nun	1·82	0·02	—
Laugher	1·65	0·16	—
Barb	2·00	0·03	—

Barb	2·00	—	0·03
Spot	1·90	0·02	—
Spot	1·90	0·07	—
Swallow, red	1·85	0·18	—
Swallow, blue	2·00	—	0·03
Pouter	2·42	—	0·11
Pouter, German	2·30	—	0·09
Bussorah Carrier	2·17	—	0·09
Number of specimens	28	22	5

I measured most of the birds which came into my possession, from the feathered *base* of the beak (the length of beak itself being so variable) to the end of the tail, and to the oil-gland, but unfortunately (except in a few cases) not to the root of the tail; I measured each bird from the extreme tip to tip of wing; and the length of the terminal folded part of the wing, from the extremity of the primaries to the joint of the radius. I measured the feet without the claws, from the end of the middle toe to the end of the hind toe; and the tarsus and middle toe together. I have taken in every case the mean measurement of two wild rock-pigeons from the Shetland Islands, as the standard of comparison. The following table shows the actual length of the feet in each bird; and the difference between the length which the feet ought to have had according to the size of body of each, in comparison with the size of body and length of feet of the rock-pigeon, calculated (with a few specified exceptions) by the standard of the length of the body from the base of the beak to the oil-gland. I have preferred this standard, owing to the variability of the length of tail. But I have made similar calculations, taking as the standard the length from tip to tip of wing, and likewise in most cases from the base of the beak to the end of the tail; and the result has always been closely similar. To give an example: the first bird in the table, being a Short-faced Tumbler, is much smaller than the rock-pigeon, and would naturally have shorter feet; but it is found on calculation to have feet too short by ·11 of an inch, in comparison with the feet of the rock-pigeon, relatively to the size of the body in these two birds, as measured from the base of beak to the oil-gland. So again, when this same Tumbler and the rock-pigeon were compared by the length of their wings, or by the extreme length of their bodies, the feet of the Tumbler were likewise found to be too short in very nearly the same proportion. I am well aware that the measurements pretend to greater accuracy than is possible, but it was less trouble to write down the actual measurements given by the compasses in each case than an approximation.

Table II.

Pigeons with their beaks longer than that of the Rock-pigeon, proportionally to the size of their bodies.

Name of Breed.	Actual length of Feet	Difference between actual and calculated length of feet, in proportion to length of feet and size of body in the Rock-pigeon.	
		Too short by	Too long by
Wild rock-pigeon (mean measurement)	2·02		
Short-faced Tumbler, bald-head	1·57	0·11	—
Carrier	2·60	—	0·31
Carrier	2·60	—	0·25
Carrier	2·40	—	0·21
Carrier Dragon	2·25	—	0·06
Bagadotten Carrier	2·80	—	0·56
Scanderoon, white	2·80	—	0·37
Scanderoon, Pigeon cygne	2·85	—	0·29
Runt	2·75	—	0·27
Number of specimens	8	—	8

In these two tables (Tables I and II) we see in the first column the actual length of the feet in thirty-six birds belonging to various breeds, and in the two other columns we see by how much the feet are too short or too long, according to the size of bird, in comparison with the rock-pigeon. In the first table twenty-two specimens have their feet too short, on an average by a little above the tenth of an inch (viz. ·107); and five specimens have their feet on an average a very little too long, namely, by ·07 of an inch. But some of these latter cases can be explained; for instance, with Pouters the legs and feet are selected for length, and thus any natural tendency to a diminution in the length of the feet will have been counteracted. In the Swallow and Barb, when the calculation was made on any standard of comparison besides the one used (viz. length of body from base of beak to oil-gland), the feet were found to be too small.

In the second table we have eight birds, with their beaks much longer than in the rock-pigeon, both actually and proportionally with the size of body, and their feet are in an equally marked manner longer, namely, in proportion, on an average by ·29 of an inch. I should here state that in Table I there are a few partial exceptions to the beak being proportionally shorter than in the rock-pigeon: thus the beak of the English Frill-back is just perceptibly longer, and that of the Bussorah Carrier of the same length or slightly longer, than in the rock-pigeon. The beaks of Spots, Swallows, and Laughers are only a very little shorter, or of the same proportional length, but slenderer. Nevertheless, these two tables, taken conjointly, indicate pretty plainly some kind of correlation between the length of the beak and the size of the feet. Breeders of cattle and horses believe that there is an analogous connection between the length of the limbs and head; they assert that a race-horse with the head of a dray-horse, or a grey-hound with the head of a bulldog, would be a monstrous production. As fancy pigeons are generally kept in small aviaries, and are abundantly supplied with food, they must walk about much less than the wild rock-pigeon; and it may be admitted as highly probable that the reduction in the size of the feet in the twenty-two birds in the first table has been caused by disuse,[38] and that this reduction has acted by correlation on the beaks of the great majority of the birds in Table I. When, on the other hand, the beak has been much elongated by the continued selection of successive slight increments of length, the feet by correlation have likewise become much elongated in comparison with those of the wild rock-pigeon, notwithstanding their lessened use.

As I had taken measures from the end of the middle toe to the heel of the tarsus in the rock-pigeon and in the above thirty-six birds, I have made calculations analogous with those above given, and the result is the same— namely, that in the short-beaked breeds, with equally few exceptions as in the former case, the middle toe conjointly with the tarsus has decreased in length; whereas in the long-beaked breeds it has increased in length, though not quite so uniformly as in the former case, for the leg, in some varieties of the Runt varies much in length.

As fancy pigeons are generally confined in aviaries of moderate size, and as even when not confined they do not search for their own food, they must during many generations have used their wings incomparably less than the wild rock-pigeon. Hence it seemed to me probable that all the parts of the skeleton subservient to flight would be found to be reduced in size. With respect to the sternum, I have carefully measured its extreme length in twelve birds of different breeds, and in two wild rock-pigeons from the Shetland Islands. For the proportional comparison I have tried three standards of measurement, with all twelve birds namely, the length from the base of the beak to the oil-gland, to the end of the tail, and from the extreme tip to tip of wings. The result has been in each case nearly the same, the sternum being invariably found to be shorter than in the wild rock-pigeon. I will give only a single table, as calculated by the standard from the base of the beak to the oil-gland; for the result in this case is nearly the mean between the results obtained by the two other standards.

Length of Sternum.

Name of Breed	Actual Length. Inches	Too short by
Wild Rock-pigeon	2·55	—
Wild Rock-pigeon	2·55	—
Pied Scanderoon	2·80	0·60
Bagadotten Carrier	2·80	0·17
Dragon	2·45	0·41
Carrier	2·75	0·35
Short-faced Tumbler	2·05	0·28
Barb	2·35	0·34
Nun	2·27	0·15
German Pouter	2·36	0·54
Jacobin	2·33	0·22
English Frill-back	2·40	0·43
Swallow	2·45	0·17

This table shows that in these twelve breeds the sternum is of an average one-third of an inch (exactly ·332) shorter than in the rock-pigeon, proportionally with the size of their bodies; so that the sternum has been reduced by between one-seventh and one-eighth of its entire length; and this is a considerable reduction.

I have also measured in twenty-one birds, including the above dozen, the prominence of the crest of the sternum relatively to its length, independently of the size of the body.

In two of the twenty-one birds the crest was prominent in the same relative degree as in the rock-pigeon; in seven it was more prominent; but in five out of these seven, namely, in a Fantail, two Scanderoons, and two English Carriers, this greater prominence may to a certain extent be explained, as a prominent breast is admired and selected by fanciers; in the remaining twelve birds the prominence was less. Hence it follows that the crest exhibits a slight, though uncertain, tendency to be reduced in prominence in a greater degree than does the length of the sternum relatively to the size of body, in comparison with the rock-pigeon.

I have measured the length of the scapula in nine different large and small-sized breeds, and in all the scapula is proportionally shorter (taking the same standard as before) than in the wild rock-pigeon. The reduction in length on an average is very nearly one-fifth of an inch, or about one-ninth of the length of the scapula in the rock-pigeon.

The arms of the furcula in all the specimens which I compared, diverged less, proportionally with the size of body, than in the rock-pigeon; and the whole furculum was proportionally shorter. Thus in a Runt, which measured from tip to tip of wings 38½ inches, the furculum was only a very little longer (with the arms hardly more divergent) than in a rock-pigeon which measured from tip to tip 26½ inches. In a Barb, which in all its measurements was a little larger than the same rock-pigeon, the furculum was a quarter of an inch shorter. In a Pouter, the furculum had not been lengthened proportionally with the increased length of the body. In a Short-faced Tumbler, which measured from tip to tip of wings 24 inches, therefore only 2½ inches less than the rock-pigeon, the furculum was barely two-thirds of the length of that of the rock-pigeon.

We thus clearly see that the sternum, scapula, and furculum are all reduced in proportional length; but when we turn to the wings we find what at first appears a wholly different and unexpected result. I may here remark that I have not picked out specimens, but have used every measurement made by me. Taking the length from the base of beak to the end of the tail as the standard of comparison, I find that, out of thirty-five birds of various breeds, twenty-five have wings of greater, and ten have them of less proportional length, than in the rock-pigeon. But from the frequently correlated length of the tail and wing-feathers, it is better to take as the standard of comparison the length from the base of the beak to the oil-gland; and by this standard, out of twenty-six of the same birds which had been thus measured, twenty-one had wings too long, and only five had them too short. In the twenty-one birds the wings exceeded in length those of the rock-pigeon, on an average, by 1-1/3 inch; whilst in the five birds they were less in length by only ·8 of an inch. As I was much surprised that the wings of closely confined birds should thus so frequently have been increased in length, it occurred to me that it might be solely due to the greater length of the wing-feathers; for this certainly is the case with the Jacobin, which has wings of unusual length. As in almost every case I had measured the folded wings, I subtracted the length of this terminal part from that of the expanded wings, and thus I obtained, with a moderate degree of accuracy, the length of the wings from the ends of the two radii, answering from wrist to wrist in our arms. The wings, thus measured in the same twenty-five birds, now gave a widely different result; for they were proportionally with those of the rock-pigeon too short in seventeen birds, and in only eight too long. Of these eight birds, five were long-beaked,[39] and this fact perhaps indicates that there is some correlation of the length of the beak with the length of the bones of the wings, in the same manner as with that of the feet and tarsi. The shortening of the humerus and radius in the seventeen birds may probably be attributed to disuse, as in the case of the scapula and furculum to which the wing-bones are attached;—the lengthening of the wing-feathers, and consequently the expansion of the wings from tip to tip, being, on the other hand, as completely independent of use and disuse as is the growth of the hair or wool on our long-haired dogs or long-woolled sheep.

To sum up: we may confidently admit that the length of the sternum, and frequently the prominence of its crest, the length of the scapula and furculum, have all been reduced in size in comparison with the same parts in the rock-pigeon. And I presume that this may be attributed to disuse or lessened exercise. The wings, as measured from the ends of the radii, have likewise been generally reduced in length; but, owing to the increased growth of the wing-feathers, the wings, from tip to tip, are commonly longer than in the rock-pigeon. The feet, as well as the tarsi conjointly with the middle toe, have likewise in most cases become reduced; and this it is probable has been caused by their lessened use; but the existence of some sort of correlation between the feet and beak is shown more plainly than the effects of disuse. We have also some faint indication of a similar correlation between the main bones of the wing and the beak.

Summary on the Points of Difference between the several Domestic Races, and between the individual Birds.—The beak, together with the bones of the face, differ remarkably in length, breadth, shape, and curvature. The skull differs in shape, and greatly in the angle formed by the union of the pre-maxillary, nasal, and maxillo-jugal bones. The curvature of the lower jaw and the reflection of its upper margin, as well as the gape of the mouth, differ in a highly remarkable manner. The tongue varies much in length, both independently and in correlation with the length of the beak. The development of the naked, wattled skin over the nostrils and round the eyes varies in an extreme degree. The eyelids and the external orifices of the nostrils vary in length, and are to a certain extent correlated with the degree of development of the wattle. The size and form of the œsophagus and crop, and their capacity for inflation, differ immensely. The length of the neck varies. With the varying shape of the body, the breadth and number of the ribs, the presence of processes, the number of the sacral vertebræ, and the length of the sternum, all vary. The number and size of the coccygeal vertebræ vary, apparently in correlation with the increased size of the tail. The size and shape of the perforations in the sternum, and the size and divergence of the arms of the furculum, differ. The oil-gland varies in development, and is sometimes quite aborted. The direction and length of certain feathers have been much modified, as in the hood of the

Jacobin and the frill of the Turbit. The wing and tail-feathers generally vary in length together, but sometimes independently of each other and of the size of the body. The number and position of the tail-feather vary to an unparalleled degree. The primary and secondary wing-feathers occasionally vary in number, apparently in correlation with the length of the wing. The length of the leg and the size of the feet, and, in connection with the latter, the number of the scutellæ, all vary. A web of skin sometimes connects the bases of the two inner toes, and almost invariably the two outer toes when the feet are feathered.

The size of the body differs greatly: a Runt has been known to weigh more than five times as much as a Short-faced Tumbler. The eggs differ in size and shape. According to Parmentier,[40] some races use much straw in building their nests, and others use little; but I cannot hear of any recent corroboration of this statement. The length of time required for hatching the eggs is uniform in all the breeds. The period at which the characteristic plumage of some breeds is acquired, and at which certain changes of colour supervene, differs. The degree to which the young birds are clothed with down when first hatched is different, and is correlated in a singular manner with the colour of the plumage. The manner of flight, and certain inherited movements, such as clapping the wings, tumbling either in the air or on the ground, and the manner of courting the female, present the most singular differences. In disposition the several races differ. Some races are very silent; others coo in a highly peculiar manner.

Although many different races have kept true in character during several centuries, as we shall hereafter more fully see, yet there is far more individual variability in the most constant breeds than in birds in a state of nature. There is hardly any exception to the rule that those characters vary most which are now most valued and attended to by fanciers, and which consequently are now being improved by continued selection. This is indirectly admitted by fanciers when they complain that it is much more difficult to breed high fancy pigeons up to the proper standard of excellence than the so-called toy pigeons, which differ from each other merely in colour; for particular colours when once acquired are not liable to continued improvement or augmentation. Some characters become attached, from quite unknown causes, more strongly to the male than to the female sex; so that we have in certain races, a tendency towards the appearance of secondary sexual characters,[41] of which the aboriginal rock-pigeon displays not a trace.

REFERENCES

[1] The Hon. C. Murray has sent me some very valuable specimens from Persia; and H.M. Consul, Mr. Keith Abbott, has given me information on the pigeons of the same country. I am deeply indebted to Sir Walter Elliot for an immense collection of skins from Madras, with much information regarding them. Mr. Blyth has freely communicated to me his stores of knowledge on this and all other related subjects. The Rajah Sir James

Brooke sent me specimens from Borneo, as has H.M. Consul, Mr. Swinhoe, from Amoy in China, and Dr. Daniell from the west coast of Africa.

[2] Mr. B. P. Brent, well known for his various contributions to poultry literature, has aided me in every way during several years: so has Mr. Tegetmeier, with unwearied kindness. This latter gentleman, who is well known for his works on poultry, and who has largely bred pigeons, has looked over this and the following chapters. Mr. Bult formerly showed me his unrivalled collection of Pouters, and gave me specimens. I had access to Mr. Wicking's collection, which contained a greater assortment of kinds than could anywhere else be seen; and he has always aided me with specimens and information given in the freest manner. Mr. Haynes and Mr. Corker have given me specimens of their magnificent Carriers. To Mr. Harrison Weir I am likewise indebted. Nor must I by any means pass over the assistance received from Mr. J. M. Eaton, Mr. Baker, Mr. Evans, and Mr. J. Baily, jun., of Mount-street—to the latter gentleman I have been indebted for some valuable specimens. To all these gentlemen I beg permission to return my sincere and cordial thanks.

[3] 'Les Pigeons de Volière et de Colombier' Paris 1824. During forty-five years the sole occupation of M. Corbié was the care of the pigeons belonging to the Duchess of Berry. Bonizzi has described a large number of coloured varieties in Italy: 'Le variazioni dei colombi Domestici,' Padova, 1873.

[4] 'Coup d'Oeil sur l'Ordre des Pigeons' par Prince C. L. Bonaparte, Paris, 1855. This author makes 288 species, ranked under 85 genera.

[5] As I so often refer to the size of the *C. livia*, or rock-pigeon, it may be convenient to give the mean between the measurements of two wild birds, kindly sent me by Dr. Edmondstone from the Shetland Islands.

	Inches
From feathered base of beak to end of tail:	14·25
From feathered base of beak to oil-gland:	9·50
From tip of beak to end of tail:	15·02
Of tail-feathers:	4·62
From tip to tip of wing:	26·75
Of folded wing:	9·25
Beak:	
Length from tip of beak to feathered base:	·77
Thickness, measured vertically at distal end of nostrils:	·23

Breadth, measured at same place:	·16
Feet:	
From end of middle toe (without claw) to distal end of tibia:	2·77
From end of middle toe to end of hind toe (without claws):	2·02

Weight: 14-1/4 ounces.

[6] This drawing was made from a dead bird. The six following figures were drawn with great care by Mr. Luke Wells from living birds selected by Mr. Tegetmeier. It may be confidently asserted that the characters of the six breeds which have been figured are not in the least exaggerated.

[7] ‘Das Ganze der Taubenzucht:’ Weimar, 1837, pl. 11 and 12.

[8] Boitard and Corbié, ‘Les Pigeons,’ etc., p. 177, pl. 6.

[9] ‘Die Taubenzucht,’ Ulm, 1824, s. 42.

[10] This treatise was written by Sayzid Mohammed Musari, who died in 1770: I owe to the great kindness of Sir W. Elliot a translation of this curious treatise.

[11] ‘Poultry Chronicle,’ vol. 2, p. 573.

[12] ‘Annals and Mag. of Nat. History,’ vol. xix, 1847, p. 105.

[13] This gland occurs in most birds; but Nitzsch (in his ‘Pterylographie,’ 1840, p. 55) states that it is absent in two species of Columba, in several species of Psittacus, in some species of Otis, and in most or all birds of the Ostrich family. It can hardly be an accidental coincidence that the two species of Columba, which are destitute of an oil-gland, have an unusual number of tail-feathers, namely 16, and in this respect resemble Fantails.

[14] *See* the two excellent editions published by Mr. J. M. Eaton in 1852 and 1858, entitled ‘A Treatise on Fancy Pigeons.’

[15] English translation, by F. Gladwin, 4th edition, vol. i. The habit of the Lotan is also described in the Persian treatise before alluded to, published about 100 years ago: at this date the Lotans were generally white and crested as at present. Mr. Blyth describes these birds in ‘Annals and Mag. of Nat. Hist.,’ vol. xiv., 1847, p. 104; he says that they “may be seen at any of the Calcutta bird-dealers.”

[16] ‘Journal of Horticulture,’ Oct. 22, 1861, p. 76.

[17] *See* the account of the House-tumblers kept at Glasgow, in the ‘Cottage Gardener,’ 1858, p. 285. Also Mr. Brent’s paper, ‘Journal of Horticulture,’ 1861, p. 76.

[18] J. M. Eaton, 'Treatise on Pigeons,' 1852, p. 9.

[19] J. M. Eaton, 'Treatise,' edit. 1858, p. 76.

[20] Neumeister, 'Taubenzucht,' tab. 4. fig. i.

[21] Riedel, 'Die Taubenzucht,' 1824, s. 26. Bechstein, 'Naturgeschichte Deutschlands,' Band iv. s. 36, 1795.

[22] Willughby's 'Ornithology,' edited by Ray.

[23] J. M. Eaton's edition (1858) of Moore, p. 98.

[24] Pigeon pattu plongeur. 'Les Pigeons,' etc., p. 165.

[25] 'Naturgeschichte Deutschlands,' Band iv. s. 47.

[26] Mr. W. B. Tegetmeier, 'Journal of Horticulture,' Jan. 20, 1863, p. 58.

[27] 'Coup-d'œil sur L'Ordre des Pigeons,' par C. L. Bonaparte ('Comptes Rendus'), 1854-55. Mr. Blyth, in 'Annals of Nat. Hist.,' vol. xix., 1847, p. 41, mentions, as a very singular fact, "that of the two species of Ectopistes, which are nearly allied to each other, one should have fourteen tail-feathers, while the other, the passenger pigeon of North America, should possess but the usual number—twelve."

[28] Described and figured in the 'Poultry Chronicle,' vol. iii., 1855, p. 82.

[29] 'The Pigeon Book,' by Mr. B. P. Brent, 1859, p. 41.

[30] 'Die staarhälsige Taube. Das Ganze, etc.,' s. 21, tab. i. fig. 4.

[31] 'A Treatise on the Almond-Tumbler,' by J. M. Eaton, 1852, p. 8, *et passim.*

[32] 'A Treatise, etc.,' p. 10.

[33] Boitard and Corbié 'Les Pigeons,' etc., 1824, p. 173.

[34] 'Le Pigeon Voyageur Belge,' 1865, p. 87. I have given in my 'Descent of Man' (6th edit. p. 466) some curious cases, on the authority of Mr. Tegetmeier, of silver-coloured (*i.e.* very pale blue) birds being generally females, and of the ease with which a race thus characterised could be produced. Bonizzi (*see* 'Variazioni dei Columbi domestici:' Padova, 1873) states that certain coloured spots are often different in the two sexes, and the certain tints are commoner in females than in male pigeons.

[35] Prof. A. Newton ('Proc. Zoolog. Soc.,' 1865, p. 716) remarks that he knows no species which present any remarkable sexual distinction; but Mr. Wallace informs me, that in the sub-family of the Treronidæ the sexes often differ considerably in colour. *See also* on sexual differences in the

Columbidæ, Gould, ‘Handbook to the Birds of Australia,’ vol. ii., pp. 109-149.

[36] I am not sure that I have designated the different kinds of vertebræ correctly: but I observe that different anatomists follow in this respect different rules, and, as I use the same terms in the comparison of all the skeletons, this, I hope, will not signify.

[37] J. M. Eaton’s ‘Treatise,’ edit. 1858, p. 78.

[38] In an analogous, but converse, manner, certain natural groups of the Columbidæ, from being more terrestrial in their habits than other allied groups, have larger feet. *See* Prince Bonaparte’s ‘Coup d’œil sur l’Ordre des Pigeons.’

[39] It perhaps deserves notice that besides these five birds two of the eight were Barbs, which, as I have shown, must be classed in the same group with the long-beaked Carriers and Runts. Barbs may properly be called short-beaked Carriers. It would, therefore, appear as if, during the reduction of their beaks, their wings had retained a little of that excess of length which is characteristic of their nearest relations and progenitors.

[40] Temminck, ‘Hist. Nat. Gén. des Pigeons et des Gallinacés,’ tom. i., 1813, p. 170.

[41] This term was used by John Hunter for such differences in structure between the males and females, as are not directly connected with the act of reproduction, as the tail of the peacock, the horns of deer, etc.

CHAPTER VI.
PIGEONS—*continued.*

ON THE ABORIGINAL PARENT-STOCK OF THE SEVERAL DOMESTIC RACES—HABITS OF LIFE—WILD RACES OF THE ROCK-PIGEON—Dovecot-PIGEONS—PROOFS OF THE DESCENT OF THE SEVERAL RACES FROM COLUMBA LIVIA—FERTILITY OF THE RACES WHEN CROSSED—REVERSION TO THE PLUMAGE OF THE WILD ROCK-PIGEON—CIRCUMSTANCES FAVOURABLE TO THE FORMATION OF THE RACES—ANTIQUITY AND HISTORY OF THE PRINCIPAL RACES—MANNER OF THEIR FORMATION—SELECTION—UNCONSCIOUS SELECTION—CARE TAKEN BY FANCIERS IN SELECTING THEIR BIRDS—SLIGHTLY DIFFERENT STRAINS GRADUALLY CHANGE INTO WELL-

MARKED BREEDS—EXTINCTION OF INTERMEDIATE FORMS—CERTAIN BREEDS REMAIN PERMANENT, WHILST OTHERS CHANGE—SUMMARY.

The differences described in the last chapter between the eleven chief domestic races and between individual birds of the same race, would be of little significance, if they had not all descended from a single wild stock. The question of their origin is therefore of fundamental importance, and must be discussed at considerable length. No one will think this superfluous who considers the great amount of difference between the races, who knows how ancient many of them are, and how truly they breed at the present day. Fanciers almost unanimously believe that the different races are descended from several wild stocks, whereas most naturalists believe that all are descended from the Columba livia or rock-pigeon.

Temminck[1] has well observed, and Mr. Gould has made the same remark to me, that the aboriginal parent must have been a species which roosted and built its nest on rocks; and I may add that it must have been a social bird. For all the domestic races are highly social, and none are known to build or habitually to roost on trees. The awkward manner in which some pigeons, kept by me in a summer-house near an old walnut-tree, occasionally alighted on the barer branches, was evident.[2] Nevertheless, Mr. R. Scot Skirving informs me that he often saw crowds of pigeons in Upper Egypt settling on low trees, but not on palms, in preference to alighting on the mud hovels of the natives. In India Mr. Blyth[3] has been assured that the wild *C. livia,* var. *intermedia,* sometimes roosts in trees. I may here give a curious instance of compulsion leading to changed habits: the banks of the Nile above lat. 28° 30′ are perpendicular for a long distance, so that when the river is full the pigeons cannot alight on the shore to drink, and Mr. Skirving repeatedly saw whole flocks settle on the water, and drink whilst they floated down the stream. These flocks seen from a distance resembled flocks of gulls on the surface of the sea.

If any domestic race had descended from a species which was not social, or which built its nest and roosted in trees,[4] the sharp eyes of fanciers would assuredly have detected some vestige of so different an aboriginal habit. For we have reason to believe that aboriginal habits are long retained under domestication. Thus with the common ass we see signs of its original desert life in its strong dislike to cross the smallest stream of water, and in its pleasure in rolling in the dust. The same strong dislike to cross a stream is common to the camel, which has been domesticated from a very ancient period. Young pigs, though so tame, sometimes squat when frightened, and thus try to conceal themselves even on an open and bare place. Young turkeys, and occasionally even young fowls, when the hen gives the danger-cry, run away and try to hide themselves, like young partridges or pheasants, in order that their mother may take flight, of which she has lost the power. The musk-duck (*Cairina moschata*) in its native country often perches and roosts on trees,[5] and our domesticated musk-ducks, though such sluggish birds, “are fond of perching on the tops of barns, walls, etc., and, if allowed to spend the night in the hen-house, the female will generally go to roost by the side of the hens, but the drake is too heavy to mount thither with ease.”[6] We know that the dog, however well and regularly fed, often buries, like the fox, any superfluous food; and we see him turning round and round on a carpet, as if to trample down grass to form a bed; we see him on bare pavements scratching backwards as if to throw earth over his excrement, although, as I believe, this is never effected even where there is earth. In the delight with which lambs and kids crowd together and frisk on the smallest hillock, we see a vestige of their former alpine habits.

We have therefore good reason to believe that all the domestic races of the pigeon are descended either from some one or from several species which both roosted and built their nests on rocks, and were social in disposition. As only five or six wild species have these habits, and make any near approach in structure to the domesticated pigeon, I will enumerate them.

Firstly, the *Columba leuconota* resembles certain domestic varieties in its plumage, with the one marked and never-failing difference of a white band which crosses the tail at some distance from the extremity. This species, moreover, inhabits the Himalaya, close to the limit of perpetual snow; and therefore, as Mr. Blyth has remarked, is not likely to have been the parent of our domestic breeds, which thrive in the hottest countries. Secondly, the *C. rupestris,* of Central Asia, which is intermediate[7] between the *C. leuconota* and *livia*; but has nearly the same coloured tail as the former species. Thirdly, the *Columba littoralis* builds and roosts, according to Temminck, on rocks in the Malayan archipelago; it is white, excepting parts of the wing and the tip of the tail, which are black; its legs are livid-coloured, and this is a character not observed in any adult domestic pigeon; but I need not have mentioned this species or the closely-allied *C. luctuosa,* as they in fact belong to the genus Carpophaga. Fourthly, *Columba guinea,* which ranges from Guinea[8] to the Cape of Good Hope, and roosts either on trees or rocks, according to the nature of the country. This species belongs to the genus Strictoenas of Reichenbach, but is closely allied to Columba; it is to some extent coloured like certain domestic races, and has been said to be domesticated in Abyssinia; but Mr. Mansfield Parkyns, who collected the birds of that country and knows the species, informs me that this is a mistake. Moreover, the *C. guinea* is characterised by the feathers of the neck having peculiar notched tips,—a character not observed in any domestic race. Fifthly, the *Columba œnas* of Europe, which roosts on trees, and builds its nest in holes, either in trees or the ground; this species, as far as external characters go, might be the parent of several domestic races; but, though it crosses readily with the true rock-pigeon, the offspring, as we shall presently see, are sterile hybrids, and of such sterility there is not a trace when the domestic races are intercrossed. It should also be observed that if we were to admit, against all probability, that any of the foregoing five or six species were the parents of some of our domestic pigeons, not the least light would be thrown on the chief differences between the eleven most strongly-marked races.

We now come to the best known rock-pigeon, the *Columba livia,* which is often designated in Europe pre-eminently as the Rock-pigeon, and which naturalists believe to be the parent of all the domesticated breeds. This bird agrees in every essential character with the breeds which have been only slightly modified. It differs from all other species in being of a slaty-blue colour, with two black bars on the wings, and with the croup (or loins) white. Occasionally birds are seen in Faroe and the Hebrides with the black bars replaced by two or three black spots; this form has been named by Brehm[9] *C. amaliæ,* but this species has not been admitted as distinct by other ornithologists. Graba[10] even found a difference in the bars on the right and left wings of the same bird in Faroe. Another and rather more distinct form is either truly wild or has become feral on the cliffs of England and was doubtfully named by Mr. Blyth[11] as *C. affinis,* but is now no longer considered by him as a distinct species. *C. affinis* is rather smaller than the rock-pigeon of the Scottish islands, and has a very different appearance owing to the wing-coverts being chequered with black, with similar marks often extending over the back. The chequering consists of a large black spot on the two sides, but chiefly on the outer side, of each feather. The wing-bars in the true rock-pigeon and in the chequered variety are, in fact, due to similar though larger spots symmetrically crossing the secondary wing-feather and the larger coverts. Hence the chequering arises merely from an extension of these marks to other parts of the plumage. Chequered birds are not confined to the coasts of England; for they were found by Graba at Faroe; and W. Thompson[12] says that at Islay fully half the wild rock-pigeons were chequered. Colonel King, of Hythe, stocked his dovecot with young wild birds which he himself procured from nests at the Orkney Islands; and several specimens, kindly sent to me by him, were all plainly chequered. As we thus see that chequered birds occur mingled with the true rock-pigeon at three distinct sites, namely, Faroe, the Orkney Islands, and Islay, no importance can be attached to this natural variation in the plumage.

Prince C. L. Bonaparte,[13] a great divider of species, enumerates, with a mark of interrogation, as distinct from *C. livia,* the *C. turricola* of Italy, the *C. rupestris* of Daouria, and the *C. schimperi* of Abyssinia; but these birds differ from *C. livia* in characters of the most trifling value. In the British Museum there is a chequered pigeon, probably the *C. schimperi* of Bonaparte, from Abyssinia. To these may be added the *C. gymnocyclus* of G. R. Gray from W. Africa, which is slightly more distinct, and has rather more naked skin round the eyes than the rock-pigeon; but from information given me by Dr. Daniell, it is doubtful whether this is a wild bird, for dovecot-pigeons (which I have examined) are kept on the coast of Guinea.

The wild rock-pigeon of India (*C. intermedia* of Strickland) has been more generally accepted as a distinct species. It differs chiefly in the croup being blue instead of snow-white; but as Mr. Blyth informs me, the tint varies, being sometimes albescent. When this form is domesticated chequered birds appear, just as occurs in Europe with the truly wild *C. livia*. Moreover we shall immediately have proof that the blue and white croup is a highly variable character; and Bechstein[14] asserts that with dovecot-pigeons in Germany this is the most variable of all the characters of the plumage. Hence it may be concluded that *C. intermedia* cannot be ranked as specifically distinct from *C. livia*.

In Madeira there is a rock-pigeon which a few ornithologists have suspected to be distinct from *C. livia*. I have examined numerous specimens collected by Mr. E. V. Harcourt and Mr. Mason. They are rather smaller than the rock- pigeon from the Shetland Islands, and their beaks are plainly thinner, but the thickness of the beak varied in the several specimens. In plumage there is remarkable diversity; some specimens are identical in every feather (I speak after actual comparison) with the rock-pigeon of the Shetland Islands; others are chequered, like *C. affinis* from the cliffs of England, but generally to a greater degree, being almost black over the whole back; others are identical with the so-called *C. intermedia* of India in the degree of blueness of the croup; whilst others have this part very pale or very dark blue, and are likewise chequered. So much variability raises a strong suspicion that these birds are domestic pigeons which have become feral.

From these facts it can hardly be doubted that *C. livia*, *affinis*, *intermedia*, and the forms marked with an interrogation by Bonaparte ought all to be included under a single species. But it is quite immaterial whether or not they are thus ranked, and whether some one of these forms or all are the progenitors of the various domestic kinds, as far as any light can thus be thrown on the differences between the more strongly-marked races. That common dovecot-pigeons, which are kept in various parts of the world, are descended from one or from several of the above-mentioned wild varieties of *C. livia*, no one who compares them will doubt. But before making a few remarks on dovecot-pigeons, it should be stated that the wild rock-pigeon has been found easy to tame in several countries. We have seen that Colonel King at Hythe stocked his dovecot more than twenty years ago with young wild birds taken at the Orkney Islands, and since then they have greatly multiplied. The accurate Macgillivray[15] asserts that he completely tamed a wild rock-pigeon in the Hebrides; and several accounts are on records of these pigeons having bred in dovecots in the Shetland Islands. In India, as Captain Hutton informs me, the wild rock-pigeon is easily tamed, and breeds readily with the domestic kind; and Mr. Blyth[16] asserts that wild birds come frequently to the dovecots and mingle freely with their inhabitants. In the ancient ‘Ayeen Akbery’ it is written that, if a few wild pigeons be taken, “they are speedily joined by a thousand others of their kind.”

Dovecot-pigeons are those which are kept in dovecots in a semi- domesticated state; for no special care is taken of them, and they procure their own food, except during the severest weather. In England, and, judging from MM. Boitard and Corbié’s work, in France, the common dovecot- pigeon exactly resembles the chequered variety of *C. livia;* but I have seen dovecots brought from Yorkshire without any trace of chequering, like the wild rock-pigeon of the Shetland Islands. The chequered dovecots from the Orkney Islands, after having been domesticated by Colonel King for more than twenty years, differed slightly from each other in the darkness of their plumage and in the thickness of their beaks; the thinnest beak being rather thicker than the thickest one in the Madeira birds. In Germany, according to Bechstein, the common dovecot-pigeon is not chequered. In India they often become chequered, and sometimes pied with white; the croup also, as I am informed by Mr. Blyth, becomes nearly white. I have received from Sir. J. Brooke some dovecot-pigeons, which originally came from the S. Natunas Islands in the Malay Archipelago, and which had been crossed with the Singapore dovecots: they were small and the darkest variety was extremely like the dark chequered variety with a blue croup from Madeira; but the beak was not so thin, though decidedly thinner than in the rock- pigeon from the Shetland Islands. A dovecot-pigeon sent to me by Mr. Swinhoe from Foochow, in China, was likewise rather small, but differed in no other respect. I have also received through the kindness of Dr. Daniell, four living dovecot-pigeons from Sierra Leone,[17] these were fully as large as the Shetland rock-pigeon, with even bulkier bodies. In plumage some of them were identical with the Shetland rock pigeon, but with the metallic tints apparently rather more brilliant; others had a blue croup, and resembled the chequered variety of *C. intermedia* of India; and some were so much chequered as to be nearly black. In these four birds the beak differed slightly in length, but in all it was decidedly shorter, more massive, and stronger than in the wild rock-pigeon from the Shetland Islands, or in the English dovecot. When the beaks of these African pigeons were compared with the thinnest beaks of the wild Madeira specimens, the contrast was great; the former being fully one-third thicker in a vertical direction than the latter; so that any one at first would have felt inclined to rank these birds as specifically distinct; yet so perfectly graduated a series could be formed between the above-mentioned varieties, that it was obviously impossible to separate them.

To sum up: the wild *Columba livia*, including under this name *C. affinis*, *intermedia*, and the other still more closely-affined geographical races, has a vast range from the southern coast of Norway and the Faroe Islands to the shores of the Mediterranean, to Madeira and the Canary Islands, to Abyssinia, India, and Japan. It varies greatly in plumage, being in many places chequered with black, and having either a white or blue croup or loins; it varies also slightly in the size of the beak and body. Dovecot-pigeons, which no one disputes are descended from one or more of the above wild forms, present a similar but greater range of variation in plumage, in the size of body, and in the length and thickness of the beak. There seems to be some relation between the croup being blue or white, and the temperature of the country inhabited by both wild and dovecot pigeons; for nearly all the dovecot-pigeons in the northern parts of Europe have a white croup, like that of the wild European rock-pigeon; and nearly all the dovecot-pigeons of India have a blue croup like that of the wild *C. intermedia* of India. As in various countries the wild rock-pigeon has been found easy to tame, it seems extremely probable that the dovecot-pigeons throughout the world are the descendants of at least two and perhaps more wild stocks; but these, as we have just seen, cannot be ranked as specifically distinct.

With respect to the variation of *C. livia*, we may without fear of contradiction go one step further. Those pigeon-fanciers who believe that all the chief races, such as Carriers, Pouters, Fantails, etc., are descended from distinct aboriginal stocks, yet admit that the so-called toy-pigeons, which differ from the rock-pigeon in little except colour, are descended from this bird. By toy-pigeons are meant such birds as Spots, Nuns, Helmets, Swallows, Priests, Monks, Porcelains, Swabians, Archangels, Breasts, Shields, and others in Europe, and many others in India. It would indeed be as puerile to suppose that all these birds are descended from so many distinct wild stocks as to suppose this to be the case with the many varieties of the gooseberry, heartsease, or dahlia. Yet these kinds all breed true, and many of them include sub-varieties which likewise transmit their character truly. They differ greatly from each other and from the rock-pigeon in plumage, slightly in size and proportions of body, in size of feet, and in the length and thickness of their beaks. They differ from each other in these respects more than do dovecot-pigeons. Although we may safely admit that dovecot-pigeons, which vary slightly, and that toy- pigeons, which vary in a greater degree in accordance with their more highly-domesticated condition, are descended from *C. livia*, including under this name the above-enumerated wild geographical races; yet the question becomes far more difficult when we consider the eleven principal races, most of which have been profoundly modified. It can, however, be shown, by indirect evidence of a perfectly conclusive nature, that these principal races are not descended from so many wild stocks; and if this be once admitted, few will dispute that they are the descendants of *C. livia*, which agrees with them so closely in habits and in most characters, which varies in a state of nature, and which has certainly undergone a considerable amount of variation, as in the toy-pigeons. We shall moreover presently see how eminently favourable circumstances have been for a great amount of modification in the more carefully tended breeds.

The reasons for concluding that the several principal races are not descended from so many aboriginal and unknown stocks may be grouped under the following six heads:—

Firstly.—If the eleven chief races have not arisen from the variation of some one species, together with its geographical races, they must be descended from several extremely distinct aboriginal species; for no amount of crossing between only six or seven wild forms could produce races so distinct as Pouters, Carriers, Runts, Fantails, Turbits, Short-faced Tumblers, Jacobins, and Trumpeters. How could crossing produce, for instance, a Pouter or a Fantail, unless the two supposed aboriginal parents possessed the remarkable characters of these breeds? I am aware that some naturalists, following Pallas, believe that crossing gives a strong tendency to variation, independently of the characters inherited from either parent. They believe that it would be easier to raise a Pouter or Fantail pigeon from crossing two distinct species, neither of which possessed the characters of these races, than from any single species. I can find few facts in support of this doctrine, and believe in it only to a limited degree; but in a future chapter I shall have to recur to this subject. For our present purpose the point is not material. The question which concerns us is, whether or not many new and important characters have arisen since man first domesticated the pigeon. On the ordinary view, variability is due to changed conditions of life; on the Pallasian doctrine, variability, or the appearance of new characters, is due to some mysterious effect from the crossing of two species, neither of which possesses the characters in question. In some few instances it is possible that well-marked races may have been formed by crossing; for instance, a Barb might perhaps be formed by a cross between a long-beaked Carrier, having large eye-wattles, and some short-beaked pigeon. That many races have been in some degree modified by crossing, and that certain varieties which are distinguished only by peculiar tints have arisen from crosses between differently-coloured varieties, is almost certain. On the doctrine, therefore, that the chief races owe their differences to their descent from distinct species, we must admit that at least eight or nine, or more probably a dozen species, all having the same habit of breeding and roosting on rocks and living in society, either now exist somewhere, or formerly existed, but have become extinct as wild birds. Considering how carefully wild pigeons have been collected throughout the world, and what conspicuous birds they are, especially when frequenting rocks, it is extremely improbable that eight or nine species, which were long ago domesticated and therefore must have inhabited some anciently known country, should still exist in the wild state and be unknown to ornithologists.

The hypothesis that such species formerly existed, but have become extinct, is in some slight degree more probable. But the extinction of so many species within the historical period is a bold hypothesis, seeing how little influence man has had in exterminating the common rock-pigeon, which agrees in all its habits of life with the domestic races. The *C. livia* now exists and flourishes on the small northern islands of Faroe, on many islands off the coast of Scotland, on Sardinia, and the shores of the Mediterranean, and in the centre of India. Fanciers have sometimes imagined that the several supposed parent-species were originally confined to small islands, and thus might readily have been exterminated; but the facts just given do not favour the probability of their extinction, even on small islands. Nor is it probable, from what is known of the distribution of birds, that the islands near Europe should have been inhabited by peculiar species of pigeons; and if we assume that distant oceanic islands were the homes of the supposed parent-species, we must remember that ancient voyages were tediously slow, and that ships were then ill-provided with fresh food, so that it would not have been easy to bring home living birds. I have said ancient voyages, for nearly all the races of the pigeon were known before the year 1600, so that the supposed wild species must have been captured and domesticated before that date.

Secondly.—The doctrine that the chief domestic races are descended from several aboriginal species, implies that several species were formerly so thoroughly domesticated as to breed readily when confined. Although it is easy to tame most wild birds, experience shows us that it is difficult to get them to breed freely under confinement; although it must be owned that this is less difficult with pigeons than with most other birds. During the last two or three hundred years, many birds have been kept in aviaries, but hardly one has been added to our list of thoroughly reclaimed species: yet on the above doctrine we must admit that in ancient times nearly a dozen kinds of pigeons, now unknown in the wild state, were thoroughly domesticated.

Thirdly.—Most of our domesticated animals have run wild in various parts of the world; but birds, owing apparently to their partial loss of the power of flight, less often than quadrupeds. Nevertheless I have met with accounts showing that the common fowl has become feral in South America and perhaps in West Africa, and on several islands: the turkey was at one time almost feral on the banks of the Parana; and the Guinea-fowl has become perfectly wild at Ascension and in Jamaica. In this latter island the peacock, also, "has become a maroon bird." The common duck wanders from its home and becomes almost wild in Norfolk. Hybrids between the common and musk-duck which have become wild have been shot in North America, Belgium, and near the Caspian Sea. The goose is said to have run wild in La Plata. The common dovecot-pigeon has become wild at Juan Fernandez, Norfolk Island, Ascension, probably at Madeira, on the shores of Scotland, and, as is asserted, on the banks of the Hudson in North America.[18] But how different is the case, when we turn to the eleven chief domestic races of the pigeon, which are supposed by some authors to be descended from so many distinct species! no one has ever pretended that any one of these races has been found wild in any quarter of the world; yet they have been transported to all countries, and some of them must have been carried back to their native homes. On the view that all the races are the product of variation, we can understand why they have not become feral, for the great amount of modification which they have undergone shows how long and how thoroughly they have been domesticated; and this would unfit them for a wild life.

Fourthly.—If it be assumed that the characteristic differences between the various domestic races are due to descent from several aboriginal species, we must conclude that man chose for domestication in ancient times, either intentionally or by chance, a most abnormal set of pigeons; for that species resembling such birds as Pouters, Fantails, Carriers, Barbs, Short-faced Tumblers, Turbits, etc., would be in the highest degree abnormal, as compared with all the existing members of the great pigeon family, cannot be doubted. Thus we should have to believe that man not only formerly succeeded in thoroughly domesticating several highly abnormal species, but that these same species have since all become extinct, or are at least now unknown. This double accident is so extremely improbable that the assumed existence of so many abnormal species would require to be supported by the strongest evidence. On the other hand, if all the races are descended from *C. livia*, we can understand, as will hereafter be more fully explained, how any slight deviation in structure which first appeared would continually be augmented by the preservation of the most strongly marked individuals; and as the power of selection would be applied according to man's fancy, and not for the bird's own good, the accumulated amount of deviation would certainly be of an abnormal nature in comparison with the structure of pigeons living in a state of nature.

I have already alluded to the remarkable fact that the characteristic differences between the chief domestic races are eminently variable; we see this plainly in the great difference in the number of the tail-feathers in the Fantail, in the development of the crop in Pouters, in the length of the beak in Tumblers, in the state of the wattle in Carriers, etc. If these characters are the result of successive variations added together by selection, we can understand why they should be so variable: for these are the very parts which have varied since the domestication of the pigeon, and therefore would be likely still to vary; these variations moreover have been recently, and are still being accumulated by man's selection; therefore they have not as yet become firmly fixed.

Fifthly.—All the domestic races pair readily together, and, what is equally important, their mongrel offspring are perfectly fertile. To ascertain this fact I made many experiments, which are given in the note below; and recently Mr. Tegetmeier has made similar experiments with the same result.[19] The accurate Neumeister asserts that when dovecots are crossed with pigeons of any other breed, the mongrels are extremely fertile and hardy.[20] MM. Boitard and Corbié[21] affirm, after their great experience, that the more distinct the breeds are which are crossed, the more productive are their mongrel offspring. I admit that the doctrine first broached by Pallas is highly probable, if not actually proved, namely, that closely allied species, which in a state of nature or when first captured would have been in some degree sterile if crossed, lose this sterility after a long course of domestication; yet when we consider the great difference between such races as Pouters, Carriers, Runts, Fantails, Turbits, Tumblers etc., the fact of their perfect, or even increased, fertility when intercrossed in the most complicated manner becomes a strong argument in favour of their having all descended from a single species. This argument is rendered much stronger when we hear (I append in a note[22] all the cases which I have collected) that hardly a single well-ascertained instance is known of hybrids between two true species of pigeons being fertile, *inter se,* or even when crossed with one of their pure parents.

Sixthly.—Excluding certain important characteristic differences, the chief races agree most closely both with each other and with *C. livia* in all other respects. As previously observed, all are eminently sociable; all dislike to perch or roost, and refuse to build in trees; all lay two eggs, and this is not a universal rule with the Columbidæ; all, as far as I can hear, require the same time for hatching their eggs; all can endure the same great range of climate; all prefer the same food, and are passionately fond of salt; all exhibit (with the asserted exception of the Finnikin and Turner which do not differ much in any other character) the same peculiar gestures when courting the females; and all (with the exception of Trumpeters and Laughers, which likewise do not differ much in any other character) coo in the same peculiar manner, unlike the voice of any other wild pigeon.

All the coloured breeds display the same peculiar metallic tints on the breast, a character far from general with pigeons. Each race presents nearly the same range of variation in colour; and in most of the races we have the same singular correlation between the development of down in the young and the future colour of plumage. All have the proportional length of their toes, and of their primary wing-feathers, nearly the same,—characters which are apt to differ in the several members of the Columbidæ. In those races which present some remarkable deviation of structure, such as in the tail of Fantails, crop of Pouters, beak of Carriers and Tumblers, etc., the other parts remain nearly unaltered. Now every naturalist will admit that it would be scarcely possible to pick out a dozen natural species in any family which should agree closely in habits and in general structure, and yet should differ greatly in a few characters alone. This fact is explicable through the doctrine of natural selection; for each successive modification of structure in each natural species is preserved, solely because it is of service; and such modifications when largely accumulated imply a great change in the habits of life, and this will almost certainly lead to other changes of structure throughout the whole organisation. On the other hand, if the several races of the pigeon have been produced by man through selection and variation, we can readily understand how it is that they should still all resemble each other in habits and in those many characters which man has not cared to modify, whilst they differ to so prodigious a degree in those parts which have struck his eye or pleased his fancy.

Besides the points above enumerated, in which all the domestic races resemble *C. livia* and each other, there is one which deserves special notice. The wild rock-pigeon is of a slaty-blue colour; the wings are crossed by two bars; the croup varies in colour, being generally white in the pigeon of Europe, and blue in that of India; the tail has a black bar close to the end, and the outer webs of the outer tail-feathers are edged with white, except near the tips. These combined characters are not found in any wild pigeon besides *C. livia*. I have looked carefully through the great collections of pigeons in the British Museum, and I find that a dark bar at the end of the tail is common; that the white edging to the outer tail-feathers is not rare; but that the white croup is extremely rare, and the two black bars on the wings occur in no other pigeon, excepting the alpine *C. leuconota* and *C. rupestris* of Asia. Now if we turn to the domestic races, it is highly remarkable, as an eminent fancier, Mr. Wicking, observed to me, that, whenever a blue bird appears in any race, the wings almost invariably show the double black bars.[23] The primary wing-feathers may be white or black, and the whole body may be of any colour, but if the wing-coverts are blue, the two black bars are sure to appear. I have myself seen, or acquired trustworthy evidence, as given below,[24] of blue birds with black bars on the wing, with the croup either white or very pale or dark blue, with the tail having a terminal black bar, and with the outer feathers externally edged with white or very pale coloured, in the following races, which, as I carefully observed in each case, appeared to be perfectly true: namely, in Pouters, Fantails, Tumblers, Jacobins, Turbits, Barbs, Carriers, Runts of three distinct varieties, Trumpeters, Swallows, and in many other toy-pigeons, which as being closely allied to *C. livia,* are not worth enumerating. Thus we see that, in purely-bred races of every kind known in Europe, blue birds occasionally appear having all the marks which characterise *C. livia,* and which concur in no other wild species. Mr. Blyth, also, has made the same observation with respect to the various domestic races known in India.

Certain variations in the plumage are equally common in the wild *C. livia,* in dovecot-pigeons, and in all the most highly modified races. Thus, in all, the croup varies from white to blue, being most frequently white in Europe, and very generally blue in India.[25] We have seen that the wild *C. livia* in Europe, and dovecots in all parts of the world, often have the upper wing-coverts chequered with black; and all the most distinct races, when blue, are occasionally chequered in precisely the same manner. Thus I have seen Pouters, Fantails, Carriers, Turbits, Tumblers (Indian and English), Swallows, Bald-pates, and other toy-pigeons blue and chequered; and Mr. Esquilant has seen a chequered Runt. I bred from two pure blue Tumblers a chequered bird.

The facts hitherto given refer to the occasional appearance in pure races of blue birds with black wing-bars, and likewise of blue and chequered birds; but it will now be seen that when two birds belonging to distinct races are crossed, neither of which have, nor probably have had during many generations, a trace of blue in their plumage, or a trace of wing-bars and the other characteristic marks, they very frequently produce mongrel offspring of a blue colour, sometimes chequered, with black wing-bars, etc.; or if not of a blue colour, yet with the several characteristic marks more or less plainly developed. I was led to investigate this subject from MM. Boitard and Corbié[26] having asserted that from crosses between certain breeds it is rare to get anything but bisets or dovecot pigeons, which, as we know, are blue birds with the usual characteristic marks. We shall hereafter see that this subject possesses, independently of our present object, considerable interest, so that I will give the results of my own trials in full. I selected for experiment races which, when pure, very seldom produce birds of a blue colour, or have bars on their wings and tail.

The Nun is white, with the head, tail, and primary wing-feathers black; it is a breed which was established as long ago as the year 1600. I crossed a male Nun with a female red common Tumbler, which latter variety generally breeds true. Thus neither parent had a trace of blue in the plumage, or of bars on the wing and tail. I should premise that common Tumblers are rarely blue in England. From the above cross I reared several young: one was red over the whole back, but with the tail as blue as that of the rock-pigeon; the terminal bar, however, was absent, but the outer feathers were edged with white: a second and third nearly resembled the first, but the tail in both presented a trace of the bar at the end: a fourth was brownish, and the wings showed a trace of the double bar: a fifth was pale blue over the whole breast, back, croup, and tail, but the neck and primary wing-feathers were reddish; the wings presented two distinct bars of a red colour; the tail was not barred, but the outer feathers were edged with white. I crossed this last curiously coloured bird with a black mongrel of complicated descent, namely, from a black Barb, a Spot, and Almond-tumbler, so that the two young birds produced from this cross included the blood of five varieties, none of which had a trace of blue or of wing and tail-bars: one of the two young birds was brownish-black, with black wing-bars; the other was reddish-dun, with reddish wing-bars, paler than the rest of the body, with the croup pale blue, the tail bluish with a trace of the terminal bar.

Mr. Eaton[27] matched two Short-faced Tumblers, namely, a splash cock and kite hen (neither of which are blue or barred), and from the first nest he got a perfect blue bird, and from the second a silver or pale blue bird, both of which, in accordance with all analogy, no doubt presented the usual characteristic marks.

I crossed two male black Barbs with two female red Spots. These latter have the whole body and wings white, with a spot on the forehead, the tail and tail-coverts red; the race existed at least as long ago as 1676, and now breeds perfectly true, as was known to be the case in the year 1735.[28] Barbs are uniformly-coloured birds, with rarely even a trace of bars on the wing or tail; they are known to breed very true. The mongrels thus raised were black or nearly black, or dark or pale brown, sometimes slightly piebald with white: of these birds no less than six presented double wing-bars; in two the bars were conspicuous and quite black; in seven some white feathers appeared on the croup; and in two or three there was a trace of the terminal bar to the tail, but in none were the outer tail-feathers edged with white.

I crossed black Barbs (of two excellent strains) with purely-bred, snow-white Fantails. The mongrels were generally quite black, with a few of the primary wing and tail feathers white: others were dark reddish-brown, and others snow-white: none had a trace of wing-bars or of the white croup. I then paired together two of these mongrels, namely, a brown and black bird, and their offspring displayed wing-bars, faint, but of a darker brown than the rest of body. In a second brood from the same parents a brown bird was produced, with several white feathers confined to the croup.

I crossed a male dun Dragon belonging to a family which had been dun- coloured without wing-bars during several generations, with a uniform red Barb (bred from two black Barbs); and the offspring presented decided but faint traces of wing-bars. I crossed a uniform red male Runt with a White trumpeter; and the offspring had a slaty-blue tail with a bar at the end, and with the outer feathers edged with white. I also crossed a female black and white chequered Trumpeter (of a different strain from the last) with a male Almond-tumbler, neither of which exhibited a trace of blue, or of the white croup, or of the bar at end of tail: nor is it probable that the progenitors of these two birds had for many generations exhibited any of these characters, for I have never even heard of a blue Trumpeter in this country, and my Almond-tumbler was purely bred; yet the tail of this mongrel was bluish, with a broad black bar at the end, and the croup was perfectly white. It may be observed in several of these cases, that the tail first shows a tendency to become by reversion blue; and this fact of the persistency of colour in the tail and tail-coverts[29] will surprise no one who has attended to the crossing of pigeons.

The last case which I will give is the most curious. I paired a mongrel female Barb-fantail with a mongrel male Barb-spot; neither of which mongrels had the least blue about them. Let it be remembered that blue Barbs are excessively rare; that Spots, as has been already stated, were perfectly characterised in the year 1676, and breed perfectly true; this likewise is the case with white Fantails, so much so that I have never heard of white Fantails throwing any other colour. Nevertheless the offspring from the above two mongrels was of exactly the same blue tint as that of the wild rock-pigeon from the Shetland Islands over the whole back and wings; the double black wing-bars were equally conspicuous; the tail was exactly alike in all its characters, and the croup was pure white; the head, however, was tinted with a shade of red, evidently derived from the Spot, and was of a paler blue than in the rock-pigeon, as was the stomach. So that two black Barbs, a red Spot, and a white Fantail, as the four purely-bred grandparents, produced a bird exhibiting the general blue colour, together with every characteristic mark, the wild *Columba livia*.

With respect to crossed breeds frequently producing blue birds chequered with black, and resembling in all respects both the dovecot-pigeon and the chequered wild variety of the rock-pigeon, the statement before referred to by MM. Boitard and Corbié would almost suffice; but I will give three instances of the appearance of such birds from crosses in which one alone of the parents or great-grandparents was blue, but not chequered. I crossed a male blue Turbit with a snow-white Trumpeter, and the following year with a dark, leaden-brown, Short-faced Tumbler; the offspring from the first cross were as perfectly chequered as any dovecot-pigeon; and from the second, so much so as to be nearly as black as the most darkly chequered rock-pigeon from Madeira. Another bird, whose great-grandparents were a white Trumpeter, a white Fantail, a white Red-spot, a red Runt, and a blue Pouter, was slaty-blue and chequered exactly like a dovecot-pigeon. I may here add a remark made to me by Mr. Wicking, who has had more experience than any other person in England in breeding pigeons of various colours: namely, that when a blue, or a blue and chequered bird, having black wing-bars, once appears in any race and is allowed to breed, these characters are so strongly transmitted that it is extremely difficult to eradicate them.

What, then, are we to conclude from this tendency in all the chief domestic races, both when purely bred and more especially when intercrossed, to produce offspring of a blue colour, with the same characteristic marks, varying in the same manner, as in *Columbia livia*? If we admit that these races are all descended from *C. livia,* no breeder will doubt that the occasional appearance of blue birds thus characterised is accounted for on the well-known principle of “throwing back” or reversion. Why crossing should give so strong a tendency to reversion, we do not with certainty know; but abundant evidence of this fact will be given in the following chapters. It is probable that I might have bred even for a century pure black Barbs, Spots, Nuns, white Fantails, Trumpeters, etc., without obtaining a single blue or barred bird; yet by crossing these breeds I reared in the first and second generation, during the course of only three or four years, a considerable number of young birds, more or less plainly coloured blue, and with most of the characteristic marks. When black and white, or black and red birds, are crossed, it would appear that a slight tendency exists in both parents to produce blue offspring, and that this, when combined, overpowers the separate tendency in either parent to produce black, or white, or red offspring.

If we reject the belief that all the races of the pigeon are the modified descendants of *C. livia*, and suppose that they are descended from several aboriginal stocks, then we must choose between the three following assumptions: firstly, that at least eight or nine species formerly existed which were aboriginally coloured in various ways, but have since varied in exactly the same manner so as to assume the colouring of *C. livia*; but this assumption throws not the least light on the appearance of such colours and marks when the races are crossed. Or secondly, we may assume that the aboriginal species were all coloured blue, and had the wing-bars and other characteristic marks of *C. livia*,—a supposition which is highly improbable, as besides this one species no existing member of the Columbidæ presents these combined characters; and it would not be possible to find any other instance of several species identical in plumage, yet as different in important points of structure as are Pouters, Fantails, Carriers, Tumblers, etc. Or lastly, we may assume that all the races, whether descended from *C. livia* or from several aboriginal species, although they have been bred with so much care and are so highly valued by fanciers, have all been crossed within a dozen or score of generations with *C. livia*, and have thus acquired their tendency to produce blue birds with the several characteristic marks. I have said that it must be assumed that each race has been crossed with *C. livia* within a dozen, or, at the utmost, within a score of generations; for there is no reason to believe that crossed offspring ever revert to one of their ancestors when removed by a greater number of generations. In a breed which has been crossed only once, the tendency to reversion will naturally become less and less in the succeeding generations, as in each there will be less and less of the blood of the foreign breed; but when there has been no cross with a distinct breed, and there is a tendency in both parents to revert to some long-lost character, this tendency, for all that we can see to the contrary, may be transmitted undiminished for an indefinite number of generations. These two distinct cases of reversion are often confounded together by those who have written on inheritance.

Considering, on the one hand, the improbability of the three assumptions which have just been discussed, and, on the other hand, how simply the facts are explained on the principle of reversion, we may conclude that the occasional appearance in all the races, both when purely bred and more especially when crossed, of blue birds, sometimes chequered, with double wing-bars, with white or blue croups, with a bar at the end of the tail, and with the outer tail-feathers edged with white, affords an argument of the greatest weight in favour of the view that all are descended from *Columba* *livia*, including under this name the three or four wild varieties or sub-species before enumerated.

To sum up the six foregoing arguments, which are opposed to the belief that the chief domestic races are the descendants of at least eight or nine or perhaps a dozen species; for the crossing of any less number would not yield the characteristic differences between the several races. *Firstly*, the improbability that so many species should still exist somewhere, but be unknown to ornithologists, or that they should have become within the historical period extinct, although man has had so little influence in exterminating the wild *C. livia*. *Secondly*, the improbability of man in former times having thoroughly domesticated and rendered fertile under confinement so many species. *Thirdly*, these supposed species having nowhere become feral. *Fourthly*, the extraordinary fact that man should, intentionally or by chance, have chosen for domestication several species, extremely abnormal in character; and furthermore, the points of structure which render these supposed species so abnormal being now highly variable. *Fifthly*, the fact of all the races, though differing in many important points of structure, producing perfectly fertile mongrels; whilst all the hybrids which have been produced between even closely allied species in the pigeon-family are sterile. *Sixthly*, the remarkable statements just given on the tendency in all the races, both when purely bred and when crossed, to revert in numerous minute details of colouring to the character of the wild rock-pigeon, and to vary in a similar manner. To these arguments may be added the extreme improbability that a number of species formerly existed, which differed greatly from each other in some few points, but which resembled each other as closely as do the domestic races in other points of structure, in voice, and in all their habits of life. When these several facts and arguments are fairly taken into consideration, it would require an overwhelming amount of evidence to make us admit that the chief domestic races are descended from several aboriginal stocks; and of such evidence there is absolutely none.

The belief that the chief domestic races are descended from several wild stocks no doubt has arisen from the apparent improbability of such great modifications of structure having been effected since man first domesticated the rock-pigeon. Nor am I surprised at any degree of hesitation in admitting their common parentage: formerly, when I went into my aviaries and watched such birds as Pouters, Carriers, Barbs, Fantails, and Short-faced Tumblers, etc., I could not persuade myself that all had descended from the same wild stock, and that man had consequently in one sense created these remarkable modifications. Therefore I have argued the question of their origin at great, and, as some will think, superfluous length.

Finally, in favour of the belief that all the races are descended from a single stock, we have in *Columba livia* a still existing and widely distributed species, which can be and has been domesticated in various countries. This species agrees in most points of structure and in all its habits of life, as well as occasionally in every detail of plumage, with the several domestic races. It breeds freely with them, and produces fertile offspring. It varies in a state of nature,[30] and still more so when semi-domesticated, as shown by comparing the Sierra Leone pigeons with those of India, or with those which apparently have run wild in Madeira. It has undergone a still greater amount of variation in the case of the numerous toy-pigeons, which no one supposes to be descended from distinct species; yet some of these toy-pigeons have transmitted their character truly for centuries. Why, then, should we hesitate to believe in that greater amount of variation which is necessary for the production of the eleven chief races? It should be borne in mind that in two of the most strongly-marked races, namely, Carriers and Short-faced Tumblers, the extreme forms can be connected with the parent-species by graduated differences not greater than those which may be observed between the dovecot-pigeons inhabiting different countries, or between the various kinds of toy-pigeons,—gradations which must certainly be attributed to variation.

That circumstances have been eminently favourable for the modification of the pigeon through variation and selection will now be shown. The earliest record, as has been pointed out to me by Professor Lepsius, of pigeons in a domesticated condition, occurs in the fifth Egyptian dynasty, about 3000 B.C.;[31] but Mr. Birch, of the British Museum, informs me that the pigeon appears in a bill of fare in the previous dynasty. Domestic pigeons are mentioned in Genesis, Leviticus, and Isaiah.[32] In the time of the Romans, as we hear from Pliny,[33] immense prices were given for pigeons; "nay, they are come to this pass, that they can reckon up their pedigree and race." In India, about the year 1600, pigeons were much valued by Akbar Khan: 20,000 birds were carried about with the court, and the merchants brought valuable collections. "The monarch of Iran and Turan sent him some very rare breeds. His Majesty," says the courtly historian, "by crossing the breeds, which method was never practised before, has improved them astonishingly."[34] Akber Khan possessed seventeen distinct kinds, eight of which were valuable for beauty alone. At about this same period of 1600 the Dutch, according to Aldrovandi, were as eager about pigeons as the Romans had formerly been. The breeds which were kept during the fifteenth century in Europe and in India apparently differed from each other. Tavernier, in his Travels in 1677, speaks, as does Chardin in 1735, of the vast number of pigeon-houses in Persia; and the former remarks that, as Christians were not permitted to keep pigeons, some of the vulgar actually turned Mahometans for this sole purpose. The Emperor of Morocco had his favourite keeper of pigeons, as is mentioned in Moore's treatise, published 1737. In England, from the time of Willughby in 1678 to the present day, as well as in Germany and in France, numerous treatises have been published on the pigeon. In India, about a hundred years ago, a Persian treatise was written; and the writer thought it no light affair, for he begins with a solemn invocation, "in the name of God, the gracious and merciful." Many large towns, in Europe and the United States, now have their societies of devoted pigeon-fanciers: at present there are three such societies in London. In India, as I hear from Mr. Blyth, the inhabitants of Delhi and of some other great cities are eager fanciers. Mr. Layard informs me that most of the known breeds are kept in Ceylon. In China, according to

Mr. Swinhoe of Amoy, and Dr. Lockhart of Shangai, Carriers, Fantails, Tumblers, and other varieties are reared with care, especially by the bonzes or priests. The Chinese fasten a kind of whistle to the tail-feathers of their pigeons, and as the flock wheels through the air they produce a sweet sound. In Egypt the late Abbas Pacha was a great fancier of Fantails. Many pigeons are kept at Cairo and Constantinople, and these have lately been imported by native merchants, as I hear from Sir W. Elliot, into Southern India, and sold at high prices.

The foregoing statements show in how many countries, and during how long a period, many men have been passionately devoted to the breeding of pigeons. Hear how an enthusiastic fancier at the present day writes: “If it were possible for noblemen and gentlemen to know the amazing amount of solace and pleasure derived from Almond Tumblers, when they begin to understand their properties, I should think that scarce any nobleman or gentleman would be without their aviaries of Almond Tumblers.”[35] The pleasure thus taken is of paramount importance, as it leads amateurs carefully to note and preserve each slight deviation of structure which strikes their fancy. Pigeons are often closely confined during their whole lives; they do not partake of their naturally varied diet; they have often been transported from one climate to another; and all these changes in their conditions of life would be likely to cause variability. Pigeons have been domesticated for nearly 5000 years, and have been kept in many places, so that the numbers reared under domestication must have been enormous: and this is another circumstance of high importance, for it obviously favours the chance of rare modifications of structure occasionally appearing. Slight variations of all kinds would almost certainly be observed, and, if valued, would, owing to the following circumstances, be preserved and propagated with unusual facility. Pigeons, differently from any other domesticated animal, can easily be mated for life, and, though kept with other pigeons, rarely prove unfaithful to each other. Even when the male does break his marriage-vow, he does not permanently desert his mate. I have bred in the same aviaries many pigeons of different kinds, and never reared a single bird of an impure strain. Hence a fancier can with the greatest ease select and match his birds. He will also see the good results of his care; for pigeons breed with extraordinary rapidity. He may freely reject inferior birds, as they serve at an early age as excellent food.

History of the principal Races of the Pigeon.[36]

Before discussing the means and steps by which the chief races have been formed, it will be advisable to give some historical details, for more is known of the history of the pigeon, little though this is, than of any other domesticated animal. Some of the cases are interesting as proving how long domestic varieties may be propagated with exactly the same or nearly the same characters; and other cases are still more interesting as showing how slowly but steadily races have been greatly modified during successive generations. In the last chapter I stated that Trumpeters and Laughers, both so remarkable for their voices, seem to have been perfectly characterised in 1735; and

Laughers were apparently known in India before the year 1600. Spots in 1676, and Nuns in the time of Aldrovandi, before 1600, were coloured exactly as they now are. Common Tumblers and Ground Tumblers displayed in India, before the year 1600, the same extraordinary peculiarities of flight as at the present day, for they are well described in the 'Ayeen Akbery.' These breeds may all have existed for a much longer period; we know only that they were perfectly characterised at the dates above given. The *average* length of life of the domestic pigeon is probably about five or six years; if so, some of these races have retained their character perfectly for at least forty or fifty generations.

Pouters.—These birds, as far as a very short description serves for comparison, appear to have been well characterised in Aldrovandi's time,[37] before the year 1600. Length of body and length of leg are at the present time the two chief points of excellence. In 1735 Moore said (see Mr. J. M. Eaton's edition)—and Moore was a first-rate fancier—that he once saw a bird with a body 20 inches in length, "though 17 or 18 inches is reckoned a very good length;" and he has seen the legs very nearly 7 inches in length, yet a leg 6½ or 6¾ long "must be allowed to be a very good one." Mr. Bult, the most successful breeder of Pouters in the world, informs me that at present (1858) the standard length of the body is not less than 18 inches; but he has measured one bird 19 inches in length, and has heard of 20 and 22 inches, but doubts the truth of these latter statements. The standard length of the leg is now 7 inches, but Mr. Bult has recently measured two of his own birds with legs 7½ long. So that in the 123 years which have elapsed since 1735 there has been hardly any increase in the standard length of the body; 17 or 18 inches was formerly reckoned a very good length, and now 18 inches is the minimum standard; but the length of leg seems to have increased, as Moore never saw one quite 7 inches long; now the standard is 7, and two of Mr. Bult's birds measured 7½ inches in length. The extremely slight improvement in Pouters, except in the length of the leg, during the last 123 years, may be partly accounted for by the neglect which they suffered, as I am informed by Mr. Bult, until within the last 20 or 30 years. About 1765[38] there was a change of fashion, stouter and more feathered legs being preferred to thin and nearly naked legs.

Fantails.—The first notice of the existence of this breed is in India, before the year 1600, as given in the 'Ayeen Akbery;'[39] at this date, judging from Aldrovandi, the breed was unknown in Europe. In 1677 Willughby speaks of a Fantail with 26 tail-feathers; in 1735 Moore saw one with 36 feathers; and in 1824 MM. Boitard and Corbié assert that in France birds can easily be found with 42 tail-feathers. In England, the number of the tail-feathers is not at present so much regarded as their upward direction and expansion. The general carriage of the bird is likewise now much valued. The old descriptions do not suffice to show whether in these latter respects there has been much improvement: but if Fantails with their heads and tails touching had formerly existed, as at the present time, the fact would almost certainly have been noticed. The Fantails which are now found in India probably show the state of the race, as far as carriage is concerned, at the date of their introduction into Europe; and some, said to have been brought from Calcutta, which I kept alive, were in a marked manner inferior to our exhibition birds. The Java Fantail shows the same difference in carriage; and although Mr. Swinhoe has counted 18 and 24 tail-feathers in his birds, a first-rate specimen sent to me had only 14 tail-feathers.

Jacobins.—This breed existed before 1600, but the hood, judging from the figure given by Aldrovandi, did not enclose the head nearly so perfectly as at present: nor was the head then white; nor were the wings and tail so long, but this last character might have been overlooked by the rude artist. In Moore's time, in 1735, the Jacobin was considered the smallest kind of pigeon, and the bill is said to be very short. Hence either the Jacobin, or the other kinds with which it was then compared, must since that time have been considerably modified; for Moore's description (and it must be remembered that he was a first-rate judge) is clearly not applicable, as far as size of body and length of beak are concerned, to our present Jacobins. In 1795, judging from Bechstein, the breed had assumed its present character.

Turbits.—It has generally been supposed by the older writers on pigeons, that the Turbit is the Cortbeck of Aldrovandi; but if this be the case, it is an extraordinary fact that the characteristic frill should not have been noticed. The beak, moreover, of the Cortbeck is described as closely resembling that of the Jacobin, which shows a change in the one or the other race. The Turbit, with its characteristic frill, and bearing its present name, is described by Willughby in 1677; and the bill is said to be like that of the bullfinch,—a good comparison, but now more strictly applicable to the beak of the Barb. The sub-breed called the Owl was well known in Moore's time, in 1735.

Tumblers.—Common Tumblers, as well as Ground Tumblers, perfect as far as tumbling is concerned, existed in India before the year 1600; and at this period diversified modes of flight, such as flying at night, the ascent to a great height, and manner of descent, seem to have been much attended to in India, as at the present time. Belon[40] in 1555 saw in Paphlagonia what he describes as "a very new thing, viz. pigeons which flew so high in the air that they were lost to view, but returned to their pigeon-house without separating." This manner of flight is characteristic of our present Tumblers, but it is clear that Belon would have mentioned the act of tumbling if the pigeons described by him had tumbled. Tumblers were not known in Europe in 1600, as they are not mentioned by Aldrovandi, who discusses the flight of pigeons. They are briefly alluded to by Willughby, in 1687, as small pigeons "which show like footballs in the air." The short-faced race did not exist at this period, as Willughby could not have overlooked birds so remarkable for their small size and short beaks. We can even trace some of the steps by which this race has been produced. Moore in 1735 enumerates correctly the chief points of excellence, but does not give any description of the several sub-breeds; and from this fact Mr. Eaton infers[41] that the Short-faced Tumbler had not then come to full perfection. Moore even speaks of the Jacobin as being the smallest pigeon. Thirty years afterwards, in 1765, in the Treatise dedicated to Mayor, short-faced

Almond Tumblers are fully described, but the author, an excellent fancier, expressly states in his Preface (p. xiv.) that, "from great care and expense in breeding them, they have arrived to so great perfection and are so different from what they were 20 or 30 years past, that an old fancier would have condemned them for no other reason than because they are not like what used to be thought good when he was in the fancy before." Hence it would appear that there was a rather sudden change in the character of the short-faced Tumbler at about this period; and there is reason to suspect that a dwarfed and half-monstrous bird, the parent-form of the several short-faced sub-breeds, then appeared. I suspect this because short-faced Tumblers are born with their beaks (ascertained by careful measurement) as short, proportionally with the size of their bodies, as in the adult bird; and in this respect they differ greatly from all other breeds, which slowly acquire during growth their various characteristic qualities.

Since the year 1765 there has been some change in one of the chief characters of the short-faced Tumbler, namely, in the length of the beak. Fanciers measure the "head and beak" from the tip of the beak to the front corner of the eyeball. About the year 1765 a "head and beak" was considered good,[42] which, measured in the usual manner, was 7/8 of an inch in length; now it ought not to exceed 5/8 of an inch; "it is however possible," as Mr. Eaton candidly confesses,"for a bird to be considered as pleasant or neat even at 6/8 of an inch, but exceeding that length it must be looked upon as unworthy of attention." Mr. Eaton states that he has never seen in the course of his life more than two or three birds with the "head and beak" not exceeding half an inch in length; "still I believe in the course of a few years that the head and beak will be shortened, and that half-inch birds will not be considered so great a curiosity as at the present time." That Mr. Eaton's opinion deserves attention cannot be doubted, considering his success in winning prizes at our exhibitions. Finally in regard to the Tumbler it may be concluded from the facts above given that it was originally introduced into Europe, probably first into England, from the East; and that it then resembled our common English Tumbler, or more probably the Persian or Indian Tumbler, with a beak only just perceptibly shorter than that of the common dovecot-pigeon. With respect to the short-faced Tumbler, which is not known to exist in the East, there can hardly be a doubt that the whole wonderful change in the size of the head, beak, body and feet, and in general carriage, has been produced during the last two centuries by continued selection, aided probably by the birth of a semi- monstrous bird somewhere about the year 1750.

Runts.—Of their history little can be said. In the time of Pliny the pigeons of Campania were the largest known; and from this fact alone some authors assert that they were Runts. In Aldrovandi's time, in 1600, two sub-breeds existed; but one of them, the short-beaked, is now extinct in Europe.

Barbs.—Notwithstanding statements to the contrary, it seems to me impossible to recognise the Barb in Aldrovandi's description and figures; four breeds, however, existed in the year 1600 which evidently were allied both to Barbs and Carriers. To show how difficult it is to recognise some of the breeds described by Aldrovandi I will give the different opinions in regard to the above four kinds, named by him *C. indica*, *cretensis*, *gutturosa*, and *persica*. Willughby thought that the *Columba indica* was a Turbit, but the eminent fancier Mr. Brent believes that it was an inferior Barb: *C. cretensis*, with a short beak and a swelling on the upper mandible, cannot be recognised: *C.* (falsely called) *gutturosa*, which from its *rostrum, breve, crassum, et tuberosum* seems to me to come nearest to the Barb, Mr. Brent believes to be a Carrier; and lastly, the *C. persica et turcica*, Mr. Brent thinks, and I quite concur with him, was a short-beaked Carrier with very little wattle. In 1687 the Barb was known in England, and Willughby describes the beak as like that of the Turbit; but it is not credible that his Barbs should have had a beak like that of our present birds, for so accurate an observer could not have overlooked its great breadth.

English Carrier.—We may look in vain in Aldrovandi's work for any bird resembling our prize Carriers; the *C. persica et turcica* of this author comes the nearest, but is said to have had a short thick beak; therefore it must have approached in character a Barb, and have differed greatly from our Carriers. In Willughby's time, in 1677, we can clearly recognise the Carrier, yet he adds, "the bill is not short, but of a moderate length;" a description which no one would apply to our present Carriers, so conspicuous for the extraordinary length of their beaks. The old names given in Europe to the Carrier, and the several names now in use in India, indicate that Carriers originally came from Persia; and Willughby's description would perfectly apply to the Bussorah Carrier as it now exists in Madras. In later times we can partially trace the progress of change in our English Carriers: Moore, in 1735, says "an inch and a half is reckoned a long beak, though there are very good Carriers that are found not to exceed an inch and a quarter." These birds must have resembled or perhaps been a little superior to the Carriers, previously described, now found in Persia. In England at the present day "there are," as Mr. Eaton[43] states, "beaks that would measure (from edge of eye to tip of beak) one inch and three-quarters, and some few even two inches in length."

From these historical details we see that nearly all the chief domestic races existed before the year 1600. Some remarkable only for colour appear to have been identical with our present breeds, some were nearly the same, some considerably different, and some have since become extinct. Several breeds, such as Finnikins and Turners, the swallow-tailed pigeon of Bechstein and the Carmelite, seem to have originated and to have disappeared within this same period. Any one now visiting a well-stocked English aviary would certainly pick out as the most distinct kinds, the massive Runt, the Carrier with its wonderfully elongated beak and great wattles, the Barb with its short broad beak and eye-wattles, the short-faced Tumbler with its small conical beak, the Pouter with its great crop, long legs and body, the Fantail with its upraised, widely-expanded, well-feathered tail, the Turbit with its frill and short blunt beak, and the Jacobin with his hood. Now, if this same person could have viewed the pigeons kept before 1600 by Akber Khan in India and by Aldrovandi in Europe, he would have seen the Jacobin with a less perfect hood; the Turbit apparently without its frill; the Pouter with shorter legs, and in every way less remarkable—that is, if Aldrovandi's Pouter resembled the old German kind; the Fantail would have been far less singular in appearance, and would have had much fewer feathers in its tail; he would have seen excellent flying Tumblers, but he would in vain have looked for the marvellous short-faced breeds; he would have seen birds allied to Barbs, but it is extremely doubtful whether he would have met with our actual Barbs; and lastly, he would have found Carriers with beaks and wattle incomparably less developed than in our English Carriers. He might have classed most of the breeds in the same groups as at present; but the differences between the groups were then far less strongly pronounced than at present. In short, the several breeds had at this early period not diverged in so great a degree as now from their aboriginal common parent, the wild rock-pigeon.

Manner of Formation of the chief Races.

We will now consider more closely the probable steps by which the chief races have been formed. As long as pigeons are kept semi-domesticated in dovecots in their native country, without any care in selecting and matching them, they are liable to little more variation than the wild *C. livia*, namely, in the wings becoming chequered with black, in the croup being blue or white, and in the size of the body. When, however, dovecot-pigeons are transported into diversified countries, such as Sierra Leone, the Malay archipelago, and Madeira, they are exposed to new conditions of life; and apparently in consequence vary in a somewhat greater degree. When closely confined, either for the pleasure of watching them, or to prevent their straying, they must be exposed, even in their native climate, to considerably different conditions; for they cannot obtain their natural diversity of food; and, what is probably more important, they are abundantly fed, whilst debarred from taking much exercise. Under these circumstances we might expect to find, from the analogy of all other domesticated animals, a greater amount of individual variability than with the wild pigeon; and this is the case. The want of exercise apparently tends to reduce the size of the feet and organs of flight; and then, from the law of correlation of growth, the beak apparently becomes affected. From what we now see occasionally taking place in our aviaries, we may conclude that sudden variations or sports, such as the appearance of a crest of feathers on the head, of feathered feet, of a new shade of colour, of an additional feather in the tail or wing, would occur at rare intervals during the many centuries which have elapsed since the pigeon was first domesticated. At the present day such "sports" are generally rejected as blemishes; and there is so much mystery in the breeding of pigeons that, if a valuable sport did occur, its history would often be concealed. Before the last hundred and fifty years, there is hardly a chance of the history of any such sport having been recorded. But it by no means follows from this that such sports in former times, when the pigeon had undergone much less variation, would have been rejected. We are profoundly ignorant of the cause of each sudden and apparently spontaneous variation, as well as of the infinitely numerous shades of difference between the birds of the same family.

But in a future chapter we shall see that all such variations appear to be the indirect result of changes of some kind in the conditions of life.

Hence, after a long course of domestication, we might expect to see in the pigeon much individual variability, and occasional sudden variations, as well as slight modifications from the lessened use of certain parts, together with the effects of correlation of growth. But without selection all this would produce only a trifling or no result; for without such aid differences of all kinds would, from the two following causes, soon disappear. In a healthy and vigorous lot of pigeons many more young birds are killed for food or die than are reared to maturity; so that an individual having any peculiar character, if not selected, would run a good chance of being destroyed; and if not destroyed, the peculiarity in question would generally be obliterated by free intercrossing. It might, however, occasionally happen that the same variation repeatedly occurred, owing to the action of peculiar and uniform conditions of life, and in this case it would prevail independently of selection. But when selection is brought into play all is changed; for this is the foundation-stone in the formation of new races; and with the pigeon, circumstances, as we have already seen, are eminently favourable for selection. When a bird presenting some conspicuous variation has been preserved, and its offspring have been selected, carefully matched, and again propagated, and so onwards during successive generations, the principle is so obvious that nothing more need be said about it. This may be called *methodical selection,* for the breeder has a distinct object in view, namely, to preserve some character which has actually appeared; or to create some improvement already pictured in his mind.

Another form of selection has hardly been noticed by those authors who have discussed this subject, but is even more important. This form may be called *unconscious selection,* for the breeder selects his birds unconsciously, unintentionally, and without method, yet he surely though slowly produces a great result. I refer to the effects which follow from each fancier at first procuring and afterwards rearing as good birds as he can, according to his skill, and according to the standard of excellence at each successive period. He does not wish permanently to modify the breed; he does not look to the distant future, or speculate on the final result of the slow accumulation during many generations of successive slight changes; he is content if he possesses a good stock, and more than content if he can beat his rivals. The fancier in the time of Aldrovandi, when in the year 1600 he admired his own Jacobins, Pouters, or Carriers, never reflected what their descendants in the year 1860 would become: he would have been astonished could he have seen our Jacobins, our improved English Carriers, and our Pouters; he would probably have denied that they were the descendants of his own once-admired stock, and he would perhaps not have valued them, for no other reason, as was written in 1765, "than because they were not like what used to be thought good when he was in the fancy." No one will attribute the lengthened beak of the Carrier, the shortened beak of the Short-faced Tumbler, the lengthened leg of the Pouter, the more perfectly enclosed hood of the Jacobin, etc.—changes effected since the time of

Aldrovandi, or even since a much later period,—to the direct and immediate action of the conditions of life. For these several races have been modified in various and even in directly opposite ways, though kept under the same climate and treated in all respects in as nearly uniform a manner as possible. Each slight change in the length or shortness of the beak, in the length of leg, etc., has no doubt been indirectly and remotely caused by some change in the conditions to which the bird has been subjected, but we must attribute the final result, as is manifest in those cases of which we have any historical record, to the continued selection and accumulation of many slight successive variations.

The action of unconscious selection, as far as pigeons are concerned, depends on a universal principle in human nature, namely, on our rivalry, and desire to outdo our neighbours. We see this in every fleeting fashion, even in our dress, and it leads the fancier to endeavour to exaggerate every peculiarity in his breeds. A great authority on pigeons,[44] says, “Fanciers do not and will not admire a medium standard, that is, half and half, which is neither here nor there, but admire extremes.” After remarking that the fancier of Short-faced Beard Tumblers wishes for a very short beak, and that the fancier of Long-faced Beard Tumblers wishes for a very long beak, he says, with respect to one of intermediate length, “Don’t deceive yourself. Do you suppose for a moment the short or the long-faced fancier would accept such a bird as a gift? Certainly not; the short-faced fancier could see no beauty in it; the long-faced fancier would swear there was no use in it, etc.” In these comical passages, written seriously, we see the principle which has ever guided fanciers, and has led to such great modifications in all the domestic races which are valued solely for their beauty or curiosity.

Fashions in pigeon-breeding endure for long periods; we cannot change the structure of a bird as quickly as we can the fashion of our dress. In the time of Aldrovandi, no doubt the more the pouter inflated his crop, the more he was valued. Nevertheless, fashions do to a certain extent change; first one point of structure and then another is attended to; or different breeds are admired at different times and in different countries. As the author just quoted remarks, “the fancy ebbs and flows; a thorough fancier now-a-days never stoops to breed toy-birds;” yet these very “toys” are now most carefully bred in Germany. Breeds which at the present time are highly valued in India are considered worthless in England. No doubt, when breeds are neglected, they degenerate; still we may believe that, as long as they are kept under the same conditions of life, characters once gained will be partially retained for a long time, and may form the starting-point for a future course of selection.

Let it not be objected to this view of the action of unconscious selection that fanciers would not observe or care for extremely slight differences. Those alone who have associated with fanciers can be thoroughly aware of their accurate powers of discrimination acquired by long practice, and of the care and labour which they bestow on their birds. I have known a fancier deliberately study his birds day after day to settle which to match together and which to reject. Observe how difficult the subject appears to one of the most eminent and experienced fanciers. Mr. Eaton, the winner of many prizes, says, "I would here particularly guard you against keeping too great a variety of pigeons, otherwise you will know a little about all the kinds, but nothing about one as it ought to be known." "It is possible there may be a few fanciers that have a good general knowledge of the several fancy pigeons, but there are many who labour under the delusion of supposing they know what they do not." Speaking exclusively of one sub- variety of one race, namely, the short-faced almond tumbler, and after saying that some fanciers sacrifice every property to obtain a good head and beak, and that other fanciers sacrifice everything for plumage, he remarks: "Some young fanciers who are over covetous go in for all the five properties at once, and they have their reward by getting nothing." In India, as I hear from Mr. Blyth, pigeons are likewise selected and matched with the greatest care. We must not judge of the slight divergences from existing varieties which would have been valued in ancient days, by those which are now valued after the formation of so many races, each with its own standard of perfection, kept uniform by our numerous Exhibitions. The ambition of the most energetic fancier may be fully satisfied by the difficulty of excelling other fanciers in the breeds already established, without trying to form a new one.

A difficulty with respect to the power of selection will perhaps already have occurred to the reader, namely, what could have led fanciers first to attempt to make such singular breeds as Pouters, Fantails, Carriers, etc.? But it is this very difficulty which the principle of unconscious selection removes. Undoubtedly no fancier ever did intentionally make such an attempt. All that we need suppose is that a variation occurred sufficiently marked to catch the discriminating eye of some ancient fancier, and then unconscious selection carried on for many generations, that is, the wish of succeeding fanciers to excel their rivals, would do the rest. In the case of the Fantail we may suppose that the first progenitor of the breed had a tail only slightly erected, as may now be seen in certain Runts,[45] with some increase in the number of the tail-feathers, as now occasionally occurs with Nuns. In the case of the Pouter we may suppose that some bird inflated its crop a little more than other pigeons, as is now the case in a slight degree with the œesophagus of the Turbit. We do not know the origin of the common Tumbler, but we may suppose that a bird was born with some affection of the brain, leading it to make somersaults in the air;[46] and before the year 1600 pigeons remarkable for their diversified manner of flight were much valued in India, and by the order of the Emperor Akber Khan were sedulously trained and carefully matched.

In the foregoing cases we have supposed that a sudden variation, conspicuous enough to catch a fancier's eye, first appeared; but even this degree of abruptness in the process of variation is not necessary for the formation of a new breed. When the same kind of pigeon has been kept pure, and has been bred during a long period by two or more fanciers, slight differences in the strain can often be recognised. Thus I have seen first-rate Jacobins in one man's possession which certainly differed slightly in several characters from those kept by another. I possessed some excellent Barbs descended from a pair which had won a prize, and another lot descended from a stock formerly kept by that famous fancier Sir John Sebright, and these plainly differed in the form of the beak; but the differences were so slight that they could hardly be given by words. Again, the common English and Dutch Tumbler differ in a somewhat greater degree, both in length of beak and shape of head. What first caused these slight differences cannot be explained any more than why one man has a long nose and another a short one. In the strains long kept distinct by different fanciers, such differences are so common that they cannot be accounted for by the accident of the birds first chosen for breeding having been originally as different as they now are. The explanation no doubt lies in selection of a slightly different nature having been applied in each case; for no two fanciers have exactly the same taste, and consequently no two, in choosing and carefully matching their birds, prefer or select exactly the same. As each man naturally admires his own birds, he goes on continually exaggerating by selection whatever slight peculiarities they may possess. This will more especially happen with fanciers living in different countries, who do not compare their stocks or aim at a common standard of perfection. Thus, when a mere strain has once been formed, unconscious selection steadily tends to augment the amount of difference, and thus converts the strain into a sub-breed and this ultimately into a well-marked breed or race.

The principle of correlation of growth should never be lost sight of. Most pigeons have small feet, apparently caused by their lessened use, and from correlation, as it would appear, their beaks have likewise become reduced in length. The beak is a conspicuous organ, and, as soon as it had thus become perceptibly shortened, fanciers would almost certainly strive to reduce it still more by the continued selection of birds with the shortest beaks; whilst at the same time other fanciers, as we know has actually been the case, would in other sub-breeds, strive to increase its length. With the increased length of the beak, the tongue becomes greatly lengthened, as do the eyelids with the increased development of the eye-wattles; with the reduced or increased size of the feet, the number of the scutellæ vary; with the length of the wing, the number of the primary wing-feathers differ; and with the increased length of the body in the pouter the number of the sacral vertebræ is augmented. These important and correlated differences of structure do not invariably characterise any breed; but if they had been attended to and selected with as much care as the more conspicuous external differences, there can hardly be a doubt that they would have been rendered constant. Fanciers could assuredly have made a race of Tumblers with nine instead of ten primary wing-feathers, seeing how often the number nine appears without any wish on their part, and indeed in the case of the white-winged varieties in opposition to their wish. In a similar manner, if the vertebræ had been visible and had been attended to by fanciers, assuredly an additional number might easily have been fixed in the Pouter. If these latter characters had once been rendered constant, we should never have suspected that they had at first been highly variable, or that they had arisen from correlation, in the one case with the shortness of the wings, and in the other case with the length of the body.

In order to understand how the chief domestic races have become distinctly separated from each other, it is important to bear in mind, that fanciers constantly try to breed from the best birds, and consequently that those which are inferior in the requisite qualities are in each generation neglected; so that after a time the less improved parent-stocks and many subsequently formed intermediate grades become extinct. This has occurred in the case of the Pouter, Turbit, and Trumpeter, for these highly improved breeds are now left without any links closely connecting them either with each other or with the aboriginal rock-pigeon. In other countries, indeed, where the same care has not been applied, or where the same fashion has not prevailed, the earlier forms may long remain unaltered, or altered only in a slight degree, and we are thus sometimes enabled to recover the connecting links. This is the case in Persia and India with the Tumbler and Carrier, which there differ but slightly from the rock-pigeon in the proportions of their beaks. So again in Java, the Fantail sometimes has only fourteen caudal feathers, and the tail is much less elevated and expanded than in our improved birds; so that the Java bird forms a link between a first-rate Fantail and the rock-pigeon.

Occasionally a breed may be retained for some particular quality in a nearly unaltered condition in the same country, together with highly modified off-shoots or sub-breeds, which are valued for some distinct property. We see this exemplified in England, where the common Tumbler, which is valued only for its flight, does not differ much from its parent-form, the Eastern Tumbler; whereas the Short-faced Tumbler has been prodigiously modified, from being valued, not for its flight, but for other qualities. But the common-flying Tumbler of Europe has already begun to branch out into slightly different sub-breeds, such as the common English Tumbler, the Dutch Roller, the Glasgow House-tumbler, and the Long-faced Beard Tumbler, etc.; and in the course of centuries, unless fashions greatly change, these sub-breeds will diverge through the slow and insensible process of unconscious selection, and become modified, in a greater and greater degree. After a time the perfectly graduated links which now connect all these sub-breeds together, will be lost, for there would be no object and much difficulty in retaining such a host of intermediate sub-varieties.

The principle of divergence, together with the extinction of the many previously existing intermediate forms, is so important for understanding the origin of domestic races, as well as of species in a state of nature, that I will enlarge a little more on this subject. Our third main group includes Carriers, Barbs, and Runts, which are plainly related to one another, yet wonderfully distinct in several important characters. According to the view given in the last chapter, these three races have probably descended from an unknown race having an intermediate character, and this race from the rock-pigeon. Their characteristic differences are believed to be due to different breeders having at an early period admired different points of structure; and then, on the acknowledged principle of admiring extremes, having gone on breeding, without any thought of the future, as good birds as they could,—Carrier-fanciers preferring long beaks with much wattle,—Barb-fanciers preferring short thick beaks with much eye-wattle,—and Runt-fanciers not caring about the beak or wattle, but only for the size and weight of the body. This process would have led to the neglect and final extinction of the earlier, inferior, and intermediate birds; and thus it has come to pass, that in Europe these three races are now so extraordinarily distinct from each other. But in the East, whence they were originally brought, the fashion has been different, and we there see breeds which connect the highly modified English Carrier with the rock-pigeon, and others which to a certain extent connect Carriers and Runts. Looking back to the time of Aldrovandi, we find that there existed in Europe, before the year 1600, four breeds which were closely allied to Carriers and Barbs, but which competent authorities cannot now identify with our present Barbs and Carriers; nor can Aldrovandi's Runts be identified with our present Runts. These four breeds certainly did not differ from each other nearly so much as do our existing English Carriers, Barbs, and Runts. All this is exactly what might have been anticipated. If we could collect all the pigeons which have ever lived, from before the time of the Romans to the present day, we should be able to group them in several lines, diverging from the parent rock-pigeon. Each line would consist of almost insensible steps, occasionally broken by some slightly greater variation or sport, and each would culminate in one of our present highly modified forms. Of the many former connecting links, some would be found to have become absolutely extinct without having left any issue, whilst others, though extinct, would be recognised as the progenitors of the existing races.

I have heard it remarked as a strange circumstance that we occasionally hear of the local or complete extinction of domestic races, whilst we hear nothing of their origin. How, it has been asked, can these losses be compensated, and more than compensated, for we know that with almost all domesticated animals the races have largely increased in number since the time of the Romans? But on the view here given, we can understand this apparent contradiction. The extinction of a race within historical times is an event likely to be noticed; but its gradual and scarcely sensible modification through unconscious selection, and its subsequent divergence, either in the same or more commonly in distant countries, into two or more strains, and their gradual conversion into sub-breeds, and these into well- marked breeds are events which would rarely be noticed. The death of a tree, that has attained gigantic dimensions, is recorded; the slow growth of smaller trees and their increase in number excite no attention.

In accordance with the belief in the great power of selection, and of the little direct power of changed conditions of life, except in causing general variability or plasticity of organisation, it is not surprising that dovecot-pigeons have remained unaltered from time immemorial; and that some toy-pigeons, which differ in little else besides colour from the dovecot-pigeon, have retained the same character for several centuries. For when one of these toy-pigeons had once become beautifully and symmetrically coloured,—when, for instance, a Spot had been produced with the crown of its head, its tail, and tail-coverts of a uniform colour, the rest of the body being snow-white,—no alteration or improvement would be desired. On the other hand, it is not surprising that during this same interval of time our highly-bred pigeons have undergone an astonishing amount of change; for in regard to them there is no defined limit to the wish of the fancier, and there is no known limit to the variability of their characters. What is there to stop the fancier desiring to give to his Carrier a longer and longer beak, or to his Tumbler a shorter and shorter beak? nor has the extreme limit of variability in the beak, if there be any such limit, as yet been reached. Notwithstanding the great improvement effected within recent times in the Short-faced Almond Tumbler, Mr. Eaton remarks, “the field is still as open for fresh competitors as it was one hundred years ago;” but this is perhaps an exaggerated assertion, for the young of all highly-improved fancy birds are extremely liable to disease and death.

I have heard it objected that the formation of the several domestic races of the pigeon throws no light on the origin of the wild species of the Columbidæ, because their differences are not of the same nature. The domestic races, for instance do not differ, or differ hardly at all, in the relative lengths and shape of the primary wing-feathers, in the relative length of the hind toe, or in habits of life, as in roosting and building in trees. But the above objection shows how completely the principle of selection has been misunderstood. It is not likely that characters selected by the caprice of man should resemble differences preserved under natural conditions either from being of direct service to each species, or from standing in correlation with other modified and serviceable structures. Until man selects birds differing in the relative length of the wing-feathers or toes, etc., no sensible change in these parts should be expected. Nor could man do anything unless these parts happened to vary under domestication: I do not positively assert that this is the case, although I have seen traces of such variability in the wing-feathers, and certainly in the tail-feathers. It would be a strange fact if the relative length of the hind toe should never vary, seeing how variable the foot is both in size and in the number of the scutellæ. With respect to the domestic races not roosting or building in trees, it is obvious that fanciers would never attend to or select such changes in habits; but we have seen that the pigeons in Egypt, which do not for some reason like settling on the low mud hovels of the natives, are led, apparently by compulsion, to perch in crowds on the trees. We may even affirm that, if our domestic races had become greatly modified in any of the above specified respects, and it could be shown that fanciers had never attended to such points, or that they did not stand in correlation with other selected characters, the fact, on the principles advocated in this chapter, would have offered a serious difficulty.

Let us briefly sum up the last two chapters on the pigeon. We may conclude with confidence that all the domestic races, notwithstanding their great amount of difference, are descended from the *Columba livia*, including under this name certain wild races. But the differences between the latter throw no light whatever on the characters which distinguish the domestic races. In each breed or sub-breed the individual birds are more variable than birds in a state of nature; and occasionally they vary in a sudden and strongly-marked manner. This plasticity of organisation apparently results from changed conditions of life. Disuse has reduced certain parts of the body. Correlation of growth so ties the organisation together, that when one part varies other parts vary at the same time. When several breeds have once been formed, their intercrossing aids the progress of modification, and has even produced new sub-breeds. But as, in the construction of a building, mere stones or bricks are of little avail without the builder's art, so, in the production of new races, selection has been the presiding power. Fanciers can act by selection on excessively slight individual differences, as well as on those greater differences which are called sports. Selection is followed methodically when the fancier tries to improve and modify a breed according to a prefixed standard of excellence; or he acts unmethodically and unconsciously, by merely trying to rear as good birds as he can, without any wish or intention to alter the breed. The progress of selection almost inevitably leads to the neglect and ultimate extinction of the earlier and less improved forms, as well as of many intermediate links in each long line of descent. Thus it has come to pass that most of our present races are so marvellously distinct from each other, and from the aboriginal rock-pigeon.

REFERENCES

[1] Temminck 'Hist. Nat. Gén. des Pigeons,' etc., tom. i. p. 191.

[2] I have heard through Sir C. Lyell from Miss Buckley, that some half-bred Carriers kept during many years near London regularly settled by day on some adjoining trees, and, after being disturbed in their loft by their young being taken, roosted on them at night.

[3] 'Annals and Mag. of Nat. Hist.,' 2nd ser., vol. xx., 1857, p. 509; and in a late volume of the Journal of the Asiatic Society.

[4] In works written on the pigeon by fanciers I have sometimes observed the mistaken belief expressed that the species which naturalists called ground-pigeons (in contradistinction to arboreal pigeons) do not perch and build on trees. In these same works by fanciers wild species resembling the chief domestic races are often said to exist in various parts of the world; but such species are quite unknown to naturalists.

[5] Sir R. Schomburgk in 'Journal R. Geograph. Soc.,' vol. xiii., 1844, p. 32.

[6] Rev. E. S. Dixon 'Ornamental Poultry,' 1848, pp. 63, 66.

[7] 'Proc. Zoolog. Soc.,' 1859, p. 400.

[8] Temminck, 'Hist. Nat. Gén. des Pigeons,' tom. i.; also 'Les Pigeons' par Mme. Knip and Temminck. Bonaparte, however, in his 'Coup- d'œil' believes that two closely allied species are confounded together under this name. The *C. leucocephala* of the West Indies is stated by Temminck to be a rock-pigeon; but I am informed by Mr. Gosse that this is an error.

[9] ‘Handbuch der Naturgesch. Vögel Deutschlands.’

[10] ‘Tagebuch, Reise nach Färo,’ 1830, s. 62.

[11] ‘Annals and Mag. of Nat. Hist.,’ vol. xix., 1847, p. 102. This excellent paper on pigeons is well worth consulting.

[12] ‘Natural History of Ireland,’ Birds, vol. ii. (1850), p. 11. For Graba *see* previous reference.

[13] ‘Coup-d’œil sur l’Ordre des Pigeons,’ ‘Comptes Rendus,’ 1854-55.

[14] ‘Naturgeschichte. Deutschlands,’ Band. iv. 1795, s. 14.

[15] ‘History of British Birds,’ vol. i. pp. 275-284. Mr. Andrew Duncan tamed a rock-pigeon in the Shetland Islands. Mr. James Barclay, and Mr. Smith of Uyea Sound, both say that the wild rock-pigeon can be easily tamed; and the former gentleman asserts that the tamed birds breed four times a year. Dr. Lawrence Edmondstone informs me that a wild rock-pigeon came and settled in his dovecot in Balta Sound in the Shetland Islands, and bred with his pigeons; he has also given me other instances of the wild rock-pigeon having been taken young and breeding in captivity.

[16] ‘Annals and Mag. of Nat. History,’ vol. xix. 1847, p. 103, and vol. for 1857, p. 512.

[17] Domestic pigeons of the common kind are mentioned as being pretty numerous in John Barbut’s ‘Description of the Coast of Guinea’ (p. 215), published in 1746; they are said, in accordance with the name which they bear, to have been imported.

[18] With respect to feral pigeons—for Juan Fernandez, *see* Bertero in ‘Annal. des Sc. Nat.,’ tom. xxi. p. 351. For Norfolk Islands, *see* Rev. E. S. Dixon in the ‘Dovecote,’ 1851, p. 14, on the authority of Mr. Gould. For Ascension I rely on MS. information given me by Mr. Layard. For the banks of the Hudson, *see* Blyth in ‘Annals of Nat. Hist.,’ vol. xx., 1857, p. 511. For Scotland, *see* Macgillivray, ‘British Birds,’ vol. i. p. 275; also Thompson’s ‘Nat. Hist. of Ireland, Birds,’ vol. ii. p. 11. For ducks, *see* Rev. E. S. Dixon, ‘Ornamental Poultry,’ 1847, p. 122. For the feral hybrids of the common and musk-ducks, *see* Audubon’s ‘American Ornithology,’ and Selys-Longchamp’s ‘Hybrides dans la Famille des Anatides.’ For the goose, Isidore Geoffroy St.-Hilaire, ‘Hist. Nat. Gén.,’ tom. iii. p. 498. For guinea-fowls, *see* Gosse’s ‘Naturalist’s Sojourn in Jamaica,’ p. 124; and his ‘Birds of Jamaica,’ for fuller particulars. I saw the wild guinea-fowl in Ascension. For the peacock, *see* ‘A Week at Port Royal,’ by a competent authority, Mr. R. Hill, p. 42. For the turkey I rely on oral information; I ascertained that they were not Curassows. With respect to fowls I will give the references in the next chapter.

[19] I have drawn out a long table of the various crosses made by fanciers between the several domestic breeds but I do not think it worth while

publishing. I have myself made for this special purpose many crosses, and all were perfectly fertile. I have united in one bird five of the most distinct races, and with patience I might undoubtedly have thus united all. The case of five distinct breeds being blended together with unimpaired fertility is important, because Gärtner has shown that it is a very general, though not, as he thought, universal rule, that complex crosses between several species are excessively sterile. I have met with only two or three cases of reported sterility in the offspring of certain races when crossed. Pistor ('Das Ganze der Feldtaubenzucht,' 1831, s. 15) asserts that the mongrels from Barbs and Fantails are sterile: I have proved this to be erroneous, not only by crossing those hybrids with several other hybrids of the same parentage, but by the more severe test of pairing brother and sister hybrids *inter se*, and they were *perfectly* fertile. Temminck has stated ('Hist. Nat. Gén. des Pigeons,' tom. i. p. 197) that the Turbit or Owl will not cross readily with other breeds: but my Turbits crossed, when left free with Almond Tumblers and with Trumpeters; the same thing has occurred (Rev. E. S. Dixon, 'The Dovecote,' p. 107) between Turbits and Dovecots and Nuns. I have crossed Turbits with Barbs, as has M. Boitard (p. 34), who says the hybrids were very fertile. Hybrids from a Turbit and Fantail have been known to breed *inter se* (Riedel, 'Taubenzucht,' s. 25, and Bechstein, 'Naturgesch. Deutsch.,' B. iv. s. 44. Turbits (Riedel, s. 26) have been crossed with Pouters and with Jacobins, and with a hybrid Jacobin-trumpeter (Riedel, s. 27). The latter author has, however, made some vague statements (s. 22) on the sterility of Turbits when crossed with certain other crossed breeds. But I have little doubt that the Rev. E. S. Dixon's explanation of such statements is correct, viz. that individual birds both with Turbits and other breeds are occasionally sterile.

[20] 'Das Ganze der Taubenzucht,' s. 18.

[21] 'Les Pigeons,' etc., p. 35.

[22] Domestic pigeons pair readily with the allied *C. œnas* (Bechstein, 'Naturgesch. Deutschlands,' B. iv. s. 3); and Mr. Brent has made the same cross several times in England, but the young were very apt to die at about ten days old; one hybrid which he reared (from *C. œnas* and a male Antwerp Carrier) paired with a Dragon, but never laid eggs. Bechstein further states (s. 26) that the domestic pigeon will cross with *C. palumbus*, *Turtur risoria*, and *T. vulgaris*, but nothing is said of the fertility of the hybrids, and this would have been mentioned had the fact been ascertained. In the Zoological Gardens (MS. report to me from Mr. James Hunt) a male hybrid from *Turtur vulgaris* and a domestic pigeon "paired with several different species of pigeons and doves, but none of the eggs were good." Hybrids from *C. œnas* and *gymnophthalmos* were sterile. In Loudon's 'Mag. of Nat. Hist.,' vol. vii. 1834, p. 154, it is said that a male hybrid (from *Turtur vulgaris* male, and the cream-coloured *T. risoria* female) paired during two years with a female *T. risoria*, and the latter laid many eggs, but all were sterile. MM. Boitard and Corbié ('Les Pigeons,' p. 235) state that the hybrids from these two turtle-doves are invariably sterile both *inter se* and with either pure parent. The experiment was tried by M. Corbié "avec une espèce d'obstination;" and likewise by M. Mauduyt, and by M. Vieillot.

Temminck also found the hybrids from these two species quite barren. Therefore, when Bechstein (‘Naturgesch. Deutschlands Vögel,’ B. iv. s. 101) asserts that the hybrids from these two turtle-doves propagate *inter se* equally well with pure species, and when a writer in the ‘Field’ newspaper (in a letter dated Nov. 10th, 1858) makes a similar assertion, it would appear that there must be some mistake; though what the mistake is I know not, as Bechstein at least must have known the white *variety* of *T. risoria*: it would be an unparalleled fact if the same two species sometimes produced *extremely* fertile, and sometimes *extremely* barren, offspring. In the MS. report from the Zoological Gardens it is said that hybrids from *Turtur vulgaris* and *suratensis*, and from *T. vulgaris* and *Ectopistes migratorius*, were sterile. Two of the latter male hybrids paired with their pure parents, viz. *Turtur vulgaris* and the Ectopistes, and likewise with *T. risoria* and with *Columba œnas,* and many eggs were produced, but all were barren. At Paris, hybrids have been raised (Isid. Geoffrey Saint-Hilaire, ‘Hist. Nat. Générale,’ tom. iii. p. 180) from *Turtur auritus* with *T. cambayensis* and with *T. suratensis*; but nothing is said of their fertility. At the Zoological Gardens of London the *Goura coronata* and *victoriæ* produced a hybrid which paired with the pure *G. coronata*, and laid several eggs, but these proved barren. In 1860 *Columba gymnophthalmos* and *maculosa* produced hybrids in these same gardens.

[23] There is one exception to the rule, namely, in a sub-variety of the Swallow of German origin, which is figured by Neumeister, and was shown to me by Mr. Wicking. This bird is blue, but has not the black wing-bars; for our object, however, in tracing the descent of the chief races, this exception signifies the less as the Swallow approaches closely in structure to *C. livia*. In many sub-varieties the black bars are replaced by bars of various colours. The figures given by Neumeister are sufficient to show that, if the wings alone are blue, the black wing-bars appear.

[24] I have observed blue birds with all the above-mentioned marks in the following races, which seemed to be perfectly pure, and were shown at various exhibitions. Pouters, with the double black wing-bars, with white croup, dark bar to end of tail, and white edging to outer tail-feathers. Turbits, with all these same characters. Fantails with the same; but the croup in some was bluish or pure blue. Mr. Wicking bred blue Fantails from two black birds. Carriers (including the Bagadotten of Neumeister) with all the marks: two birds which I examined had white, and two had blue croups; the white edging to the outer tail-feathers was not present in all. Mr. Corker, a great breeder, assures me that, if black carriers are matched for many successive generations, the offspring become first ash-coloured, and then blue with black wing-bars. Runts of the elongated breed had the same marks, but the croup was pale blue; the outer tail-feathers had white edges. Neumeister figures the great Florence Runt of a blue colour with black bars. Jacobins are very rarely blue, but I have received authentic accounts of at least two instances of the blue variety with black bars having appeared in England; blue Jacobins were bred by Mr. Brent from two black birds. I have seen common Tumblers, both Indian and English, and Short-faced Tumblers, of a blue colour, with black wing-bars, with the black bar at the end of the tail, and with the outer tail-feathers edged with white; the croup in all was blue,

or extremely pale blue, never absolutely white. Blue Barbs and Trumpeters seem to be excessively rare; but Neumeister, who may be implicitly trusted, figures blue varieties of both, with black wing-bars. Mr. Brent informs me that he has seen a blue Barb; and Mr. H. Weir, as I am informed by Mr. Tegetmeier, once bred a silver (which means very pale blue) Barb from two yellow birds.

[25] Mr. Blyth informs me that all the domestic races in India have the croup blue; but this is not invariable, for I possess a very pale blue Simmali pigeon with the croup perfectly white, sent to me by Sir W. Elliot from Madras. A slaty-blue and chequered Nakshi pigeon has some white feathers on the croup alone. In some other Indian pigeons there were a few white feathers confined to the croup, and I have noticed the same fact in a carrier from Persia. The Java Fantail (imported into Amoy, and thence sent me) has a perfectly white croup.

[26] ‘Les Pigeons,’ etc., p. 37.

[27] ‘Treatise on Pigeons,’ 1858, p. 145.

[28] J. Moore’s ‘Columbarium,’ 1735; in J. M. Eaton’s edition, 1852, p. 71.

[29] I could give numerous examples; two will suffice. A mongrel, whose four grandparents were a white Turbit, white Trumpeter, white Fantail, and blue Pouter, was white all over, except a very few feathers about the head and on the wings, but the whole tail and tail-coverts were dark bluish-grey. Another mongrel whose four grandparents were a red Runt, white Trumpeter, white Fantail, and the same blue Pouter, was pure white all over, except the tail and upper tail-coverts, which were pale fawn, and except the faintest trace of double wing-bars of the same pale fawn tint.

[30] It deserves notice, as bearing on the general subject of variation, that not only *C. livia* presents several wild forms, regarded by some naturalists as species and by others as sub-species or as mere varieties, but that the species of several allied genera are in the same predicament. This is the case, as Mr. Blyth has remarked to me, with Treron, Palumbus, and Turtur.

[31] ‘Denkmäler,’ Abth. ii. Bl. 70.

[32] ‘The ‘Dovecote,’ by the Rev. E. S. Dixon, 1851, pp. 11-13. Adolphe Pictet (in his ‘Les Origines Indo-Européennes,’ 1859, p. 399) states that there are in the ancient Sanscrit language between 25 and 30 names for the pigeon, and other 15 or 16 Persian names; none of these are common to the European languages. This fact indicates the antiquity of the domestication of the pigeon in the East.

[33] English translation, 1601, Book x. ch. xxxvii.

[34] ‘Ayeen Akbery,’ translated by F. Gladwin, 4to edit., vol. i. p. 270.

[35] J. M. Eaton, ‘Treatise on the Almond Tumbler,’ 1851; Preface, p. 6.

[36] As in the following discussion I often speak of the present time, I should state that this chapter was completed in the year 1858.

[37] ‘Ornithologie,’ 1600, vol. ii. p. 360.

[38] ‘A Treatise on Domestic Pigeons,’ dedicated to Mr. Mayor, 1765. Preface, p. 14.

[39] Mr. Blyth has given a translation of part of the ‘Ayeen Akbery’ in ‘Annals and Mag. of Nat. Hist.,’ vol. xix. 1847, p. 104.

[40] ‘L’Histoire de la Nature des Oiseaux,’ p. 314.

[41] ‘Treatise on Pigeons,’ 1852, p. 64.

[42] J. M. Eaton ‘Treatise on the Breeding and Managing of the Almond Tumbler,’ 1851. Compare p. v. of Preface, p. 9, and p. 32.

[43] ‘Treatise on Pigeons,’ 1852, p. 41.

[44] Eaton’s ‘Treatise on Pigeons,’ 1858, p. 86.

[45] *See* Neumeister’s figure of the Florence Runt, tab. 13 in ‘Das Ganze der Taubenzucht.’

[46] Mr. W. J. Moore gives a full account of the Ground Tumblers of India (‘Indian Medical Gazette,’ Jan. and Feb. 1873), and says the pricking the base of the brain, and giving hydrocyanic acid, together with strychnine, to an ordinary pigeon, brings on convulsive movements exactly like those of a Tumbler. One pigeon, the brain of which had been pricked, completely recovered, and ever afterwards occasionally made somersaults.

CHAPTER VII.
FOWLS.

BRIEF DESCRIPTIONS OF THE CHIEF BREEDS—ARGUMENTS IN FAVOUR OF THEIR DESCENT FROM SEVERAL SPECIES—ARGUMENTS IN FAVOUR OF ALL THE BREEDS HAVING DESCENDED FROM GALLUS BANKIVA—REVERSION TO THE PARENT-STOCK IN COLOUR—ANALOGOUS VARIATIONS—ANCIENT HISTORY OF THE FOWL—EXTERNAL DIFFERENCES BETWEEN THE SEVERAL BREEDS—EGGS—CHICKENS—SECONDARY SEXUAL CHARACTERS—WING-AND TAIL-FEATHERS, VOICE, DISPOSITION, ETC—OSTEOLOGICAL DIFFERENCES

IN THE SKULL, VERTEBRÆ, ETC—EFFECTS OF USE AND DISUSE ON CERTAIN PARTS—CORRELATION OF GROWTH.

As some naturalists may not be familiar with the chief breeds of the fowl, it will be advisable to give a condensed description of them.[1] From what I have read and seen of specimens brought from several quarters of the world, I believe that most of the chief kinds have been imported into England, but many sub-breeds are probably still unknown here. The following discussion on the origin of the various breeds and on their characteristic differences does not pretend to completeness, but may be of some interest to the naturalist. The classification of the breeds cannot, as far as I can see, be made natural. They differ from each other in different degrees, and do not afford characters in subordination to each other, by which they can be ranked in group under group. They seem all to have diverged by independent and different roads from a single type. Each chief breed includes differently coloured sub-varieties, most of which can be truly propagated, but it would be superfluous to describe them. I have classed the various crested fowls as sub-breeds under the Polish fowl; but I have great doubts whether this is a natural arrangement, showing true affinity or blood relationship. It is scarcely possible to avoid laying stress on the commonness of a breed; and if certain foreign sub-breeds had been largely kept in this country they would perhaps have been raised to the rank of main-breeds. Several breeds are abnormal in character; that is, they differ in certain points from all wild Gallinaceous birds. At first I made a division of the breeds into normal and abnormal, but the result was wholly unsatisfactory.

1. GAME BREED.—This may be considered as the typical breed, as it deviates only slightly from the wild *Gallus bankiva*, or, as perhaps more correctly named, *ferrugineus*. Beak strong; comb single and upright. Spurs long and sharp. Feathers closely appressed to the body. Tail with the normal number of 14 feathers. Eggs often pale buff. Disposition indomitably courageous, exhibited even in the hens and chickens. An unusual number of differently coloured varieties exist, such as black and brown-breasted reds, duckwings, blacks, whites, piles, etc., with their legs of various colours.

2. MALAY BREED.—Body of great size, with head, neck, and legs elongated; carriage erect; tail small, sloping downwards, generally formed of 16 feathers; comb and wattle small; ear-lobe and face red; skin yellowish; feathers closely appressed to the body; neck-hackles short, narrow, and hard. Eggs often pale buff. Chickens feather late. Disposition savage. Of Eastern origin.

3. COCHIN, OR SHANGAI BREED.—Size great; wing feathers short, arched, much hidden in the soft downy plumage; barely capable of flight; tail short, generally formed of 16 feathers, developed at a late period in the young males; legs thick, feathered; spurs short, thick; nail of middle toe flat and broad; an additional toe not rarely developed; skin yellowish. Comb and wattle well developed. Skull with deep medial furrow;

occipital foramen, sub-triangular, vertically elongated. Voice peculiar. Eggs rough, buff-coloured. Disposition extremely quiet. Of Chinese origin.

4. DORKING BREED.—Size great; body square, compact; feet with an additional toe; comb well developed, but varies much in form; wattles well developed; colour of plumage various. Skull remarkably broad between the orbits. Of English origin.

The white Dorking may be considered as a distinct sub-breed, being a less massive bird.

Fig. 30—Spanish Fowl

5. SPANISH BREED (fig. 30).—Tall, with stately carriage; tarsi long; comb single, deeply serrated, of immense size; wattles largely developed; the large ear-lobes and sides of face white. Plumage black glossed with green. Do not incubate. Tender in constitution, the comb being often injured by frost. Eggs white, smooth, of large size. Chickens feather late but the young cocks show their masculine characters, and crow at an early age. Of Mediterranean origin.

The *Andalusians* may be ranked as a sub-breed: they are of a slaty-blue colour, and their chickens are well feathered. A smaller, short-legged Dutch sub-breed has been described by some authors as distinct.

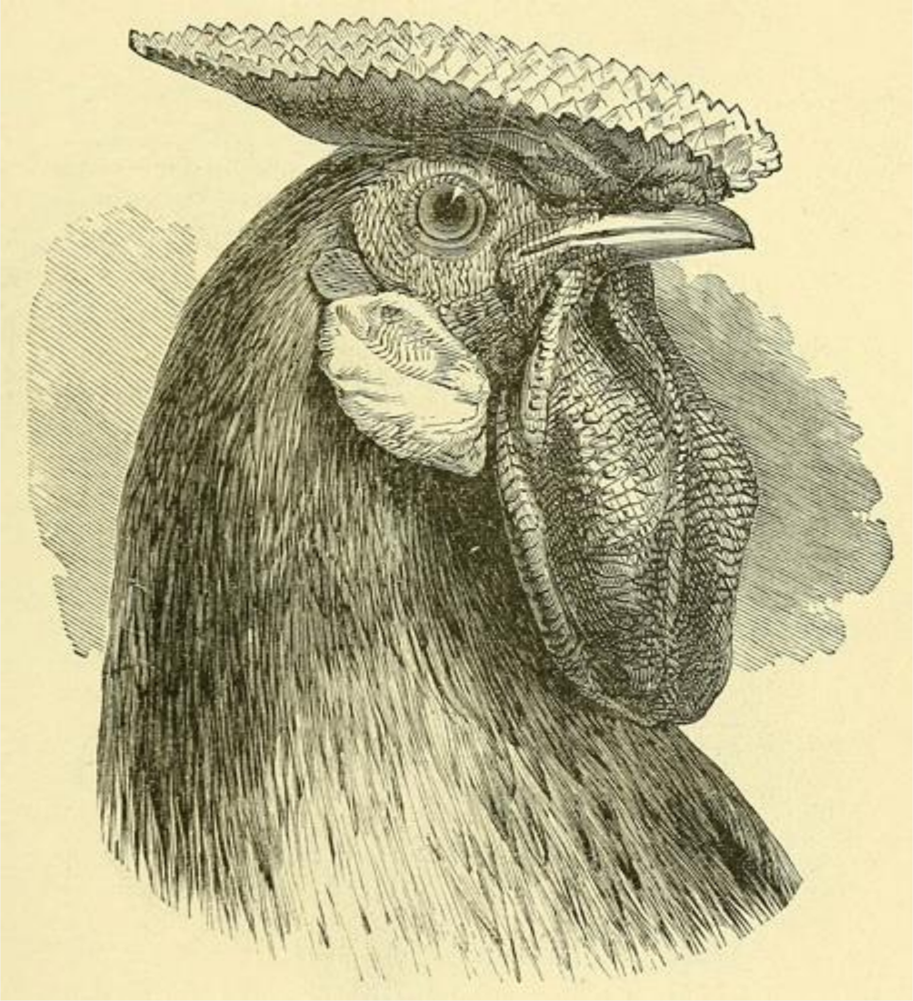


Fig. 31—Hamburgh Fowl

6. HAMBURGH BREED (fig 31).—Size moderate; comb flat, produced backwards, covered with numerous small points; wattle of moderate dimensions; ear lobe white; legs blueish, thin. Do not incubate. Skull, with the tips of the ascending branches of the premaxillary and with the nasal bones standing a little separate from each other; anterior margin of the frontal bones less depressed than usual.

There are two sub-breeds; the *spangled* Hamburgh, of English origin, with the tips of the feathers marked with a dark spot; and the *pencilled* Hamburgh, of Dutch origin, with dark transverse lines across each feather, and with the body rather smaller. Both these sub-breeds include gold and silver varieties, as well as some other sub-varieties. Black Hamburghs have been produced by a cross with the Spanish breed.

Fig. 32—Polish Fowl

7. CRESTED OR POLISH BREED (fig 32).—Head with a large, rounded crest of feathers, supported on a hemispherical protuberance of the frontal bones, which includes the anterior part of the brain. The ascending branches of premaxillary bones and the inner nasal processes are much shortened. The orifice of the nostrils raised and crescentic. Beak short. Comb absent, or small and of crescentic shape; wattles either present or replaced by a beard-like tuft of feathers. Legs leaden-blue. Sexual differences appear late in life. Do not incubate. There are several beautiful varieties which differ in colour and slightly in other respects.

The following sub-breeds agree in having a crest, more or less developed, with the comb, when present, of crescentic shape. The skull presents nearly the same remarkable peculiarities of structure as in the true Polish fowl.

Sub-breed *(a) Sultans*.—A Turkish breed, resembling white Polish fowls with a large crest and beard with short and well-feathered legs. The tail is furnished with additional sickle feathers. Do not incubate.[2]

Sub-breed *(b) Ptarmigans.*—An inferior breed closely allied to the last, white, rather small, legs much feathered, with the crest pointed; comb small, cupped; wattles small.

Sub-breed *(c) Ghoondooks.*—Another Turkish breed having an extraordinary appearance; black and tailless; crest and beard large; legs feathered. The inner processes of the two nasal bones come into contact with each other, owing to the complete abortion of the ascending branches of the premaxillaries. I have seen an allied white, tailless breed from Turkey.

Sub-breed *(d) Crève-cœur.*—A French breed of large size, barely capable of flight, with short black legs, head crested, comb produced into two points or horns, sometimes a little branched like the horns of a stag; both beard and wattles present. Eggs large. Disposition quiet.[3]

Sub-breed *(e) Horned fowl.*—With a small crest; comb produced into two great points, supported on two bony protuberances.

Sub-breed *(f) Houdan.*—A French breed; of moderate size, short-legged with five toes, well developed; plumage invariably mottled with black, white, and straw-yellow; head furnished with a crest, on a triple comb placed transversely; both wattles and beard present.[4]

Sub-breed *(g) Guelderlands.*—No comb, head said to be surmounted by a longitudinal crest of soft velvety feathers; nostrils said to be crescentic; wattles well developed; legs feathered; colour black. From North America. The Breda fowl seems to be closely allied to the Guelderland.

8. BANTAM BREED.—Originally from Japan[5] characterised by small size alone; carriage bold and erect. There are several sub-breeds, such as the Cochin, Game, and Sebright Bantams, some of which have been recently formed by various crosses. The Black Bantam has a differently shaped skull, with the occipital foramen like that of the Cochin fowl.

9. RUMPLESS FOWLS.—These are so variable in character[6] that they hardly deserve to be called a breed. Any one who will examine the caudal vertebræ will see how monstrous the breed is.

10. CREEPERS OR JUMPERS.—These are characterised by an almost monstrous shortness of legs, so that they move by jumping rather than by walking; they are said not to scratch up the ground. I have examined a Burmese variety, which had a skull of rather unusual shape.

11. FRIZZLED OR CAFFRE FOWLS.—Not uncommon in India, with the feathers curling backwards, and with the primary feathers of the wing and tail imperfect; periosteum of bones black.

12. SILK FOWLS.—Feathers silky, with the primary wing and tail-feathers imperfect; skin and periosteum of bones black; comb and wattles dark leaden-blue; ear-

lappets tinged with blue; legs thin, often furnished with an additional toe. Size rather small.

13. SOOTY FOWLS.—An Indian breed, having the peculiar appearance of a white bird smeared with soot, with black skin and periosteum. The hens alone are thus characterised.

From this synopsis we see that the several breeds differ considerably, and they would have been nearly as interesting for us as pigeons, if there had been equally good evidence that all had descended from one parent-species. Most fanciers believe that they are descended from several primitive stocks. The Rev. E. S. Dixon[7] argues strongly on this side of the question; and one fancier even denounces the opposite conclusion by asking, “Do we not perceive pervading this spirit, the spirit of the *Deist*?” Most naturalists, with the exception of a few, such as Temminck, believe that all the breeds have proceeded from a single species; but authority on such a point goes for little. Fanciers look to all parts of the world as the possible sources of their unknown stocks; thus ignoring the laws of geographical distribution. They know well that the several kinds breed truly even in colour. They assert, but, as we shall see, on very weak grounds, that most of the breeds are extremely ancient. They are strongly impressed with the great difference between the chief kinds, and they ask with force, can differences in climate, food, or treatment have produced birds so different as the black stately Spanish, the diminutive elegant Bantam, the heavy Cochin with its many peculiarities, and the Polish fowl with its great top-knot and protuberant skull? But fanciers, whilst admitting and even overrating the effects of crossing the various breeds, do not sufficiently regard the probability of the occasional birth, during the course of centuries, of birds with abnormal and hereditary peculiarities; they overlook the effects of correlation of growth—of the long-continued use and disuse of parts, and of some direct result from changed food and climate, though on this latter head I have found no sufficient evidence; and lastly, they all, as far as I know, entirely overlook the all-important subject of unconscious or unmethodical selection, though they are well aware that their birds differ individually and that by selecting the best birds for a few generations they can improve their stocks.

An amateur writes[8] as follows: “The fact that poultry have until lately received but little attention at the hands of the fancier, and been entirely confined to the domains of the producer for the market, would alone suggest the improbability of that constant and unremitting attention having been observed in breeding, which is requisite to the consummating in the offspring of any two birds transmittable forms not exhibited by the parents.” This at first sight appears true. But in a future chapter on Selection, abundant facts will be given showing not only that careful breeding, but that actual selection was practised during ancient periods, and by barely civilised races of man. In the case of the fowl I can adduce no direct facts showing that selection was anciently practised; but the Romans at the commencement of the Christian era kept six or seven breeds, and Columella “particularly recommends as the best, those sorts that have five toes and white ears."[9] In the fifteenth century several breeds were known and described in Europe; and in China, at nearly the same period, seven kinds were named. A more striking case is that at present, in one of the Philippine Islands, the semi-barbarous inhabitants have distinct native names for no less than nine sub-breeds of the Game fowl.[10] Azara,[11] who wrote towards the close of the last century, states that in the interior parts of South America, where I should not have expected that the least care would have been taken of poultry, a black-skinned and black-boned breed is kept, from being considered fertile and its flesh good for sick persons. Now every one who has kept poultry knows how impossible it is to keep several breeds distinct unless the utmost care be taken in separating the sexes. Will it then be pretended that those persons who, in ancient times and in semi-civilised countries took pains to keep the breeds distinct, and who therefore valued them, would not occasionally have destroyed inferior birds and occasionally have preserved their best birds? This is all that is required. It is not pretended that any one in ancient times intended to form a new breed, or to modify an old breed according to some ideal standard of excellence. He who cared for poultry would merely wish to obtain, and afterwards to rear, the best birds which he could; but this occasional preservation of the best birds would in the course of time modify the breed, as surely, though by no means as rapidly, as does methodical selection at the present day, If one person out of a hundred or out of a thousand attended to the breeding of his birds, this would be sufficient; for the birds thus tended would soon become superior to others, and would form a new strain; and this strain would, as explained in the last chapter, slowly have its characteristic differences augmented, and at last be converted into a new sub-breed or breed. But breeds would often be for a time neglected and would deteriorate; they would, however, partially retain their character, and afterwards might again come into fashion and be raised to a standard of perfection higher than their former standard; as has actually occurred quite recently with Polish fowls. If, however, a breed were utterly neglected, it would become extinct, as has recently happened with one of the Polish sub-breeds. Whenever in the course of past centuries a bird appeared with some slight abnormal structure, such as with a lark-like crest on its head, it would probably often have been preserved from that love of novelty which leads some persons in England to keep rumpless fowls, and others in India to keep frizzled fowls. And after a time any such abnormal appearance would be carefully preserved, from being esteemed a sign of the purity and excellence of the breed; for on this principle the Romans eighteen centuries ago valued the fifth toe and the white ear-lobe in their fowls.

Thus from the occasional appearance of abnormal characters, though at first only slight in degree; from the effects of the use and the disuse of parts; possibly from the direct effects of changed climate and food; from correlation of growth; from occasional reversions to old and long-lost characters; from the crossing of breeds, when more than one had been formed; but, above all, from unconscious selection carried on during many generations, there is no insuperable difficulty, to the best of my judgment, in believing that all the breeds have descended from some one parent-source. Can any single species be named from which we may reasonably suppose that all are descended? The Gallus bankiva apparently fulfils every requirement. I have already given as fair an account as I could of the arguments in favour of the multiple origin of the several breeds; and now I will give those in favour of their common descent from *G. bankiva*.

But it will be convenient first briefly to describe all the known species of Gallus. The *G. sonneratii* does not range into the northern parts of India; according to Colonel Sykes,[12] it presents at different heights of the Ghauts, two strongly marked varieties, perhaps deserving to be called species. It was at one time thought to be the primitive stock of all our domestic breeds, and this shows that it closely approaches the common fowl in general structure; but its hackles partially consist of highly peculiar, horny laminæ, transversely banded with three colours; and I have met no authentic account of any such character having been observed in any domestic breed.[13] This species also differs greatly from the common fowl, in the comb being finely serrated, and in the loins being destitute of true hackles. Its voice is utterly different. It crosses readily in India with domestic hens; and Mr. Blyth[14] raised nearly 100 hybrid chickens; but they were tender and mostly died whilst young. Those which were reared were absolutely sterile when crossed inter se or with either parent. At the Zoological Gardens, however, some ‘hybrids of the same parentage were not quite so sterile: Mr. Dixon, as he informed me, made, with Mr. Yarrell’s aid, particular inquiries on this subject, and was assured that out of 50 eggs only five or six chickens were reared. Some, however, of these half-bred birds were crossed with one of their parents, namely, a Bantam, and produced a few extremely feeble chickens. Mr. Dixon also procured some of these same birds and crossed them in several ways, but all were more or less infertile. Nearly similar experiments have recently been tried on a great scale in the Zoological Gardens with almost the same result.[15] Out of 500 eggs, raised from various first crosses and hybrids, between *G. sonneratii*, *bankiva*, and *varius*, only 12 chickens were reared, and of these only three were the product of hybrids *inter se*. From these facts, and from the above-mentioned strongly-marked differences in structure between the domestic fowl and *G. sonneratii*, we may reject this latter species as the parent of any domestic breed.

Ceylon possesses a fowl peculiar to the island, viz. *G. stanleyii*; this species approaches so closely (except in the colouring of the comb) to the domestic fowl, that Messrs. Layard and Kellaert[16] would have considered it, as they inform me, as one of the parent-stocks, had it not been for its singularly different voice. This bird, like the last, crosses readily with tame hens, and even visits solitary farms and ravishes them. Two hybrids, a male and female, thus produced, were found by Mr. Mitford to be quite sterile: both inherited the peculiar voice of *G. stanleyii*. This species, then, may in all probability be rejected as one of the primitive stocks of the domestic fowl.

Java and the islands eastward as far as Flores are inhabited by *G. varius* (or *furcatus*), which differs in so many characters—green plumage, unserrated comb, and single median wattle—that no one supposes it to have been the parent of any one of our breeds;

yet, as I am informed by Mr. Crawfurd,[17] hybrids are commonly raised between the male *G. varius* and the common hen, and are kept for their great beauty, but are invariably sterile: this, however, was not the case with some bred in the Zoological Gardens. These hybrids were at one time thought to be specifically distinct, and were named *G. æneus*. Mr. Blyth and others believe that the *G. temminckii*[18] (of which the history is not known) is a similar hybrid. Sir J. Brooke sent me some skins of domestic fowls from Borneo, and across the tail of one of these, as Mr. Tegetmeier observed, there were transverse blue bands like those which he had seen on the tail-feathers of hybrids from *G. varius,* reared in the Zoological Gardens. This fact apparently indicates that some of the fowls of Borneo have been slightly affected by crosses with *G. varius,* but the case may possibly be one of analogous variation. I may just allude to the *G. giganteus,* so often referred to in works on poultry as a wild species; but Marsden[19] the first describer, speaks of it as a tame breed; and the specimen in the British Museum evidently has the aspect of a domestic variety.

The last species to be mentioned, namely, *Gallus bankiva,* has a much wider geographical range than the three previous species; it inhabits Northern India as far west as Sinde, and ascends the Himalaya to a height of 4000 ft.; it inhabits Burmah, the Malay peninsula, the Indo-Chinese countries, the Philippine Islands, and the Malayan archipelago as far eastward as Timor. This species varies considerably in the wild state. Mr. Blyth informs me that the specimens, both male and female, brought from near the Himalaya, are rather paler coloured than those from other parts of India; whilst those from the Malay peninsula and Java are brighter coloured than the Indian birds. I have seen specimens from these countries, and the difference of tint in the hackles was conspicuous. The Malayan hens were a shade redder on the breast and neck than the Indian hens. The Malayan males generally had a red ear-lappet, instead of a white one as in India; but Mr. Blyth has seen one Indian specimen without the white ear-lappet. The legs are leaden blue in the Indian, whereas they show some tendency to be yellowish in the Malayan and Javan specimens. In the former Mr. Blyth finds the tarsus remarkably variable in length. According to Temminck[20] the Timor specimens differ as a local race from that of Java. These several wild varieties have not as yet been ranked as distinct species; if they should, as is not unlikely, be hereafter thus ranked, the circumstance would be quite immaterial as far as the parentage and differences of our domestic breeds are concerned. The wild *G. bankiva* agrees most closely with the black-breasted red Game-breed, in colouring and in all other respects, except in being smaller, and in the tail being carried more horizontally. But the manner in which the tail is carried is highly variable in many of our breeds, for, as Mr. Brent informs me, the tail slopes much in the Malays, is erect in the Games and some other breeds, and is more than erect in Dorkings, Bantams, etc. There is one other difference namely, that in *G. bankiva,* according to Mr. Blyth, the neck-hackles when first moulted are replaced during two or three months not by other hackles, as with our domestic poultry, but by short blackish feathers.[21] Mr. Brent, however, has remarked that these black feathers remain in the wild bird after the development of the lower hackles, and appear in the domestic bird at the same time with them: so that the only difference is that the lower hackles are replaced more slowly in the wild than in the tame bird; but as confinement is known sometimes to affect the masculine plumage, this slight difference cannot be considered of any importance. It is a significant fact that the voice of both the male and female *G. bankiva* closely resembles, as Mr. Blyth and others have noted, the voice of both sexes of the common domestic fowl; but the last note of the crow of the wild bird is rather less prolonged. Captain Hutton, well known for his researches into the natural history of India, informs me that he has seen several crossed fowls from the wild species and the Chinese bantam; these crossed fowls *bred freely* with bantams, but unfortunately were not crossed *inter se*. Captain Hutton reared chickens from the eggs of the *Gallus bankiva*; and these, though at first very wild, afterwards became so tame that they would crowd round his feet. He did not succeed in rearing them to maturity; but as he remarks, "no wild gallinaceous bird thrives well at first on hard grain." Mr. Blyth also found much difficulty in keeping *G. bankiva* in confinement. In the Philippine Islands, however, the natives must succeed better, as they keep wild cocks to fight with their domestic game-birds.[22] Sir Walter Elliot informs me that the hen of a native domestic breed of Pegu is undistinguishable from the hen of the wild *G. bankiva*; and the natives constantly catch wild cocks by taking tame cocks to fight with them in the woods.[23] Mr. Crawfurd remarks that from etymology it might be argued that the fowl was first domesticated by the Malays and Javanese.[24] It is also a curious fact, of which I have been assured by Mr. Blyth, that wild specimens of the *Gallus bankiva*, brought from the countries east of the Bay of Bengal, are far more easily tamed than those of India; nor is this an unparalleled fact, for, as Humboldt long ago remarked, the same species sometimes evinces a more tameable disposition in one country than in another. If we suppose that the *G. bankiva* was first tamed in Malaya and afterwards imported into India, we can understand an observation made to me by Mr. Blyth, that the domestic fowls of India do not resemble the wild *G. bankiva* of India more closely than do those of Europe.

From the extremely close resemblance in colour, general structure, and especially in voice, between *Gallus bankiva* and the Game fowl; from their fertility, as far as this has been ascertained, when crossed; from the possibility of the wild species being tamed, and from its varying in the wild state, we may confidently look at it as the parent of the most typical of all the domestic breeds, namely, the Game fowl. It is a significant fact, that almost all the naturalists in India, namely Sir W. Elliot, Mr. S. N. Ward, Mr. Layard, Mr. J. C. Jerdon, and Mr. Blyth,[25] who are familiar with G. bankiva, believe that it is the parent of most or all our domestic breeds. But even if it be admitted that G. bankiva is the parent of the Game breed, yet it may be urged that other wild species have been the parents of the other domestic breeds; and that these species still exist, though unknown, in some country, or have become extinct. The extinction, however, of several species of fowls, is an improbable hypothesis, seeing that the four known species have not become extinct in the most ancient and thickly peopled regions of the East. There is, in fact, not one other kind of domesticated bird, of which the wild parent-form is unknown, that is become extinct. For the discovery of new, or the rediscovery of old species of Gallus, we must not look, as fanciers often look, to the whole world. The larger gallinaceous birds, as Mr. Blyth has remarked,[26] generally have a restricted range: we see this well illustrated in India, where the genus Gallus inhabits the base of the Himalaya, and is succeeded higher up by Gallophasis, and still higher up by Phasianus. Australia, with its islands, is out of the question as the home for unknown species of the genus. It is, also, as improbable that Gallus should inhabit South America[27] as that a humming-bird should be found in the Old World. From the character of the other gallinaceous birds of Africa, it is not probable that Gallus is an African genus. We need not look to the western parts of Asia, for Messrs. Blyth and Crawfurd, who have attended to this subject, doubt whether Gallus ever existed in a wild state even as far west as Persia. Although the earliest Greek writers speak of the fowl as a Persian bird, this probably merely indicates its line of importation. For the discovery of unknown species we must look to India, to the Indo-Chinese countries, and to the northern parts of the Malay Archipelago. The southern portion of China is the most likely country; but as Mr. Blyth informs me, skins have been exported from China during a long period, and living birds are largely kept there in aviaries, so that any native species of Gallus would probably have become known. Mr. Birch, of the British Museum, has translated for me passages from a Chinese Encyclopædia published in 1609, but compiled from more ancient documents, in which it is said that fowls are creatures of the West, and were introduced into the East (*i.e.* China) in a dynasty 1400 B.C. Whatever may be thought of so ancient a date, we see that the Indo-Chinese and Indian regions were formerly considered by the Chinese as the source of the domestic fowl. From these several considerations we must look to the present metropolis of the genus, namely, to the south-eastern parts of Asia, for the discovery of species which were formerly domesticated, but are now unknown in the wild state; and the most experienced ornithologists do not consider it probable that such species will be discovered.

In considering whether the domestic breeds are descended from one species, namely, *G. bankiva*, or from several, we must not quite overlook, though we must not exaggerate, the importance of the test of fertility. Most of our domestic breeds have been so often crossed, and their mongrels so largely kept, that it is almost certain, if any degree of infertility had existed between them, it would have been detected. On the other hand, the four known species of Gallus when crossed with each other, or when crossed, with the exception of *G. bankiva*, with the domestic fowl, produce infertile hybrids.

Finally, we have not such good evidence with fowls as with pigeons, of all the breeds having descended from a single primitive stock. In both cases the argument of fertility must go for something; in both we have the improbability of man having succeeded in ancient times in thoroughly domesticating several supposed species,—most of these supposed species being extremely abnormal as compared with their natural allies,—all being now either unknown or extinct, though the parent-form of no other domesticated bird has been lost. But in searching for the supposed parent-stocks of the various breeds of the pigeon, we were enabled to confine our search to species having peculiar habits of life; whilst with fowls there is nothing in their habits in any marked manner distinct from those of other gallinaceous birds. In the case of pigeons, I have shown that purely-bred birds of every race and the crossed offspring of distinct races frequently resemble, or revert to, the wild rock-pigeon in general colour and in each characteristic mark. With fowls we have facts of a similar nature, but less strongly pronounced, which we will now discuss.

Reversion and Analogous Variation.—Purely-bred Game, Malay, Cochin, Dorking, Bantam, and, as I hear from Mr. Tegetmeier, Silk fowls, may frequently or occasionally be met with, which are almost identical in plumage with the wild *G. bankiva*. This is a fact well deserving attention, when we reflect that these breeds rank amongst the most distinct. Fowls thus coloured are called by amateurs black-breasted reds. Hamburghs properly have a very different plumage; nevertheless, as Mr. Tegetmeier informs me, "the great difficulty in breeding cocks of the golden-spangled variety is their tendency to have black breasts and red backs. The males of white Bantams and white Cochins, as they come to maturity, often assume a yellowish or saffron tinge; and the longer neck hackles of black Bantam cocks,"[28] when two or three years old, not uncommonly become ruddy; these latter Bantams occasionally "even moult brassy-winged, or actually red-shouldered." So that in these several cases we see a plain tendency to reversion to the hues of *G. bankiva*, even during the lifetime of the individual bird. With Spanish, Polish, pencilled Hamburgh, silver-spangled Hamburgh fowls, and with some other less common breeds, I have never heard of a black-breasted red bird having appeared.

From my experience with pigeons, I made the following crosses. I first killed all my own poultry, no others living near my house, and then procured, by Mr. Tegetmeier's assistance, a first-rate black Spanish cock, and hens of the following pure breeds,—white Game, white Cochin, silver-spangled Polish, silver-spangled Hamburgh, silver-pencilled Hamburgh, and white Silk. In none of these breeds is there a trace of red, nor when kept pure have I ever heard of the appearance of a red feather; though such an occurrence would perhaps not be very improbable with white Games and white Cochins. Of the many chickens reared from the above six crosses the majority were black, both in the down and in the first plumage; some were white, and a very few were mottled black and white. In one lot of eleven mixed eggs from the white Game and white Cochin by the black Spanish cock, seven of the chickens were white, and only four black. I mention this fact to show that whiteness of plumage is strongly inherited, and that the belief in the prepotent power in the male to transmit his colour is not always correct. The chickens were hatched in the spring, and in the latter part of August several of the young cocks began to exhibit a change, which with some of them increased during the following years. Thus a young male bird from the silver-spangled Polish hen was in its first plumage coal-black, and combined in its comb, crest, wattle, and beard, the characters of both parents; but when two years old the secondary wing-feathers became largely and symmetrically marked with white, and, wherever in *G. bankiva* the hackles are red, they were in this bird greenish-black along the shaft, narrowly bordered with brownish-black, and this again broadly bordered with very pale yellowish-brown; so that in general appearance the plumage had become pale-coloured instead of black. In this case, with advancing age there was a great change, but no reversion to the red colour of *G. bankiva*.

A cock with a regular rose comb derived either from the spangled or pencilled silver Hamburgh was likewise at first quite black; but in less than a year the neck-hackles, as in the last case, became whitish, whilst those on the loins assumed a decided reddish-yellow tint; and here we see the first symptom of reversion; this likewise occurred with some other young cocks, which need not here be described. It has also been recorded[29] by a breeder, that he crossed two silver-pencilled Hamburgh hens with a Spanish cock, and reared a number of chickens, all of which were black, the cocks having *golden* and the hens brownish hackles; so that in this instance likewise there was a clear tendency to reversion.

Two young cocks from my white Game hen were at first snow white; of these, one subsequently assumed male orange-coloured hackles, chiefly on the loins, and the other an abundance of fine orange-red hackles on the neck, loins, and upper wing-coverts. Here again we have a more decided, though partial, reversion to the colours of *G. bankiva*. This second cock was in fact coloured like an inferior “pile Came cock;”—now this sub-breed can be produced, as I am informed by Mr. Tegetmeier, by crossing a black-breasted red Game cock with a white Game hen, and the “pile” sub-breed thus produced can afterwards be truly propagated. So that we have the curious fact of the glossy-black Spanish cock and the black-breasted red Game cock when crossed with white Game hens producing offspring of nearly the same colours.

I reared several birds from the white Silk hen by the Spanish cock: all were coal-black, and all plainly showed their parentage in having blackish combs and bones; none inherited the so-called silky feathers, and the non-inheritance of this character has been observed by others. The hens never varied in their plumage. As the young cocks grew old, one of them assumed yellowish-white hackles, and thus resembled in a considerable degree the cross from the Hamburgh hen; the other became a gorgeous bird, so much so that an acquaintance had it preserved and stuffed simply from its beauty. When stalking about it closely resembled the wild *Gallus bankiva,* but with the red feathers rather darker. On close comparison one considerable difference presented itself, namely, that the primary and secondary wing-feathers were edged with greenish-black, instead of being edged, as in *G. bankiva,* with fulvous and red tints. The space, also, across the back, which bears dark-green feathers, was broader, and the comb was blackish. In all other respects, even in trifling details of plumage, there was the closest accordance. Altogether it was a marvellous sight to compare this bird first with *G. bankiva,* and then with its father, the glossy green-black Spanish cock, and with its diminutive mother, the white Silk hen. This case of reversion is the more extraordinary as the Spanish breed has long been known to breed true, and no instance is on record of its throwing a single red feather. The Silk hen likewise breeds true, and is believed to be ancient, for Aldrovandi, before 1600, alludes probably to this breed, and described it as covered with wool. It is so peculiar in many characters that some writers have considered it as specifically distinct; yet, as we now see, when crossed with the Spanish fowl, it yields offspring closely resembling the wild *G. bankiva*.

Mr. Tegetmeier has been so kind as to repeat, at my request, the cross between a Spanish cock and Silk hen, and he obtained similar results; for he thus raised, besides a black hen, seven cocks, all of which were dark-bodied with more or less orange-red hackles. In the ensuing year he paired the black hen with one of her brothers, and raised three young cocks, all coloured like their father, and a black hen mottled with white.

The hens from the six above-described crosses showed hardly any tendency to revert to the mottled-brown plumage of the female *G. bankiva*: one hen, however, from the white Cochin, which was at first coal-black, became slightly brown or sooty. Several hens, which were for a long time snow-white, acquired as they grew old a few black feathers. A hen from the white Game, which was for a long time entirely black glossed with green, when two years old had some of the primary wing feathers greyish-white, and a multitude of feathers over her body narrowly and symmetrically tipped or laced with white. I had expected that some of the chickens whilst covered with down would have assumed the longitudinal stripes so general with gallinaceous birds; but this did not occur in a single instance. Two or three alone were reddish-brown about their heads. I was unfortunate in losing nearly all the white chickens from the first crosses; so that black prevailed with the grandchildren; but they were much diversified in colour, some being sooty, others mottled, and one blackish chicken had its feathers oddly tipped and barred with brown.

I will here add a few miscellaneous facts connected with reversion, and with the law of analogous variation. This law implies, as stated in a previous chapter, that the varieties of one species frequently mock distinct but allied species; and this fact is explained, according to the views which I maintain, on the principle of allied species having descended from one primitive form. The white Silk fowl with black skin and bones degenerates, as has been observed by Mr. Hewitt and Mr. R. Orton, in our climate; that is, it reverts to the ordinary colour of the common fowl in its skin and bones, due care having been taken to prevent any cross. In Germany[30] a distinct breed with black bones, and with black, not silky plumage, has likewise been observed to degenerate.

Mr. Tegetmeier informs me that, when distinct breeds are crossed, fowls are frequently produced with their feathers marked or pencilled by narrow transverse lines of a darker colour. This may be in part explained by direct reversion to the parent-form, the Bankiva hen; for this bird has all its upper plumage finely mottled with dark and rufous brown, with the mottling partially and obscurely arranged in transverse lines. But the tendency to pencilling is probably much strengthened by the law of analogous variation, for the hens of some other species of Gallus are more plainly pencilled, and the hens of many gallinaceous birds belonging to other genera, as the partridge, have pencilled feathers. Mr. Tegetmeier has also remarked to me that, although with domestic pigeons we have so great a diversity of colouring, we never see either pencilled or spangled feathers; and this fact is intelligible on the law of analogous variation, as neither the wild rock pigeon nor any closely allied species has such feathers. The frequent appearance of pencilling in crossed birds probably accounts for the existence of "cuckoo" sub-breeds in the Game, Polish, Dorking, Cochin, Andalusian, and Bantam breeds. The plumage of these birds is slaty-blue or grey, with each feather transversely barred with darker lines, so as to resemble in some degree the plumage of the cuckoo. It is a singular fact, considering that the male of no species of Gallus is in the least barred, that the cuckoo-like plumage has often been transferred to the male, more especially in the cuckoo Dorking; and the fact is all the more singular, as in gold- and silver-pencilled Hamburghs, in which pencilling is characteristic of the breed, the male is hardly at all pencilled, this kind of plumage being confined to the female.

Another case of analogous variation is the occurrence of spangled sub-breeds of Hamburgh, Polish, Malay, and Bantam fowls. Spangled feathers have a dark mark, properly crescent-shaped, on their tips; whilst pencilled feathers have several transverse bars. The spangling cannot be due to reversion to *G. bankiva*; nor does it often follow, as I hear from Mr. Tegetmeier, from crossing distinct breeds; but it is a case of analogous variation, for many gallinaceous birds have spangled feathers,—for instance, the common pheasant. Hence spangled breeds are often called "pheasant"-fowls. Another case of analogous variation in several domestic breeds is inexplicable; it is, that the chickens, whilst covered with down, of the black Spanish, black Game, black Polish, and black Bantam, all have white throats and breasts, and often have some white on their wings.[31] The editor of the 'Poultry Chronicle'[32] remarks that all the breeds which properly have red ear-lappets occasionally produce birds with white ear-Tappets. This remark more especially applies to the Game breed, which of all comes nearest to the *G. bankiva*; and we have seen that with this species living in a state of nature, the ear-lappets vary in colour, being red in the Malayan countries, and generally, but not invariably, white in India.

In concluding this part of my subject, I may repeat that there exists one widely-ranging, varying, and common species of Gallus, namely, *G. bankiva*, which can be tamed, produces fertile offspring when crossed with common fowls, and closely resembles in its whole structure, plumage, and voice the Game breed; hence it may be safely ranked as the parent of this, the most typical domesticated breed. We have seen that there is much difficulty in believing that other, now unknown, species have been the parents of the other domestic breeds. We know that all the breeds are most closely allied, as shown by their similarity in most points of structure and in habits, and by the analogous manner in which they vary. We have also seen that several of the most distinct breeds occasionally or habitually closely resemble in plumage *G. bankiva,* and that the crossed offspring of other breeds, which are not thus coloured, show a stronger or weaker tendency to revert to this same plumage. Some of the breeds, which appear the most distinct and the least likely to have proceeded from *G. bankiva,* such as Polish fowls, with their protuberant and little ossified skulls, and Cochins, with their imperfect tail and small wings, bear in these characters the plain marks of their artificial origin. We know well that of late years methodical selection has greatly improved and fixed many characters; and we have every reason to believe that unconscious selection, carried on for many generations, will have steadily augmented each new peculiarity, and thus have given rise to new breeds. As soon as two or three breeds were once formed, crossing would come into play in changing their character and in increasing their number. Brahma Pootras, according to an account lately published in America, offer a good instance of a breed, lately formed by a cross, which can be truly propagated. The well-known Sebright Bantams offer another and similar instance. Hence it may be concluded that not only the Game-breed but that all our breeds are probably the descendants of the Malayan or Indian variety of *G. bankiva.* If so, this species has varied greatly since it was first domesticated; but there has been ample time, as we shall now show.

History of the Fowl.—Rütimeyer found no remains of the fowl in the ancient Swiss lake-dwellings; but, according to Jeitteles,[33] such have certainly since been found associated with extinct animals and prehistoric remains. It is, therefore a strange fact that the fowl is not mentioned in the Old Testament, nor figured on the ancient Egyptian monuments. It is not referred to by Homer or Hesiod (about 900 B.C.); but is mentioned by Theognis and Aristophanes between 400 and 500 B.C. It is figured on some of the Babylonian cylinders, between the sixth and seventh centuries B.C., of which Mr. Layard sent me an impression; and on the Harpy Tomb in Lycia, about 600 B.C.: so that the fowl apparently reached Europe in a domesticated condition somewhere about the sixth century B.C. It had travelled still farther westward by the time of the Christian era, for it was found in Britain by Julius Cæsar. In India it must have been domesticated when the Institutes of Manu were written, that is, according to Sir W. Jones, 1200 B.C., but, according to the later authority of Mr. H. Wilson, only 800 B.C., for the domestic fowl is forbidden, whilst the wild is permitted to be eaten. If, as before remarked, we may trust the old Chinese Encyclopædia, the fowl must have been domesticated several centuries earlier, as it is said to have been introduced from the West into China 1400 B.C.

Sufficient materials do not exist for tracing the history of the separate breeds. About the commencement of the Christian era, Columella mentions a five-toed fighting breed, and some provincial breeds; but we know nothing about them. He also alludes to dwarf fowls; but these cannot have been the same with our Bantams, which, as Mr. Crawfurd has shown, were imported from Japan into Bantam in Java. A dwarf fowl, probably the true Bantam, is referred to in an old Japanese Encyclopædia, as I am informed by Mr. Birch. In the Chinese Encyclopædia published in 1596, but compiled from various sources, some of high antiquity, seven breeds are mentioned, including what we should now call Jumpers or Creepers, and likewise fowls with black feathers, bones, and flesh. In 1600 Aldrovandi describes seven or eight breeds of fowls, and this is the most ancient record from which the age of our European breeds can be inferred. The *Gallus turcicus* certainly seems to be a pencilled Hamburgh; but Mr. Brent, a most capable judge, thinks that Aldrovandi "evidently figured what he happened to see, and not the best of the breed." Mr. Brent, indeed, considers all Aldrovandi's fowls as of impure breed; but it is a far more probable view that all our breeds have been much improved and modified since his time; for, as he went to the expense of so many figures, he probably would have secured characteristic specimens. The Silk fowl, however, probably then existed in its present state, as did almost certainly the fowl with frizzled or reversed feathers. Mr. Dixon[34] considers Aldrovandi's Paduan fowl as "a variety of the Polish," whereas Mr. Brent believes it to have been more nearly allied to the Malay. The anatomical peculiarities of the skull of the Polish breed were noticed by P. Borelli in 1656. I may add that in 1737 one Polish sub-breed, viz., the Golden-spangled, was known; but judging from Albin's description, the comb was then larger, the crest of feathers much smaller, the breast more coarsely spotted, and the stomach and thighs much blacker: a Golden-spangled Polish fowl in this condition would now be of no value.

Differences in External and Internal Structure between the Breeds: Individual Variability.—Fowls have been exposed to diversified conditions of life, and as we have just seen there has been ample time for much variability and for the slow action of unconscious selection. As there are good grounds for believing that all the breeds are descended from Gallus bankiva, it will be worth while to describe in some detail the chief points of difference. Beginning with the eggs and chickens, I will pass on to their secondary sexual characters, and then to their differences in external structure and in the skeleton. I enter on the following details chiefly to show how variable almost every character has become under domestication.

Eggs.—Mr. Dixon remarks[35] that "to every hen belongs an individual peculiarity in the form, colour, and size of her egg, which never changes during her life-time, so long as she remains in health, and which is as well known to those who are in the habit of taking her produce, as the hand-writing of their nearest acquaintance." I believe that this is generally true, and that, if no great number of hens be kept, the eggs of each can almost always be recognised. The eggs of differently sized breeds naturally differ much in size; but apparently, not always in strict relation to the size of the hen: thus the Malay is a larger bird than the Spanish, but she produces not such large eggs; white Bantams are said to lay smaller eggs than other Bantams;[36] white Cochins, on the other hand, as I hear from Mr. Tegetmeier, certainly lay larger eggs than buff Cochins. The eggs, however, of the different breeds vary considerably in character; for instance, Mr. Ballance states[37] that his Malay "pullets of last year laid eggs equal in size to those of any duck, and other Malay hens, two or three years old, laid eggs very little larger than a good sized Bantam's egg. Some were as white as a Spanish hen's egg, and others varied from a light cream-colour to a deep rich buff, or even to a brown." The shape also varies, the two ends being much more equally rounded in Cochins than in Games or Polish. Spanish fowls lay smoother eggs than Cochins, of which the eggs are generally granulated. The shell in this latter breed, and more especially in Malays is apt to be thicker than in Games or Spanish; but the Minorcas, a sub-breed of Spanish, are said to lay harder eggs than true Spanish.[38] The colour differs considerably,—the Cochins laying buff-coloured eggs; the Malays a paler variable buff; and Games a still paler buff. It would appear that darker-coloured eggs characterise the breeds which have lately come from the East, or are still closely allied to those now living there. The colour of the yolk, according to Ferguson, as well as of the shell, differs slightly in the sub-breeds of the Game. I am also informed by Mr. Brent that dark partridge-coloured Cochin hens lay darker coloured eggs than the other Cochin sub-breeds. The flavour and richness of the egg certainly differ in different breeds. The productiveness of the several breeds is very different. Spanish, Polish, and Hamburgh hens have lost the incubating instinct.

Chickens.—As the young of almost all gallinaceous birds, even of the black curassow and black grouse, whilst covered with down, are longitudinally striped on the back,—of which character, when adult, neither sex retains a trace,—it might have been expected that the chickens of all our domestic fowls would have been similarly striped.[39] This could, however, hardly have been expected, when the adult plumage in both sexes has undergone so great a change as to be wholly white or black. In white fowls of various breeds the chickens are uniformly yellowish white, passing in the black-boned Silk fowl into bright canary-yellow. This is also generally the case with the chickens of white Cochins, but I hear from Mr. Zurhost that they are sometimes of a buff or oak colour, and that all those of this latter colour, which were watched, turned out males. The chickens of buff Cochins are of a golden-yellow, easily distinguishable from the paler tint of the white Cochins, and are often longitudinally streaked with dark shades: the chickens of silver-cinnamon Cochins are almost always of a buff colour. The chickens of the white Game and white Dorking breeds, when held in particular lights, sometimes exhibit (on the authority of Mr. Brent) faint traces of longitudinal stripes. Fowls which are entirely black, namely, Spanish, black Game, black Polish, and black Bantams, display a new character, for their chickens have their breasts and throats more or less white, with sometimes a little white elsewhere. Spanish chickens also, occasionally (Brent), have, where the down was white, their first true feathers tipped for a time with white. The primordially striped character is retained by the chickens of most of the Game sub-breeds (Brent, Dixon); by Dorkings; by the partridge and grouse-coloured sub-breeds of Cochins (Brent), but not, as we have seen, by the sub-breeds; by the pheasant-Malay (Dixon), but apparently not (at which I am much surprised) by other Malays. The following breeds and sub-breeds are barely, or not at all, longitudinally striped: viz., gold and silver pencilled Hamburghs, which can hardly be distinguished from each other (Brent) in the down, both having a few dark spots on the head and rump, with occasionally a longitudinal stripe (Dixon) on the back of the neck. I have seen only one chicken of the silver-spangled Hamburgh, and this was obscurely striped along the back. Gold-spangled Polish chickens (Tegetmeier) are of a warm russet brown; and silver-spangled Polish chickens are grey, sometimes (Dixon) with dashes of ochre on the head, wings, and breast. Cuckoo and blue-dun fowls (Dixon) are grey in the down. The chickens of Sebright Bantams (Dixon) are uniformly dark brown, whilst those of the brown-breasted red Game Bantam are black, with some white on the throat and breast. From these facts we see that young chickens of the different breeds, and even of the same main breed, differ much in their downy plumage; and, although longitudinal stripes characterise the young of all wild gallinaceous birds, they disappear in several domestic breeds. Perhaps it may be accepted as a general rule that the more the adult plumage differs from that of the adult *G. bankiva,* the more completely the chickens have lost their stripes.

With respect to the period of life at which the characters proper to each breed first appear, it is obvious that such structures as additional toes must be formed long before birth. In Polish fowls, the extraordinary protuberance of the anterior part of the skull is well developed before the chickens come out of the egg;[40] but the crest, which is supported on the protuberance, is at first feebly developed, nor does it attain its full size until the second year. The Spanish cock is pre-eminent for his magnificent comb, and this is developed at an unusually early age; so that the young males can be distinguished from the females when only a few weeks old, and therefore earlier than in other breeds; they likewise crow very early, namely, when about six weeks old. In the Dutch sub-breed of the Spanish fowl the white ear-lappets are developed earlier than in the common Spanish breed.[41] Cochins are characterised by a small tail, and in the young cocks the tail is developed at an unusually late period.[42] Game fowls are notorious for their pugnacity; and the young cocks crow, clap their little wings, and fight obstinately with each other, even whilst under their mother’s care.[43] “I have often had,” says one author,[44] “whole broods, scarcely feathered, stone-blind from fighting; the rival couples moping in corners, and renewing their battles on obtaining the first ray of light.” The weapons and pugnacity of all male gallinaceous birds evidently serve the purpose of gaining possession of the females; so that the tendency in our Game chickens to fight at an extremely early age is not only useless, but injurious, as they suffer much from their wounds. The training for battle during an early age may be natural to the wild Gallus bankiva; but as man during many generations has gone on selecting the most obstinately pugnacious cocks, it is more probable that their pugnacity has been unnaturally increased, and unnaturally transferred to the young male chickens. In the same manner, it is probable that the extraordinary development of the comb in the Spanish cock has been unintentionally transferred to the young cocks; for fanciers would not care whether their young birds had large combs, but would select for breeding the adults which had the finest combs, whether or not developed at an early period. The last point which need here be noticed is that, though the chickens of Spanish and Malay fowls are well covered with down, the true feathers are acquired at an unusually late age; so that for a time the young birds are partially naked, and are liable to suffer from cold.

Secondary Sexual Characters.—The two sexes in the parent-form, the *Gallus bankiva*, differ much in colour. In our domestic breeds the difference is never greater, but is often less, and varies much in degree even in the sub-breeds of the same main breed. Thus in certain Game fowls the difference is as great as in the parent-form, whilst in the black and white sub-breeds there is no difference in plumage. Mr. Brent informs me that he has seen two strains of black-breasted red Games, of which the cocks could not be distinguished, whilst the hens in one were partridge-brown and in the other fawn-brown. A similar case has been observed in the strains of the brown-breasted red Game. The hen of the "duck-winged Game" is "extremely beautiful," and differs much from the hens of all the other Game sub-breeds; but generally, as with the blue and grey Game and with some sub-varieties of the pile-game, a moderately close relation may be observed between the males and females in the variation of their plumage.[45] A similar relation is also evident when we compare the several varieties of Cochins. In the two sexes of gold and silver-spangled and of buff Polish fowls, there is much general similarity in the colouring and marks of the whole plumage, excepting of course in the hackles, crest, and beard. In spangled Hamburghs, there is likewise a considerable degree of similarity between the two sexes. In pencilled Hamburghs, on the other hand, there is much dissimilarity; the pencilling which is characteristic of the hens being almost absent in the males of both the golden and silver varieties. But, as we have already seen, it cannot be given as a general rule that male fowls never have pencilled feathers, for Cuckoo Dorkings are "remarkable from having nearly similar markings in both sexes."

It is a singular fact that the males in certain sub-breeds have lost some of their secondary masculine characters, and from their close resemblance in plumage to the females, are often called hennies. There is much diversity of opinion whether these males are in any degree sterile; that they sometimes are partially sterile seems clear,[46] but this may have been caused by too close interbreeding. That they are not quite sterile, and that the whole case is widely different from that of old females assuming masculine characters, is evident from several of these hen-like sub-breeds having been long propagated. The males and females of gold and silver-laced Sebright Bantams can be barely distinguished from each other, except by their combs, wattles, and spurs, for they are coloured alike, and the males have not hackles, nor the flowing sickle-like tail-feathers. A hen-tailed sub-breed of Hamburghs was recently much esteemed. There is also a breed of Game-fowls, in which the males and females resemble each other so closely that the cocks have often mistaken their hen-feathered opponents in the cock-pit for real hens, and by the mistake have lost their lives.[47] The cocks, though dressed in the feathers of the hen, "are high-spirited birds, and their courage has been often proved:" an engraving even has been published of one celebrated hen-tailed victor. Mr. Tegetmeier[48] has recorded the remarkable case of a brown-breasted red Game cock which, after assuming its perfect masculine plumage, became hen-feathered in the autumn of the following year; but he did not lose voice, spurs, strength, nor productiveness. This bird has now retained the same character during five seasons, and has begot both hen-feathered and male-feathered offspring. Mr. Grantley F. Berkeley relates the still more singular case of a celebrated strain of "polecat Game fowls," which produced in nearly every brood a single hen-cock. "The great peculiarity in one of these birds was that he, as the seasons succeeded each other, was not always a hen-cock, and not always of the colour called the polecat, which is black. From the polecat and hen-cock feather in one season he moulted to a full male-plumaged black-breasted red, and in the following year he returned to the former feather."[49]

I have remarked in my 'Origin of Species' that secondary sexual characters are apt to differ much in the species of the same genus, and to be unusually variable in the individuals of the same species. So it is with the breeds of the fowl, as we have already seen, as far as the colour of plumage is concerned, and so it is with the other secondary sexual characters. Firstly, the comb differs much in the various breeds,[50] and its form is eminently characteristic of each kind, with the exception of the Dorkings, in which the form has not been as yet determined on by fanciers, and fixed by selection. A single, deeply-serrated comb is the typical and most common form. It differs much in size, being immensely developed in Spanish fowls; and in a local breed called Red-caps, it is sometimes "upwards of three inches in breadth at the front, and more than four inches in length, measured to the end of the peak behind."[51] In some breeds the comb is double, and when the two ends are cemented together it forms a "cup-comb;" in the "rose-comb" it is depressed, covered with small projections, and produced backwards; in the horned and creve-coeur fowl it is produced into two horns; it is triple in the pea-combed Brahmas, short and truncated in the Malays, and absent in the Guelderlands. In the tasselled Game a few long feathers rise from the back of the comb: in many breeds a crest of feathers replaces the comb. The crest, when little developed, arises from a fleshy mass, but, when much developed, from a hemispherical protuberance of the skull. In the best Polish fowls it is so largely developed, that I have seen birds which could hardly pick up their food; and a German writer asserts[52] that they are in consequence liable to be struck by hawks. Monstrous structures of this kind would thus be suppressed in a state of nature. The wattles, also, vary much in size, being small in Malays and some other breeds; in certain Polish sub-breeds they are replaced by a great tuft of feathers called a beard.

The hackles do not differ much in the various breeds, but are short and stiff in Malays, and absent in Hennies. As in some orders male birds display extraordinarily-shaped feathers, such as naked shafts with discs at the end, etc., the following case may be worth giving. In the wild *Gallus bankiva* and in our domestic fowls, the barbs which arise from each side of the extremities of the hackles are naked or not clothed with barbules, so that they resemble bristles; but Mr. Brent sent me some scapular hackles from a young Birchen Duckwing Game cock, in which the naked barbs became densely re-clothed with barbules towards their tips; so that these tips, which were dark coloured with a metallic lustre, were separated from the lower parts by a symmetrically-shaped transparent zone formed of the naked portions of the barbs. Hence the coloured tips appeared like little separate metallic discs.

The sickle-feathers in the tail, of which there are three pair, and which are eminently characteristic of the male sex, differ much in the various breeds. They are scimitar-shaped in some Hamburghs, instead of being long and flowing as in the typical breeds. They are extremely short in Cochins, and are not at all developed in Hennies. They are carried, together with the whole tail, erect in Dorkings and Gaines; but droop much in Malays and in some Cochins. Sultans are characterised by an additional number of lateral sickle-feathers. The spurs vary much, being placed higher or lower on the shank; being extremely long and sharp in Games, and blunt and short in Cochins. These latter birds seem aware that their spurs are not efficient weapons; for though they occasionally use them, they more frequently fight, as I am informed by Mr. Tegetmeier, by seizing and shaking each other with their beaks. In some Indian Game cocks, received by Mr. Brent from Germany, there are, as he informs me, three, four, or even five spurs on each leg. Some Dorkings also have two spurs on each leg;[53] and in birds of this breed the spur is often placed almost on the outside of the leg. Double spurs are mentioned in an ancient Chinese Encyclopædia. Their occurrence may be considered as a case of analogous variation, for some wild gallinaceous birds, for instance, the Polyplectron, have double spurs.

Judging from the differences which generally distinguish the sexes in the Gallinaceæ, certain characters in our domestic fowls appear to have been transferred from the one sex to the other. In all the species (except in Turnix), when there is any conspicuous difference in plumage between the male and female, the male is always the most beautiful; but in golden-spangled Hamburghs the hen is equally beautiful with the cock, and incomparably more beautiful than the hen in any natural species of Gallus; so that here a masculine character has been transferred to the female. On the other hand, in Cuckoo Dorkings and in other cuckoo breeds the pencilling, which in Gallus is a female attribute, has been transferred to the male: nor, on the principle of analogous variation, is this transference surprising, as the males in many gallinaceous genera are barred or pencilled. With most of these birds head ornaments of all kinds are more fully developed in the male than in the female; but in Polish fowls the crest or top-knot, which in the male replaces the comb, is equally developed in both sexes. In the males of certain other sub-breeds, which from the hen having a small crest, are called lark-crested, "a single upright comb sometimes almost entirely takes the place of the crest."[54] From this latter case, and more especially from some facts presently to be given with respect to the protuberance of the skull in Polish fowls, the crest in this breed must be viewed as a feminine character which has been transferred to the male. In the Spanish breed the male, as we know, has an immense comb, and this has been partially transferred to the female, for her comb is unusually large, though not upright. In Game fowls the bold and savage disposition of the male has likewise been largely transferred to the female;[55] and she sometimes even possesses the eminently masculine character of spurs. Many cases are on record of fertile hens being furnished with spurs; and in Germany, according to Bechstein,[56] the spurs in the Silk hen are sometimes very long. He mentions also another breed similarly characterised, in which the hens are excellent layers, but are apt to disturb and break their eggs owing to their spurs.

Mr. Layard[57] has given an account of a breed of fowls in Ceylon with black skin, bones, and wattle, but with ordinary feathers, and which cannot "be more aptly described than by comparing them to a white fowl drawn down a sooty chimney; it is, however," adds Mr. Layard, "a remarkable fact that a male bird of the pure sooty variety is almost as rare as a tortoise-shell tom-cat." Mr. Blyth found the same rule to hold good with this breed near Calcutta. The males and females, on the other hand, of the black-boned European breed, with silky feathers, do not differ from each other; so that in the one breed, black skin and bones and the same kind of plumage are common to both sexes, whilst in the other breed, these characters are confined to the female sex.

At the present day all the breeds of Polish fowls have the great bony protuberance on their skulls, which includes part of the brain and supports the crest, equally developed in both sexes. But formerly in Germany the skull of the hen alone was protuberant: Blumenbach,[58] who particularly attended to abnormal peculiarities in domestic animals, states, in 1805, that this was the case; and Bechstein had previously, in 1793 observed the same fact. This latter author has carefully described the effects on the skull of a crest not only in the case of fowls, but of ducks, geese, and canaries. He states that with fowls, when the crest is not much developed, it is supported on a fatty mass; but when much developed, it is always supported on a bony protuberance of variable size. He well describes the peculiarities of this protuberance; he attended also to the effects of the modified shape of the brain on the intellect of these birds, and disputes Pallas' statement that they are stupid. He then expressly remarks that he never observed this protuberance in male fowls. Hence there can be no doubt that this extraordinary character in the skulls of Polish fowls was formerly in Germany confined to the female sex, but has now been transferred to the males, and has thus become common to both sexes.

External Differences, not connected with the Sexes, between the Breeds and between individual Birds.

The size of the body differs greatly. Mr. Tegetmeier has known a Brahma to weigh 17 pounds; a fine Malay cock 10 pounds; whilst a first-rate Sebright Bantam weighs hardly more than 1 pound. During the last 20 years the size of some of our breeds has been largely increased by methodical selection, whilst that of other breeds has been much diminished. We have already seen how greatly colour varies even within the same breed; we know that the wild *G. bankiva* varies slightly in colour; we know that colour is variable in all our domestic animals; nevertheless some eminent fanciers have so little faith in variability, that they have actually argued that the chief Game sub-breeds, which differ from each other in nothing but colour, are descended from distinct wild species! Crossing often causes strange modification of colour. Mr. Tegetmeier informs me that when buff and white Cochins are crossed, some of the chickens are almost invariably black. According to Mr. Brent, black and white Cochins occasionally produce chickens of a slaty-blue tint; and this same tint results, as Mr. Tegetmeier tells me, from crossing white Cochins with black Spanish fowls, or white Dorkings with black Minorcas.[59] A good observer[60] states that a first-rate silver-spangled Hamburgh hen gradually lost the most characteristic qualities of the breed, for the black lacing to her feathers disappeared, and her legs changed from leaden-blue to white: but what makes the case remarkable is, that this tendency ran in the blood for her sister changed in a similar but less strongly marked manner; and chickens produced from this latter hen were at first almost pure white, "but on moulting acquired black colours and some spangled feathers with almost obliterated markings;" so that a new variety arose in this singular manner. The skin in the different breeds differs much in colour, being white in common kinds, yellow in Malays and Cochins, and black in Silk fowls; thus mocking, as M. Godron[61] remarks the three principal types of skin in mankind. The same author adds that, as different kinds of fowls living in distant and isolated parts of the world have black skin and bones, this colour must have appeared at various times and places.

The shape and carriage of the body, and the shape of the head differ much. The beak varies slightly in length and curvature, but incomparably less than with pigeons. In most crested fowls the nostrils offer a remarkable peculiarity in being raised with a crescentic outline. The primary wing-feathers are short in Cochins; in a male, which must have been more than twice as heavy as *G. bankiva*, these feathers were in both birds of the same length. I have counted, with Mr. Tegetmeier's aid, the primary wing-feathers in thirteen cocks and hens of various breeds; in four of them, namely in two Hamburghs, a Cochin, and Game bantam, there were 10, instead of the normal number 9; but in counting these feathers I have followed the practice of fanciers, and have *not* included the first minute primary feather, barely three-quarters of an inch in length. These feathers differ considerably in relative length, the fourth, or the fifth, or the sixth, being the longest; with the third either equal to, or considerably shorter than the fifth. In wild gallinaceous species the relative length and number of the main wing and tail-feathers are extremely constant.

The tail differs much in erectness and size, being small in Malays and very small in Cochins. In thirteen fowls of various breeds which I have examined, five had the normal number of 14 feathers, including in this number the two middle sickle-feathers; six others (viz., a Caffre cock, Gold-spangled Polish cock, Cochin hen, Sultan hen, Game hen and Malay hen had 16; and two (an old Cochin cock and Malay hen) had 17 feathers. The rumpless fowl has no tail and in one which I possessed there was no oil-gland; but this bird though the os coccygis was extremely imperfect, had a vestige of a tail with two rather long feathers in the position of the outer caudals. This bird came from a family where, as I was told, the breed had kept true for twenty years; but rumpless fowls often produce chickens with tails.[62] An eminent physiologist[63] has recently spoken of this breed as a distinct species; had he examined the deformed state of the os coccyx he would never have come to this conclusion; he was probably misled by the statement, which may be found in some works, that tailless fowls are wild in Ceylon; but this statement, as I have been assured by Mr. Layard and Dr. Kellaert who have so closely studied the birds of Ceylon, is utterly false.

The tarsi vary considerably in length, being relatively to the femur considerably longer in the Spanish and Frizzled, and shorter in the Silk and Bantam breeds, than in the wild *G. bankiva*; but in the latter, as we have seen, the tarsi vary in length. The tarsi are often feathered. The feet in many breeds are furnished with additional toes. Golden-spangled Polish fowls are said[64] to have the skin between their toes much developed: Mr. Tegetmeier observed this in one bird, but it was not so in one which I examined. Prof. Hoffmann has sent me a sketch of the feet of a fowl of the common breed at Giessen, with a web extending between the three toes, for about a third of their length. In Cochins the middle toe is said[65] to be nearly double the length of the lateral toes, and therefore much longer than in *G. bankiva* or in other fowls; but this was not the case in two which I examined. The nail of the middle toe in this same breed is surprisingly broad and flat, but in a variable degree in two birds which I examined; of this structure in the nail there is only a trace in *G. bankiva.*

The voice differs slightly, as I am informed by Mr. Dixon, in almost every breed. The Malays[66] have a loud, deep, somewhat prolonged crow, but with considerable individual difference. Colonel Sykes remarks that the domestic Kulm cock in India has not the shrill clear pipe of the English bird, and "his scale of notes appears more limited." Dr. Hooker was struck with the "prolonged howling screech" of the cocks in Sikhim.[67] The crow of the Cochin is notoriously and ludicrously different from that of the common cock. The disposition of the different breeds is widely different, varying from the savage and defiant temper of the Game-cock to the extremely peaceable temper of the Cochins. The latter, it has been asserted, "graze to a much greater extent than any other varieties." The Spanish fowls suffer more from frost than other breeds.

Before we pass on to the skeleton, the degree of distinctness of the several breeds from *G. bankiva* ought to be noticed. Some writers speak of the Spanish as one of the most distinct breeds, and so it is in general aspect; but its characteristic differences are not important. The Malay appears to me more distinct, from its tall stature, small drooping tail with more than fourteen tail-feathers, and from its small comb and wattles; nevertheless, one Malay sub-breed is coloured almost exactly like *G. bankiva*. Some authors consider the Polish fowl as very distinct; but this is a semi-monstrous breed, as shown by the protuberant and irregularly perforated skull. The Cochin, from its deeply furrowed frontal bones, peculiarly shaped occipital foramen, short wing-feathers, short tail containing more than fourteen feathers, broad nail to the middle toe, fluffy plumage, rough and dark-coloured eggs, and especially from its peculiar voice, is probably the most distinct of all the breeds. If any one of our breeds has descended from some unknown species, distinct from *G. bankiva,* it is probably the Cochin; but the balance of evidence does not favour this view. All the characteristic differences of the Cochin breed are more or less variable, and may be detected in a greater or lesser degree in other breeds. One sub-breed is coloured closely like *G. bankiva*. The feathered legs, often furnished with an additional toe, the wings incapable of flight, the extremely quiet disposition, indicate a long course of domestication; and these fowls come from China, where we know that plants and animals have been tended from a remote period with extraordinary care, and where consequently we might expect to find profoundly modified domestic races.

Osteological Differences.—I have examined twenty-seven skeletons and fifty-three skulls of various breeds, including three of *G. bankiva*: nearly half of these skulls I owe to the kindness of Mr. Tegetmeier, and three of the skeletons to Mr. Eyton.

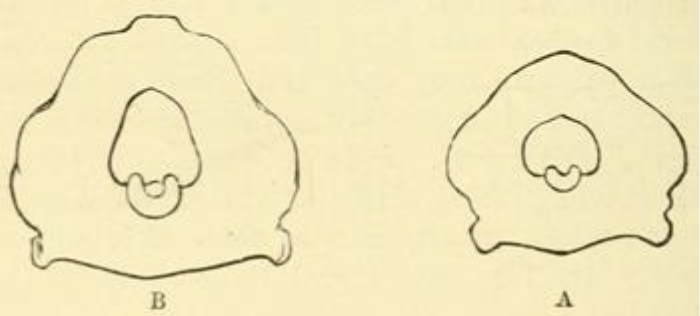


Fig. 33—Occipital Foramen of the Skulls of Fowls

The *Skull* differs greatly in size in different breeds, being nearly twice as long in the largest Cochins, but not nearly twice as broad, as in Bantams. The bones at the base, from the occipital foramen to the anterior end (including the quadrates and pterygoids), are absolutely identical in *shape* in all the skulls. So is the lower jaw. In the forehead slight differences are often perceptible between the males and females, evidently caused by the presence of the comb. In every case I take the skull of *G. bankiva* as the standard of comparison. In four Games, in one Malay hen, in an African cock, in a Frizzled cock from Madras, in two black-boned Silk hens, no differences worth notice occur. In three *Spanish* cocks, the form of the forehead between the orbits differs considerably; in one it is considerably depressed, whilst in the two others it is rather prominent, with a deep medial furrow; the skull of the hen is smooth. In three skulls of *Sebright Bantams* the crown is more globular, and slopes more abruptly to the occiput, than in *G. bankiva*. In a Bantam or Jumper from Burmah these same characters are more strongly pronounced, and the supra-occiput is more pointed. In a black Bantam the skull is not so globular, and the occipital foramen is very large, and has nearly the same sub-triangular outline presently to be described in Cochins; and in this skull the two ascending branches of the premaxillary are overlapped in a singular manner by the processes of the nasal bone, but, as I have seen only one specimen, some of these differences may be individual. Of Cochins and Brahmas (the latter a crossed race approaching closely to Cochins) I have examined seven skulls; at the point where the ascending branches of the premaxillary rest on the frontal bone the surface is much depressed, and from this depression a deep medial furrow extends backwards to a variable distance; the edges of this fissure are rather prominent, as is the top of the skull behind and over the orbits. These characters are less developed in the hens. The pterygoids, and the processes of the lower jaw, are broader, relatively to the size of the head, than in *G. bankiva*; and this is likewise the case with Dorkings when of large size. The fork of the hyoid bone in Cochins is twice as wide as in *G. bankiva,* whereas the length of the other hyoid bones is only as three to two. But the most remarkable character is the shape of the occipital foramen: in *G. bankiva* (A) the breadth in a horizontal line exceeds the height in a vertical line, and the outline is nearly circular; whereas in Cochins (B) the outline is sub-triangular, and the vertical line exceeds the horizontal line in length. This same form likewise occurs in the black Bantam above referred to, and an approach to it may be seen in some Dorkings, and in a slight degree in certain other breeds.

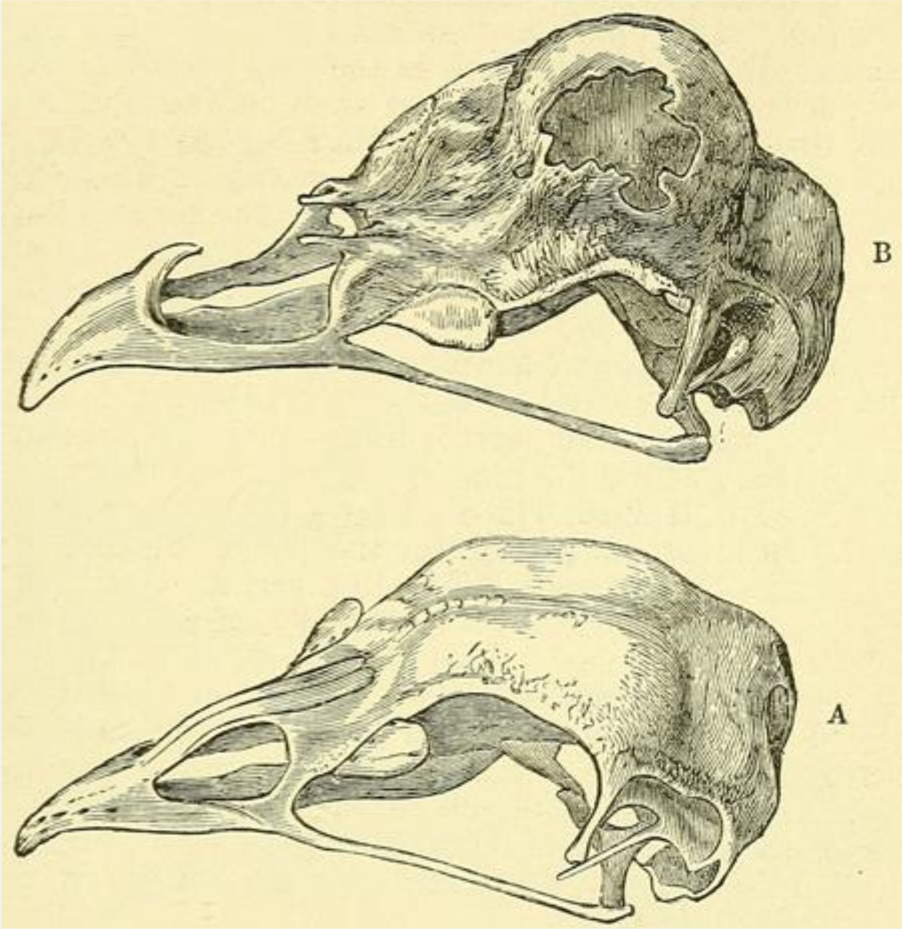


Fig. 34—Skulls of Fowls

Of *Dorkings* I have examined three skulls, one belonging to the white-sub-breed; the one character deserving notice is the breadth of the frontal bones, which are moderately furrowed in the middle; thus in a skull which was less than once and a half the length of that of *G. bankiva*, the breadth between the orbits was exactly double. Of *Hamburghs* I have examined four skulls (male and female) of the pencilled sub-breed, and one (male) of the spangled sub-breed; the nasal bones stand remarkably wide apart, but in a variable degree; consequently narrow membrane-covered spaces are left between the tips of the two ascending branches of the pre-maxillary bones, which are rather short, and between these branches and the nasal bones. The surface of the frontal bone, on which the branches of the premaxillary rest, is very little depressed. These peculiarities no doubt stand in close relation with the broad, flattened rose-comb characteristic of the Hamburgh breed.

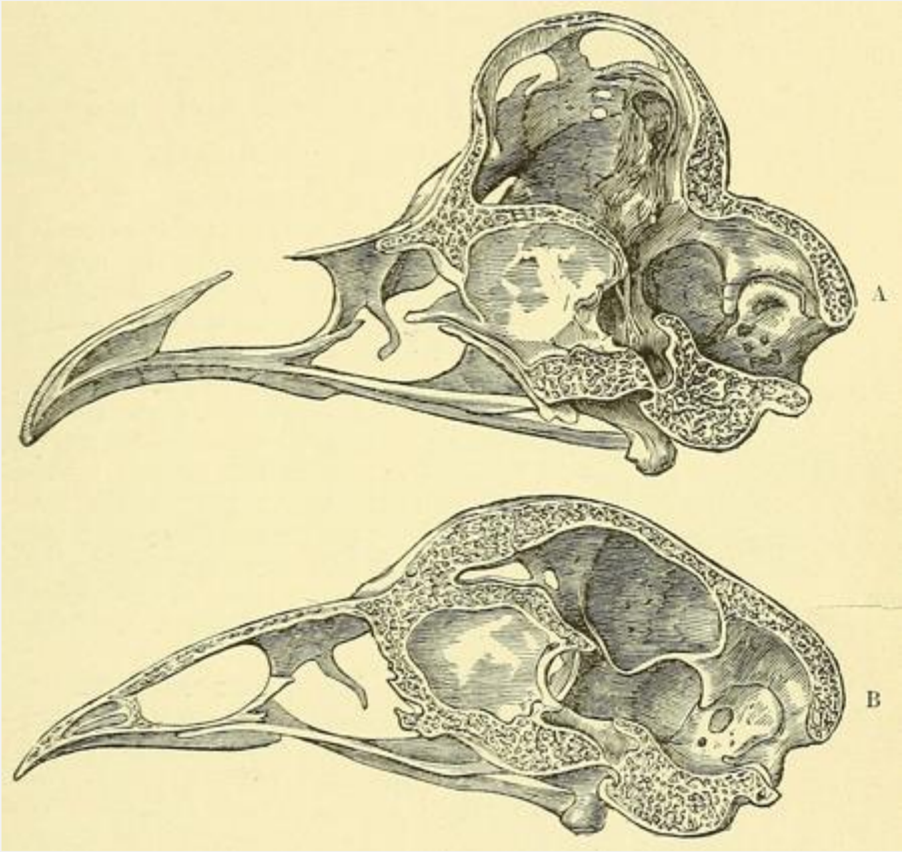


Fig. 35—Longitudinal sections of Skulls of Fowls

I have examined fourteen skulls of *Polish and other crested breeds.* Their differences are extraordinary. First for nine skulls of different sub-breeds of English Polish fowls. The hemispherical protuberance of the frontal bones[68] may be seen in fig. 34, in which (B) the skull of a white-crested Polish fowl is shown obliquely from above, with the skull (A) of *G. bankiva* in the same position. In fig. 35 longitudinal sections are given of the skull of a Polish fowl, and, for comparison, of a Cochin of the same size. The protuberance in all Polish fowls occupies the same position but differs much in size. In one of my nine specimens it was extremely slight. The degree to which the protuberance is ossified varies greatly, larger or smaller portions of bone being replaced by membrane. In one specimen there was only a single open pore; generally, there are many variously shaped open spaces, the bone forming an irregular reticulation. A medial, longitudinal, arched ribbon of bone is generally retained, but in one specimen there was no bone whatever over the whole protuberance, and the skull, when cleaned and viewed from above, presented the appearance of an open basin. The change in the whole internal form of the skull is surprisingly great. The brain is modified in a corresponding manner, as is shown in the two longitudinal sections, which deserve attentive consideration. The upper and anterior cavity of the three into which the skull may be divided, is the one which is so greatly modified; it is evidently much larger than in the Cochin skull of the same size, and extends much further beyond the interorbital septum, but laterally is less deep. This cavity, as I hear from Mr. Tegetmeier, is entirely filled with brain. In the skull of the Cochin and of all ordinary fowls a strong internal ridge of bone separates the anterior from the central cavity; but this ridge is quite absent in the Polish skull here figured. The shape of the central cavity is circular in the Polish, and lengthened in the Cochin skull. The shape of the posterior cavity, together with the position, size, and number of the pores for the nerves, differ much in these two skulls. A pit deeply penetrating the occipital bone of the Cochin is entirely absent in this Polish skull, whilst in another specimen it was well developed. In this second specimen the whole internal surface of the posterior cavity likewise differs to a certain extent in shape. I made sections of two other skulls,—namely, of a Polish fowl with the protuberance singularly little developed, and of a Sultan in which it was a little more developed; and when these two skulls were placed between the two above figured (fig. 35), a perfect gradation in the configuration of each part of the internal surface could be traced. In the Polish skull, with a small protuberance, the ridge between the anterior and middle cavities was present, but low; and in the Sultan this ridge was replaced by a narrow furrow standing on a broad raised eminence.

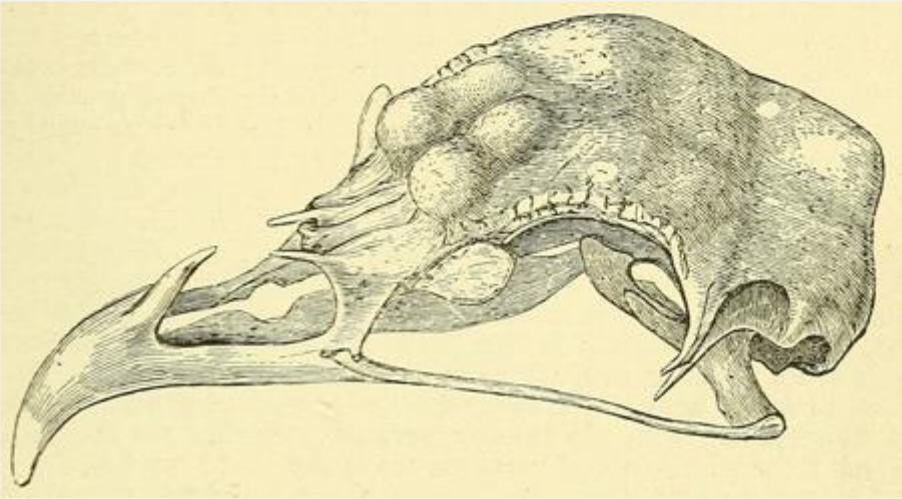


Fig. 36—Skulls of Horned Fowl

It may naturally be asked whether these remarkable modifications in the form of the brain affect the intellect of Polish fowls; some writers have stated that they are extremely stupid, but Bechstein and Mr. Tegetmeier have shown that this is by no means generally the case. Nevertheless Bechstein[69] states that he had a Polish hen which "was crazy, and anxiously wandered about all day long." A hen in my possession was solitary in her habits, and was often so absorbed in reverie that she could be touched; she was also deficient in the most singular manner in the faculty of finding her way, so that, if she strayed a hundred yards from her feeding-place, she was completely lost, and would then obstinately try to proceed in a wrong direction. I have received other and similar accounts of Polish fowls appearing stupid or half-idiotic.[70]

To return to the skull of Polish fowls. The posterior part, viewed externally, differs little from that of *G. bankiva*. In most fowls the posterior-lateral process of the frontal bone and the process of the squamosal bone run together and are ossified near their extremities: this union of the two bones, however, is not constant in any breed; and in eleven out of fourteen skulls of crested breeds, these processes were quite distinct. These processes, when not united, instead of being inclined anteriorly, as in all common breeds, descend at right angles to the lower jaw; and in this case the longer axis of the bony cavity of the ear is likewise more perpendicular, than in other breeds. When the squamosal process is free instead of expanding at the tip, it is reduced to an extremely fine and pointed style, of variable length. The pterygoid and quadrate bones present no differences. The palatine bones are a little more curved upwards at their posterior ends. The frontal bones, anteriorly to the protuberance, are, as in Dorkings, very broad, but in a variable degree. The nasal bones either stand far apart, as in Hamburghs, or almost touch each other, and in one instance were ossified together. Each nasal bone properly sends out in front two long processes of equal lengths, forming a fork; but in all the Polish skulls, except one, the inner process was considerably, but in a variable degree, shortened and somewhat upturned. In all the skulls, except one, the two ascending branches of the premaxillary, instead of running up between the processes of the nasal bones and resting on the ethmoid bone, are much shortened and terminate in a blunt, somewhat upturned point. In those skulls in which the nasal bones approach quite close to each other or are ossified together, it would be impossible for the ascending branches of the premaxillary to reach the ethmoid and frontal bones; hence we see that even the relative connection of the bones has been changed. Apparently in consequence of the branches of the premaxillary and of the inner processes of the nasal bones being somewhat upturned, the external orifices of the nostrils are upraised and assume a crescentic outline.

I must still say a few words on some of the foreign Crested breeds. The skull of a crested, rumpless, white Turkish fowl was very slightly protuberant, and but little perforated; the ascending branches of the premaxillary were well developed. In another Turkish breed, called Ghoondooks, the skull was considerably protuberant and perforated; the ascending branches of the premaxillary were so much aborted that they projected only 1/15th of an inch; and the inner processes of the nasal bone were so completely aborted, that the surface where they should have projected was quite smooth. Here then we see these two bones modified to an extreme degree. Of Sultans (another Turkish breed) I examined two skulls; in that of the female the protuberance was much larger than in the male. In both skulls the ascending branches of the premaxillary were very short, and in both the nasal portion of the inner processes of the nasal bones were ossified together. These Sultan skulls differed from those of English Polish fowls in the frontal bones, anteriorly to the protuberance, not being broad.

The last skull which I need describe is a unique one, lent to me by Mr. Tegetmeier: it resembles a Polish skull in most of its characters, but has not the great frontal protuberance; it has, however, two rounded knobs of a different nature, which stand more in front, above the lachrymal bones. These curious knobs, into which the brain does not enter, are separated from each other by a deep medial furrow; and this is perforated by a few minute pores. The nasal bones stand rather wide apart, with their inner processes, and the ascending branches of the premaxillary, upturned and shortened. The two knobs no doubt supported the two great horn-like projections of the comb.

From the foregoing facts we see in how astonishing a manner some of the bones of the skull vary in Crested fowls. The protuberance may certainly be called in one sense a monstrosity, as being wholly unlike anything observed in nature: but as in ordinary cases it is not injurious to the bird, and as it is strictly inherited, it can hardly in another sense be called a monstrosity. A series may be formed commencing with the black-boned Silk fowl, which has a very small crest with the skull beneath penetrated only by a few minute orifices, but with no other change in its structure; and from this first stage we may proceed to fowls with a moderately large crest, which rests, according to Bechstein, on a fleshy mass, but without any protuberance in the skull. I may add that I have seen a similar fleshy or fibrous mass beneath the tuft of feathers on the head of the Tufted duck; and in this case there was no actual protuberance in the skull, but it had become a little more globular. Lastly, when we come to fowls with a largely developed crest, the skull becomes largely protuberant and is perforated by a multitude of irregular open spaces. The close relation between the crest and the size of the bony protuberance is shown in another way; for Mr. Tegetmeier informs me that if chickens lately hatched be selected with a large bony protuberance, when adult they will have a large crest. There can be no doubt that in former times the breeder of Polish fowls attended solely to the crest, and not to the skull; nevertheless, by increasing the crest, in which he has been wonderfully successful, he has unintentionally made the skull protuberant to an astonishing degree; and through correlation of growth, he has at the same time affected the form and relative connexion of the premaxillary and nasal bones, the shape of the orifice of the nose, the breadth of the frontal bones, the shape of the post-lateral processes of the frontal and squamosal bones, the direction of the axis of the bony cavity of the ear, and lastly the internal configuration of the whole skull together with the shape of the brain.

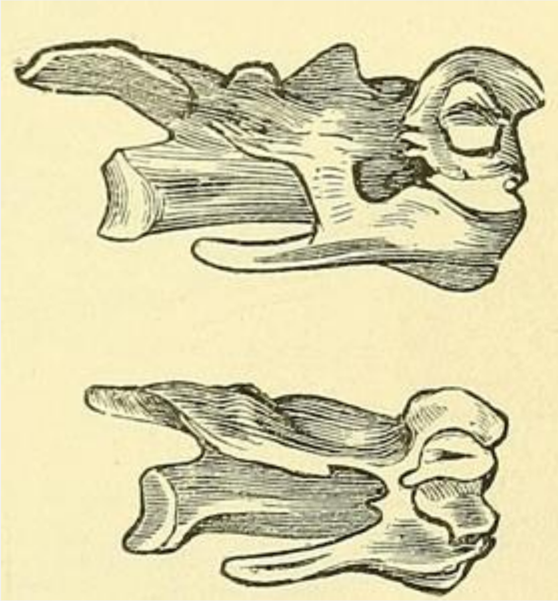


Fig. 37—Sixth Cervical Verterbra of Fowls

Vertebræ.—In *G. bankiva* there are fourteen cervical, seven dorsal with ribs, apparently fifteen lumbar and sacral, and six caudal vertebræ;[71] but the lumbar and sacral are so much anchylosed that I am not sure of their number, and this makes the comparison of the total number of vertebræ in the several breeds difficult. I have spoken of six caudal vertebræ, because the basal one is almost completely anchylosed with the pelvis; but if we consider the number as seven, the caudal vertebræ agree in all the skeletons. The cervical vertebræ are, as just stated, in appearance fourteen; but out of twenty-three skeletons in a fit state for examination, in five of them, namely, in two Games, in two pencilled Hamburghs, and in a Polish, the fourteenth vertebra bore ribs, which, though small, were perfectly developed with a double articulation. The presence of these little ribs cannot be considered as a fact of much importance, for all the cervical vertebræ bear representatives of ribs; but their development in the fourteenth vertebra reduces the size of the passages in the transverse processes, and makes this vertebra exactly like the first dorsal vertebra. The addition of these little ribs does not affect the fourteenth cervical alone, for properly the ribs of the first true dorsal vertebra are destitute of processes; but in some of the skeletons in which the fourteenth cervical bore little ribs the first pair of true ribs had well-developed processes. When we know that the sparrow has only nine, and the swan twenty-three cervical vertebræ,[72] we need feel no surprise at the number of the cervical vertebræ in the fowl being, as it appears, variable.

There are seven dorsal vertebræ bearing ribs; the first dorsal is never anchylosed with the succeeding four, which are generally anchylosed together. In one Sultan fowl, however, the two first dorsal vertebræ were free. In two skeletons, the fifth dorsal was free; generally the sixth is free (as in *G. bankiva*), but sometimes only at its posterior end, where in contact with the seventh. The seventh dorsal vertebra, in every case excepting in one Spanish cock, was anchylosed with the lumbar vertebræ. So that the degree to which these middle dorsal vertebræ are anchylosed is variable.

Seven is the normal number of true ribs, but in two skeletons of the Sultan fowl (in which the fourteenth cervical vertebra was not furnished with little ribs) there were eight pairs; the eighth pair seemed to be developed on a vertebra corresponding with the first lumbar in *G. bankiva*; the sternal portion of both the seventh and eighth ribs did not reach the sternum. In four skeletons in which ribs were developed on the fourteenth cervical vertebra, there were, when these cervical ribs are included, eight pairs; but in one Game cock, in which the fourteenth cervical was furnished with ribs, there were only six pairs of true dorsal ribs; the sixth pair in this case did not have processes, and thus resembled the seventh pair in other skeletons; in this Game cock, as far as could be judged from the appearance of the lumbar vertebræ, a whole dorsal vertebra with its ribs was missing. We thus see that the ribs (whether or not the little pair attached to the fourteenth cervical vertebra be counted) vary from six to eight pair. The sixth pair is frequently not furnished with processes. The sternal portion of the seventh pair is extremely broad in Cochins, and is completely ossified. As previously stated, it is scarcely possible to count the lumbo-sacral vertebræ; but they certainly do not correspond in shape or number in the several skeletons. The caudal vertebræ are closely similar in all the skeletons, the only difference being whether or not the basal one is anchylosed to the pelvis; they hardly vary even in length, not being shorter in Cochins, with their short tail-feathers, than in other breeds; in a Spanish cock, however, the caudal vertebræ were a little elongated. In three rumpless fowls the caudal vertebræ were few in number, and anchylosed together into a misformed mass.

In the individual vertebræ the differences in structure are very slight. In the atlas the cavity for the occipital condyle is either ossified into a ring, or is, as in Bankiva, open on its upper margin. The upper arc of the spinal canal is a little more arched in Cochins, in conformity with the shape of the occipital foramen, than in *G. bankiva*. In several skeletons a difference, but not of much importance, may be observed, which commences at the fourth cervical vertebra, and is greatest at about the sixth, seventh, or eighth vertebra; this consists in the hæmal descending processes being united to the body of the vertebra by a sort of buttress. This structure may be observed in Cochins, Polish, some Hamburghs, and probably other breeds; but is absent, or barely developed, in Game, Dorking, Spanish, Bantam, and several other breeds examined by me. On the dorsal surface of the sixth cervical vertebra in Cochins three prominent points are more strongly developed than in the corresponding vertebra of the Game fowl or *G. bankiva*.

Pelvis.—This differs in some few points in the several skeletons. The anterior margin of the ilium seems at first to vary much in outline, but this is chiefly due to the degree to which the margin in the middle part is ossified to the crest of the vertebræ; the outline, however, does differ in being more truncated in Bantams, and more rounded in certain breeds, as in Cochins. The outline of the ischiadic foramen differs considerably, being nearly circular in Bantams, instead of egg-shaped as in the Bankiva, and more regularly oval in some skeletons, as in the Spanish. The obturator notch is also much less elongated in some skeletons than in others. The end of the pubic bone presents the greatest difference; being hardly enlarged in the Bankiva; considerably and gradually enlarged in Cochins, and in a lesser degree in some other breeds; and abruptly enlarged in Bantams. In one Bantam this bone extended very little beyond the extremity of the ischium. The whole pelvis in this latter bird differed widely in its proportions, being far broader proportionally to its length than in Bankiva.

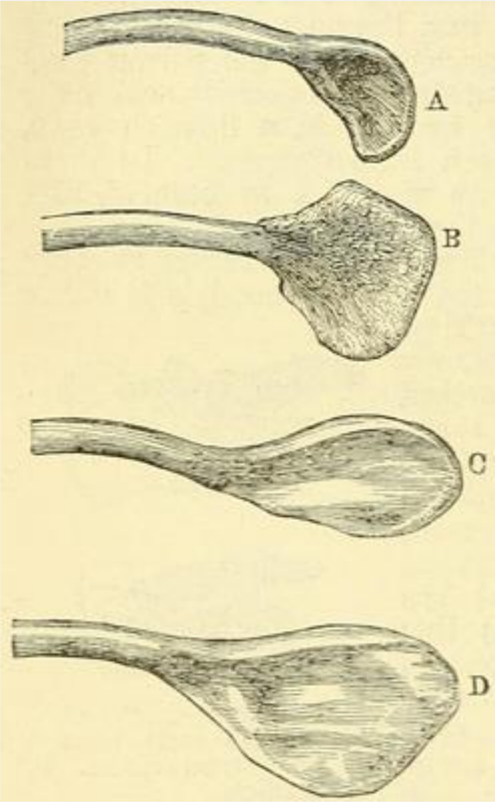


Fig. 38—Extremity of the Furcula of Fowls

Sternum.—This bone is generally so much deformed that it is scarcely possible to compare its shape strictly in the several breeds. The form of the triangular extremity of the lateral processes differs considerably, being either almost equilateral or much elongated. The front margin of the crest is more or less perpendicular and varies greatly, as does the curvature of the posterior end, and the flatness of the lower surface. The outline of the manubrial process also varies, being wedge-shaped in the Bankiva, and rounded in the Spanish breed. The *furculum* differs in being more or less arched, and greatly, as may be seen in the accompanying outlines, in the shape of the terminal plate; but the shape of this part differed a little in two skeletons of the wild Bankiva. The *coracoid* presents no difference worth notice. The *scapula* varies in shape, being of nearly uniform breadth in Bankiva, much broader in the middle in the Polish fowl, and abruptly narrowed towards the apex in the two Sultan fowls.

I carefully compared each separate bone of the leg and wing, relatively to the same bones in the wild Bankiva, in the following breeds, which I thought were the most likely to differ; namely, in Cochin, Dorking, Spanish, Polish, Burmese Bantam, Frizzled Indian, and black-boned Silk fowls; and it was truly surprising to see how absolutely every process, articulation, and pore agreed, though the bones differed greatly in size. The agreement is far more absolute than in other parts of the skeleton. In stating this, I do not refer to the relative thickness and length of the several bones; for the tarsi varied considerably in both these respects. But the other limb-bones varied little even in relative length.

Finally, I have not examined a sufficient number of skeletons to say whether any of the foregoing differences, except in the skull, are characteristic of the several breeds. Apparently some differences are more common in certain breeds than in others,—as an additional rib to the fourteenth cervical vertebra in Hamburghs and Games, and the breadth of the end of the pubic bone in Cochins. Both skeletons of the Sultan fowl had eight dorsal vertebræ, and the end of the scapula in both was somewhat attenuated. In the skull, the deep medial furrow in the frontal bones and the vertically elongated occipital foramen seem to be characteristic of Cochins; as is the great breadth of the frontal bones in Dorkings; the separation and open spaces between the tips of the ascending branches of the premaxillaries and nasal bones, as well as the front part of the skull being but little depressed, characterise Hamburghs; the globular shape of the posterior part of the skull seems to be characteristic of laced Bantams; and lastly, the protuberance of the skull with the ascending branches of the premaxillaries partially aborted, together with the other differences before specified, are eminently characteristic of Polish and other Crested fowls.

But the most striking result of my examination of the skeleton is the great variability of all the bones except those of the extremities. To a certain extent we can understand why the skeleton fluctuates so much in structure; fowls have been exposed to unnatural conditions of life, and their whole organisation has thus been rendered variable; but the breeder is quite indifferent to, and never intentionally selects, any modification in the skeleton. External characters, if not attended to by man, such as the number of the tail and wing feathers and their relative lengths, which in wild birds are generally constant,—fluctuate in our domestic fowls in the same manner as the several parts of the skeleton. An additional toe is a “point” in Dorkings, and has become a fixed character, but is variable in Cochins and Silk fowls. The colour of the plumage and the form of the comb are in most breeds, or even sub-breeds, eminently fixed characters; but in Dorkings these points have not been attended to, and are variable. When any modification in the skeleton is related to some external character which man values, it has been, unintentionally on his part, acted on by selection, and has become more or less fixed. We see this in the wonderful protuberance of the skull, which supports the crest of feathers in Polish fowls, and which by correlation has affected other parts of the skull. We see the same result in the two protuberances which support the horns in the horned fowl, and in the flattened shape of the front of the skull in Hamburghs consequent on their flattened and broad "rose-combs." We know not in the least whether additional ribs, or the changed outline of the occipital foramen, or the changed form of the scapula, or of the extremity of the furculum, are in any way correlated with other structures, or have arisen from the changed conditions and habits of life to which our fowls have been subjected; but there is no reason to doubt that these various modifications in the skeleton could be rendered, either by direct selection, or by the selection of correlated structures, as constant and as characteristic of each breed, as are the size and shape of the body, the colour of the plumage, and the form of the comb.

Effects of the Disuse of Parts.

Judging from the habits of our European gallinaceous birds, *Gallus bankiva* in its native haunts would use its legs and wings more than do our domestic fowls, which rarely fly except to their roosts. The Silk and the Frizzled fowls, from having imperfect wing-feathers, cannot fly at all; and there is reason to believe that both these breeds are ancient, so that their progenitors during many generations cannot have flown. The Cochins, also, from their short wings and heavy bodies, can hardly fly up to a low perch. Therefore in these breeds, especially in the two first, a considerable diminution in the wing-bones might have been expected, but this is not the case. In every specimen, after disarticulating and cleaning the bones, I carefully compared the relative length of the two main bones of the wing to each other, and of the two main bones of the leg to each other, with those of *G. bankiva*; and it was surprising to see (except in the case of the tarsi) how exactly the same relative length had been retained. This fact is curious, from showing how truly the proportions of an organ may be inherited, although not fully exercised during many generations. I then compared in several breeds the length of the femur and tibia with the humerus and ulna, and likewise these same bones with those of *G. bankiva*; the result was that the wing-bones in all the breeds (except the Burmese Jumper, which has unnaturally short legs, are slightly shortened relatively to the leg-bones; but the decrease is so slight that it may be due to the standard specimen of *G. bankiva* having accidentally had wings of slightly greater length than usual; so that the measurements are not worth giving. But it deserves notice that the Silk and Frizzled fowls, which are quite incapable of flight, had their wings *less* reduced relatively to their legs than in almost any other breed! We have seen with domesticated pigeons that the bones of the wings are somewhat reduced in length, whilst the primary feathers are rather increased in length, and it is just possible, though not probable, that in the Silk and Frizzled fowls any tendency to decrease in the length of the wing-bones from disuse may have been checked through the law of compensation, by the decreased growth of the wing-feathers, and consequent increased supply of nutriment. The wing-bones, however, in both these breeds, are found to be slightly reduced in length when judged by the standard of the length of the sternum or head, relatively to these same parts in *G. bankiva*.

The actual weight of the main bones of the leg and wing in twelve breeds is given in the two first columns in Table I. The calculated weight of the wing-bones relatively to the leg-bones, in comparison with the leg and wing-bones of *G. bankiva*, are given in the third column,—the weight of the wing-bones in *G. bankiva* being called a hundred.[73]

Table I.

	Names of Breeds.	Actual Weight of Femur and Tibia.	Actual Weight of Humerus and Ulna.	Weight of Wing-bones relatively to the Leg-bones in comparison with these same bones in *G. bankiva.*
		Grains.	Grains.	
	Gallus bankiva (wild male)	86	54	100
1	Cochin (male)	311	162	83
2	Dorking (male)	557	248	70
3	Spanish (Minorca) (male)	386	183	75
4	Gold-Spangled Polish (male)	306	145	75
5	Game, black-breasted (male)	293	143	77
6	Malay (female)	231	116	80
7	Sultan (male)	189	94	79
8	Indian Frizzled (male)	206	88	67
9	Burmese Jumper (female)	53	36	108
10	Hamburgh (pencilled) (male)	157	104	106
11	Hamburgh (pencilled) (female)	114	77	108
12	Silk (black-boned) (female)	88	57	103

In the eight first birds, belonging to distinct breeds, in this table, we see a decided reduction in the weight of the bones of the wing.

In the Indian Frizzled fowl, which cannot fly, the reduction is carried to the greatest extent, namely, to thirty-three per cent of their proper proportional weight. In the next four birds, including the Silk hen, which is incapable of flight, we see that the wings, relatively to the legs, are slightly increased in weight; but it should be observed that, if in these birds the legs had become from any cause reduced in weight, this would give the false appearance of the wings having increased in relative weight. Now a reduction of this nature has certainly occurred with the Burmese Jumper, in which the legs are abnormally short, and in the two Hamburghs and Silk fowl, the legs, though not short, are formed of remarkably thin and light bones. I make these statements, not judging by mere eyesight, but after having calculated the weights of the leg-bones relatively to those of G. bankiva, according to the only two standards of comparison which I could use, namely, the relative lengths of the head and sternum; for I do not know the weight of the body in *G. bankiva*, which would have been a better standard. According to these standards, the leg-bones in these four fowls are in a marked manner far lighter than in any other breed. It may therefore be concluded that in all cases in which the legs have not been through some unknown cause much reduced in weight, the wing-bones have become reduced in weight relatively to the leg-bones, in comparison with those of *G. bankiva*. And this reduction of weight may, I apprehend, safely be attributed to disuse.

To make Table I quite satisfactory, it ought to have been shown that in the eight first birds the leg-bones have not actually increased in weight out of due proportion with the rest of the body; this I cannot show, from not knowing, as already remarked, the weight of the wild Bankiva.[74] I am indeed inclined to suspect that the leg-bones in the Dorking, No. 2 in the table, are proportionally too heavy; but this bird was a very large one, weighing 7 pounds 2 ounces, though very thin. Its leg-bones were more than ten times as heavy as those of the Burmese Jumper! I tried to ascertain the length both of the leg-bones and wing-bones relatively to other parts of the body and skeleton: but the whole organisation in these birds, which have been so long domesticated, has become so variable, that no certain conclusions could be reached. For instance, the legs of the above Dorking cock were nearly three-quarters of an inch too short relatively to the length of the sternum, and more than three-quarters of an inch too long relatively to the length of the skull, in comparison with these same parts in *G. bankiva*.

Table II.

Names of Breeds.	Length of Sternum.	Depth of Crest of Sternum	Depth of Crest relatively to the length of the Sternum, in comparison with *G. bankiva.*

		Inches.	Inches	
	Gallus bankiva (male)	4·20	1·40	100
1	Cochin (male)	5·83	1·55	78
2	Dorking (male)	6·95	1·97	84
3	Spanish (male)	6·10	1·83	90
4	Polish (male)	5·07	1·50	87
5	Game (male)	5·55	1·55	81
6	Malay (female)	5·10	1·50	87
7	Sultan (male)	4·47	1·36	90
8	Frizzled hen (male)	4·25	1·20	84
9	Burmese Jumper (female)	3·06	0·85	81
10	Hamburgh (male)	5·08	1·40	81
11	Hamburgh (female)	4·55	1·26	81
12	Silk fowl (female)	4·49	1·01	66

In Table II in the two first columns we see in inches and decimals the length of the sternum, and the extreme depth of its crest to which the pectoral muscles are attached. In the third column we have the calculated depth of the crest, relatively to the length of the sternum, in comparison with these same parts in *G. bankiva*.[75]

By looking to the third column we see that in every case the depth of the crest relatively to the length of the sternum, in comparison with *G. bankiva*, is diminished, generally between 10 and 20 per cent. But the degree of reduction varies much, partly in consequence of the frequently deformed state of the sternum. In the Silk fowl, which cannot fly, the crest is 34 per cent less deep than what it ought to have been. This reduction of the crest in all the breeds probably accounts for the great variability, before referred to, in the curvature of the furculum, and in the shape of its sternal extremity. Medical men believe that the abnormal form of the spine so commonly observed in women of the higher ranks results from the attached muscles not being fully exercised. So it is with our domestic fowls, for they use their pectoral muscles but little, and, out of twenty-five sternums examined by me, three alone were perfectly symmetrical, ten were moderately crooked, and twelve were deformed to an extreme degree. Mr. Romanes, however, believes that the malformation is due to fowls whilst young resting their sternums on the sticks on which they roost.

Finally, we may conclude with respect to the various breeds of the fowl, that the main bones of the wing have probably been shortened in a very slight degree; that they have certainly become lighter relatively to the leg-bones in all the breeds in which these latter bones are not unnaturally short or delicate; and that the crest of the sternum, to which the pectoral muscles are attached, has invariably become less prominent, the whole sternum being also extremely liable to deformity. These results we may attribute to the lessened use of the wings.

Correlation of Growth.—I will here sum up the few facts which I have collected on this obscure, but important, subject. In Cochin and Game fowls there is perhaps some relation between the colour of the plumage and the darkness of the egg-shell. In Sultans the additional sickle-feathers in the tail are apparently related to the general redundancy of the plumage, as shown by the feathered legs, large crest, and beard. In two tailless fowls which I examined the oil-gland was aborted. A large crest of feathers, as Mr. Tegetmeier has remarked, seems always accompanied by a great diminution or almost entire absence of the comb. A large beard is similarly accompanied by diminished or absent wattles. These latter cases apparently come under the law of compensation or balancement of growth. A large beard beneath the lower jaw and a large top-knot on the skull often go together. The comb when of any peculiar shape, as with Horned, Spanish, and Hamburgh fowls, affects in a corresponding manner the underlying skull; and we have seen how wonderfully this is the case with Crested fowls when the crest is largely developed. With the protuberance of the frontal bones the shape of the internal surface of the skull and of the brain is greatly modified. The presence of a crest influences in some unknown way the development of the ascending branches of the premaxillary bone, and of the inner processes of the nasal bones; and likewise the shape of the external orifice of the nostrils. There is a plain and curious correlation between a crest of feathers and the imperfectly ossified condition of the skull. Not only does this hold good with nearly all crested fowls, but likewise with tufted ducks, and as Dr. Gunther informs me with tufted geese in Germany.

Lastly, the feathers composing the crest in male Polish fowls resemble hackles, and differ greatly in shape from those in the crest of the female. The neck, wing-coverts, and loins in the male bird are properly covered with hackles, and it would appear that feathers of this shape have spread by correlation to the head of the male. This little fact is interesting; because, though both sexes of some wild gallinaceous birds have their heads similarly ornamented, yet there is often a difference in the size and shape of feathers forming their crests. Furthermore, there is in some cases, as in the male Gold and in the male Amherst pheasants (*P. pictus* and *amherstiæ*), a close relation in colour, as well as in structure, between the plumes on the head and on the loins. It would therefore appear that the same law has regulated the state of the feathers on the head and body, both with species living under natural conditions, and with birds which have varied under domestication.

REFERENCES

[1] I have drawn up this brief synopsis from various sources, but chiefly from information given me by Mr. Tegetmeier. This gentleman has kindly looked through this chapter; and from his well-known knowledge, the statements here given may be fully trusted. Mr. Tegetmeier has likewise assisted me in every possible way in obtaining for me information and specimens. I must not let this opportunity pass without expressing my cordial thanks to Mr. B. P. Brent, a well-known writer on poultry, for continuous assistance and the gift of many specimens.

[2] The best account of Sultans is by Miss Watts in 'The Poultry Yard,' 1856, p. 79. I owe to Mr. Brent's kindness the examination of some specimens of this breed.

[3] A good description, with figures, is given of this sub-breed in the 'Journal of Horticulture,' June 10, 1862, p. 206.

[4] A description, with figures, is given of this breed in 'Journal of Horticulture,' June 3, 1862, p. 186. Some writers describe the comb as two-horned.

[5] Mr. Crawfurd 'Descript. Dict. of the Indian Islands,' p. 113. Bantams are mentioned in an ancient native Japanese Encyclopædia, as I am informed by Mr. Birch of the British Museum.

[6] 'Ornamental and Domestic Poultry,' 1848.

[7] 'Ornamental and Domestic Poultry,' 1848.

[8] Ferguson's 'Illustrated Series of Rare and Prize Poultry,' 1854, p. vi. Preface.

[9] Rev. E. S. Dixon in his 'Ornamental Poultry,' p. 203, gives an account of Columella's work.

[10] Mr. Crawfurd 'On the Relation of the Domesticated Animals to Civilization,' separately printed, p. 6; first read before the Brit. Assoc. at Oxford 1860.

[11] 'Quadrupèdes du Paraguay,' tom. ii. p. 324.

[12] 'Proc. Zoolog. Soc.,' 1832, p. 151.

[13] These feathers have been described by Dr. W. Marshall 'Der Zoolog. Garten,' April 1874, p. 124. I examined the feathers of some hybrids raised in the Zoological Gardens between the male *G. sonneratii* and a red game-

hen, and they exhibited the true character of those of *G. sonneratii,* except that the horny laminæe were much smaller.

[14] *See also* an excellent letter on the Poultry of India, by Mr. Blyth, in 'Gardener's Chronicle,' 1851, p. 619.

[15] Mr. S. J. Salter, in 'Natural History Review,' April 1863, p. 276.

[16] *See also* Mr. Layard's paper in 'Annals and Mag. of Nat. History,' 2nd series, vol. xiv. p. 62.

[17] *See also* Mr. Crawfurd's 'Descriptive Dict. of the Indian Islands,' 1856, p. 113.

[18] Described by Mr. G. R. Gray, 'Proc. Zoolog. Soc.,' 1849, p. 62.

[19] The passage from Marsden is given by Mr. Dixon in his 'Poultry Book,' p. 176. No ornithologist now ranks this bird as a distinct species.

[20] 'Coup-d'œeil général sur l'Inde Archipélagique,' tom. iii. (1849) p. 177; *see also* Mr. Blyth in 'Indian Sporting Review,' vol. ii. p. 5, 1856.

[21] Mr. Blyth, in 'Annals and Mag. of Nat. Hist.,' 2nd ser., vol. i. (1848), p. 455.

[22] Crawfurd, 'Desc. Dict. of Indian Islands,' 1856, p. 112.

[23] In Burmah, as I hear from Mr. Blyth, the wild and tame poultry constantly cross together, and irregular transitional forms may be seen.

[24] Ibid. p. 113.

[25] Mr. Jerdon, in the 'Madras Journ. of Lit. and Science,' vol. xxii. p. 2, speaking of *G. bankiva,* says, "unquestionably the origin of most of the varieties of our common fowls." For Mr. Blyth *see* his excellent article in 'Gardener's Chron.,' 1851, p. 619; and in 'Annals and Mag. of Nat. Hist.,' vol. xx., 1847, p. 388.

[26] 'Gardener's Chronicle,' 1851, p. 619.

[27] I have consulted an eminent authority, Mr. Sclater, on this subject, and he thinks that I have not expressed myself too strongly. I am aware that one ancient author, Acosta, speaks of fowls as having inhabited S. America at the period of its discovery; and more recently, about 1795, Olivier de Serres speaks of wild fowls in the forests of Guiana; these were probably feral birds. Dr. Daniell tells me, he believes that fowls have become wild on the west coast of Equatorial Africa; they may, however, not be true fowls, but gallinaceous birds belonging to the genus Phasidus. The old voyager Barbut says that poultry are not natural to Guinea. Capt. W. Allen ('Narrative of Niger Expedition,' 1848, vol. ii. p. 42) describes wild fowls on Ilha dos Rollas, an island near St. Thomas's on the west coast of Africa; the natives

informed him that they had escaped from a vessel wrecked there many years ago; they were extremely wild and had “a cry quite different to that of the domestic fowl,” and their appearance was somewhat changed. Hence it is not a little doubtful, notwithstanding the statement of the natives, whether these birds really were fowls. That the fowl has become feral on several islands is certain. Mr. Fry, a very capable judge, informed Mr. Layard, in a letter, that the fowls which have run wild on Ascension “had nearly all got back to their primitive colours, red, and black cocks, and smoky-grey hens.” But unfortunately we do not know the colour of the poultry which were turned out. Fowls have become feral on the Nicobar Islands (Blyth in the ‘Indian Field,’ 1858, p. 62), and in the Ladrones (Anson’s Voyage). Those found in the Pellew Islands (Crawfurd) are believed to be feral; and lastly, it is asserted that they have become feral in New Zealand, but whether this is correct I know not.

[28] Mr. Hewitt, in ‘The Poultry Book,’ by W. B. Tegetmeier, 1866, p. 248.

[29] ‘Journal of Horticulture,’ Jan. 14th, 1862, p. 325.

[30] ‘Die Hühner- und Pfauenzucht,’ Ulm, 1827, s. 17. For Mr. Hewitt’s statement with respect to the white Silk fowl *see* the ‘Poultry Book,’ by W. B. Tegetmeier, 1866, p. 222. I am indebted to Mr. Orton for a letter on the same subject.

[31] Dixon ‘Ornamental and Domestic Poultry,’ p. 253, 324, 335. For game fowls, *see* Ferguson on ‘Prize Poultry,’ p. 260.

[32] ‘Poultry Chronicle,’ vol. ii. p. 71.

[33] ‘Die vorgeschichtlichen Alterthümer,’ II. Theil, 1872, p. 5. Dr. Pickering, in his ‘Races of Man,’ 1850, p. 374, says that the head and neck of a fowl is carried in a Tribute-procession to Thoutmousis III. (1445 B.C.); but Mr. Birch of the British Museum doubts whether the figure can be identified as the head of a fowl. Some caution is necessary with reference to the absence of figures of the fowl on the ancient Egyptian monuments, on account of the strong and widely prevalent prejudice against this bird. I am informed by the Rev. S. Erhardt that on the east coast of Africa, from 4° to 6° south of the equator, most of the pagan tribes at the present day hold the fowl in aversion. The natives of the Pellew Islands would not eat the fowl nor will the Indians in some parts of S. America. For the ancient history of the fowl *see also* Volz ‘Beiträge zur Culturgeschichte,’ 1852, s. 77; and Isid. Geoffroy St.-Hilaire, ‘Hist. Nat. Gén.,’ tom. iii. p. 61. Mr. Crawfurd has given an admirable history of the fowl in his paper ‘On the Relation of Domesticated Animals to Civilisation,’ read before the Brit. Assoc. at Oxford in 1860, and since printed separately. I quote from him on the Greek poet Theognis, and on the Harpy Tomb described by Sir C. Fellowes. I quote from a letter of Mr. Blyth’s with respect to the Institutes of Manu.

[34] ‘Ornamental and Domestic Poultry,’ 1847, p. 185; for passages translated from Columella, *see* p. 312. For Golden Hamburghs *see* Albin’s ‘Natural History of Birds,’ 3 vols., with plates 1731-38.

[35] ‘Ornamental and Domestic Poultry,’ p. 152.

[36] Ferguson on ‘Rare Prize Poultry,’ p. 297. This writer, I am informed, cannot generally be trusted. He gives, however, figures and much information on eggs. *See* pp. 34 and 235 on the eggs of the Game fowl.

[37] *See* ‘Poultry Book,’ by Mr. Tegetmeier, 1866, pp. 81 and 78.

[38] ‘The Cottage Gardener,’ Oct. 1855, p. 13. On the thinness of the eggs of Game-fowls *see* Mowbray on Poultry, 7th edit., p. 13.

[39] My information, which is very far from perfect, on chickens in the down, is derived chiefly from Mr. Dixon’s ‘Ornamental and Domestic Poultry.’ Mr. B. P. Brent has also communicated to me many facts by letter, as has Mr. Tegetmeier. I will in each case mark my authority by the name within brackets. For the chickens of white Silk-fowls *see* Tegetmeier’s ‘Poultry Book,’ 1866, p. 221.

[40] As I hear from Mr. Tegetmeier; *see also* ‘Proc. Zoolog. Soc.,’ 1856, p. 366. On the late development of the crest *see* ‘Poultry Chronicle,’ vol. ii. p. 132.

[41] On these points, *see* ‘Poultry Chronicle,’ vol. iii. p. 166; and Tegetmeier’s ‘Poultry Book,’ 1866, pp. 105 and 121.

[42] Dixon, ‘Ornamental and Domestic Poultry,’ p. 273.

[43] Ferguson on ‘Rare and Prize Poultry,’ p. 261.

[44] Mowbray on Poultry, 7th edit., 1834, p. 13.

[45] *See* the full description of the varieties of the Game-breed in Tegetmeier’s ‘Poultry Book,’ 1866, p. 131. For Cuckoo Dorkings, p. 97.

[46] Mr. Hewitt in Tegetmeier’s ‘Poultry Book,’ 1866, pp. 246 and 156. For hen-tailed game-cocks, *see* p. 131.

[47] ‘The Field,’ April 20th, 1861. The writer says he has seen half-a-dozen cocks thus sacrificed.

[48] ‘Proceedings of Zoolog. Soc.,’ March 1861, p. 102. The engraving of the hen-tailed cock just alluded to was exhibited before the Society.

[49] ‘The Field,’ April 20th, 1861.

[50] I am much indebted to Mr. Brent for an account, with sketches, of all the variations of the comb known to him, and likewise with respect to the tail as presently to be given.

[51] The ‘Poultry Book,’ by Tegetmeier, 1866, p. 234.

[52] ‘Die Hühner-und Pfauenzucht,’ 1827, s. 11.

[53] ‘Poultry Chronicle,’ vol. i. p. 595. Mr. Brent has informed me of the same fact. With respect to the position of the spurs in Dorkings *see* ‘Cottage Gardener,’ Sept. 18th, 1860, p. 380.

[54] Dixon, ‘Ornamental and Domestic Poultry,’ p. 320.

[55] Mr. Tegetmeier informs me that Game hens have been found so combative, that it is now generally the practice to exhibit each hen in a separate pen.

[56] ‘Naturgeschichte Deutschlands,’ Band iii. (1793), s. 339, 407.

[57] On the Ornithology of Ceylon in ‘Annals and Mag. of Nat. History,’ 2nd series, vol. xiv. (1854), p. 63.

[58] ‘Handbuch der vergleich. Anatomie,’ 1805, p. 85, note. Mr. Tegetmeier, who gives in ‘Proc. Zoolog. Soc.,’ Nov. 25th, 1856, a very interesting account of the skulls of Polish fowls, not knowing of Bechstein’s account, has disputed the accuracy of Blumenbach’s statement. For Bechstein *see* ‘Naturgeschichte Deutschlands,’ Band iii. (1793), s. 399, note. I may add that at the first exhibition of Poultry at the Zoological Gardens in May, 1845, I saw some fowls, called Friezland fowls, of which the hens were crested, and the cocks furnished with a comb.

[59] ‘Cottage Gardener,’ Jan. 3rd, 1860, p. 218.

[60] Mr. Williams, in a paper read before the Dublin Nat. Hist. Soc., quoted in ‘Cottage Gardener,’ 1856, p. 161.

[61] ‘De l’Espèce,’ 1859, p. 442. For the occurrence of black-boned fowls in South America, *see* Roulin in ‘Mém. de l’Acad. des Sciences,’ tom. vi. p. 351; and Azara, ‘Quadrupèdes du Paraguay,’ tom. ii. p. 324. A frizzled fowl sent to me from Madras had black bones.

[62] Mr. Hewitt, in Tegetmeier’s ‘Poultry Book,’ 1866, p. 231.

[63] Dr. Broca, in Brown-Séquard’s ‘Journal de Phys.,’ tom. ii. p. 361.

[64] Dixon’s ‘Ornamental Poultry,’ p. 325.

[65] ‘Poultry Chronicle,’ vol. i. p. 485. Tegetmeier’s ‘Poultry Book,’ 1866, p. 41. On Cochins grazing, ibid., p. 46.

[66] Ferguson on ‘Prize Poultry,’ p. 87.

[67] Col. Sykes in ‘Proc. Zoolog. Soc.,’ 1832, p. 151. Dr. Hooker’s ‘Himalayan Journals,’ vol. i. p. 314.

[68] *See* Mr. Tegetmeier’s account with woodcuts of the skull of Polish fowls in ‘Proc. Zoolog. Soc.,’ Nov. 25th, 1856. For other references, *see* Isid. Geoffroy Saint-Hilaire, ‘Hist. Gén. des Anomalies,’

tom. i. p. 287. M. C. Dareste suspects ('Recherches sur les Conditions de la Vie,' etc., Lille 1863, p. 36) that the protuberance is not formed by the frontal bones, but by the ossification of the dura mater.

[69] 'Naturgeschichte Deutschlands,' Band iii. (1793), s. 400.

[70] The 'Field,' May 11th, 1861. I have received communications to a similar effect from Messrs. Brent and Tegetmeier.

[71] It appears that I have not correctly designated the several groups of vertebræ, for a great authority, Mr. W. K. Parker ('Transact. Zoolog. Soc.,' vol. v. p. 198), specifies 16 cervical, 4 dorsal, 15 lumbar, and 6 caudal vertebræ in this genus. But I have used the same terms in all the following descriptions.

[72] Macgillivray, 'British Birds,' vol. i. p. 25.

[73] It may be well to explain how the calculation has been made for the third column. In *G. bankiva* the leg-bones are to the wing-bones as 86 : 54, or as (neglecting decimals) 100 : 62;—in Cochins as 311 : 162, or as 100 : 52;—in Dorkings as 557 : 248, or as 100 : 44; and so on for the other breeds. We thus get the series of 62, 52, 44 for the relative weights of the wing-bones in *G. bankiva*, Cochins, Dorkings, etc. And now taking 100, instead of 62, for the weight of the wing-bones in *G. bankiva*, we get, by another rule of three, 83 as the weight of the wing-bones in Cochins; 70 in the Dorkings; and so on for the remainder of the third column in the table.

[74] Mr. Blyth (in 'Annals and Mag. of Nat. Hist.,' 2nd series, vol. i., 1848, p. 456) gives 3¼ pounds as the weight of a full-grown male *G. bankiva*; but from what I have seen of the skins and skeletons of various breeds, I cannot believe that my two specimens of *G. bankiva* could have weighed so much.

[75] The third column is calculated on the same principle as explained in footnote 73 above.

CHAPTER VIII.
DUCK—GOOSE—PEACOCK—TURKEY—GUINEA-FOWL—CANARY-BIRD—GOLD-FISH—RIVER-BEES—SILK-MOTHS.

DUCKS, SEVERAL BREEDS OF—PROGRESS OF DOMESTICATION—ORIGIN OF FROM THE COMMON WILD-DUCK—DIFFERENCES IN THE DIFFERENT BREEDS—OSTEOLOGICAL DIFFERENCES—EFFECTS OF USE AND DISUSE ON THE LIMB-BONES.

GOOSE, ANCIENTLY DOMESTICATED—LITTLE VARIATION OF—SEBASTOPOL BREED.

PEACOCK, ORIGIN OF BLACK-SHOULDERED BREED.

TURKEY,BREEDS OF—CROSSED WITH THE UNITED STATES SPECIES—EFFECTS OF CLIMATE ON.

GUINEA-FOWL, CANARY-BIRD, GOLD-FISH, HIVE-BEES.

SILK-MOTHS, SPECIES AND BREEDS OF—ANCIENTLY DOMESTICATED—CARE IN THEIR SELECTION—DIFFERENCES IN THE DIFFERENT RACES—IN THE EGG, CATERPILLAR, AND COCOON STATES—INHERITANCE OF CHARACTERS—IMPERFECT WINGS—LOST INSTINCTS—CORRELATED CHARACTERS.

I will, as in previous cases, first briefly describe the chief domestic breeds of the duck:—

BREED 1. *Common Domestic Duck.*—Varies much in colour and in proportions, and differs in instincts and disposition from the wild duck. There are several sub-breeds:—(1) The Aylesbury, of great size, white, with pale-yellow beak and legs; abdominal dermal sack largely developed. (2) The Rouen, of great size, coloured like the wild duck, with green or mottled beak; dermal sack largely developed. (3) Tufted Duck, with a large top-knot of fine downy feathers, supported on a fleshy mass, with the skull perforated beneath. The top-knot in a duck which I imported from Holland was two and a half inches in diameter. (4) Labrador (or Canadian, or Buenos Ayres, or East Indian); plumage entirely black; beak broader, relatively to its length, than in the wild duck; eggs slightly tinted with black. This sub-breed perhaps ought to be ranked as a breed; it includes two sub-varieties, one as large as the common domestic duck, which I have kept alive, and the other smaller and often capable of flight.[1] I presume it is this latter sub-variety which has been described in France[2] as flying well, being rather wild, and when cooked having the flavour of the wild duck; nevertheless this sub-variety is polygamous, like other domesticated ducks and unlike the wild duck. These black Labrador ducks breed true; but a case is given by Dr. Turral of the French sub-variety producing young with some white feathers on the head and neck, and with an ochre-coloured patch on the breast.

BREED 2. *Hook-billed Duck.*—This bird presents an extraordinary appearance from the downward curvature of the beak. The head is often tufted. The common colour is white, but some are coloured like wild ducks. It is an ancient breed, having been noticed in 1676.[3] It shows its prolonged domestication by almost incessantly laying eggs, like the fowls which are called everlasting layers.[4]

BREED 3. *Call Duck.*—Remarkable from its small size, and from the extraordinary loquacity of the female. Beak short. These birds are either white, or coloured like the wild duck.

BREED 4. *Penguin Duck.*—This is the most remarkable of all the breeds, and seems to have originated in the Malayan archipelago. It walks with its body extremely erect, and with its thin neck stretched straight upwards. Beak rather short. Tail upturned, including only 18 feathers. Femur and metatarsus elongated.

Almost all naturalists admit that the several breeds are descended from the common wild duck (*Anas boschas*); most fanciers, on the other hand, take as usual a very different view.[5] Unless we deny that domestication, prolonged during centuries, can affect even such unimportant characters as colour, size, and in a slight degree proportional dimensions and mental disposition, there is no reason whatever to doubt that the domestic duck is descended from the common wild species, for the one differs from the other in no important character. We have some historical evidence with respect to the period and progress of the domestication of the duck. It was unknown[6] to the ancient Egyptians, to the Jews of the Old Testament, and to the Greeks of the Homeric period. About eighteen centuries ago Columella[7] and Varro speak of the necessity of keeping ducks in netted enclosures like other wild fowl, so that at this period there was danger of their flying away. Moreover, the plan recommended by Columella to those who wish to increase their stock of ducks, namely, to collect the eggs of the wild bird and to place them under a hen, shows, as Mr. Dixon remarks, "that the duck had not at this time become a naturalised and prolific inmate of the Roman poultry-yard." The origin of the domestic duck from the wild species is recognised in nearly every language of Europe, as Aldrovandi long ago remarked, by the same name being applied to both. The wild duck has a wide range from the Himalayas to North America. It crosses readily with the domestic bird, and the crossed offspring are perfectly fertile.

Both in North America and Europe the wild duck has been found easy to tame and breed. In Sweden this experiment was carefully tried by Tiburtius; he succeeded in rearing wild ducks for three generations, but, though they were treated like common ducks, they did not vary even in a single feather. The young birds suffered from being allowed to swim about in cold water,[8] as is known to be the case, though the fact is a strange one, with the young of the common domestic duck. An accurate and well-known observer in England[9] has described in detail his often repeated and successful experiments in domesticating the wild duck. Young birds are easily reared from eggs hatched under a bantam; but to succeed it is indispensable not to place the eggs of both the wild and tame duck under the same hen, for in this case "the young wild ducks die off, leaving their more hardy brethren in undisturbed possession of their foster-mother's care. The difference of habit at the onset in the newly-hatched ducklings almost entails such a result to a certainty." The wild ducklings were from the first quite tame towards those who took care of them as long as they wore the same clothes, and likewise to the dogs and cats of the house. They would even snap with their beaks at the dogs, and drive them away from any spot which they coveted. But they were much alarmed at strange men and dogs. Differently from what occurred in Sweden, Mr. Hewitt found that his young birds always changed and deteriorated in character in the course of two or three generations; notwithstanding that great care was taken to prevent their crossing with tame ducks. After the third generation his birds lost the elegant carriage of the wild species, and began to acquire the gait of the common duck. They increased in size in each generation, and their legs became less fine. The white collar round the neck of the mallard became broader and less regular, and some of the longer primary wing-feathers became more or less white. When this occurred, Mr. Hewitt destroyed nearly the whole of his stock and procured fresh eggs from wild nests; so that he never bred the same family for more than five or six generations. His birds continued to pair together, and never became polygamous like the common domestic duck. I have given these details, because no other case, as far as I know, has been so carefully recorded by a competent observer of the progress of change in wild birds reared for several generations in a domestic condition.

From these considerations there can hardly be a doubt that the wild duck is the parent of the common domestic kind; nor need we look to other species for the parentage of the more distinct breeds, namely, Penguin, Call, Hook-billed, Tufted, and Labrador ducks. I will not repeat the arguments used in the previous chapters on the improbability of man having in ancient times domesticated several species since become unknown or extinct, though ducks are not readily exterminated in the wild state;—on some of the supposed parent-species having had abnormal characters in comparison with all the other species of the genus, as with Hook-billed and Penguin ducks;—on all the breeds, as far as is known being fertile together;[10]—on all the breeds having the same general disposition, instinct, etc. But one fact bearing on this question may be noticed: in the great duck family, one species alone, namely, the male of *A. boschas*, has its four middle tail-feathers curled upwardly; now in every one of the above-named domestic breeds these curled feathers exist, and on the supposition that they are descended from distinct species, we must assume that man formerly hit upon species all of which had this now unique character. Moreover, sub-varieties of each breed are coloured almost exactly like the wild duck, as I have seen with the largest and smallest breeds, namely Rouens and Call ducks, and, as Mr. Brent states,[11] is the case with Hook-billed ducks. This gentleman, as he informs me, crossed a white Aylesbury drake and a black Labrador duck, and some of the ducklings as they grew up assumed the plumage of the wild duck.

With respect to Penguins, I have not seen many specimens, and none were coloured precisely like the wild duck; but Sir James Brooke sent me three skins from Lombok and Bali, in the Malayan archipelago; the two females were paler and more rufous than the wild duck, and the drake differed in having the whole under and upper surface (excepting the neck, tail-coverts, tail, and wings) silver-grey, finely pencilled with dark lines, closely like certain parts of the plumage of the wild mallard. But I found this drake to be identical in every feather with a variety of the common breed procured from a farm-yard in Kent, and I have occasionally elsewhere seen similar specimens. The occurrence of a duck bred under so peculiar a climate as that of the Malayan archipelago, where the wild species does not exist, with exactly the same plumage as may occasionally be seen in our farm-yards, is a fact worth notice. Nevertheless the climate of the Malayan archipelago apparently tends to cause the duck to vary much, for Zollinger,[12] speaking of the Penguin breed, says that in Lombok "there is an unusual and very wonderful variety of ducks." One Penguin drake which I kept alive differed from those of which the skins were sent me from Lombok, in having its breast and back partially coloured with chestnut-brown, thus more closely resembling the Mallard.

From these several facts, more especially from the drakes of all the breeds having curled tail-feathers, and from certain sub-varieties in each breed occasionally resembling in general plumage the wild duck, we may conclude with confidence that all the breeds are descended from *A. boschas.*

I will now notice some of the peculiarities characteristic of the several breeds. The eggs vary in colour; some common ducks laying pale-greenish and others quite white eggs. The eggs which are first laid during each season by the black Labrador duck, are tinted black, as if rubbed with ink. A good observer assured me that one year his ducks of this breed laid almost perfectly white eggs. Another curious case shows what singular variations sometimes occur and are inherited; Mr. Hansell[13] relates that he had a common duck which always laid eggs with the yolk of a dark-brown colour like melted glue; and the young ducks, hatched from these eggs, laid the same kind of eggs, so that the breed had to be destroyed.

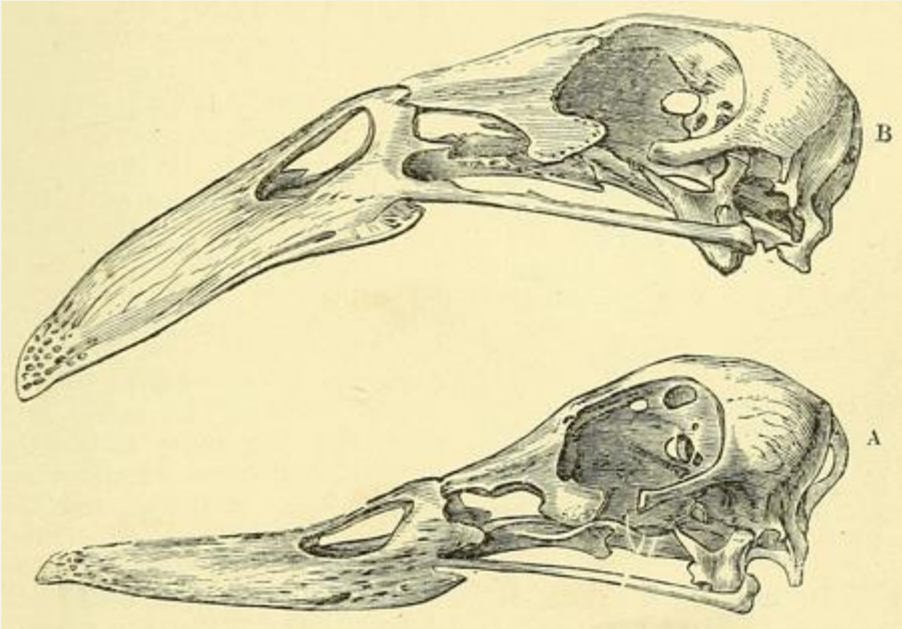


Fig 39—Skulls of Ducks, viewed laterally.
A. Wild Duck. B. Hook-billed Duck.

The Hook-billed duck is highly remarkable (see fig. 39, of skull); and its peculiar beak has been inherited at least since the year 1676. This structure is evidently analogous with that described in the Bagadotten carrier pigeon. Mr. Brent[14] says that, when Hook-billed ducks are crossed with common ducks, "many young ones are produced with the upper mandible shorter than the lower, which not unfrequently causes the death of the bird." With ducks a tuft of feathers on the head is by no means a rare occurrence; namely, in the True-tufted breed, the Hook-billed, the common farm-yard kind, and in a duck having no other peculiarity which was sent to me from the Malayan archipelago. The tuft is only so far interesting as it affects the skull, which is thus rendered slightly more globular, and is perforated by numerous apertures. Call ducks are remarkable from their extraordinary loquacity: the drake only hisses like common drakes; nevertheless, when paired with the common duck, he transmits to his female offspring a strong quacking tendency. This loquacity seems at first a surprising character to have been acquired under domestication. But the voice varies in the different breeds; Mr. Brent[15] says that Hook-billed ducks are very loquacious, and that Rouens utter a "dull, loud, and monotonous cry, easily distinguishable by an experienced ear." As the loquacity of the Call duck is highly serviceable, these birds being used in decoys, this quality may have been increased by selection. For instance, Colonel Hawker says, if young wild ducks cannot be got for a decoy, "by way of make-shift, *select* tame birds which are the most clamorous, even if their colour should not be like that of wild ones."[16] It has been erroneously asserted that Call ducks hatch their eggs in less time than common ducks.[17]

The Penguin duck is the most remarkable of all the breeds; the thin neck and body are carried erect; the wings are small; the tail is upturned; and the thigh-bones and metatarsi are considerably lengthened in proportion with the same bones in the wild duck. In five specimens examined by me there were only eighteen tail-feathers instead of twenty as in the wild duck; but I have also found only eighteen and nineteen tail-feathers in two Labrador ducks. On the middle toe, in three specimens, there were twenty-seven or twenty-eight scutellæ, whereas in two wild ducks there were thirty-one and thirty-two. The Penguin when crossed transmits with much power its peculiar form of body and gait to its offspring; this was manifest with some hybrids raised in the Zoological Gardens between one of these birds and the Egyptian goose,[18] (*Anser ægyptiacus*) and likewise with some mongrels which I raised between the Penguin and Labrador duck. I am not much surprised that some writers should maintain that this breed must be descended from an unknown and distinct species; but from the reasons already assigned, it seems to me far more probable that it is the descendant, much modified by domestication under an unnatural climate, of *Anas boschas.*

Osteological Characters.—The skulls of the several breeds differ from each other and from the skull of the wild duck in very little except in the proportional length and curvature of the premaxillaries. These latter bones in the Call duck are short, and a line drawn from their extremities to the summit of the skull is nearly straight, instead of being concave as in the common duck; so that the skull resembles that of a small goose. In the Hook-billed duck (fig. 39), these same bones as well as the lower jaw curve downwards in a most remarkable manner, as represented. In the Labrador duck the premaxillaries are rather broader than in the wild duck; and in two skulls of this breed the vertical ridges on each side of the supra-occipital bone are very prominent. In the Penguin the premaxillaries are relatively shorter than in the wild duck; and the inferior points of the paramastoids more prominent. In a Dutch tufted duck, the skull under the enormous tuft was slightly more globular and was perforated by two large apertures; in this skull the lachrymal bones were produced much further backwards, so as to have a different shape and nearly to touch the post. lat. processes of the frontal bones, thus almost completing the bony orbit of the eye. As the quadrate and pterygoid bones are of such complex shape and stand in relation with so many other bones, I carefully compared them in all the principal breeds; but excepting in size they presented no difference.

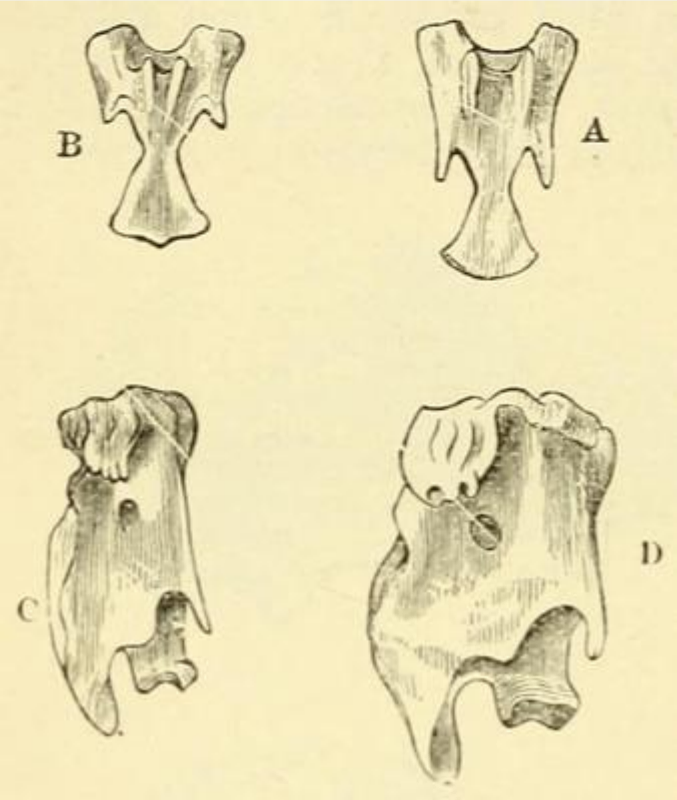


Fig 40—Cervical Verterbræ of Ducks.

Vertebræ and Ribs.—In one skeleton of the Labrador duck there were the usual fifteen cervical vertebræ and the usual nine dorsal vertebræ bearing ribs; in the other skeleton there were fifteen cervical and ten dorsal vertebræ with ribs; nor, as far as could be judged, was this owing merely to a rib having been developed on the first lumbar vertebra; for in both skeletons the lumbar vertebræ agreed perfectly in number, shape, and size with those of the wild duck. In two skeletons of the Call duck there were fifteen cervical and nine dorsal vertebræ; in a third skeleton small ribs were attached to the so-called fifteenth cervical vertebra, making ten pairs of ribs; but these ten ribs do not correspond, or arise from the same vertebra, with the ten in the above-mentioned Labrador duck. In the Call duck, which had small ribs attached to the fifteenth cervical vertebra, the hæmal spines of the thirteenth and fourteenth (cervical) and of the seventeenth (dorsal) vertebræ corresponded with the spines on the fourteenth, fifteenth, and eighteenth vertebræ of the wild duck: so that each of these vertebræ had acquired a structure proper to one posterior to it in position. In the eighth cervical vertebra of this same Call duck (fig. 40, B), the two branches of the hæmal spine stand much closer together than in the wild duck (A), and the descending hæmal processes are much shortened. In the Penguin duck the neck from its thinness and erectness falsely appears (as ascertained by measurement) to be much elongated, but the cervical and dorsal vertebræ present no difference; the posterior dorsal vertebræ, however, are more completely anchylosed to the pelvis than in the wild duck. The Aylesbury duck has fifteen cervical and ten dorsal vertebræ furnished with ribs, but the same number of lumbar, sacral, and caudal vertebræ, as far as could be traced, as in the wild duck. The cervical vertebræ in this same duck (fig. 40, D) were much broader and thicker relatively to their length than in the wild (C); so much so, that I have thought it worth while to give a sketch of the twelfth cervical vertebra in these two birds. From the foregoing statements we see that the fifteenth cervical vertebra occasionally becomes modified into a dorsal vertebra, and when this occurs all the adjoining vertebræ are modified. We also see that an additional dorsal vertebra bearing a rib is occasionally developed, the number of the cervical and lumbar vertebræ apparently remaining the same as usual.

I examined the bony enlargement of the trachea in the males of the Penguin, Call, Hook-billed, Labrador, and Aylesbury breeds; and in all it was identical in shape.

The *pelvis* is remarkably uniform; but in the skeleton of the Hook-billed duck the anterior part is much bowed inwards; in the Aylesbury and some other breeds the ischiadic foramen is less elongated. In the sternum, furculum, coracoids, and scapulæ, the differences are so slight and so variable as not to be worth notice, except that in two skeletons of the Penguin duck the terminal portion of the scapula was much attenuated.

In the bones of the leg and wing no modification in shape could be observed. But in the Penguin and Hook-billed ducks, the terminal phalanges of the wing are a little shortened. In the former, the femur, and metatarsus (but not the tibia) are considerably lengthened, relatively to the same bones in the wild duck, and to the wing-bones in both birds. This elongation of the leg-bones could be seen whilst the bird was alive, and is no doubt connected with its peculiar upright manner of walking. In a large Aylesbury duck, on the other hand, the tibia was the only bone of the leg which relatively to the other bones was slightly lengthened.

On the effects of the increased and decreased Use of the Limbs.—In all the breeds the bones of the wing (measured separately after having been cleaned) relatively to those of the leg have become slightly shortened, in comparison with the same bones in the wild duck, as may be seen in Table I.

Table I

Name of Breed	Length of Femur, Tibia, and Metatarsus together	Length of Humerus, Radius, and Metacarpus together	Or as
	Inches	Inches	
Wild mallard	7·14	9·28	100 : 129
Aylesbury	8·64	10·43	100 : 120

Tufted (Dutch)	8·25	9·83	100 : 119
Penguin	7·12	8·78	100 : 123
Call	6·20	7·77	100 : 125
	Length of same Bones	Length of all the Bones of Wing	
	Inches	Inches	
Wild duck (another specimen)	6·85	10·07	100 : 147
Common domestic duck	8·15	11·26	100 : 138

In Table I we see, by comparison with the wild duck, that the reduction in the length of the bones of the wing, relatively to those of the legs, though slight, is universal. The reduction is least in the Call duck, which has the power and the habit of frequently flying.

In weight there is a greater relative difference between the bones of the leg and wing, as may be seen in Table II:—

Table II

Name of Breed	Weight of Femur, Tibia, and Metatarsus	Weight of Humerus, Radius, and Metacarpus	Or as
	Grains	Grains	
Wild mallard	54	97	100 : 179
Aylesbury	164	204	100 : 124
Hooked-bill	107	160	100 : 149
Tufted (Dutch)	111	148	100 : 133
Penguin	75	90.5	100 : 120
Labrador	141	165	100 : 117
Call	57	93	100 : 163

	Weight of all the Bones of the Leg and Foot	Weight of all the Bones of the Wing	
	Grains	Grains	
Wild (another specimen)	66	115	100 : 173
Common domestic duck	127	158	100 : 124

In these domesticated birds, the considerably lessened weight of the bones of the wing (*i.e.* on an average, twenty-five per cent of their proper proportional weight), as well as their slightly lessened length, relatively to the leg-bones, might follow, not from any actual decrease in the wing-bones, but from the increased weight and length of the bones of the legs. Table IIIa shows that the leg-bones relatively to the weight of the entire skeleton have really increased in weight; but Table IIIb shows that according to the same standard the wing-bones have also really decreased in weight; so that the relative disproportion shown in the foregoing tables between the wing and leg-bones, in comparison with those of the wild duck, is partly due to the increase in weight and length of the leg-bones, and partly to the decrease in weight and length of the wing-bones.

Table III

Name of Breed	Weight of entire Skeleton. (N.B. One Metatarsus and Foot was removed from each skeleton, as it had been accidentally lost in two cases.)	Weight of Femur, Tibia, and Metatarsus	Or as
	Grains	Grains	
Wild mallard	839	54	1000 : 64
Aylesbury	1925	164	1000 : 85
Tufted (Dutch)	1404	111	1000 : 79
Penguin	871	75	1000 : 86

Call (from Mr. Fox)	717	57	1000 : 79

	Weight of Skeleton as above.	Weight of Humerus, Radius and Metacarpus.	
	Grains	Grains	
Wild mallard	839	97	1000 : 115
Aylesbury	1925	204	1000 : 105
Tufted (Dutch)	1404	148	1000 : 105
Penguin	871	90	1000 : 103
Call (from Mr. Baker)	914	100	1000 : 109
Call (from Mr. Fox)	717	92	1000 : 129

With respect to Table III, I may first state that I tested them by taking another skeleton of a wild duck and of a common domestic duck, and by comparing the weight of *all* the bones of the leg with *all* those of the wings, and the result was the same. In the first of these tables we see that the leg-bones in each case have increased in actual weight. It might have been expected that, with the increased or decreased weight of the entire skeleton, the leg-bones would have become proportionally heavier or lighter; but their greater weight in all the breeds relatively to the other bones can be accounted for only by these domestic birds having used their legs in walking and standing much more than the wild, for they never fly, and the more artificial breeds rarely swim. In the second table we see, with the exception of one case, a plain reduction in the weight of the bones of the wing, and this no doubt has resulted from their lessened use. The one exceptional case, namely, in one of the Call ducks, is in truth no exception, for this bird was constantly in the habit of flying about; and I have seen it day after day rise from my grounds, and fly for a long time in circles of more than a mile in diameter. In this Call duck there is not only no decrease, but an actual increase in the weight of the wing-bones relatively to those of the wild-duck; and this probably is consequent on the remarkable lightness and thinness of all the bones of the skeleton.

Lastly, I weighed the furculum, coracoids, and scapula of a wild duck and of a common domestic duck, and I found that their weight, relatively to that of the whole skeleton, was as one hundred in the former to eighty-nine in the latter; this shows that these bones in the domestic duck have been reduced eleven per cent of their due proportional weight. The prominence of the crest of the sternum, relatively to its length, is also much reduced in all the domestic breeds. These changes have evidently been caused by the lessened use of the wings.

It is well known that several birds, belonging to different Orders, and inhabiting oceanic islands, have their wings greatly reduced in size and are incapable of flight. I suggested in my ‘Origin of Species’ that, as these birds are not persecuted by any enemies, the reduction of their wings had probably been caused by gradual disuse. Hence, during the earlier stages of the process of reduction, such birds would probably have resembled our domesticated ducks in the state of their organs of flight. This is the case with the water-hen (*Gallinula nesiotis*) of Tristan d’Acunha, which “can flutter a little, but obviously uses its legs, and not its wings, as a mode of escape.” Now Mr. Sclater[19] finds in this bird that the wings, sternum, and coracoids are all reduced in length, and the crest of the sternum in depth, in comparison with the same bones in the European water-hen (*G. chloropus*). On the other hand, the thigh-bones and pelvis are increased in length, the former by four lines, relatively to the same bones in the common water-hen. Hence in the skeleton of this natural species nearly the same changes have occurred, only carried a little further, as with our domestic ducks, and in this latter case I presume no one will dispute that they have resulted from the lessened use of the wings and the increased use of the legs.

THE GOOSE.

This bird deserves some notice, as hardly any other anciently domesticated bird or quadruped has varied so little. That geese were anciently domesticated we know from certain verses in Homer; and from these birds having been kept (388 B.C.) in the Capitol at Rome as sacred to Juno, which sacredness implies great antiquity.[20] That the goose has varied in some degree, we may infer from naturalists not being unanimous with respect to its wild parent-form; though the difficulty is chiefly due to the existence of three or four closely allied wild European species.[21] A large majority of capable judges are convinced that our geese are descended from the wild Grey-leg goose (*A. ferus*); the young of which can easily be tamed.[22] This species, when crossed with the domestic goose, produced in the Zoological Gardens, as I was assured in 1849, perfectly fertile offspring.[23] Yarrell[24] has observed that the lower part of the trachea of the domestic goose is sometimes flattened, and that a ring of white feathers sometimes surrounds the base of the beak. These characters seem at first sight good indications of a cross at some former period with the white-fronted goose (*A. albifrons*); but the white ring is variable in this latter species, and we must not overlook the law of analogous variation; that is, of one species assuming some of the characters of allied species.

As the goose has proved so little flexible in its organisation under long-continued domestication, the amount of variation which it has undergone may be worth giving. It has increased in size and in productiveness;[25] and varies from white to a dusky colour. Several observers[26] have stated that the gander is more frequently white than the goose, and that when old it almost invariably becomes white; but this is not the case with the parent-form, the *A. ferus*. Here, again, the law of analogous variation may have come into play, as the almost snow-white male of the Rock goose (*Bernicla antarctica*) standing on the sea-shore by his dusky partner is a sight well known to those who have traversed the sounds of Tierra del Fuego and the Falkland Islands. Some geese have top-knots; and the skull beneath, as before stated, is perforated. A sub-breed has lately been formed with the feathers reversed at the back of the head and neck.[27] The beak varies a little in size, and is of a yellower tint than in the wild species; but its colour and that of the legs are both slightly variable.[28] This latter fact deserves attention, because the colour of the legs and beak is highly serviceable in discriminating the several closely allied wild forms.[29] At our Shows two breeds are exhibited; viz., the Embden and Toulouse; but they differ in nothing except colour.[30] Recently a smaller and singular variety has been imported from Sebastopol,[31] with the scapular feathers (as I hear from Mr. Tegetmeier, who sent me specimens) greatly elongated, curled, and even spirally twisted. The margins of these feathers are rendered plumose by the divergence of the barbs and barbules, so that they resemble in some degree those on the back of the black Australian swan. These feathers are likewise remarkable from the central shaft, which is excessively thin and transparent, being split into fine filaments, which, after running for a space free, sometimes coalesce again. It is a curious fact that these filaments are regularly clothed on each side with fine down or barbules, precisely like those on the proper barbs of the feather. This structure of the feathers is transmitted to half-bred birds. In *Gallus sonneratii* the barbs and barbules blend together, and form thin horny plates of the same nature with the shaft: in this variety of the goose, the shaft divides into filaments which acquire barbules, and thus resemble true barbs.

Although the domestic goose certainly differs somewhat from any known wild species, yet the amount of variation which it has undergone, as compared with that of most domesticated animals, is singularly small. This fact can be partially accounted for by selection not having come largely into play. Birds of all kinds which present many distinct races are valued as pets or ornaments; no one makes a pet of the goose; the name, indeed, in more languages than one, is a term of reproach. The goose is valued for its size and flavour, for the whiteness of its feathers which adds to their value, and for its prolificness and tameness. In all these points the goose differs from the wild parent-form; and these are the points which have been selected. Even in ancient times the Roman gourmands valued the liver of the *white* goose; and Pierre Belon[32] in 1555 speaks of two varieties, one of which was larger, more fecund, and of a better colour than the other; and he expressly states that good managers attended to the colour of their goslings, so that they might know which to preserve and select for breeding.

THE PEACOCK.

This is another bird which has hardly varied under domestication, except in sometimes being white or piebald. Mr. Waterhouse carefully compared, as he informs me, skins of the wild Indian and domestic bird, and they were identical in every respect, except that the plumage of the latter was perhaps rather thicker. Whether our birds are descended from those introduced into Europe in the time of Alexander, or have been subsequently imported, is doubtful. They do not breed very freely with us, and are seldom kept in large numbers,—circumstances which would greatly interfere with the gradual selection and formation of new breeds. There is one strange fact with respect to the peacock, namely, the occasional appearance in England of the "japanned" or "black-shouldered" kind. This form has lately been named on the high authority of Mr. Sclater as a distinct species, viz. *Pavo nigripennis*, which he believes will hereafter be found wild in some country, but not in India, where it is certainly unknown. The males of these japanned birds differ conspicuously from the common peacock in the colour of their secondary wing-feathers, scapulars, wing-coverts, and thighs, and are I think more beautiful; they are rather smaller than the common sort, and are always beaten by them in their battles, as I hear from the Hon. A. S. G. Canning. The females are much paler coloured than those of the common kind. Both sexes, as Mr. Canning informs me, are white when they leave the egg, and they differ from the young of the white variety only in having a peculiar pinkish tinge on their wings. These japanned birds, though appearing suddenly in flocks of the common kind, propagate their kind quite truly. Although they do not resemble the hybrids which have been raised between *P. cristatus* and *muticus*, nevertheless they are in some respects intermediate in character between these two species; and this fact favours, as Mr. Sclater believes, the view that they form a distinct and natural species.[33]

On the other hand, Sir H. Heron states[34] that this breed suddenly appeared within his memory in Lord Brownlow's large stock of pied, white, and common peacocks. The same thing occurred in Sir J. Trevelyan's flock composed entirely of the common kind, and in Mr. Thornton's stock of common and pied peacocks. It is remarkable that in these two latter instances the black-shouldered kind, though a smaller and weaker bird, increased, "to the extinction of the previously existing breed." I have also received through Mr. Sclater a statement from Mr. Hudson Gurney that he reared many years ago a pair of black-shouldered peacocks from the common kind; and another ornithologist, Prof. A. Newton, states that, five or six years ago, a female bird, in all respects similar to the female of the black-shouldered kind, was produced from a stock of common peacocks in his possession, which during more than twenty years had not been crossed with birds of any other strain. Mr. Jenner Weir informs me that a peacock at Blackheath whilst young was white, but as it became older gradually assumed the characters of the black-shouldered variety; both its parents were common peacocks. Lastly, Mr. Canning has given a case of a female of this same variety appearing in

Ireland in a flock of the ordinary kind.[35] Here, then, we have seven well authenticated cases in Great Britain of japanned birds, having suddenly appeared within recent times in flocks of the common peafowl. This variety must also have formerly appeared in Europe, for Mr. Canning has seen an old picture, and another is referred to in the 'Field,' with this variety represented. These facts seem to me to indicate that the japanned peacock is a strongly marked variety or "sport," which tends at all times and in many places to reappear. This view is supported by the young being at first white like the young of the white breed, which is undoubtedly a variation. If, on the other hand, we believe the japanned peacock to be a distinct species, we must suppose that in all the above cases the common breed had at some former period been crossed by it, but had lost every trace of the cross; yet that the offspring of these birds suddenly and completely reacquired through reversion the characters of *P. nigripennis*. I have heard of no other such case in the animal or vegetable kingdom. To perceive the full improbability of such an occurrence, we may suppose that a breed of dogs had been crossed at some former period with a wolf, but had lost every trace of the wolf-like character, yet that the breed gave birth in seven instances in the same country, within no great length of time, to a wolf perfect in every character; and we must further suppose that in two of the cases, the newly produced wolves afterwards spontaneously increased to such an extent as to lead to the extinction of the parent breed of dogs. So remarkable a bird as the *P. nigripennis*, when first imported, would have realised a large price; it is therefore improbable that it should have been silently introduced and its history subsequently lost. On the whole the evidence seems to me, as it did to Sir R. Heron, to be decisive in favour of the japanned or black-shouldered breed being a variation, induced by some unknown cause. On this view, the case is the most remarkable one ever recorded of the abrupt appearance of a new form, which so closely resembles a true species that it has deceived one of the most experienced of living ornithologists.

THE TURKEY.

It seems fairly well established by Mr. Gould,[36] that the turkey, in accordance with the history of its first introduction, is descended from a wild Mexican form, which had been domesticated by the natives before the discovery of America, and which is now generally ranked as a local race, and not as a distinct species. However this may be, the case deserves notice because in the United States wild male turkeys sometimes court the domestic hens, which are descended from the Mexican form, "and are generally received by them with great pleasure."[37] Several accounts have likewise been published of young birds, reared in the United States from the eggs of the wild species, crossing and commingling with the common breed. In England, also, this same species has been kept in several parks; from two of which the Rev. W. D. Fox procured birds, and they crossed freely with the common domestic kind, and during many years afterwards, as he informs me, the turkeys in his neighbourhood clearly showed traces of their crossed parentage. We here have an instance of a domestic race being modified by a cross with a distinct wild race or species. F. Michaux[38] suspected in 1802 that the common domestic turkey was not descended from the United States species alone, but likewise from a southern form, and he went so far as to believe that English and French turkeys differed from having different proportions of the blood of the two parent-forms.

English turkeys are smaller than either wild form. They have not varied in any great degree; but there are some breeds which can be distinguished as Norfolks, Suffolks, Whites, and Copper-coloured (or Cambridge), all of which, if precluded from crossing with other breeds propagate their kind truly. Of these kinds, the most distinct is the small, hardy, dull-black Norfolk turkey, of which the chickens are black, occasionally with white patches about the head. The other breeds scarcely differ except in colour, and their chickens are generally mottled all over with brownish-grey.[39] The inferior tail-coverts vary in number, and according to a German superstition the hen lays as many eggs as the cock has feathers of this kind.[40] Albin in 1738, and Temminck within a much later period, describe a beautiful breed, dusky-yellowish, brown above and white beneath, with a large top-knot of soft plumose feather. The spurs of the male were rudimentary. This breed has been for a long time extinct in Europe; but a living specimen has lately been imported from the east coast of Africa, which still retains the top-knot and the same general colouring and rudimentary spurs.[41] Mr. Wilmot has described[42] a white turkey-cock having a crest formed of "feathers about four inches long, with bare quills, and a tuft of soft white down growing at the end." Many of the young birds inherited this kind of crest, but afterwards it fell off or was pecked out by the other birds. This is an interesting case, as with care a new breed might probably have been formed; and a top-knot of this nature would have been to a certain extent analogous to that borne by the males in several allied genera, such as Euplocomus, Lophophorus, and Pavo.

Wild turkeys, believed in every instance to have been imported from the United States, have been kept in the parks of Lords Powis, Leicester, Hill, and Derby. The Rev. W. D. Fox procured birds from the two first-named parks, and he informs me that they certainly differed a little from each other in the shape of their bodies and in the barred plumage on their wings. These birds likewise differed from Lord Hill's stock. Some of the latter kept at Oulton by Sir P. Egerton, though precluded from crossing with common turkeys, occasionally produced much paler-coloured birds, and one that was almost white, but not an albino. These half-wild turkeys, in thus differing slightly from each other, present an analogous case with the wild cattle kept in the several British parks. We must suppose that such differences have resulted from the prevention of free intercrossing between birds ranging over a wide area, and from the changed conditions to which they have been exposed in England. In India the climate has apparently wrought a still greater change in the turkey, for it is described by Mr. Blyth[43] as being much degenerated in size, "utterly incapable of rising on the wing," of a black colour, and "with the long pendulous appendages over the beak enormously developed."

THE GUINEA FOWL.

The domesticated Guinea fowl is now believed by some naturalists to be descended from the *Numida ptilorhynca,* which inhabits very hot, and, in parts, extremely arid districts in Eastern Africa; consequently it has been exposed in this country to extremely different conditions of life. Nevertheless it has hardly varied at all, except in the plumage being either paler or darker-coloured. It is a singular fact that this bird varies more in colour in the West Indies and on the Spanish Main, under a hot though humid climate, than in Europe.[44] The Guinea fowl has become thoroughly feral in Jamaica and in St. Domingo,[45] and has diminished in size; the legs are black, whereas the legs of the aboriginal African bird are said to be grey. This small change is worth notice on account of the often-repeated statement that all feral animals invariably revert in every character to their original type.

THE CANARY BIRD.

As this bird has been recently domesticated, namely, within the last 350 years, its variability deserves notice. It has been crossed with nine or ten other species of Fringillidæ, and some of the hybrids are almost completely fertile; but we have no evidence that any distinct breed has originated from such crosses. Notwithstanding the modern domestication of the canary, many varieties have been produced; even before the year 1718 a list of twenty-seven varieties was published in France,[46] and in 1779 a long schedule of the desired qualities was printed by the London Canary Society, so that methodical selection has been practised during a considerable period. The greater number of the varieties differ only in colour and in the markings of their plumage. Some breeds however, differ in shape, such as the hooped or bowed canaries, and the Belgian canaries with their much elongated bodies. Mr. Brent[47] measured one of the latter and found it eight inches in length, whilst the wild canary is only five and a quarter inches long. There are top-knotted canaries, and it is a singular fact that, if two top-knotted birds are matched, the young, instead of having very fine top-knots, are generally bald, or even have a wound on their heads.[48] It would appear as if the top-knot were due to some morbid condition, which is increased to an injurious degree when two birds in this state are paired. There is a feather-footed breed, and another with a kind of frill running down the breast. One other character deserves notice from being confined to one period of life, and from being strictly inherited at the same period; namely, the wing and tail feathers in prize canaries being black, “but this colour is retained only until the first moult; once moulted, the peculiarity ceases.”[49] Canaries differ much in disposition and character, and in some small degree in song. They produce eggs three or four times during the year.

GOLD-FISH.

Besides mammals and birds, only a few animals belonging to the other great classes have been domesticated; but to show that it is an almost universal law that animals, when removed from their natural conditions of life, vary, and that races can be formed when selection is applied, it is necessary to say a few words on gold-fish, bees, and silk-moths.

Gold-fish (*Cyprinus auratus*) were introduced into Europe only two or three centuries ago; but they have been kept in confinement from an ancient period in China. Mr. Blyth[50] suspects, from the analogous variation of other fishes, that golden-coloured fish do not occur in a state of nature. These fishes frequently live under the most unnatural conditions, and their variability in colour, size, and in some important points of structure is very great. M. Sauvigny has described and given coloured drawings of no less than eighty-nine varieties.[51] Many of the varieties, however, such as triple tail-fins, etc., ought to be called monstrosities; but it is difficult to draw any distinct line between a variation and a monstrosity. As gold-fish are kept for ornament or curiosity, and as "the Chinese are just the people to have secluded a chance variety of any kind, and to have matched and paired from it,"[52] it might have been predicted that selection would have been largely practised in the formation of new breeds; and this is the case. In an old Chinese work it is said that fish with vermilion scales were first raised in confinement during the Sung dynasty (which commenced A.D. 960), "and now they are cultivated in families everywhere for the sake of ornament." In another and more ancient work, it is said that "there is not a household where the gold-fish is not cultivated, in *rivalry* as to its colour, and as a source of profit," etc.[53] Although many breeds exist, it is a singular fact that the variations are often not inherited. Sir R. Heron[54] kept many of these fishes, and placed all the deformed ones, namely, those destitute of dorsal fins and those furnished with a double anal fin, or triple tail, in a pond by themselves; but they did "not produce a greater proportion of deformed offspring than the perfect fishes."

Passing over an almost infinite diversity of colour, we meet with the most extraordinary modifications of structure. Thus, out of about two dozen specimens bought in London, Mr. Yarrell observed some with the dorsal fin extending along more than half the length of the back: others with this fin reduced to only five or six rays: and one with no dorsal fin. The anal fins are sometimes double, and the tail is often triple. This latter deviation of structure seems generally to occur "at the expense of the whole or part of some other fin;"[55] but Bory de Saint-Vincent[56] saw at Madrid gold-fish furnished with a dorsal fin and a triple tail. One variety is characterised by a hump on its back near the head; and the Rev. L. Jenyns[57] has described a most singular variety, imported from China, almost globular in form like a Diodon, with "the fleshy part of the tail as if entirely cut away? the caudal fin being set on a little behind the dorsal and immediately above the anal." In this fish the anal and caudal fins were double; the anal fin being attached to the body in a vertical line: the eyes also were enormously large and protuberant.

HIVE-BEES.

Bees have been domesticated from an ancient period; if indeed their state can be considered one of domestication, for they search for their own food, with the exception of a little generally given to them during the winter. Their habitation is a hive instead of a hole in a tree. Bees, however, have been transported into almost every quarter of the world, so that climate ought to have produced whatever direct effect it is capable of producing. It is frequently asserted that the bees in different parts of Great Britain differ in size, colour, and temper; and Godron[58] says that they are generally larger in the south than in other parts of France; it has also been asserted that the little brown bees of High Burgundy, when transported to La Bresse become large and yellow in the second generation. But these statements require confirmation. As far as size is concerned, it is known that bees produced in very old combs are smaller, owing to the cells having become smaller from the successive old cocoons. The best authorities[59] concur that, with the exception of the Ligurian race or species, presently to be mentioned, distinct breeds do not exist in Britain or on the Continent. There is, however, even in the same stock, some variability in colour. Thus, Mr. Woodbury states,[60] that he has several times seen queen bees of the common kind annulated with yellow-like Ligurian queens, and the latter dark-coloured like common bees. He has also observed variations in the colour of the drones, without any corresponding difference in the queens or workers of the same hive. The great apiarian, Dzierzon, in answer to my queries on this subject, says,[61] that in Germany bees of some stocks are decidedly dark, whilst others are remarkable for their yellow colour. Bees also seem to differ in habits in different districts, for Dzierzon adds, "If many stocks with their offspring are more inclined to swarm, whilst others are richer in honey, so that some bee-keepers even distinguish between swarming and honey-gathering bees, this is a habit which has become second nature, caused by the customary mode of keeping the bees and the pasturage of the district. For example, what a difference in this respect one may perceive to exist between the bees of the Luneburg heath and those of this country!" . . . "Removing an old queen and substituting a young one of the current year is here an infallible mode of keeping the strongest stock from swarming and preventing drone-breeding; whilst the same means if adopted in Hanover would certainly be of no avail." I procured a hive full of dead bees from Jamaica, where they have long been naturalised, and, on carefully comparing them under the microscope with my own bees, I could detect not a trace of difference.

This remarkable uniformity in the hive-bee, wherever kept, may probably be accounted for by the great difficulty, or rather impossibility, of bringing selection into play by pairing particular queens and drones, for these insects unite only during flight.

Nor is there any record, with a single partial exception, of any person having separated and bred from a hive in which the workers presented some appreciable difference. In order to form a new breed, seclusion from other bees would, as we now know, be indispensable; for since the introduction of the Ligurian bee into Germany and England, it has been found that the drones wander at least two miles from their own hives, and often cross with the queens of the common bee.[62] The Ligurian bee, although perfectly fertile when crossed with the common kind, is ranked by most naturalists as a distinct species, whilst by others it is ranked as a variety: but this form need not here be noticed, as there is no reason to believe that it is the product of domestication. The Egyptian and some other bees are likewise ranked by Dr. Gerstäcker,[63] but not by other highly competent judges, as geographical races; he grounds his conclusion in chief part on the fact that in certain districts, as in the Crimea and Rhodes, they vary so much in colour, that the several geographical races can be closely connected by intermediate forms.

I have alluded to a single instance of the separation and preservation of a particular stock of bees. Mr. Lowe[64] procured some bees from a cottager a few miles from Edinburgh, and perceived that they differed from the common bee in the hairs on the head and thorax being lighter coloured and more profuse in quantity. From the date of the introduction of the Ligurian bee into Great Britain we may feel sure that these bees had not been crossed with this form. Mr. Lowe propagated this variety, but unfortunately did not separate the stock from his other bees, and after three generations the new character was almost completely lost. Nevertheless, as he adds, "a great number of the bees still retain traces, though faint, of the original colony." This case shows us what could probably be effected by careful and long-continued selection applied exclusively to the workers, for, as we have seen, queens and drones cannot be selected and paired.

SILK-MOTHS.

These insects are in several respects interesting to us, more especially because they have varied largely at an early period of life, and the variations have been inherited at corresponding periods. As the value of the silk-moth depends entirely on the cocoon, every change in its structure and qualities has been carefully attended to, and races differing much in the cocoon, but hardly at all in the adult state, have been produced. With the races of most other domestic animals, the young resemble each other closely, whilst the adults differ much.

It would be useless, even if it were possible, to describe all the many kinds of silkworms. Several distinct species exist in India and China which produce useful silk, and some of these are capable of freely crossing with the common silk-moth, as has been recently ascertained in France. Captain Hutton[65] states that throughout the world at least six species have been domesticated; and he believes that the silk-moths reared in Europe belong to two or three species. This, however, is not the opinion of several capable judges who have particularly attended to the cultivation of this insect in France; and hardly accords with some facts presently to be given.

The common silk-moth (*Bombyx mori*) was brought to Constantinople in the sixth century, whence it was carried into Italy, and in 1494 into France.[66] Everything has been favourable for the variation of this insect. It is believed to have been domesticated in China as long ago as 2700 B.C. It has been kept under unnatural and diversified conditions of life, and has been transported into many countries. There is reason to believe that the nature of the food given to the caterpillar influences to a certain extent the character of the breed.[67] Disuse has apparently aided in checking the development of the wings. But the most important element in the production of the many now existing, much modified races, no doubt has been the close attention which has long been applied in many countries to every promising variation. The care taken in Europe in the selection of the best cocoons and moths for breeding is notorious,[68] and the production of eggs is followed as a distinct trade in parts of France. I have made inquiries through Dr. Falconer, and am assured that in India the natives are equally careful in the process of selection. In China the production of eggs is confined to certain favourable districts, and the raisers are precluded by law from producing silk, so that their whole attention may be necessarily given up to this one object.[69]

The following details on the differences between the several breeds are taken, when not stated to the contrary, from M. Robinet's excellent work,[70] which bears every sign of care and large experience. The *eggs* in the different races vary in colour, in shape (being round, elliptic or oval), and in size. The eggs laid in June in the south of France, and in July in the central provinces, do not hatch until the following spring; and it is in vain, says M. Robinet, to expose them to a temperature gradually raised, in order that the caterpillar may be quickly developed. Yet occasionally, without any known cause, batches of eggs are produced, which immediately begin to undergo the proper changes, and are hatched in from twenty to thirty days. From these and some other analogous facts it may be concluded that the Trevoltini silkworms of Italy, of which the caterpillars are hatched in from fifteen to twenty days, do not necessarily form, as has been maintained, a distinct species. Although the breeds which live in temperate countries produce eggs which cannot be immediately hatched by artificial heat, yet when they are removed to and reared in a hot country they gradually acquire the character of quick development, as in the Trevoltini races.[71]

Caterpillars.—These vary greatly in size and colour. The skin is generally white, sometimes mottled with black or grey, and occasionally quite black. The colour, however, as M. Robinet asserts, is not constant, even in perfectly pure breeds; except in the race *tigrée*, so called from being marked with transverse black stripes. As the general colour of the caterpillar is not correlated with that of the silk,[72] this character is disregarded by cultivators, and has not been fixed by selection. Captain Hutton, in the paper before referred to, has argued with much force that the dark tiger-like marks, which so frequently appear during the later moults in the caterpillars of various breeds, are due to reversion; for the caterpillars of several allied wild species of Bombyx are marked and coloured in this manner. He separated some caterpillars with the tiger-like marks, and in the succeeding spring (pp. 149, 298) nearly all the caterpillars reared from them were dark-brindled, and the tints became still darker in the third generation. The moths reared from these caterpillars[73] also became darker, and resembled in colouring the wild *B. huttoni*. On this view of the tiger-like marks being due to reversion, the persistency with which they are transmitted is intelligible.

Several years ago Mrs. Whitby took great pains in breeding silkworms on a large scale, and she informed me that some of her caterpillars had dark eyebrows. This is probably the first step in reversion towards the tiger-like marks, and I was curious to know whether so trifling a character would be inherited. At my request she separated in 1848 twenty of these caterpillars, and having kept the moths separate, bred from them. Of the many caterpillars thus reared, "every one without exception had eyebrows, some darker and more decidedly marked than the others, but *all* had eyebrows more or less plainly visible." Black caterpillars occasionally appear amongst those of the common kind, but in so variable a manner, that, according to M. Robinet, the same race will one year exclusively produce white caterpillars, and the next year many black ones; nevertheless, I have been informed by M. A. Bossi of Geneva, that, if these black caterpillars are separately bred from, they reproduce the same colour; but the cocoons and moths reared from them do not present any difference.

The caterpillar in Europe ordinarily moults four times before passing into the cocoon stage; but there are races "à trois mues," and the Trevoltini race likewise moults only thrice. It might have been thought that so important a physiological difference would not have arisen under domestication; but M. Robinet[74] states that, on the one hand, ordinary caterpillars occasionally spin their cocoons after only three moults, and, on the other hand, "presque toutes les races à trois mues, que nous avons expérimentees, ont fait quatre mues à la seconde ou à la troisième année, ce qui semble prouver qu'il a suffi de les placer dans des conditions favorables pour leur rendre une faculté qu'elles avaient perdue sous des influences moins favorables."

Cocoons.—The caterpillar in changing into the cocoon loses about 50 per cent of its weight; but the amount of loss differs in different breeds, and this is of importance to the cultivator. The cocoon in the different races presents characteristic differences; being large or small;—nearly spherical with no constriction, as in the Race de Loriol, or cylindrical, with either a deep or slight constriction in the middle; with the two ends, or with one end alone, more or less pointed. The silk varies in fineness and quality, and in being nearly white, but of two tints, or yellow. Generally the colour of the silk is not strictly inherited: but in the chapter on Selection I shall give a curious account how, in the course of sixty-five generations, the number of yellow cocoons in one breed has been reduced in France from one hundred to thirty-five in the thousand. According to Robinet, the white race, called Sina, by careful selection during the last seventy-five years, “est arrivée à un tel état de pureté, qu’on ne voit pas un seul cocon jaune dans des millions de cocons blancs.”[75] Cocoons are sometimes formed, as is well known, entirely destitute of silk, which yet produce moths; unfortunately Mrs. Whitby was prevented by an accident from ascertaining whether this character would prove hereditary.

Adult stage.—I can find no account of any constant difference in the moths of the most distinct races. Mrs. Whitby assured me that there was none in the several kinds bred by her; and I have received a similar statement from the eminent naturalist, M. de Quatrefages. Captain Hutton also says[76] that the moths of all kinds vary much in colour, but in nearly the same inconstant manner. Considering how much the cocoons in the several races differ, this fact is of interest, and may probably be accounted for on the same principle as the fluctuating variability of colour in the caterpillar, namely, that there has been no motive for selecting and perpetuating any particular variation.

The males of the wild Bombycidæ “fly swiftly in the day-time and evening, but the females are usually very sluggish and inactive.”[77] In several moths of this family the females have abortive wings, but no instance is known of the males being incapable of flight, for in this case the species could hardly have been perpetuated. In the silk-moth both sexes have imperfect, crumpled wings, and are incapable of flight; but still there is a trace of the characteristic difference in the two sexes; for though, on comparing a number of males and females, I could detect no difference in the development of their wings, yet I was assured by Mrs. Whitby that the males of the moths bred by her used their wings more than the females, and could flutter downwards, though never upwards. She also states that, when the females first emerge from the cocoon, their wings are less expanded than those of the male. The degree of imperfection, however, in the wings varies much in different races and under different circumstances. M. Quatrefages[78] says that he has seen a number of moths with their wings reduced to a third, fourth, or tenth part of their normal dimensions, and even to mere short straight stumps: “il me semble qu’il y a là un véritable arrêt de développement partiel.” On the other hand, he describes the female moths of the André Jean breed as having “leurs ailes larges et étalées. Un seul présente quelques courbures irrégulières et des plis anormaux.” As moths and butterflies of all kinds reared from wild caterpillars under confinement often have crippled wings, the same cause, whatever it may be, has probably acted on silk-moths, but the disuse of their wings during so many generations has, it may be suspected, likewise come into play.

The moths of many breeds fail to glue their eggs to the surface on which they are laid,[79] but this proceeds, according to Capt. Hutton,[80] merely from the glands of the ovipositor being weakened.

As with other long-domesticated animals, the instincts of the silk-moth have suffered. The caterpillars, when placed on a mulberry-tree, often commit the strange mistake of devouring the base of the leaf on which they are feeding, and consequently fall down;

but they are capable, according to M. Robinet,[81] of again crawling up the trunk. Even this capacity sometimes fails, for M. Martins[82] placed some caterpillars on a tree, and those which fell were not able to remount and perished of hunger; they were even incapable of passing from leaf to leaf.

Some of the modifications which the silk-moth has undergone stand in correlation with one another. Thus, the eggs of the moths which produce white cocoons and of those which produce yellow cocoons differ slightly in tint. The abdominal feet, also, of the caterpillars which yield white cocoons are always white, whilst those which give yellow cocoons are invariably yellow.[83] We have seen that the caterpillars with dark tiger-like stripes produce moths which are more darkly shaded than other moths. It seems well established[84] that in France the caterpillars of the races which produce white silk, and certain black caterpillars, have resisted, better than other races, the disease which has recently devastated the silk-districts. Lastly, the races differ constitutionally, for some do not succeed so well under a temperate climate as others; and a damp soil does not equally injure all the races.[85]

From these various facts we learn that silk-moths, like the higher animals, vary greatly under long-continued domestication. We learn also the more important fact that variations may occur at various periods of life, and be inherited at a corresponding period. And finally we see that insects are amenable to the great principle of Selection.

REFERENCES

[1] 'Poultry Chronicle,' 1854, vol. ii. p. 91 and vol. i. p. 330.

[2] Dr. Turral, 'Bull. Soc. d'Acclimat.,' tom. vii., 1860, p. 541.

[3] Willughby's 'Ornithology,' by Ray, p. 381. This breed is also figured by Albin in 1734 in his 'Nat. Hist. of Birds,' vol. ii. p. 86.

[4] F. Cuvier, in 'Annales du Muséum,' tom. ix. p. 128, says that moulting and incubation alone stops these ducks laying. Mr. B. P. Brent makes a similar remark in the 'Poultry Chronicle,' 1855, vol. iii. p. 512.

[5] Rev. E. S. Dixon, 'Ornamental and Domestic Poultry' (1848), p. 117. Mr. B. P. Brent, in 'Poultry Chronicle,' vol. iii., 1855, p. 512.

[6] Crawfurd on the 'Relation of Domesticated Animals to Civilisation,' read before the Brit. Assoc. at Oxford, 1860.

[7] Dureau de La Malle, in 'Annales des Sciences Nat.,' tom. xvii. p. 164; and tom. xxi. p. 55. Rev. E. S. Dixon, 'Ornamental Poultry,' p. 118. Tame ducks were not known in Aristotle's time, as remarked by Volz, in his 'Beiträge zur Kulturgeschichte,' 1852, s. 78.

[8] I quote this account from 'Die Enten-und Schwanenzucht,' Ulm 1828, s. 143. *See* Audubon's 'Ornithological Biography,' vol. iii. p. 168, on the

taming of ducks on the Mississippi. For the same fact in England, *see* Mr. Waterton in Loudon's 'Mag. of Nat. Hist.,' vol. viii. 1835, p. 542; and Mr. St. John, 'Wild Sports and Nat. Hist. of the Highlands,' 1846, p. 129.

[9] Mr. E. Hewitt, in 'Journal of Horticulture,' 1862, p. 773; and 1863, p. 39.

[10] I have met with several statements on the fertility of the several breeds when crossed. Mr. Yarrell assured me that Call and common ducks are perfectly fertile together. I crossed Hook-billed and common ducks, and a Penguin and Labrador, and the crossed Ducks were quite fertile, though they were not bred *inter se,* so that the experiment was not fully tried. Some half-bred Penguins and Labradors were again crossed with Penguins, and subsequently bred by me *inter se,* and they were extremely fertile.

[11] 'Poultry Chronicle,' 1855, vol. iii. p. 512.

[12] 'Journal of the Indian Archipelago,' vol. v. p. 334.

[13] 'The Zoologist,' vols. vii, viii. (1849-1850), p. 2353.

[14] 'Poultry Chronicle,' 1855, vol. iii. p. 512.

[15] 'Poultry Chronicle,' vol. iii. 1855, p. 312. With respect to Rouens *see* ditto vol. i. 1854, p. 167.

[16] Col. Hawker's 'Instructions to young Sportsmen,' quoted by Mr. Dixon in his 'Ornamental Poultry,' p. 125.

[17] 'Cottage Gardener,' April 9th, 1861.

[18] These hybrids have been described by M. Selys-Longchamps in the 'Bulletins (tom. xii. No 10) Acad. Roy. de Bruxelles.'

[19] 'Proc. Zoolog. Soc.,' 1861, p. 261.

[20] 'Ceylon,' by Sir J. E. Tennent, 1859, vol. i. p. 485; also J. Crawfurd on the 'Relation of Domest. Animals to Civilisation,' read before Brit. Assoc. 1860. *See also* 'Ornamental Poultry,' by Rev. E. S. Dixon, 1848, p. 132. The goose figured on the Egyptian monuments seems to have been the Red goose of Egypt.

[21] Macgillivray's 'British Birds,' vol. iv. p. 593.

[22] Mr. A. Strickland ('Annals and Mag. of Nat. Hist.,' 3rd series, vol. iii. 1859, p. 122) reared some young wild geese, and found them in habits and in all characters identical with the domestic goose.

[23] *See also* Hunter's 'Essays,' edited by Owen, vol. ii. p. 322.

[24] Yarrell's 'British Birds,' vol. iii. p. 142.

[25] L. Lloyd, 'Scandinavian Adventures,' 1854, vol. ii. p. 413, says that the wild goose lays from five to eight eggs, which is a much fewer number than that laid by our domestic goose.

[26] The Rev. L. Jenyns (Blomefield) seems first to have made this observation in his 'British Animals.' *See also* Yarrell, and Dixon in his 'Ornamental Poultry' (p. 139), and 'Gardener's Chronicle,' 1857, p. 45.

[27] Mr. Bartlet exhibited the head and neck of a bird thus characterised before the Zoological Soc., Feb. 1860.

[28] W. Thompson, 'Natural Hist. of Ireland,' 1851, vol. iii. p. 31. The Rev. E. S. Dixon gave me some information on the varying colour of the beak and legs.

[29] Mr. A. Strickland, in 'Annals and Mag. of Nat. Hist.,' 3rd series, vol. iii., 1859, p. 122.

[30] 'Poultry Chronicle,' vol. i., 1854, p. 498; vol. iii. p. 210.

[31] 'The Cottage Gardener.' Sept. 4th, 1860, p. 348.

[32] 'L'Hist. de la Nature des Oiseaux,' par P. Belon, 1555, p. 156. With respect to the livers of white geese being preferred by the Romans *see* Isid. Geoffroy St.-Hilaire 'Hist. Nat. Gén.,' tom. iii. p. 58.

[33] Mr. Sclater on the black-shouldered peacock of Latham, 'Proc. Zoolog. Soc.,' April 24th, 1860. Mr. Swinhoe at one time believed, ('Ibis,' July, 1868) that this kind of peafowl was found wild in Cochin China, but he has since informed me that he feels very doubtful on this head.

[34] 'Proc. Zoolog. Soc.,' April 14th, 1835.

[35] 'The Field,' May 6th, 1871. I am much indebted to Mr. Canning for information with respect to his birds.

[36] 'Proc. Zoolog. Soc.,' April 8th, 1856, p. 61. Prof. Baird believes (as quoted in Tegetmeier's 'Poultry Book,' 1866, p. 269) that our turkeys are descended from a West Indian species now extinct. But besides the improbability of a bird having long ago become extinct in these large and luxuriant islands, it appears (as we shall presently see) that the turkey degenerates in India, and this fact indicates that it was not aboriginally an inhabitant of the lowlands of the tropics.

[37] Audubon's 'Ornithological Biography,' vol. i., 1831, pp. 4-13; and 'Naturalist's Library,' vol. xiv., Birds, p. 138.

[38] F. Michaux, 'Travels in N. America,' 1802, Eng. translat., p. 217.

[39] 'Ornamental Poetry,' by the Rev. E. S. Dixon, 1848, p. 34.

[40] Bechstein, ‘Naturgesch. Deutschlands,’ B. iii., 1793, s. 309.

[41] Mr. Bartlett in ‘Land and Water,’ Oct. 31st, 1868, p. 233; and Mr. Tegetmeier in the ‘Field,’ July 17th, 1869, p. 46.

[42] ‘Gardener’s Chronicle,’ 1852, p. 699.

[43] E. Blyth, in ‘Annals and Mag. of Nat. Hist.,’ 1847, vol. xx. p. 391.

[44] Roulin makes this remark in ‘Mém. de divers Savans, l’Acad. des Sciences,’ tom. vi., 1835, p. 349. Mr. Hill, of Spanish Town, in a letter to me, describes five varieties of the Guinea fowl in Jamaica. I have seen singular pale-coloured varieties imported from Barbadoes and Demerara.

[45] For St. Domingo, *see* M. A. Salle, in ‘Proc. Zoolog. Soc.’ 1857, p. 236. Mr. Hill remarks to me, in his letter, on the colour of the legs of the feral birds in Jamaica.

[46] Mr. B. P. Brent, ‘The Canary, British Finches,’ etc., pp. 21, 30.

[47] ‘Cottage Gardener,’ Dec. 11th, 1855, p. 184: an account is here given of all the varieties. For many measurements of the wild birds, *see* Mr. E. Vernon Harcourt, ibid., Dec. 25th, 1855, p. 223.

[48] Bechstein, ‘Naturgesch. der Stubenvögel,’ 1840, s. 243; *see* s. 252 on the inherited song of Canary-birds. With respect to their baldness *see also* W. Kidd’s ‘Treatise on Song-Birds.’

[49] W. Kidd’s ‘Treatise on Song-Birds,’ p. 18.

[50] The ‘Indian Field,’ 1858, p. 255.

[51] Yarrell’s ‘British Fishes,’ vol. i. p. 319.

[52] Mr. Blyth in the ‘Indian Field,’ 1858, p. 255.

[53] W. F. Mayers, ‘Chinese Notes and Queries,’ Aug. 1868, p. 123.

[54] ‘Proc. Zoolog. Soc.’ May 25, 1842.)

[55] Yarrell’s ‘British Fishes,’ vol. i. p. 319.

[56] ‘Dict. Class. d’Hist. Nat.,’ tom. v. p. 276.

[57] ‘Observations in Nat. Hist.,’ 1846, p. 211. Dr. Gray has described, in ‘Annals and Mag. of Nat. Hist.,’ 1860, p. 151 a nearly similar variety but destitute of a dorsal fin.

[58] ‘De l’Espèce,’ 1859, p. 459. With respect to the bees of Burgundy *see* M. Gerard, art. ‘Espèce,’ in ‘Dict. Univers. d’Hist. Nat.’

[59] *See* a discussion on this subject, in answer to a question of mine, in 'Journal of Horticulture,' 1862, pp. 225-242; also Mr. Bevan Fox, in ditto, 1862, p. 284.

[60] This excellent observer may be implicitly trusted; *see* 'Journal of Horticulture,' July 14th, 1863, p. 39.

[61] 'Journal of Horticulture,' Sept. 9th, 1862, p. 463; *see also* Herr Kleine on same subject (Nov. 11th, p. 643, who sums up, that, though there is some variability in colour, no constant or perceptible differences can be detected in the bees of Germany.

[62] Mr. Woodbury has published several such accounts in 'Journal of Horticulture,' 1861 and 1862.

[63] 'Annals and Mag. of Nat. Hist.,' 3rd series, vol. xi. p. 339.

[64] 'The Cottage Gardener,' May 1860, p. 110; and ditto in 'Journal of Hort.,' 1862, p. 242.

[65] 'Transact. Entomolog. Soc.' 3rd series, vol. iii. pp. 143-173 and pp. 295-331.

[66] Godron, 'De l'Espèce,' 1859, tom. i. p. 460. The antiquity of the silkworm in China is given on the authority of Stanislas Julien.

[67] *See* the remarks of Prof. Westwood, Gen. Hearsey and others at the meeting of the Entomolog. Soc. of London, July, 1861.

[68] *See* for instance M. A. de Quatrefages' 'Études sur les Maladies actuelles du Ver à Soie,' 1859, p. 101.

[69] My authorities for the statements will be given in the chapter on Selection.

[70] 'Manuel de l'Éducateur de Vers à Soie,' 1848.

[71] Robinet, ibid., pp. 12, 318. I may add that the eggs of N. American silkworms taken to the Sandwich Islands produced moths at very irregular periods; and the moths thus raised yielded eggs which were even worse in this respect. Some were hatched in ten days, and others not until after the lapse of many months. No doubt a regular early character would ultimately have been acquired. *See* review in 'Athenæum,' 1844, p. 329, of J. Jarves' 'Scenes in the Sandwich Islands.'

[72] 'The Art of rearing Silk-worms,' translated from Count Dandolo, 1825, p. 23.

[73] 'Transact. Ent. Soc.,' ut supra, pp. 153, 308.

[74] Robinet, ibid., p. 317.

[75] Robinet, ibid., pp. 306-317.

[76] ‘Transact. Ent. Soc.,’ ut supra, p. 317.

[77] Stephen’s Illustrations, ‘Haustellata,’ vol. ii. p. 35. *See also* Capt. Hutton, ‘Transact. Ent. Soc.,’ ibid., p. 152.

[78] ‘Études sur les Maladies du Ver à Soie,’ 1859, pp. 304, 209.

[79] Quatrefages, ‘Études,’ etc., p. 214.

[80] ‘Transact. Ent. Soc.,’ ut supra, p. 151.

[81] ‘Manuel de l’Educateur,’ etc., p. 26.

[82] Godron, ‘De l’Espèce,’ p. 462.

[83] Quatrefages, ‘Études,’ etc., pp. 12, 209, 214.

[84] Robinet, ‘Manuel,’ etc., p. 303.

[85] Robinet, ibid., p. 15.

CHAPTER IX.
CULTIVATED PLANTS: CEREAL AND CULINARY PLANTS.

PRELIMINARY REMARKS ON THE NUMBER AND PARENTAGE OF CULTIVATED PLANTS—FIRST STEPS IN CULTIVATION—GEOGRAPHICAL DISTRIBUTION OF CULTIVATED PLANTS.

CEREALIA. DOUBTS ON THE NUMBER OF SPECIES—**WHEAT:** VARIETIES OF—INDIVIDUAL VARIABILITY—CHANGED HABITS—SELECTION—ANCIENT HISTORY OF THE VARIETIES—**MAIZE:** GREAT VARIATION OF—DIRECT ACTION OF CLIMATE ON.

CULINARY PLANTS.—**CABBAGES:** VARIETIES OF, IN FOLIAGE AND STEMS, BUT NOT IN OTHER PARTS—PARENTAGE OF—OTHER SPECIES OF BRASSICA—**PEAS:** AMOUNT OF DIFFERENCE IN THE SEVERAL KINDS, CHIEFLY IN THE PODS AND SEED—SOME VARIETIES CONSTANT, SOME HIGHLY

VARIABLE—DO NOT INTERCROSS—**BEANS**—**POTATOES:** NUMEROUS VARIETIES OF—DIFFERING LITTLE EXCEPT IN THE TUBERS—CHARACTERS INHERITED.

I shall not enter into so much detail on the variability of cultivated plants, as in the case of domesticated animals. The subject is involved in much difficulty. Botanists have generally neglected cultivated varieties, as beneath their notice. In several cases the wild prototype is unknown or doubtfully known; and in other cases it is hardly possible to distinguish between escaped seedlings and truly wild plants, so that there is no safe standard of comparison by which to judge of any supposed amount of change. Not a few botanists believe that several of our anciently cultivated plants have become so profoundly modified that it is not possible now to recognise their aboriginal parent-forms. Equally perplexing are the doubts whether some of them are descended from one species, or from several inextricably commingled by crossing and variation. Variations often pass into, and cannot be distinguished from, monstrosities; and monstrosities are of little significance for our purpose. Many varieties are propagated solely by grafts, buds, layers, bulbs, etc., and frequently it is not known how far their peculiarities can be transmitted by seminal generation. Nevertheless, some facts of value can be gleaned: and other facts will hereafter be incidentally given. One chief object in the two following chapters is to show how many characters in our cultivated plants have become variable.

Before entering on details a few general remarks on the origin of cultivated plants may be introduced. M. Alph. De Candolle[1] in an admirable discussion on this subject, in which he displays a wonderful amount of knowledge, gives a list of 157 of the most useful cultivated plants. Of these he believes that 85 are almost certainly known in their wild state; but on this head other competent judges[2] entertain great doubts. Of 40 of them, the origin is admitted by M. De Candolle to be doubtful, either from a certain amount of dissimilarity which they present when compared with their nearest allies in a wild state, or from the probability of the latter not being truly wild plants, but seedlings escaped from culture. Of the entire 157, 32 alone are ranked by M. De Candolle as quite unknown in their aboriginal condition. But it should be observed that he does not include in his list several plants which present ill-defined characters, namely, the various forms of pumpkins, millet, sorghum, kidney-bean, dolichos, capsicum, and indigo. Nor does he include flowers; and several of the more anciently cultivated flowers, such as certain roses, the common Imperial lily, the tuberose, and even the lilac, are said[3] not to be known in the wild state.

From the relative numbers above given, and from other arguments of much weight, M. De Candolle concludes that plants have rarely been so much modified by culture that they cannot be identified with their wild prototypes. But on this view, considering that savages probably would not have chosen rare plants for cultivation, that useful plants are generally conspicuous, and that they could not have been the inhabitants of deserts or of remote and recently discovered islands, it appears strange to me that so many of our cultivated plants should be still unknown or only doubtfully known in the wild state. If, on the other hand, many of these plants have been profoundly modified by culture, the difficulty disappears. The difficulty would also be removed if they have been exterminated during the progress of civilisation; but M. De Candolle has shown that this probably has seldom occurred. As soon as a plant was cultivated in any country, the half-civilised inhabitants would no longer have need to search the whole surface of the land for it, and thus lead to its extirpation; and even if this did occur during a famine, dormant seeds would be left in the ground. In tropical countries the wild luxuriance of nature, as was long ago remarked by Humboldt, overpowers the feeble efforts of man. In anciently civilised temperate countries, where the whole face of the land has been greatly changed, it can hardly be doubted that some plants have become extinct; nevertheless De Candolle has shown that all the plants historically known to have been first cultivated in Europe still exist here in the wild state.

MM. Loiseleur-Deslongchamps[4] and De Candolle have remarked that our cultivated plants, more especially the cereals, must originally have existed in nearly their present state; for otherwise they would not have been noticed and valued as objects of food. But these authors apparently have not considered the many accounts given by travellers of the wretched food collected by savages. I have read an account of the savages of Australia cooking, during a dearth, many vegetables in various ways, in the hopes of rendering them innocuous and more nutritious. Dr. Hooker found the half-starved inhabitants of a village in Sikhim suffering greatly from having eaten arum-roots,[5] which they had pounded and left for several days to ferment, so as partially to destroy their poisonous nature; and he adds that they cooked and ate many other deleterious plants. Sir Andrew Smith informs me that in South Africa a large number of fruits and succulent leaves, and especially roots, are used in times of scarcity. The natives, indeed, know the properties of a long catalogue of plants, some having been found during famines to be eatable, others injurious to health, or even destructive to life. He met a party of Baquanas who, having been expelled by the conquering Zulus, had lived for years on any roots or leaves which afforded some little nutriment and distended their stomachs, so as to relieve the pangs of hunger. They looked like walking skeletons, and suffered fearfully from constipation. Sir Andrew Smith also informs me that on such occasions the natives observe as a guide for themselves, what the wild animals, especially baboons and monkeys, eat.

From innumerable experiments made through dire necessity by the savages of every land, with the results handed down by tradition, the nutritious, stimulating, and medicinal properties of the most unpromising plants were probably first discovered. It appears, for instance, at first an inexplicable fact that untutored man, in three distant quarters of the world, should have discovered, amongst a host of native plants, that the leaves of the tea-plant and mattee, and the berries of the coffee, all included a stimulating and nutritious essence, now known to be chemically the same. We can also see that savages suffering from severe constipation would naturally observe whether any of the roots which they devoured acted as aperients. We probably owe our knowledge of the uses of almost all plants to man having originally existed in a barbarous state, and having been often compelled by severe want to try as food almost everything which he could chew and swallow.

From what we know of the habits of savages in many quarters of the world, there is no reason to suppose that our cereal plants originally existed in their present state so valuable to man. Let us look to one continent alone, namely, Africa: Barth[6] states that the slaves over a large part of the central region regularly collect the seeds of a wild grass, the *Pennisetum distichum*; in another district he saw women collecting the seeds of a Poa by swinging a sort of basket through the rich meadow-land. Near Tete, Livingstone observed the natives collecting the seeds of a wild grass, and farther south, as Andersson informs me, the natives largely use the seed of a grass of about the size of canary-seed, which they boil in water. They eat also the roots of certain reeds, and every one has read of the Bushmen prowling about and digging up with a fire-hardened stake various roots. Similar facts with respect to the collection of seeds of wild grasses in other parts of the world could be given.[7]

Accustomed as we are to our excellent vegetables and luscious fruits, we can hardly persuade ourselves that the stringy roots of the wild carrot and parsnip, or the little shoots of the wild asparagus, or crabs, sloes, etc., should ever have been valued; yet, from what we know of the habits of Australian and South African savages, we need feel no doubt on this head. The inhabitants of Switzerland during the Stone-period largely collected wild crabs, sloes, bullaces, hips of roses, elderberries, beechmast, and other wild berries and fruit.[8] Jemmy Button, a Fuegian on board the 'Beagle,' remarked to me that the poor and acid black-currants of Tierra del Fuego were too sweet for his taste.

The savage inhabitants of each land, having found out by many and hard trials what plants were useful, or could be rendered useful by various cooking processes, would after a time take the first step in cultivation by planting them near their usual abodes. Livingstone[9] states that the savage Batokas sometimes left wild fruit-trees standing in their gardens, and occasionally even planted them, "a practice seen nowhere else amongst the natives." But Du Chaillu saw a palm and some other wild fruit-trees which had been planted; and these trees were considered private property. The next step in cultivation, and this would require but little forethought, would be to sow the seeds of useful plants; and as the soil near the hovels of the natives[10] would often be in some degree manured, improved varieties would sooner or later arise. Or a wild and unusually good variety of a native plant might attract the attention of some wise old savage; and he would transplant it, or sow its seed. That superior varieties of wild fruit-trees occasionally are found is certain, as in the case of the American species of hawthorns, plums, cherries, grapes, and hickories, specified by Professor Asa Gray.[11] Downing also refers to certain wild varieties of the hickory, as being "of much larger size and finer flavour than the common species." I have referred to American fruit-trees, because we are not in this case troubled with doubts whether or not the varieties are seedlings which have escaped from cultivation. Transplanting any superior variety, or sowing its seeds, hardly implies more forethought than might be expected at an early and rude period of civilisation. Even the Australian barbarians "have a law that no plant bearing seeds is to be dug up after it has flowered;" and Sir G. Grey[12] never saw this law, evidently framed for the preservation of the plant, violated. We see the same spirit in the superstitious belief of the Fuegians, that killing water-fowl whilst very young will be followed by "much rain, snow, blow much."[13] I may add, as showing forethought in the lowest barbarians, that the Fuegians when they find a stranded whale bury large portions in the sand, and during the often-recurrent famines travel from great distances for the remnants of the half-putrid mass.

It has often been remarked[1] that we do not owe a single useful plant to Australia or the Cape of Good Hope, countries abounding to an unparalleled degree with endemic species,—or to New Zealand, or to America south of the Plata; and, according to some authors, not to America northward of Mexico. I do not believe that any edible or valuable plant, except the canary-grass, has been derived from an oceanic or uninhabited island. If nearly all our useful plants, natives of Europe; Asia, and South America, had originally existed in their present condition, the complete absence of similarly useful plants in the great countries just named would be indeed a surprising fact. But if these plants have been so greatly modified and improved by culture as no longer closely to resemble any natural species, we can understand why the above-named countries have given us no useful plants, for they were either inhabited by men who did not cultivate the ground at all, as in Australia and the Cape of Good Hope, or who cultivated it very imperfectly, as in some parts of America. These countries do yield plants which are useful to savage man; and Dr. Hooker[15] enumerates no less than 107 such species in Australia alone; but these plants have not been improved, and consequently cannot compete with those which have been cultivated and improved during thousands of years in the civilised world.

The case of New Zealand, to which fine island we as yet owe no widely cultivated plant, may seem opposed to this view; for, when first discovered, the natives cultivated several plants; but all inquirers believe, in accordance with the traditions of the natives, that the early Polynesian colonists brought with them seeds and roots, as well as the dog, which had been wisely preserved during their long voyage. The Polynesians are so frequently lost on the ocean that this degree of prudence would occur to any wandering party: hence the early colonists of New Zealand, like the later European colonists, would not have had any strong inducement to cultivate the aboriginal plants. According to De Candolle we owe thirty-three useful plants to Mexico, Peru, and Chile; nor is this surprising when we remember the civilised state of the inhabitants, as shown by the fact of their having practised artificial irrigation and made tunnels through hard rocks without the use of iron or gunpowder, and who, as we shall see in a future chapter, fully recognised, as far as animals were concerned, and therefore probably in the case of plants, the important principle of selection. We owe some plants to Brazil; and the early voyagers, namely, Vespucius and Cabral, describe the country as thickly peopled and cultivated. In North America[16] the natives cultivated maize, pumpkins, gourds, beans, and peas, "all different from ours," and tobacco; and we are hardly justified in assuming that none of our present plants are descended from these North American forms. Had North America been civilised for as long a period, and as thickly peopled, as Asia or Europe, it is probable that the native vines, walnuts, mulberries, crabs, and plums, would have given rise, after a long course of cultivation, to a multitude of varieties, some extremely different from their parent-stocks; and escaped seedlings would have caused in the New, as in the Old World, much perplexity with respect to their specific distinctness and parentage.'[17]

Cerealia.—I will now enter on details. The cereals cultivated in Europe consist of four genera—wheat, rye, barley, and oats. Of wheat the best modern authorities[18] make four or five, or even seven distinct species; of rye, one; of barley, three; and of oats, two, three, or four species. So that altogether our cereals are ranked by different authors under from ten to fifteen distinct species. These have given rise to a multitude of varieties. It is a remarkable fact that botanists are not universally agreed on the aboriginal parent-form of any one cereal plant. For instance, a high authority writes in 1855,[19] "We ourselves have no hesitation in stating our conviction, as the result of all the most reliable evidence, that none of these Cerealia exist, or have existed, truly wild in their present state, but that all are cultivated varieties of species now growing in great abundance in S. Europe or W. Asia." On the other hand, Alph. De Candolle[20] has adduced abundant evidence that common wheat (*Triticum vulgare*) has been found wild in various parts of Asia, where it is not likely to have escaped from cultivation: and there is some force in M. Godron's remark, that, supposing these plants to be escaped seedlings,[21] as they have propagated themselves in a wild state for several generations, their continued resemblance to cultivated wheat renders it probable that the latter has retained its aboriginal character. But the strong tendency to inheritance, which most of the varieties of wheat evince, as we shall presently see, is here greatly undervalued. Much weight must also be attributed to a remark by Professor Hildebrand[22] that when the seeds or fruit of cultivated plants possess qualities disadvantageous to them as a means of distribution, we may feel almost sure that they no longer retain their aboriginal condition. On the other hand, M. De Candolle insists strongly on the frequent occurrence in the Austrian dominions of rye and of one kind of oats in an apparently wild condition. With the exception of these two cases, which however are rather doubtful, and with the exception of two forms of wheat and one of barley, which he believes to have been found truly wild, M. De Candolle does not seem fully satisfied with the other reported discoveries of the parent-forms of our other cereals. With respect to oats, according to Mr. Buckmann,[23] the wild English *Avena fatua* can be converted by a few years of careful cultivation and selection into forms almost identical with two very distinct cultivated races. The whole subject of the origin and specific distinctness of the various cereal plants is a most difficult one; but we shall perhaps be able to judge a little better after considering the amount of variation which wheat has undergone.

Metzger describes seven species of wheat, Godron refers to five, and De Candolle to only four. It is not improbable that, besides the kinds known in Europe, other strongly characterised forms exist in the more distant parts of the world; for Loiseleur-Deslongchamps[24] speaks of three new species or varieties, sent to Europe in 1822 from Chinese Mongolia, which he considers as being there indigenous. Moorcroft[25] also speaks of Hasora wheat in Ladakh as very peculiar. If those botanists are right who believe that at least seven species of wheat originally existed, then the amount of variation in any important character which wheat has undergone under cultivation has been slight; but if only four or a lesser number of species originally existed, then it is evident that varieties have arisen so strongly marked, that they have been considered by capable judges as specifically distinct. But the impossibility of deciding which forms ought to be ranked as species and which as varieties, makes it useless to specify in detail the differences between the various kinds of wheat. Speaking generally, the organs of vegetation differ little;[26] but some kinds grow close and upright, whilst others spread and trail along the ground. The straw differs in being more or less hollow, and in quality. The ears[27] differ in colour and in shape, being quadrangular, compressed, or nearly cylindrical; and the florets differ in their approximation to each other, in their pubescence, and in being more or less elongated. The presence or absence of barbs is a conspicuous difference, and in certain Gramineæ serves even as a generic character;[28] although, as remarked by Godron,[29] the presence of barbs is variable in certain wild grasses, and especially in those such as *Bromus secalinus* and *Lolium temulentum*, which habitually grow mingled with our cereal crops, and which have thus unintentionally been exposed to culture. The grains differ in size, weight, and colour; in being more or less downy at one end, in being smooth or wrinkled, in being either nearly globular, oval, or elongated; and finally in internal texture, being tender or hard, or even almost horny, and in the proportion of gluten which they contain.

Nearly all the races or species of wheat vary, as Godron[30] has remarked, in an exactly parallel manner,—in the seed being downy or glabrous, and in colour,—and in the florets being barbed or not barbed, etc. Those who believe that all the kinds are descended from a single wild species may account for this parallel variation by the inheritance of a similar constitution, and a consequent tendency to vary in the same manner; and those who believe in the general theory of descent with modification may extend this view to the several species of wheat, if such ever existed in a state of nature.

Although few of the varieties of wheat present any conspicuous difference, their number is great. Dalbret cultivated during thirty years from 150 to 160 kinds, and excepting in the quality of the grain they all kept true; Colonel Le Couteur possessed upwards of 150, and Philippar 322 varieties.[31] As wheat is an annual, we thus see how strictly many trifling differences in character are inherited through many generations. Colonel Le Couteur insists strongly on this same fact. In his persevering and successful attempts to raise new varieties, he found that there was only one "secure mode to ensure the growth of pure sorts, namely, to grow them from single grains or from single ears, and to follow up the plan by afterwards sowing only the produce of the most productive so as to form a stock." But Major Hallett[32] has gone much farther, and by the continued selection of plants from the grains of the same ear, during successive generations, has made his 'Pedigree in Wheat' (and other cereals) now famous in many quarters of the world. The great amount of variability in the plants of the same variety is another interesting point, which would never have been detected except by an eye long practised to the work; thus Colonel Le Couteur relates[33] that in a field of his own wheat, which he considered at least as pure as that of any of his neighbours, Professor La Gasca found twenty-three sorts; and Professor Henslow has observed similar facts. Besides such individual variations, forms sufficiently well marked to be valued and to become widely cultivated sometimes suddenly appear: thus Mr. Shirreff has had the good fortune to raise in his lifetime seven new varieties, which are now extensively grown in many parts of Britain.[34]

As in the case of many other plants, some varieties, both old and new, are far more constant in character than others. Colonel Le Couteur was forced to reject some of his new sub-varieties, which he suspected had been produced from a cross, as incorrigibly sportive. On the other hand Major Hallett[35] has shown how wonderfully constant some varieties are, although not ancient ones, and although cultivated in various countries. With respect to the tendency to vary, Metzger[36] gives from his own experience some interesting facts: he describes three Spanish sub-varieties, more especially one known to be constant in Spain, which in Germany assumed their proper character only during hot summers; another variety kept true only in good land, but after having been cultivated for twenty-five years became more constant. He mentions two other sub-varieties which were at first inconstant, but subsequently became, apparently without any selection, accustomed to their new homes, and retained their proper character. These facts show what small changes in the conditions of life cause variability, and they further show that a variety may become habituated to new conditions. One is at first inclined to conclude with Loiseleur-Deslongchamps, that wheat cultivated in the same country is exposed to remarkably uniform conditions; but manures differ, seed is taken from one soil to another, and, what is far more important, the plants are exposed as little as possible to struggle with other plants, and are thus enabled to exist under diversified conditions. In a state of nature each plant is confined to that particular station and kind of nutriment which it can seize from the other plants by which it is surrounded.

Wheat quickly assumes new habits of life. The summer and winter kinds were classed by Linnæus as distinct species; but M. Monnier[37] has proved that the difference between them is only temporary. He sowed winter-wheat in spring, and out of one hundred plants four alone produced ripe seeds; these were sown and resown, and in three years plants were reared which ripened all their seed. Conversely, nearly all the plants raised from summer-wheat, which was sown in autumn, perished from frost; but a few were saved and produced seed, and in three years this summer-variety was converted into a winter-variety. Hence it is not surprising that wheat soon becomes to a certain extent acclimatised, and that seed brought from distant countries and sown in Europe vegetates at first, or even for a considerable period,[38] differently from our European varieties. In Canada the first settlers, according to Kalm,[39] found their winters too severe for winter-wheat brought from France, and their summers often too short for summer-wheat; and they thought that their country was useless for corn crops until they procured summer-wheat from the northern parts of Europe, which succeeded well. It is notorious that the proportion of gluten differs much under different climates. The weight of the grain is also quickly affected by climate: Loiseleur-Deslongchamps[40] sowed near Paris 54 varieties, obtained from the South of France and from the Black Sea, and 52 of these yielded seed from 10 to 40 per cent heavier than the parent-seed. He then sent these heavier grains back to the South of France, but there they immediately yielded lighter seed.

All those who have closely attended to the subject insist on the close adaptation of numerous varieties of wheat to various soils and climates even within the same country; thus Colonel Le Couteur[41] says, “It is the suitableness of each sort to each soil that will enable the farmer to pay his rent by sowing one variety, where he would be unable to do so by attempting to grow another of a seemingly better sort.” This may be in part due to each kind becoming habituated to its conditions of life, as Metzger has shown certainly occurs, but it is probably in main part due to innate differences between the several varieties.

Much has been written on the deterioration of wheat; that the quality of the flour, size of grain, time of flowering, and hardness, may be modified by climate and soil, seems nearly certain; but that the whole body of any one sub-variety ever becomes changed into another and distinct sub-variety, there is no reason to believe. What apparently does take place, according to Le Couteur,[42] is, that some one sub-variety out of the many which may always be detected in the same field is more prolific than the others, and gradually supplants the variety which was first sown.

With respect to the natural crossing of distinct varieties the evidence is conflicting, but preponderates against its frequent occurrence. Many authors maintain that impregnation takes place in the closed flower, but I am sure from my own observation that this is not the case, at least with those varieties to which I have attended. But as I shall have to discuss this subject in another work, it may be here passed over.

In conclusion, all authors admit that numerous varieties of wheat have arisen; but their differences are unimportant, unless, indeed, some of the so-called species are ranked as varieties. Those who believe that from four to seven wild species of Triticum originally existed in nearly the same condition as at present, rest their belief chiefly on the great antiquity of the several forms.[43] It is an important fact, which we have recently learnt from the admirable researches of Heer,[44] that the inhabitants of Switzerland, even so early as the Neolithic period, cultivated no less than ten cereal plants, namely, five kinds of wheat, of which at least four are commonly looked at as distinct species, three kinds of barley, a panicum, and a setaria. If it could be shown that at the earliest dawn of agriculture five kinds of wheat and three of barley had been cultivated, we should of course be compelled to look at these forms as distinct species. But, as Heer has remarked, agriculture even at the Neolithic period, had already made considerable progress; for, besides the cereals, peas, poppies, flax, and apparently apples, were cultivated. It may also be inferred, from one variety of wheat being the so called Egyptian, and from what is known of the native country of the panicum and setaria, as well as from the nature of the weeds which then grew mingled with the crops, that the lake-inhabitants either still kept up commercial intercourse with some southern people or had originally proceeded as colonists from the South.

Loiseleur-Deslongchamps[45] has argued that, if our cereal plants have been greatly modified by cultivation, the weeds which habitually grow mingled with them would have been equally modified. But this argument shows how completely the principle of selection has been overlooked. That such weeds have not varied, or at least do not vary now in any extreme degree, is the opinion of Mr. H. C. Watson and Professor Asa Gray, as they inform me; but who will pretend to say that they do not vary as much as the individual plants of the same sub-variety of wheat? We have already seen that pure varieties of wheat, cultivated in the same field, offer many slight variations, which can be selected and separately propagated; and that occasionally more strongly pronounced variations appear, which, as Mr. Shirreff has proved, are well worthy of extensive cultivation. Not until equal attention be paid to the variability and selection of weeds, can the argument from their constancy under unintentional culture be of any value. In accordance with the principles of selection we can understand how it is that in the several cultivated varieties of wheat the organs of vegetation differ so little; for if a plant with peculiar leaves appeared, it would be neglected unless the grains of corn were at the same time superior in quality or size. the selection of seed-corn was strongly recommended[46] in ancient times by Columella and Celsus; and as Virgil says,—

> “I’ve seen the largest seeds, tho’ view’d with care,
> Degenerate, unless th’ industrious hand
> Did yearly cull the largest.”

But whether in ancient times selection was methodically pursued we may well doubt, when we hear how laborious the work has been found by Le Coutour and Hallett. Although the principle of selection is so important, yet the little which man has effected, by incessant efforts[47] during thousands of years, in rendering the plants more productive or the grains more nutritious than they were in the time of the old Egyptians, would seem to speak strongly against its efficacy. But we must not forget that at each successive period the state of agriculture and the quantity of manure supplied to the land will have determined the maximum degree of productiveness; for it would be impossible to cultivate a highly productive variety, unless the land contained a sufficient supply of the necessary chemical elements.

We now know that man was sufficiently civilised to cultivate the ground at an immensely remote period; so that wheat might have been improved long ago up to that standard of excellence which was possible under the then existing state of agriculture. One small class of facts supports this view of the slow and gradual improvement of our cereals. In the most ancient lake-habitations of Switzerland, when men employed only flint-tools, the most extensively cultivated wheat was a peculiar kind, with remarkably small ears and grains.[48] "Whilst the grains of the modern forms are in section from seven to eight millimetres in length, the larger grains from the lake-habitations are six, seldom seven, and the smaller ones only four. The ear is thus much narrower, and the spikelets stand out more horizontally, than in our present forms." So again with barley, the most ancient and most extensively cultivated kind had small ears, and the grains were "smaller, shorter, and nearer to each other, than in that now grown; without the husk they were 2½ lines long, and scarcely 1½ broad, whilst those now grown have a length of three lines, and almost the same in breadth."[49] These small-grained varieties of wheat and barley are believed by Heer to be the parent-forms of certain existing allied varieties, which have supplanted their early progenitors.

Heer gives an interesting account of the first appearance and final disappearance of the several plants which were cultivated in greater or less abundance in Switzerland during former successive periods, and which generally differed more or less from our existing varieties. The peculiar small-eared and small-grained wheat, already alluded to, was the commonest kind during the Stone period; it lasted down to the Helvetico-Roman age, and then became extinct. A second kind was rare at first, but afterwards became more frequent. A third, the Egyptian wheat (*T. turgidum*), does not agree exactly with any existing variety, and was rare during the Stone period. A fourth kind (*T. dicoccum*) differs from all known varieties of this form. A fifth kind (*T. monococcum*) is known to have existed during the Stone period only by the presence of a single ear. A sixth kind, the common *T. spelta,* was not introduced into Switzerland until the Bronze age. Of barley, besides the short-eared and small-grained kind, two others were cultivated, one of which was very scarce, and resembled our present common *H. distichum.* During the Bronze age rye and oats were introduced; the oat-grains being somewhat smaller than those produced by our existing varieties. The poppy was largely cultivated during the Stone period, probably for its oil; but the variety which then existed is not now known. A peculiar pea with small seeds lasted from the Stone to the Bronze age, and then became extinct; whilst a peculiar bean, likewise having small seeds, came in at the Bronze period and lasted to the time of the Romans. These details sound like the descriptions given by palæontologists of the first appearance, the increasing rarity, and final extinction or modification of fossil species, embedded in the successive stages of a geological formation.

Finally, every one must judge for himself whether it is more probable that the several forms of wheat, barley, rye, and oats are descended from between ten and fifteen species, most of which are now either unknown or extinct, or whether they are descended from between four and eight species, which may have either closely resembled our present cultivated forms, or have been so widely different as to escape identification. In this latter case we must conclude that man cultivated the cereals at an enormously remote period, and that he formerly practised some degree of selection, which in itself is not improbable. We may, perhaps, further believe that, when wheat was first cultivated the ears and grains increased quickly in size, in the same manner as the roots of the wild carrot and parsnip are known to increase quickly in bulk under cultivation.

Maize or Indian Corn: Zea mays.—Botanists are nearly unanimous that all the cultivated kinds belong to the same species. It is undoubtedly[50] of American origin, and was grown by the aborigines throughout the continent from New England to Chili. Its cultivation must have been extremely ancient, for Tschudi[51] describes two kinds, now extinct or not known in Peru, which were taken from tombs apparently prior to the dynasty of the Incas. 'But there is even stronger evidence of antiquity, for I found on the coast of Peru[52] heads of maize, together with eighteen species of recent sea-shell, embedded in a beach which had been upraised at least 85 feet above the level of the sea. In accordance with this ancient cultivation, numerous American varieties have arisen. The aboriginal form has not as yet been discovered in the wild state. A peculiar kind,[53] in which the grains, instead of being naked, are concealed by husks as much as eleven lines in length, has been stated, but on insufficient evidence, to grow wild in Brazil. It is almost certain that the aboriginal form would have had its grains thus protected;[54] but the seeds of the Brazilian variety produce, as I hear from Professor Asa Gray, and as is stated in two published accounts, either common or husked maize; and it is not credible that a wild species, when first cultivated, should vary so quickly and in so great a degree.

Maize has varied in an extraordinary and conspicuous manner. Metzger,[55] who paid particular attention to the cultivation of this plant, makes twelve races (unter-art) with numerous sub-varieties: of the latter some are tolerably constant, others quite inconstant. The different races vary in height from 15-18 feet to only 16-18 inches, as in a dwarf variety described by Bonafous. The whole ear is variable in shape, being long and narrow, or short and thick, or branched. The ear in one variety is more than four times as long as in a dwarf kind. The seeds are arranged in the ear in from six to even twenty rows, or are placed irregularly. The seeds are coloured—white, pale-yellow, orange, red, violet, or elegantly streaked with black;[56] and in the same ear there are sometimes seeds of two colours. In a small collection I found that a single grain of one variety nearly equalled in weight seven grains of another variety. The shape of the seed varies greatly, being very flat, or nearly globular, or oval; broader than long, or longer than broad; without any point, or produced into a sharp tooth, and this tooth is sometimes recurved. One variety (the rugosa of Bonafous, and which is extensively cultivated in the United States as sweet corn) has its seeds curiously wrinkled, giving to the whole ear a singular appearance. Another variety (the cymosa of Bon.) carries its ears so crowded together that it is called *maïs à bouquet*. The seeds of some varieties contain much glucose instead of starch. Male flowers sometimes appear amongst the female flowers, and Mr. J. Scott has lately observed the rarer case of female flowers on a true male panicle, and likewise hermaphrodite flowers.[57] Azara describes[58] a variety in Paraguay the grains of which are very tender, and he states that several varieties are fitted for being cooked in various ways. The varieties also differ greatly in precocity, and have different powers of resisting dryness and the action of violent wind.[59] Some of the foregoing differences would certainly be considered of specific value with plants in a state of nature.

Le Comte Ré states that the grains of all the varieties which he cultivated ultimately assumed a yellow colour. But Bonafous[60] found that most of those which he sowed for ten consecutive years kept true to their proper tints; and he adds that in the valleys of the Pyrenees and on the plains of Piedmont a white maize has been cultivated for more than a century, and has undergone no change.

The tall kinds grown in southern latitudes, and therefore exposed to great heat, require from six to seven months to ripen their seed; whereas the dwarf kinds, grown in northern and colder climates, require only from three to four months.[61] Peter Kalm,[62] who particularly attended to this plant, says, that in the United States, in proceeding from south to north, the plants steadily diminish in bulk. Seeds brought from lat. 37° in Virginia, and sown in lat. 43°-44° in New England, produce plants which will not ripen their seed, or ripen them with the utmost difficulty. So it is with seed carried from New England to lat. 45°-47° in Canada. By taking great care at first, the southern kinds after some years' culture ripen their seed perfectly in their northern homes, so that this is an analogous case with that of the conversion of summer into winter wheat, and conversely. When tall and dwarf maize are planted together, the dwarf kinds are in full flower before the others have produced a single flower; and in Pennsylvania they ripen their seeds six weeks earlier than the tall maize. Metzger also mentions a European maize which ripens its seed four weeks earlier than another European kind. With these facts, so plainly showing inherited acclimatisation, we may readily believe Kalm, who states that in North America maize and some other plants have gradually been cultivated further and further northward. All writers agree that to keep the varieties of maize pure they must be planted separately so that they shall not cross.

The effects of the climate of Europe on the American varieties is highly remarkable. Metzger obtained seed from various parts of America, and cultivated several kinds in Germany. I will give an abstract of the changes observed[63] in one case, namely, with a tall kind (Breit-korniger mais, *Zea altissima*) brought from the warmer parts of

America. During the first year the plants were twelve feet high, and a few seeds were perfected; the lower seeds in the ear kept true to their proper form, but the upper seeds became slightly changed. In the second generation the plants were from nine to ten feet in height, and ripened their seed better; the depression on the outer side of the seed had almost disappeared, and the original beautiful white colour had become duskier. Some of the seeds had even become yellow, and in their now rounded form they approached common European maize. In the third generation nearly all resemblance to the original and very distinct American parent-form was lost. In the sixth generation this maize perfectly resembled a European variety, described as the second sub-variety of the fifth race. When Metzger published his book, this variety was still cultivated near Heidelberg, and could be distinguished from the common kind only by a somewhat more vigorous growth. Analogous results were obtained by the cultivation of another American race, the "white-tooth corn," in which the tooth nearly disappeared even in the second generation. A third race, the "chicken-corn," did not undergo so great a change, but the seeds became less polished and pellucid. In the above cases the seeds were carried from a warm to a colder climate. But Fritz Müller informs me that a dwarf variety with small rounded seeds (papa-gaien-mais), introduced from Germany into S. Brazil, produces plants as tall, with seeds as flat, as those of the kind commonly cultivated there.

These facts afford the most remarkable instance known to me of the direct and prompt action of climate on a plant. It might have been expected that the tallness of the stem, the period of vegetation, and the ripening of the seed, would have been thus affected; but it is a much more surprising fact that the seeds should have undergone so rapid and great a change. As, however, flowers, with their product the seed, are formed by the metamorphosis of the stem and leaves, any modification in these latter organs would be apt to extend, through correlation, to the organs of fructification.

Cabbage (Brassica oleracea).—Every one knows how greatly the various kinds of cabbage differ in appearance. In the Island of Jersey, from the effects of particular culture and of climate a stalk has grown to the height of sixteen feet, and "had its spring shoots at the top occupied by a magpie's nest:" the woody stems are not unfrequently from ten to twelve feet in height, and are there used as rafters[64] and as walking-sticks. We are thus reminded that in certain countries plants belonging to the generally herbaceous order of the Cruciferæ are developed into trees. Every one can appreciate the difference between green or red cabbages with great single heads; Brussel-sprouts with numerous little heads; broccolis and cauliflowers with the greater number of their flowers in an aborted condition, incapable of producing seed, and borne in a dense corymb instead of an open panicle; savoys with their blistered and wrinkled leaves; and borecoles and kails, which come nearest to the wild parent-form. There are also various frizzled and laciniated kinds, some of such beautiful colours that Vilmorin in his Catalogue of 1851 enumerates ten varieties which are valued solely for ornament. Some kinds are less commonly known, such as the Portuguese Couve Tronchuda, with the ribs of its leaves greatly thickened; and the Kohlrabi or choux-raves, with their stems enlarged into great turnip-like masses above the ground; and the recently formed new race[65] of the choux-raves, already including nine sub-varieties, in which the enlarged part lies beneath the ground like a turnip.

Although we see such great differences in the shape, size, colour, arrangement, and manner of growth of the leaves and stem, and of the flower-stems in the broccoli and cauliflower, it is remarkable that the flowers themselves, the seed-pods and seeds, present extremely slight differences or none at all.[66] I compared the flowers of all the principal kinds; those of the Couve Tronchuda are white and rather smaller than in common cabbages; those of the Portsmouth broccoli have narrower sepals, and smaller, less elongated petals; and in no other cabbage could any difference be detected. With respect to the seed-pods, in the purple Kohlrabi alone, do they differ, being a little longer and narrower than usual. I made a collection of the seeds of twenty-eight different kinds, and most of them were undistinguishable; when there was any difference it was excessively slight; thus, the seeds of various broccolis and cauliflowers, when seen in mass, are a little redder; those of the early green Ulm savoy are rather smaller; and those of the Breda kail slightly larger than usual, but not larger than the seeds of the wild cabbage from the coast of Wales. What a contrast in the amount of difference is presented if, on the one hand, we compare the leaves and stems of the various kinds of cabbage with their flowers, pods, and seeds, and on the other hand the corresponding parts in the varieties of maize and wheat! The explanation is obvious; the seeds alone are valued in our cereals, and their variations have been selected; whereas the seeds, seed-pods, and flowers, have been utterly neglected in the cabbage, whilst many useful variations in their leaves and stems have been noticed and preserved from an extremely remote period, for cabbages were cultivated by the old Celts.[67]

It would be useless to give a classified description[68] of the numerous races, sub-races, and varieties of the cabbage; but it may be mentioned that Dr. Lindley has lately proposed[69] a system founded on the state of development of the terminal and lateral leaf-buds. Thus: I. All the leaf-buds active and open, as in the wild-cabbage, kail, etc. II. All the leaf-buds active, but forming heads, as in Brussel-sprouts, etc. III. Terminal leaf-bud alone active, forming a head as in common cabbages, savoys, etc. IV. Terminal leaf-bud alone active, and open, with most of the flowers abortive and succulent, as in the cauliflower and broccoli. V. All the leaf-buds active and open, with most of the flowers abortive and succulent, as in the sprouting-broccoli. This latter variety is a new one, and bears the same relation to common broccoli, as Brussel-sprouts do to common cabbages; it suddenly appeared in a bed of common broccoli, and was found faithfully to transmit its newly-acquired and remarkable characters.

The principal kinds of cabbage existed at least as early as the sixteenth century,[70] so that numerous modifications of structure have been inherited for a long period. This fact is the more remarkable as great care must be taken to prevent the crossing of the different kinds. To give proof of this: I raised 233 seedlings from cabbages of different kinds, which had purposely been planted near each other, and of the seedlings no less than 155 were plainly deteriorated and mongrelised; nor were the remaining 78 all perfectly true. It may be doubted whether many permanent varieties have been formed by intentional or accidental crosses; for such crossed plants are found to be very inconstant. One kind, however, called "Cottager's Kail," has lately been produced by crossing common kail and Brussel-sprouts, recrossed with purple broccoli,[71] and is said to be true; but plants raised by me were not nearly so constant in character as any common kind of cabbage.

Although most of the kinds keep true if carefully preserved from crossing, yet the seed-beds must be yearly examined, and a few seedlings are generally found false; but even in this case the force of inheritance is shown, for, as Metzger has remarked[72] when speaking of Brussel-sprouts, the variations generally keep to their "unter art," or main race. But in order that any kind may be truly propagated there must be no great change in the conditions of life; thus cabbages will not form heads in hot countries, and the same thing has been observed with an English variety grown during an extremely warm and damp autumn near Paris.[73] Extremely poor soil also affects the characters of certain varieties.

Most authors believe that all the races are descended from the wild cabbage found on the western shores of Europe; but Alph. De Candolle[74] forcibly argues, on historical and other grounds, that it is more probable that two or three closely allied forms, generally ranked as distinct species, still living in the Mediterranean region, are the parents, now all commingled together, of the various cultivated kinds. In the same manner as we have often seen with domesticated animals, the supposed multiple origin of the cabbage throws no light on the characteristic differences between the cultivated forms. If our cabbages are the descendants of three or four distinct species, every trace of any sterility which may originally have existed between them is now lost, for none of the varieties can be kept distinct without scrupulous care to prevent intercrossing.

The other cultivated forms of the genus Brassica are descended, according to the view adopted by Godron and Metzger,[75] from two species, *B. napus* and *rapa*; but according to other botanists from three species; whilst others again strongly suspect that all these forms, both wild and cultivated, ought to be ranked as a single species. *Brassica napus* has given rise to two large groups, namely, Swedish turnips (believed to be of hybrid origin)[76] and Colzas, the seeds of which yield oil. *Brassica rapa* (of Koch) has also given rise to two races, namely, common turnips and the oil-giving rape. The evidence is unusually clear that these latter plants, though so different in external appearance, belong to the same species; for the turnip has been observed by Koch and Godron to lose its thick roots in uncultivated soil; and when rape and turnips are sown together they cross to such a degree that scarcely a single plant comes true.[77] Metzger by culture converted the biennial or winter rape into the annual or summer rape,—varieties which have been thought by some authors to be specifically distinct.[78]

In the production of large, fleshy, turnip-like stems, we have a case of analogous variation in three forms which are generally considered as distinct species. But scarcely any modification seems so easily acquired as a succulent enlargement of the stem or root—that is, a store of nutriment laid up for the plant's own future use. We see this in our radishes, beet, and in the less generally known "turnip-rooted" celery, and in the finocchio, or Italian variety of the common fennel. Mr. Buckman has lately proved by his interesting experiments bow quickly the roots of the wild parsnip can be enlarged, as Vilmorin formerly proved in the case of the carrot.[79]

This latter plant, in its cultivated state, differs in scarcely any character from the wild English carrot, except in general luxuriance and in the size and quality of its roots; but ten varieties, differing in the colour, shape, and quality of the root, are cultivated in England and come true by seed.[80] Hence with the carrot, as in so many other cases, for instance with the numerous varieties and sub-varieties of the radish, that part of the plant which is valued by man, falsely appears alone to have varied. The truth is that variations in this part alone have been selected; and the seedlings inheriting a tendency to vary in the same way, analogous modifications have been again and again selected, until at last a great amount of change has been effected.

With respect to the radish, M. Carrière, by sowing the seed of the wild *Raphanus raphanistrum* in rich soil, and by continued selection during several generations, raised many varieties, closely like the cultivated radish (*R. sativus*) in their roots, as well as the wonderful Chinese variety, *R. caudatus*: (see 'Journal d'Agriculture pratique,' tom. i, 1869, p. 159; also a separate essay 'Origine des Plantes Domestiques,' 1869.) *Raphanus raphanistrum* and *sativus* have often been ranked as distinct species, and owing to differences in their fruit even as distinct genera; but Professor Hoffman ('Bot. Zeitung,' 1872, p. 482) has now shown that these differences, remarkable as they are, graduate away, the fruit of *R. caudatus* being intermediate. By cultivating *R. raphanistrum* during several generations (ibid., 1873, p. 9), Professor Hoffman also obtained plants bearing fruits like those of *R. sativus*.

Pea (Pisum sativum).—Most botanists look at the garden-pea as specifically distinct from the field-pea (*P. arvense*). The latter exists in a wild state in Southern Europe; but the aboriginal parent of the garden-pea has been found by one collector alone, as he states, in the Crimea.[81] Andrew Knight crossed, as I am informed by the Rev. A. Fitch, the field-pea with a well-known garden variety, the Prussian pea, and the cross seems to have been perfectly fertile. Dr. Alefield has recently studied[82] the genus with care, and, after having cultivated about fifty varieties, concludes that certainly they all belong to the same species. It is an interesting fact already alluded to, that, according to O. Heer,[83] the peas found in the lake-habitations of Switzerland of the Stone and Bronze ages, belong to an extinct variety, with exceedingly small seeds, allied to *P. arvense* or the field-pea. The varieties of the common garden-pea are numerous, and differ considerably from one another. For comparison I planted at the same time forty-one, English and French varieties. They differed greatly in height,— namely from between

6 and 12 inches to 8 feet,[84]—in manner of growth, and in period of maturity. Some differ in general aspect even while only two or three inches in height. The stems of the *Prussian* pea are much branched. The tall kinds have larger leaves than the dwarf kinds, but not in strict proportion to their height:—*Hair's Dwarf Monmouth* has very large leaves, and the *Pois nain hatif*, and the moderately tall *Blue Prussian*, have leaves about two-thirds of the size of the tallest kind. In the *Danecroft* the leaflets are rather small and a little pointed; in the *Queen of Dwarfs* rather rounded; and in the *Queen of England* broad and large. In these three peas the slight differences in the shape of the leaves are accompanied by slight differences in colour, in the *Pois géant sans parchemin*, which bears purple flowers, the leaflets in the young plant are edged with red; and in all the peas with purple flowers the stipules are marked with red.

In the different varieties, one, two, or several flowers in a small cluster, are borne on the same peduncle; and this is a difference which is considered of specific value in some of the Leguminosæ. In all the varieties the flowers closely resemble each other except in colour and size. They are generally white, sometimes purple, but the colour is inconstant even in the same variety. In *Warner's Emperor,* which is a tall kind, the flowers are nearly double the size of the *Pois nain hatif*; but *Hair's Dwarf Monmouth*, which has large leaves, likewise has large flowers. The calyx in the *Victoria Marrow* is large, and in *Bishop's Long Pod* the sepals are rather narrow. In no other kind is there any difference in the flower.

The pods and seeds, which with natural species afford such constant characters, differ greatly in the cultivated varieties of the pea; and these are the valuable, and consequently the selected parts. *Sugar peas*, or *P*, are remarkable from their thin pods, which, whilst young, are cooked and eaten whole; and in this group, which, according to Mr. Gordon includes eleven sub-varieties, it is the pod which differs most; thus *Lewis's Negro-podded pea* has a straight, broad, smooth, and dark-purple pod, with the husk not so thin as in the other kinds; the pod of another variety is extremely bowed; that of the *Pois géant* is much pointed at the extremity; and in the variety "à grands cosses" the peas are seen through the husk in so conspicuous a manner that the pod, especially when dry, can hardly at first be recognised as that of a pea.

In the ordinary varieties the pods also differ much in size;—in colour, that of *Woodford's Green Marrow* being bright-green when dry, instead of pale brown, and that of the purple-podded pea being expressed by its name;—in smoothness, that of *Danecroft* being remarkably glossy, whereas that of the *Ne plus ultra* is rugged; in being either nearly cylindrical, or broad and flat;—in being pointed at the end, as in *Thurston's Reliance,* or much truncated, as in the *American Dwarf*. In the *Auvergne pea* the whole end of the pod is bowed upwards. In the *Queen of the Dwarfs* and in *Scimitar peas* the pod is almost elliptic in shape. I here give drawings of the four most distinct pods produced by the plants cultivated by me.

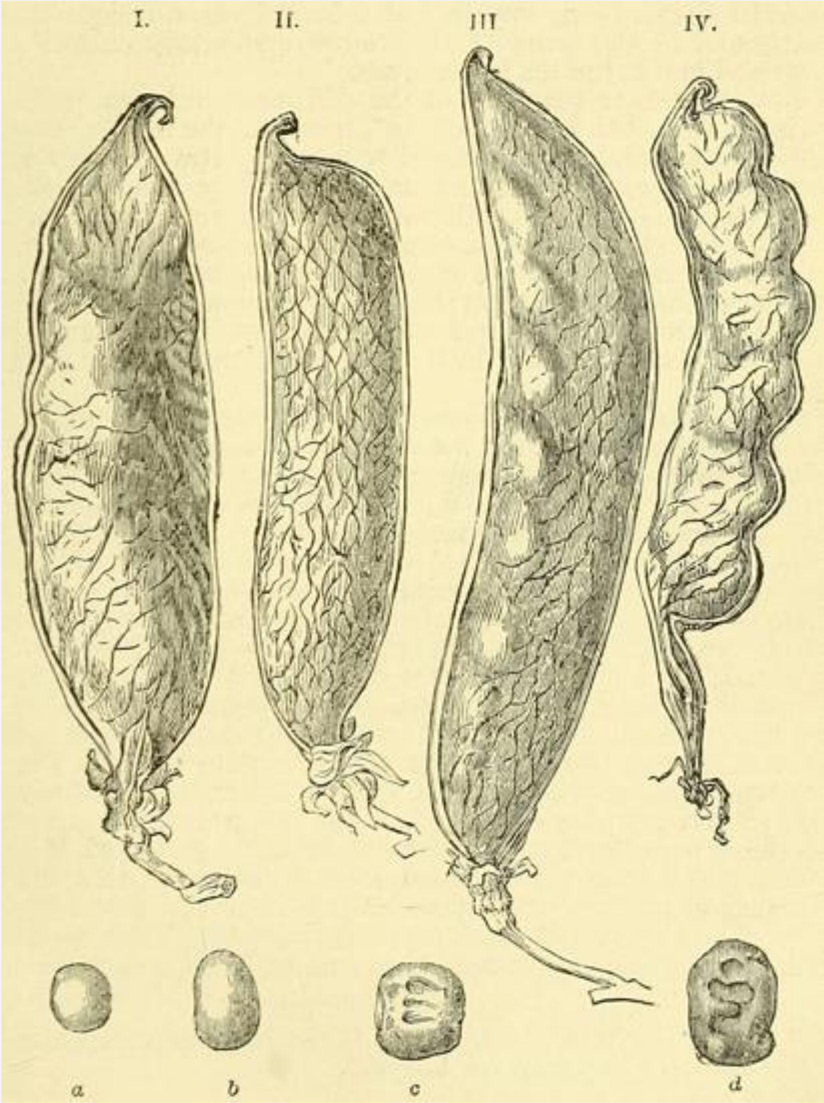


Fig. 41.—Pods of the Common Pea

In the pea itself we have every tint between almost pure white, brown, yellow, and intense green; in the varieties of the *Sugar peas* we have these same tints, together with red passing through fine purple into a dark chocolate tint. These colours are either uniform or distributed in dots, striæ, or moss-like marks; they depend in some cases on the colour of the cotyledons seen through the skin, and in other cases on the outer coats of the pea itself. In the different varieties, the pods contain, according to Mr. Gordon, from eleven or twelve to only four or five peas. The largest peas are nearly twice as much in diameter as the smallest; and the latter are not always borne by the most dwarfed kinds. Peas differ much in shape, being smooth and spherical, smooth and oblong, nearly oval in the *Queen of the Dwarfs*, and nearly cubical and crumpled in many of the larger kinds.

With respect to the value of the differences between the chief varieties, it cannot be doubted that, if one of the tall *Sugar-peas*, with purple flowers, thin-skinned pods of an extraordinary shape, including large, dark-purple peas, grew wild by the side of the lowly *Queen of the Dwarfs,* with white flowers, greyish-green, rounded leaves, scimitar-like pods, containing oblong, smooth, pale-coloured peas, which became mature at a different season: or by the side of one of the gigantic sorts, like the *Champion of England,* with leaves of great size, pointed pods, and large, green, crumpled, almost cubical peas,—all three kinds would be ranked as distinct species.

Andrew Knight[85] has observed that the varieties of peas keep very true, because they are not crossed by insects. As far as the fact of keeping true is concerned, I hear from Mr. Masters of Canterbury, well known as the originator of several new kinds, that certain varieties have remained constant for a considerable time,—for instance, *Knight's Blue Dwarf,* which came out about the year 1820.[86] But the greater number of varieties have a singularly short existence: thus Loudon remarks[87] that "sorts which were highly approved in 1821, are now, in 1833, nowhere to be found;" and on comparing the lists of 1833 with those of 1855, I find that nearly all the varieties have changed. Mr. Masters informs me that the nature of the soil causes some varieties to lose their character. As with other plants, certain varieties can be propagated truly, whilst others show a determined tendency to vary; thus two peas differing in shape, one round and the other wrinkled, were found by Mr. Masters within the same pod, but the plants raised from the wrinkled kind always evinced a strong tendency to produce round peas. Mr. Masters also raised from a plant of another variety four distinct sub-varieties, which bore blue and round, white and round, blue and wrinkled, and white and wrinkled peas; and although he sowed these four varieties separately during several successive years, each kind always reproduced all four kinds mixed together!

With respect to the varieties not naturally intercrossing, I have ascertained that the pea, which in this respect differs from some other Leguminosæ, is perfectly fertile without the aid of insects. Yet I have seen humble-bees whilst sucking the nectar depress the keel-petals, and become so thickly dusted with pollen, that it could hardly fail to be left on the stigma of the next flower which was visited. Nevertheless, distinct varieties growing closely together rarely cross; and I have reason to believe that this is due to their stigmas being prematurely fertilised in this country by pollen from the same flower. The horticulturists who raise seed-peas are thus enabled to plant distinct varieties close together without any bad consequences; and it is certain, as I have myself found, that true seed may be saved during at least several generations under these circumstances.[88] Mr. Fitch raised, as he informs me, one variety for twenty years, and it always came true, though grown close to other varieties. From the analogy of kidney-beans I should have expected[89] that varieties thus circumstanced would have occasionally crossed; and I shall give in the eleventh chapter two cases of this having occurred, as shown (in a manner hereafter to be explained) by the pollen of the one variety having acted directly on the seeds of the other. Whether many of the new varieties which incessantly appear are due to such occasional and accidental crosses, I do not know. Nor do I know whether the short existence of almost all the numerous varieties is the result of mere change of fashion, or of their having a weak constitution, from being the product of long-continued self-fertilisation. It may, however, be noticed that several of Andrew Knight's varieties, which have endured longer than most kinds, were raised towards the close of the last century by artificial crosses; some of them, I believe, were still vigorous in 1860; but now, in 1865, a writer, speaking[90] of Knight's four kinds of marrows, says, they have acquired a famous history, but their glory has departed.

With respect to Beans (*Faba vulgaris*), I will say but little. Dr. Alefield has given[91] short diagnostic characters of forty varieties. Everyone who has seen a collection must have been struck with the great difference in shape, thickness, proportional length and breadth, colour, and size which beans present. What a contrast between a Windsor and Horse-bean! As in the case of the pea, our existing varieties were preceded during the Bronze age in Switzerland[92] by a peculiar and now extinct variety producing very small beans.[93]

Potato (Solanum tuberosum).—There is little doubt about the parentage of this plant; for the cultivated varieties differ extremely little in general appearance from the wild species, which can be recognised in its native land at the first glance.[94] The varieties cultivated in Britain are numerous; thus Lawson[95] gives a description of 175 kinds. I planted eighteen kinds in adjoining rows; their stems and leaves differed but little, and in several cases there was as great a difference between the individuals of the same variety as between the different varieties. The flower varied in size, and in colour between white and purple, but in no other respect, except that in one kind the sepals were somewhat elongated. One strange variety has been described which always produces two sorts of flowers, the first double and sterile, the second single and fertile.[96] The fruit or berries also differ, but only in a slight degree.[97] The varieties are liable in very different degree to the attack of the Colorado potato-beetle.[98]

The tubers, on the other hand, present a wonderful amount of diversity. This fact accords with the principle that the valuable and selected parts of all cultivated productions present the greatest amount of modification. They differ much in size and shape, being globular, oval, flattened, kidney-like, or cylindrical. One variety from Peru is described[99] as being quite straight, and at least six inches in length, though no thicker than a man's finger. The eyes or buds differ in form, position, and colour. The manner in which the tubers are arranged on the so-called roots or rhizomes is different; thus, in the *gurken-kartoffeln* they form a pyramid with the apex downwards, and in another variety they bury themselves deep in the ground. The roots themselves run either near the surface or deep in the ground. The tubers also differ in smoothness and colour, being externally white, red, purple, or almost black, and internally white, yellow, or almost black. They differ in flavour and quality, being either waxy or mealy; in their period of maturity, and in their capacity for long preservation.

As with many other plants which have been long propagated by bulbs, tubers, cuttings, etc., by which means the same individual is exposed during a length of time to diversified conditions, seedling potatoes generally display innumerable slight differences. Several varieties, even when propagated by tubers, are far from constant, as will be seen in the chapter on Bud-variation. Dr. Anderson[100] procured seed from an Irish purple potato, which grew far from any other kind, so that it could not at least in this generation have been crossed, yet the many seedlings varied in almost every possible respect, so that "scarcely two plants were exactly alike." Some of the plants which closely resembled each other above ground, produced extremely dissimilar tubers; and some tubers which externally could hardly be distinguished, differed widely in quality when cooked. Even in this case of extreme variability, the parent-stock had some influence on the progeny, for the greater number of the seedlings resembled in some degree the parent Irish potato. Kidney potatoes must be ranked amongst the most highly cultivated and artificial races; nevertheless their peculiarities can often be strictly propagated by seed. A great authority, Mr. Rivers,[101] states that "seedlings from the ash-leaved kidney always bear a strong resemblance to their parent. Seedlings from the fluke-kidney are still more remarkable for their adherence to their parent stock, for, on closely observing a great number during two seasons, I have not been able to observe the least difference, either in earliness, productiveness, or in the size or shape of their tubers."

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[1] 'Géographie botanique raisonnée,' 1855, pp. 810 to 991.

[2] Review by Mr. Bentham in 'Hort. Journal,' vol. ix 1855, p. 133, entitled, 'Historical Notes on cultivated Plants,' by Dr. A. Targioni-Tozzetti. *See also* 'Edinburgh Review,' 1866, p. 510.

[3] 'Hist. Notes,' as above by Targioni-Tozzetti.

[4] 'Considérations sur les Céréales,' 1842, p. 37. 'Géographie Bot.,' 1855, p. 930. "Plus on suppose l'agriculture ancienne et remontant à une époque d'ignorance, plus il est probable que les cultivateurs avaient choisi des especes offrant à l'origine meme un avantage incontestable."

[5] Dr. Hooker has given me this information. *See also* his 'Himalayan Journals,' 1854, vol. ii. p. 49.

[6] 'Travels in Central Africa,' Eng. translat. vol. i. pp. 529 and 390; vol. ii. pp. 29, 265, 270. Livingstone's 'Travels,' p. 551.

[7] For instance in both North and South America. Mr. Edgeworth ('Journal Proc. Linn. Soc.,' vol. vi. Bot., 1862, p. 181) states that in the deserts of the Punjab poor women sweep up, "by a whisk into straw baskets," the seeds of four genera of grasses, namely, of Agrostis, Panicum, Cenchrus, and

Pennisetum, as well as the seeds of four other genera belonging to distinct families.

[8] Prof. O. Heer, ‘Die Pflanzen der Pfahlbauten, 1866, aus dem Neujahr. Naturforsch. Geselschaft,’ 1866; and Dr. H. Christ in Rutimeyer’s ‘Die Fauna der Pfahlbauten,’ 1861, s. 226.

[9] ‘Travels,’ p. 535. Du Chaillu, ‘Adventures in Equatorial Africa,’ 1861, p. 445.

[10] In Tierra del Fuego the spot where wigwams had formerly stood could be distinguished at a great distance by the bright green tint of the native vegetation.

[11] ‘American Acad. of Arts and Sciences,’ April 10th, 1860, p. 413. Downing, ‘The Fruits of America,’ 1845, p. 261.

[12] ‘Journals of Expeditions in Australia,’ 1841, vol. ii. p. 292.

[13] Darwin’s ‘Journal of Researches,’ 1845, p. 215.

[14] De Candolle has tabulated the facts in the most interesting manner in his ‘Géographie Bot.,’ p. 986.

[15] ‘Flora of Australia,’ Introduction, p. 110.

[16] For Canada, *see* J. Cartier’s Voyage in 1534; for Florida, *see* Narvaez and Ferdinand de Soto’s Voyages. As I have consulted these and other old Voyages in more than one general collection of Voyages, I do not give precise references to the pages. *See also,* for several references Asa Gray, in the ‘American Journal of Science,’ vol. xxiv. Nov. 1857, p. 441. For the traditions of the natives of New Zealand *see* Crawfurd’s ‘Grammar and Dict. of the Malay Language,’ 1852, p. 260.

[17] *See,* for example, Mr. Hewett C. Watson’s remarks on our wild plums and cherries and crabs: ‘Cybele Britannica,’ vol. i. pp. 330, 334, etc. Van Mons (in his ‘Arbres Fruitiers,’ 1835, tom. i. p. 444) declares that he has found the types of all our cultivated varieties in wild seedlings, but then he looks on these seedlings as so many aboriginal stocks.

[18] *See* A. De Candolle, ‘Géograph. Bot.,’ 1855, p. 928 *et seq.* Godron, ‘De l’Espèce,’ 1859, tom. ii. p. 70; and Metzger, ‘Die Getreidearten,’ etc., 1841.

[19] Mr. Bentham, in his review, entitled ‘Hist. Notes on cultivated Plants,’ by Dr. A. Targioni-Tozzetti, in ‘Journal of Hort. Soc.,’ vol. ix., 1855, p. 133. He informs me that he still retains the same opinion.

[20] ‘Géograph. Bot.,’ p. 928. The whole subject is discussed with admirable fulness and knowledge.

[21] Godron, 'De l'Espèce,' tom. ii. p. 72. A few years ago the excellent, though misinterpreted, observations of M. Fabre led many persons to believe that wheat was a modified descendant of Ægilops; but M. Godron (tom. i. p. 165) has shown by careful experiments that the first step in the series, viz. *Ægilops triticoides,* is a hybrid between wheat and *Æ. ovata.* The frequency with which these hybrids spontaneously arise, and the gradual manner in which the *Æ. triticoides* becomes converted into true wheat, alone leave any doubt with respect to M. Godron's conclusions.

[22] 'Die Verbreitungsmittel der Pflanzen,' 1873, p. 129.

[23] Report to British Association for 1857, p. 207.

[24] 'Considérations sur les Céréales,' 1842-43, p. 29.

[25] 'Travels in the Himalayan Provinces,' etc., 1841, vol. i. p. 224.

[26] Col. J. Le Couteur on the 'Varieties of Wheat,' pp. 23, 79.

[27] Loiseleur-Deslongchamps, 'Consid. sur les Céréales,' p. 11.

[28] *See* an excellent review in Hooker's 'Journ. of Botany,' vol. viii. p. 82 note.

[29] 'De l'Espèce,' tom. ii. p. 73.

[30] Ibid., tom. ii. p. 75.

[31] For Dalbret and Philippar, *see* Loiseleur-Deslongchamps 'Consid. sur les Céréales,' pp. 45, 70. Le Couteur on Wheat, pp. 6, 14-17.

[32] *See* his Essay on 'Pedigree in Wheat,' 1862; also paper read before the British Association, 1869, and other publications.

[33] 'Varieties of Wheat,' Introduction, p. 6. Marshall, in his 'Rural Economy of Yorkshire,' vol. ii. p. 9, remarks that "in every field of corn there is as much variety as in a herd of cattle."

[34] 'Gardener's Chron.' and 'Agricult. Gazette,' 1862, p. 963.

[35] 'Gardener's Chron.' Nov. 1868, p. 1199.

[36] 'Getreidearten,' 1841, s. 66, 91, 92, 116, 117.

[37] Quoted by Godron, 'De l'Espèce,' vol. ii. p. 74. So it is, according to Metzger ('Getreidearten,' s. 18), with summer and winter barley.

[38] Loiseleur-Deslongchamps, 'Céréales,' part ii. p. 224. Le Couteur, p. 70. Many other accounts could be added.

[39] 'Travels in North America,' 1753-1761, Eng. translat., vol. iii p. 165.

[40] ‘Céréales,’ part ii. pp. 179-183.

[41] ‘On the Varieties of Wheat,’ Introduct., p. 7. *See* Marshall ‘Rural Econ. of Yorkshire,’ vol. ii. p. 9. With respect to similar cases of adaptation in the varieties of oats, *see* some interesting papers in the ‘Gardener’s Chron. and Agricult. Gazette,’ 1850, pp. 204, 219.

[42] ‘On the Varieties of Wheat,’ p. 59. Mr. Shirreff, and a higher authority cannot be given (‘Gard. Chron. and Agricult. Gazette,’ 1862, p. 963), says, “I have never seen grain which has either been improved or degenerated by cultivation, so as to convey the change to the succeeding crop.”

[43] Alph. De Candolle, ‘Géograph. Bot.,’ p. 930.

[44] ‘Pflanzen der Pfahlbauten,’ 1866.

[45] ‘Les Céréales,’ p. 94.

[46] Quoted by Le Couteur, p. 16.

[47] A. De Candolle, ‘Geograph. Bot.,’ p. 932.

[48] O. Heer ‘Die Pflanzen der Pfahlbauten,’ 1866. The following passage is quoted from Dr. Christ, in ‘Die Fauna der Pfahlbauten, von Dr. Rütimeyer,’ 1861, s. 225.

[49] Heer, as quoted by Carl Vogt, ‘Lectures on Man,’ Eng. translat., p. 355.

[50] *See* Alph. De Candolle’s long discussion in his ‘Géograph. Bot.,’ p. 942. With respect to New England, *see* Silliman’s ‘American Journal,’ vol. xliv. p. 99.

[51] ‘Travels in Peru,’ Eng. translat., p. 177.

[52] ‘Geolog. Observ. on S. America,’ 1846, p. 49.

[53] This maize is figured in Bonafous’ magnificent work, ‘Hist. Nat. du Mais,’ 1836, Pl. v. bis, and in the ‘Journal of Hort. Soc.,’ vol. i. 1846, p. 115, where an account is given of the result of sowing the seed. A young Guarany Indian, on seeing this kind of maize, told Auguste St. Hilaire (*see* De Candolle, ‘Géograph. Bot.,’ p. 951) that it grew wild in the humid forests of his native land. Mr. Teschemacher. in ‘Proc. Boston Soc. Hist.,’ Oct. 19th, 1842, gives an account of sowing the seed.

[54] Moquin-Tandon, ‘Eléments de Tératologie,’ 1841, p. 126.

[55] ‘Die Getreidearten,’ 1841, s. 208. I have modified a few of Metzger’s statements in accordance with those made by Bonafous in his great work ‘Hist. Nat. du Mais,’ 1836.

[56] Godron ‘De l’Espèce,’ tom. ii. p. 80; Al. De Candolle, ibid., p. 951.

[57] ‘Transact. Bot. Soc. of Edinburgh,’ vol. viii. p. 60.

[58] ‘Voyages dans l’Amérique Méridionale,’ tom. i. p. 147.

[59] Bonafous’ ‘Hist. Nat. du Maïs,’ p. 31.

[60] Ibid., p. 31.

[61] Metzger, ‘Getreidearten,’ s. 206.

[62] ‘Description of Maize,’ by P. Kalm, 1752, in ‘Swedish Acts,’ vol. iv. I have consulted an old English MS. translation.

[63] ‘Getreidearten,’ s. 208.

[64] Cabbage Timber, ‘Gardener’s Chron.,’ 1856, p. 744, quoted from Hooker’s ‘Journal of Botany.’ A walking-stick made from a cabbage-stalk is exhibited in the Museum at Kew.

[65] ‘Journal de la Soc. Imp. d’Horticulture,’ 1855, p. 254, quoted from ‘Gartenflora,’ April, 1855.

[66] Godron ‘De l’Espèce,’ tom. ii. p. 52; Metzger, ‘Syst. Beschreibung der Kult. Kohlarten,’ 1833, s. 6.

[67] Regnier, ‘De l’Economie Publique des Celtes,’ 1818, p. 438.

[68] *See* the elder De Candolle, in ‘Transact. of Hort. Soc.,’ vol. v.; and Metzger ‘Kohlarten,’ etc.

[69] ‘Gardener’s Chronicle,’ 1859, p. 992.

[70] Alph. De Candolle, ‘Géograph. Bot.’ pp. 842 and 989.

[71] ‘Gardener’s Chron.,’ Feb. 1858, p. 128.

[72] ‘Kohlarten,’ s. 22.

[73] Godron, ‘De l’Espèce,’ tom. ii. p. 52; Metzger, ‘Kohlarten,’ s. 22.

[74] ‘Géograph. Bot.,’ p. 840.

[75] Godron, ‘De l’Espèce,’ tom. ii. p. 54; Metzger, ‘Kohlarten,’ s. 10.

[76] ‘Gardener’s Chron. and Agricult. Gazette,’ 1856, p. 729. *See,* more especially, ibid., 1868, p. 275: the writer asserts that he planted a variety of cabbage (*B. oleracea*) close to turnips (*B. rapa*) and raised from the crossed seedlings true Swedish turnips. These latter plants ought, therefore, to be classed with cabbages or turnips, and not under *B. napus.*

[77] ‘Gardener’s Chron. and Agricult. Gazette,’ 1855, p. 730.

[78] Metzger, ‘Kohlarten,’ s. 51.

[79] These experiments by Vilmorin have been quoted by many writers. An eminent botanist, Prof. Decaisne, has lately expressed doubts on the subject from his own negative results, but these cannot be valued equally with positive results. On the other hand, M. Carrière has lately stated (‘Gard. Chronicle,’ 1865, p. 1154), that he took seed from a wild carrot, growing far from any cultivated land, and even in the first generation the roots of his seedlings differed in being spindle-shaped, longer, softer, and less fibrous than those of the wild plant. From these seedlings he raised several distinct varieties.

[80] Loudon’s ‘Encyclop. of Gardening,’ p. 835.

[81] Alph. De Candolle ‘Géograph. Bot.,’ 960. Mr. Bentham (‘Hort. Journal,’ vol. ix. 1855, p. 141) believes that garden and field peas belong to the same species, and in this respect he differs from Dr. Targioni.

[82] ‘Botanische Zeitung,’ 1860, s. 204.

[83] ‘Die Pflanzen der Pfahlbauten,’ 1866, s. 23.

[84] A variety called the Rounciva attains this height, as is stated by Mr. Gordon in ‘Transact. Hort. Soc.’ (2nd series), vol. i. 1835, p. 374, from which paper I have taken some facts.

[85] ‘Phil. Tract.,’ 1799, p. 196.

[86] ‘Gardener’s Magazine,’ vol. i., 1826, p. 153.

[87] ‘Encyclopædia of Gardening,’ p. 823.

[88] *See* Dr. Anderson to the same effect in the ‘Bath Soc. Agricultural Papers,’ vol. iv. p. 87.

[89] I have published full details of experiments on this subject in the ‘Gardener’s Chronicle,’ 1857, Oct. 25th.

[90] ‘Gardener’s Chronicle,’ 1865, p. 387.

[91] ‘Bonplandia,’ x., 1862, s. 348.

[92] Heer, ‘Die Pflanzen der Pfahlbauten,’ 1866, s. 22.

[93] Mr. Bentham informs me that in Poitou and the adjoining parts of France, varieties of *Phaseolus vulgaris* are extremely numerous, and so different that they were described by Savi as distinct species. Mr. Bentham believes that all are descended from an unknown eastern species. Although the varieties differ so greatly in stature and in their seeds, “there is a remarkable sameness in the neglected characters of foliage and flowers, and

especially in the bracteoles, an insignificant character in the eyes even of botanists.”

[94] Darwin, ‘Journal of Researches,’ 1845, p. 285. Sabine, in ‘Transact. Hort. Soc.,’ vol. v. p. 249.

[95] ‘Synopsis of the Vegetable Products of Scotland,’ quoted in Wilson’s ‘British Farming,’ p. 317.

[96] Sir G. Mackenzie, in ‘Gardener’s Chronicle,’ 1845, p. 790.

[97] Putsche und Vertuch ‘Versuch einer Monographie der Kartoffeln,’ 1819, s. 9, 15. *See also* Dr. Anderson ‘Recreations in Agriculture,’ vol. iv. p. 325.

[98] Walsh, ‘The American Entomologist,’ 1869, p. 160. Also S. Tenney, ‘The American Naturalist,’ May 1871, p. 171.

[99] ‘Gardener’s Chronicle,’ 1862, p. 1052.

[100] ‘Bath Society Agricult. Papers,’ vol. v. p. 127. And ‘Recreations in Agriculture,’ vol. v. p. 86.

[101] ‘Gardener’s Chronicle,’ 1863, p. 643.

CHAPTER X.
PLANTS *continued*—FRUITS—ORNAMENTAL TREES—FLOWERS.

FRUITS. GRAPES: VARY IN ODD AND TRIFLING PARTICULARS—**MULBERRY:** THE ORANGE GROUP—SINGULAR RESULTS FROM CROSSING— **PEACH AND NECTARINE:** BUD VARIATION—ANALOGOUS VARIATION—RELATION TO THE ALMOND—**APRICOT—PLUMS:** VARIATION IN THEIR STONES— **CHERRIES:** SINGULAR VARIETIES OF—**APPLE—PEAR—STRAWBERRY:** INTERBLENDING OF THE ORIGINAL FORMS—**GOOSEBERRY:** STEADY INCREASE IN SIZE OF THE FRUIT—VARIETIES OF—**WALNUT—NUT—CUCURBITACEOUS PLANTS:** WONDERFUL VARIATION OF.

ORNAMENTAL TREES. THEIR VARIATION IN DEGREE AND KIND—ASH-TREE—SCOTCH-FIR—HAWTHORN.

FLOWERS. MULTIPLE ORIGIN OF MANY KINDS—VARIATION IN CONSTITUTIONAL PECULIARITIES—KIND OF VARIATION—**ROSES:** SEVERAL SPECIES CULTIVATED—**PANSY—DAHLIA—HYACINTH:** HISTORY AND VARIATION OF.

The Vine (Vitis vinifera).—The best authorities consider all our grapes as the descendants of one species which now grows wild in western Asia, which grew wild during the Bronze age in Italy,[1] and which has recently been found fossil in a tufaceous deposit in the south of France.[2] Some authors, however, entertain much doubt about the single parentage of our cultivated varieties, owing to the number of semi-wild forms found in Southern Europe, especially as described by Clemente[3] in a forest in Spain; but as the grape sows itself freely in Southern Europe, and as several of the chief kinds transmit their characters by seed,[4] whilst others are extremely variable, the existence of many different escaped forms could hardly fail to occur in countries where this plant has been cultivated from the remotest antiquity. That the vine varies much when propagated by seed, we may infer from the largely increased number of varieties since the earlier historical records. New hot-house varieties are produced almost every year; for instance,[5] a golden-coloured variety has been recently raised in England from a black grape without the aid of a cross. Van Mons[6] reared a multitude of varieties from the seed of one vine, which was completely separated from all others, so that there could not, at least in this generation, have been any crossing, and the seedlings presented "les analogues de toutes les sortes," and differed in almost every possible character both in the fruits and foliage.

The cultivated varieties are extremely numerous; Count Odart says that he will not deny that there may exist throughout the world 700 or 800, perhaps even 1000 varieties, but not a third of these have any value. In the catalogue of fruit cultivated in the Horticultural Gardens of London, published in 1842, 99 varieties are enumerated. Wherever the grape is grown many varieties occur: Pallas describes 24 in the Crimea, and Burnes mentions 10 in Cabool. The classification of the varieties has much perplexed writers, and Count Odart is reduced to a geographical system; but I will not enter on this subject, nor on the many and great differences between the varieties. I will merely specify a few curious and trifling peculiarities, all taken from Odart's highly esteemed work[7] for the sake of showing the diversified variability of this plant. Simon has classed grapes into two main divisions, those with downy leaves, and those with smooth leaves, but he admits that in one variety, namely the Rebazo, the leaves are either smooth, or downy; and Odart (p. 70) states that some varieties have the nerves alone, and other varieties their young leaves, downy, whilst the old ones are smooth.

The Pedro-Ximenes grape (Odart, p. 397) presents a peculiarity by which it can be at once recognised amongst a host of other varieties, namely, that when the fruit is nearly ripe the nerves of the leaves or even the whole surface becomes yellow. The Barbera d'Asti is well marked by several characters (p. 426), amongst others, "by some of the leaves, and it is always the lowest on the branches, suddenly becoming of a dark red colour." Several authors in classifying grapes have founded their main divisions on the berries being either round or oblong; and Odart admits the value of this character; yet there is one variety, the Maccabeo (p. 71), which often produces small round, and large oblong, berries in the same bunch. Certain grapes called Nebbiolo (p. 429) present a constant character, sufficient for their recognition, namely, "the slight adherence of that part of the pulp which surrounds the seeds to the rest of the berry, when cut through transversely." A Rhenish variety is mentioned (p. 228) which likes a dry soil; the fruit ripens well, but at the moment of maturity, if much rain falls, the berries are apt to rot; on the other hand, the fruit of a Swiss variety (p. 243) is valued for well sustaining prolonged humidity. This latter variety sprouts late in the spring, yet matures its fruit early; other varieties (page 362) have the fault of being too much excited by the April sun, and in consequence suffer from frost. A Styrian variety (p. 254) has brittle foot-stalks, so that the clusters of fruit are often blown off; this variety is said to be particularly attractive to wasps and bees. Other varieties have tough stalks, which resist the wind. Many other variable characters could be given, but the foregoing facts are sufficient to show in how many small structural and constitutional details the vine varies. During the vine disease in France certain old groups of varieties[8] have suffered far more from mildew than others. Thus "the group of Chasselas, so rich in varieties, did not afford a single fortunate exception;" certain other groups suffered much less; the true old Burgundy, for instance, was comparatively free from disease, and the Carminat likewise resisted the attack. The American vines, which belong to a distinct species, entirely escaped the disease in France; and we thus see that those European varieties which best resist the disease must have acquired in a slight degree the same constitutional peculiarities as the American species.

White Mulberry (Morus alba).—I mention this plant because it has varied in certain characters, namely, in the texture and quality of the leaves, fitting them to serve as food for the domesticated silkworm, in a manner not observed with other plants; but this has arisen simply from such variations in the mulberry having been attended to, selected, and rendered more or less constant. M. de Quatrefages[9] briefly describes six kinds cultivated in one valley in France: of these the *amourouso* produces excellent leaves, but is rapidly being abandoned because it produces much fruit mingled with the leaves: the *antofino* yields deeply cut leaves of the finest quality, but not in great quantity: the *claro* is much sought for because the leaves can be easily collected: lastly, the *roso* bears strong hardy leaves, produced in large quantity, but with the one inconvenience, that they are best adapted for the worms after their fourth moult. MM. Jacquemet-Bonnefont, of Lyon, however, remark in their catalogue (1862) that two sub-varieties have been confounded under the name of the roso, one having leaves too thick for the caterpillars, the other being valuable because the leaves can easily be gathered from the branches without the bark being torn.

In India the mulberry has also given rise to many varieties. The Indian form is thought by many botanists to be a distinct species; but as Royle remarks,[10] "so many varieties have been produced by cultivation that it is difficult to ascertain whether they all belong to one species;" they are, as he adds, nearly as numerous as those of the silkworm.

The Orange Group.—We here meet with great confusion in the specific distinction and parentage of the several kinds. Gallesio,[11] who almost devoted his life-time to the subject, considers that there are four species, namely, sweet and bitter oranges, lemons, and citrons, each of which has given rise to whole groups of varieties, monsters, and supposed hybrids. One high authority[12] believes that these four reputed species are all varieties of the wild *Citrus medica,* but that the shaddock (*Citrus decumana*), which is not known in a wild state, is a distinct species; though its distinctness is doubted by another writer "of great authority on such matters," namely, Dr. Buchanan Hamilton. Alph. De Candolle,[13] on the other hand—and there cannot be a more capable judge—advances what he considers sufficient evidence of the orange (he doubts whether the bitter and sweet kinds are specifically distinct), the lemon, and citron, having been found wild, and consequently that they are distinct. He mentions two other forms cultivated in Japan and Java, which he ranks undoubted species; he speaks rather more doubtfully about the shaddock, which varies much, and has not been found wild; and finally he considers some forms, such as Adam's apple and the bergamotte, as probably hybrids.

I have briefly abstracted these opinions for the sake of showing those who have never attended to such subjects, how perplexing they are. It would, therefore, be useless for my purpose to give a sketch of the conspicuous differences between the several forms. Besides the ever-recurrent difficulty of determining whether forms found wild are truly aboriginal or are escaped seedlings, many of the forms, which must be ranked as varieties, transmit their characters almost perfectly by seed. Sweet and bitter oranges differ in no important respect except in the flavour of their fruit, but Gallesio[14] is most emphatic that both kinds can be propagated by seed with absolute certainty. Consequently, in accordance with his simple rule, he classes them as distinct species; as he does sweet and bitter almonds, the peach and nectarine, etc. He admits, however, that the soft-shelled pine-tree produces not only soft-shelled but some hard-shelled seedlings, so that a little greater force in the power of inheritance would, according to this rule, raise a soft-shelled pine-tree into the dignity of an aboriginally created species. The positive assertion made by Macfayden[15] that the pips of sweet oranges produced in Jamaica, according to the nature of the soil in which they are sown, either sweet or bitter oranges, is probably an error; for M. Alph. De Candolle informs me that since the publication of his great work he has received accounts from Guiana, the Antilles, and Mauritius, that in these countries sweet oranges faithfully transmit their character.

Gallesio found that the willow-leafed and the Little China oranges reproduced their proper leaves and fruit; but the seedlings were not quite equal in merit to their parents. The red-fleshed orange, on the other hand, fails to reproduce itself. Gallesio also observed that the seeds of several other singular varieties all reproduced trees having a peculiar physiognomy, partly resembling their parent-forms. I can adduce another case: the myrtle leaved orange is ranked by all authors as a variety, but is very distinct in general aspect: in my father's greenhouse, during many years, it rarely yielded any fruit, but at last produced one; and a tree thus raised was identical with the parent-form.

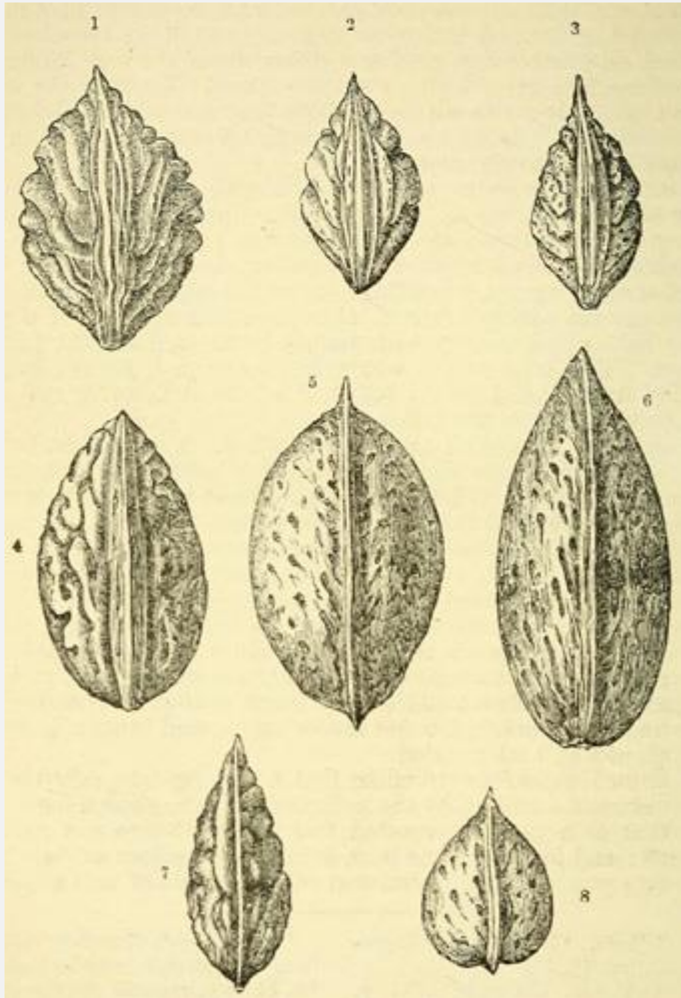
Another and more serious difficulty in determining the rank of the several forms is that, according to Gallesio,[16] they largely intercross without artificial aid; thus he positively states that seeds taken from lemon-trees (*C. lemonum*) growing mingled with the citron (*C. medica*), which is generally considered as a distinct species, produced a graduated series of varieties between these two forms. Again, an Adam's apple was produced from the seed of a sweet orange, which grew close to lemons and citrons. But such facts hardly aid us in determining whether to rank these forms as species or varieties; for it is now known that undoubted species of Verbascum, Cistus, Primula, Salix, etc., frequently cross in a state of nature. If indeed it were proved that plants of the orange tribe raised from these crosses were even partially sterile, it would be a strong argument in favour of their rank as species. Gallesio asserts that this is the case; but he does not distinguish between sterility from hybridism and from the effects of culture; and he almost destroys the force of this statement by another[17] namely, that when he impregnated the flowers of the common orange with the pollen taken from undoubted *varieties* of the orange, monstrous fruits were produced, which included "little pulp, and had no seeds, or imperfect seeds."

In this tribe of plants we meet with instances of two highly remarkable facts in vegetable physiology: Gallesio[18] impregnated an orange with pollen from a lemon, and the fruit borne on the mother tree had a raised stripe of peel like that of a lemon both in colour and taste, but the pulp was like that of an orange and included only imperfect seeds. The possibility of pollen from one variety or species directly affecting the fruit produced by another variety of species, is a subject which I shall fully discuss in the following chapter.

The second remarkable fact is, that two supposed hybrids[19] (for their hybrid nature was not ascertained), between an orange and either a lemon or citron, produced on the same tree leaves, flowers, and fruit of both pure parent-forms, as well as of a mixed or crossed nature. A bud taken from any one of the branches and grafted on another tree produces either one of the pure kinds or a capricious tree reproducing the three kinds. Whether the sweet lemon, which includes within the same fruit segments of differently flavoured pulp,[20] is an analogous case, I know not. But to this subject I shall have to recur.

I will conclude by giving from A. Risso[21] a short account of a very singular variety of the common orange. It is the "*citrus aurantium fructu variabili,*" which on the young shoots produces rounded-oval leaves spotted with yellow, borne on petioles with heart-shaped wings; when these leaves fall off, they are succeeded by longer and narrower leaves, with undulated margins, of a pale-green colour embroidered with yellow, borne on footstalks without wings. The fruit whilst young is pear-shaped, yellow, longitudinally striated, and sweet; but as it ripens, it becomes spherical, of a reddish-yellow, and bitter.

Peach and Nectarine (Amygdalus persica).—The best authorities are nearly unanimous that the peach has never been found wild. It was introduced from Persia into Europe a little before the Christian era, and at this period few varieties existed. Alph. De Candolle,[22] from the fact of the peach not having spread from Persia at an earlier period, and from its not having pure Sanscrit or Hebrew names, believes that it is not an aboriginal of Western Asia, but came from the *terra incognita* of China. The supposition, however, that the peach is a modified almond which acquired its present character at a comparatively late period, would, I presume, account for these facts; on the same principle that the nectarine, the offspring of the peach, has few native names, and became known in Europe at a still later period.



Peach and Almond Stones.

Andrew Knight,[23] from finding that a seedling-tree, raised from a sweet almond fertilised by the pollen of a peach, yielded fruit quite like that of a peach, suspected that the peach-tree is a modified almond; and in this he has been followed by various authors.[24] A first-rate peach, almost globular in shape, formed of soft and sweet pulp, surrounding a hard, much furrowed, and slightly flattened stone, certainly differs greatly from an almond, with its soft, slightly furrowed, much flattened, and elongated stone, protected by a tough, greenish layer of bitter flesh. Mr. Bentham[25] has particularly called attention to the stone of the almond being so much more flattened than that of the peach. But in the several varieties of the almond, the stone differs greatly in the degree to which it is compressed, in size, shape, strength, and in the depth of the furrows, as may be seen in fig. 42 (Nos. 4 to 8) of such kinds as I have been able to collect. With peach-stones also (Nos. 1 to 3) the degree of compression and elongation is seen to vary; so that the stone of the Chinese Honey-peach (No. 3) is much more elongated and compressed than that of the (No. 8) Smyrna almond. Mr. Rivers, of Sawbridgeworth, to whom I am indebted for some of the specimens above figured, and who has had such great horticultural experience, has called my attention to several varieties which connect the almond and the peach. In France there is a variety called the Peach-Almond, which Mr. Rivers formerly cultivated, and which is correctly described in a French catalogue as being oval and swollen, with the aspect of a peach, including a hard stone surrounded by a fleshy covering, which is sometimes eatable.[26] A remarkable statement by M. Luizet has recently appeared in the 'Revue Horticole,'[27] namely, that a Peach-almond, grafted on a peach, bore, during 1863 and 1864 almonds alone, but in 1865 bore six peaches and no almonds. M. Carriere, in commenting on this fact, cites the case of a double-flowered almond which, after producing during several years almonds, suddenly bore for two years in succession spherical fleshy peach-like fruits, but in 1865 reverted to its former state and produced large almonds.

Again, as I hear from Mr. Rivers, the double-flowering Chinese peaches resemble almonds in their manner of growth and in their flowers; the fruit is much elongated and flattened, with the flesh both bitter and sweet, but not uneatable, and it is said to be of better quality in China. From this stage one small step leads us to such inferior peaches as are occasionally raised from seed. For instance, Mr. Rivers sowed a number of peach-stones imported from the United States, where they are collected for raising stocks, and some of the trees raised by him produced peaches which were very like almonds in appearance, being small and hard, with the pulp not softening till very late in the autumn. Van Mons[28] also states that he once raised from a peach-stone a peach having the aspect of a wild tree, with fruit like that of the almond. From inferior peaches, such as these just described, we may pass by small transitions, through clingstones of poor quality, to our best and most melting kinds. From this gradation, from the cases of sudden variation above recorded, and from the fact that the peach has not been found wild, it seems to me by far the most probable view, that the peach is the descendant of the almond, improved and modified in a marvellous manner.

One fact, however, is opposed to this conclusion. A hybrid, raised by Knight from the sweet almond by the pollen of the peach, produced flowers with little or no pollen, yet bore fruit, having been apparently fertilised by a neighbouring nectarine. Another hybrid, from a sweet almond by the pollen of a nectarine, produced during the first three years imperfect blossoms, but afterwards perfect flowers with an abundance of pollen. If this slight degree of sterility cannot be accounted for by the youth of the trees (and this often causes lessened fertility), or by the monstrous state of the flowers, or by the conditions to which the trees were exposed, these two cases would afford a good argument against the peach being the descendant of the almond.

Whether or not the peach has proceeded from the almond, it has certainly given rise to nectarines, or smooth peaches, as they are called by the French. Most of the varieties, both of the peach and nectarine, reproduce themselves truly by seed. Gallesio[29] says he has verified this with respect to eight races of the peach. Mr. Rivers[30] has given some striking instances from his own experience, and it is notorious that good peaches are constantly raised in North America from seed. Many of the American sub-varieties come true or nearly true to their kind, such as the white-blossom, several of the yellow-fruited freestone peaches, the blood clingstone, the heath, and the lemon clingstone. On the other hand, a clingstone peach has been known to give rise to a freestone.[31] In England it has been noticed that seedlings inherit from their parents flowers of the same size and colour. Some characters, however, contrary to what might have been expected, often are not inherited; such as the presence and form of the glands on the leaves.[32] With respect to nectarines, both cling and freestones are known in North America to reproduce themselves by seed.[33] In England the new white nectarine was a seedling of the old white, and Mr. Rivers[34] has recorded several similar cases. From this strong tendency to inheritance, which both peach and nectarine trees exhibit,—from certain slight constitutional differences[35] in their nature,—and from the great difference in their fruit both in appearance and flavour, it is not surprising, notwithstanding that the trees differ in no other respects and cannot even be distinguished, as I am informed by Mr. Rivers, whilst young, that they have been ranked by some authors as specifically distinct. Gallesio does not doubt that they are distinct; even Alph. De Candolle does not appear perfectly assured of their specific identity: and an eminent botanist has quite recently[36] maintained that the nectarine "probably constitutes a distinct species."

Hence it may be worth while to give all the evidence on the origin of the nectarine. The facts in themselves are curious, and will hereafter have to be referred to when the important subject of bud-variation is discussed. It is asserted[37] that the Boston nectarine was produced from a peach-stone, and this nectarine reproduced itself by seed.[38] Mr. Rivers states[39] that from stones of three distinct varieties of the peach he raised three varieties of nectarine; and in one of these cases no nectarine grew near the parent peach-tree. In another instance Mr. Rivers raised a nectarine from a peach, and in the succeeding generation another nectarine from this nectarine.[40] Other such instances have been communicated to me, but they need not be given. Of the converse case, namely, of nectarine-stones yielding peach-trees (both free and clingstones), we have six undoubted instances recorded by Mr. Rivers; and in two of these instances the parent nectarines had been seedlings from other nectarines.[41]

With respect to the more curious case of full-grown peach-trees suddenly producing nectarines by bud-variation (or sports as they are called by gardeners), the evidence is superabundant; there is also good evidence of the same tree producing both peaches and nectarines, or half-and-half fruit; by this term I mean a fruit with the one-half a perfect peach, and the other half a perfect nectarine.

Peter Collinson in 1741 recorded the first case of a peach-tree producing a nectarine,[42] and in 1766 he added two other instances. In the same work, the editor, Sir J. E. Smith, describes the more remarkable case of a tree in Norfolk which usually bore both perfect nectarines and perfect peaches; but during two seasons some of the fruit were half and half in nature.

Mr. Salisbury in 1808[43] records six other cases of peach-trees producing nectarines. Three of the varieties are named; viz., the Alberge, Belle Chevreuse, and Royal George. This latter tree seldom failed to produce both kinds of fruit. He gives another case of a half-and-half fruit.

At Radford in Devonshire[44] a clingstone peach, purchased as the Chancellor, was planted in 1815, and in 1824, after having previously produced peaches alone, bore on one branch twelve nectarines; in 1825 the same branch yielded twenty-six nectarines, and in 1826 thirty-six nectarines, together with eighteen peaches. One of the peaches was almost as smooth on one side as a nectarine. The nectarines were as dark as, but smaller than, the Elruge.

At Beccles a Royal George peach[45] produced a fruit, "three parts of it being peach and one part nectarine, quite distinct in appearance as well as in flavour." The lines of division were longitudinal, as represented in the woodcut. A nectarine-tree grew five yards from this tree.

Professor Chapman states[46] that he has often seen in Virginia very old peach-trees bearing nectarines.

A writer in the 'Gardener's Chronicle' says that a peach tree planted fifteen years previously[47] produced this year a nectarine between two peaches; a nectarine-tree grew close by.

In 1844[48] a Vanguard peach-tree produced, in the midst of its ordinary fruit, a single red Roman nectarine.

Mr. Calver is stated[49] to have raised in the United States a seedling peach which produced a mixed crop of both peaches and nectarines.

Near Dorking[50] a branch of the Téton de Vénus peach, which reproduces itself truly by seed,[51] bore its own fruit "so remarkable for its prominent point, and a nectarine rather smaller but well formed and quite round."

The previous cases all refer to peaches suddenly producing nectarines, but at Carclew[52] the unique case occurred, of a nectarine-tree, raised twenty years before from seed and never grafted, producing a fruit half peach and half nectarine; subsequently bore a perfect peach.

To sum up the foregoing facts; we have excellent evidence of peach-stones producing nectarine-trees, and of nectarine-stones producing peach-Trees,—of the same tree bearing peaches and nectarines,—of peach-trees suddenly producing by bud-variation nectarines (such nectarines reproducing nectarines by seed), as well as fruit in part nectarine and in part peach,—and, lastly, of one nectarine-tree first bearing half-and-half fruit, and subsequently true peaches. As the peach came into existence before the nectarine, it might have been expected from the law of reversion that nectarines would have given birth by bud-variation or by seed to peaches, oftener than peaches to nectarines; but this is by no means the case.

Two explanations have been suggested to account for these conversions. First, that the parent trees have been in every case hybrids[53] between the peach and nectarine, and have reverted by bud-variation or by seed to one of their pure parent forms. This view in itself is not very improbable; for the Mountaineer peach, which was raised by Knight from the red nutmeg-peach by pollen of the violette hâtive nectarine,[54] produces peaches, but these are said *sometimes* to partake of the smoothness and flavour of the nectarine. But let it be observed that in the previous list no less than six well-known varieties and several unnamed varieties of the peach have once suddenly produced perfect nectarines by bud variation: and it would be an extremely rash supposition that all these varieties of the peach, which have been cultivated for years in many districts, and which show not a vestige of a mixed parentage, are, nevertheless, hybrids. A second explanation is, that the fruit of the peach has been directly affected by the pollen of the nectarine: although this certainly is possible, it cannot here apply; for we have not a shadow of evidence that a branch which has borne fruit directly affected by foreign pollen is so profoundly modified as afterwards to produce buds which continue to yield fruit of the new and modified form. Now it is known that when a bud on a peach-tree has once borne a nectarine the same branch has in several instances gone on during successive years producing nectarines. The Carclew nectarine, on the other hand, first produced half-and-half fruit, and subsequently pure peaches. Hence we may confidently accept the common view that the nectarine is a variety of the peach, which may be produced either by bud-variation or from seed. In the following chapter many analogous cases of bud-variation will he given.

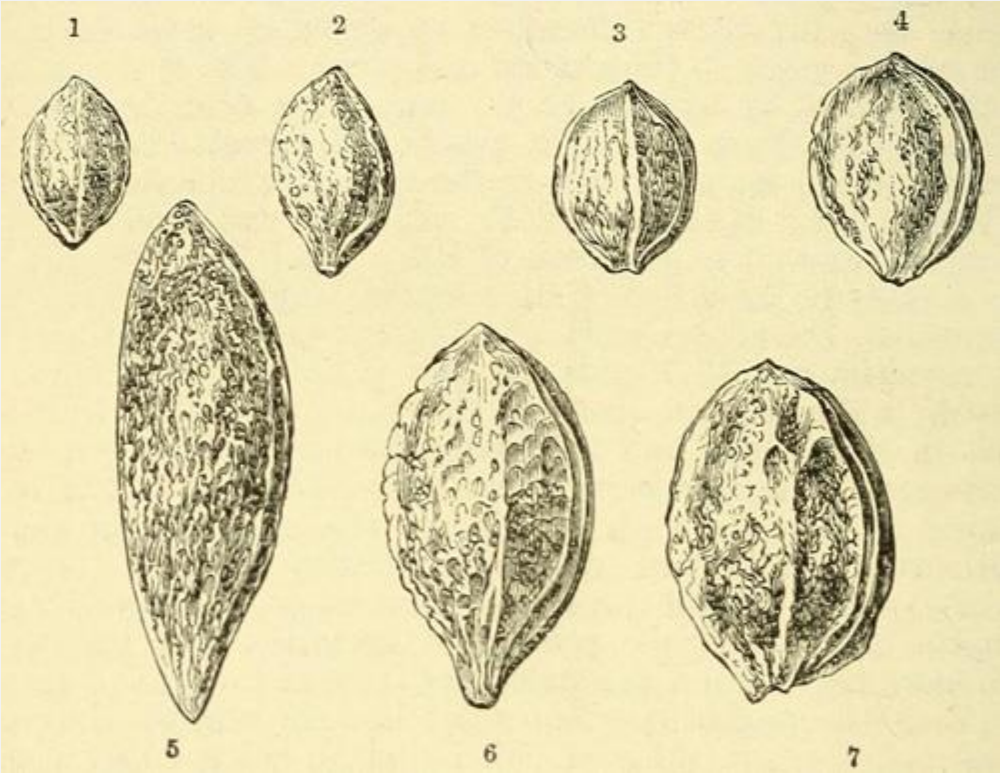
The varieties of the peach and the nectarine run in parallel lines. In both classes the kinds differ from each other in the flesh of the fruit being white, red, or yellow; in being clingstones or freestones; in the flowers being large or small, with certain other characteristic differences; and in the leaves being serrated without glands, or crenated and furnished with globose or reniform glands.[55] We can hardly account for this parallelism by supposing that each variety of the nectarine is descended from a corresponding variety of the peach; for though our nectarines are certainly the descendants of several kinds of peaches, yet a large number are the descendants of other nectarines, and they vary so much when thus reproduced that we can scarcely admit the above explanation.

The varieties of the peach have largely increased in number since the Christian era, when from two to five varieties were known;[56] and the nectarine was unknown. At the present time, besides many varieties said to exist in China, Downing describes, in the United States, seventy-nine native and imported varieties of the peach; and a few years ago Lindley[57] enumerated one hundred and sixty-four varieties of the peach and nectarine grown in England. I have already indicated the chief points of difference between the several varieties. Nectarines, even when produced from distinct kinds of peaches, always possess their own peculiar flavour, and are smooth and small. Clingstone and freestone peaches, which differ in the ripe flesh either firmly adhering to the stone, or easily separating from it, also differ in the character of the stone itself; that of the freestones or melters being more deeply fissured, with the sides of the fissures smoother than in clingstones. In the various kinds the flowers differ not only in size, but in the larger flowers the petals are differently shaped, more imbricated, generally red in the centre and pale towards the margin: whereas in the smaller flowers the margin of the petal is usually more darkly coloured. One variety has nearly white flowers. The leaves are more or less serrated, and are either destitute of glands, or have globose or reniform glands;[58] and some few peaches, such as the Brugnen, bear on the same tree both globular and kidney-shaped glands.[59] According to Robertson[60] the trees with glandular leaves are liable to blister, but not in any great degree to mildew; whilst the non-glandular trees are more subject to curl, to mildew, and to the attacks of aphides. The varieties differ in the period of their maturity, in the fruit keeping well, and in hardiness,—the latter circumstance being especially attended to in the United States. Certain varieties, such as the Bellegarde, stand forcing in hot-houses better than other varieties. The flat-peach of China is the most remarkable of all the varieties; it is so much depressed towards the summit, that the stone is here covered only by roughened skin and not by a fleshy layer.[61] Another Chinese variety, called the Honey-peach, is remarkable from the fruit terminating in a long sharp point; its leaves are glandless and widely dentate.[62] The Emperor of Russia peach is a third singular variety, having deeply double-serrated leaves; the fruit is deeply cleft with one-half projecting considerably beyond the other: it originated in America, and its seedlings inherit similar leaves.[63]

The peach has also produced in China a small class of trees valued for ornament, namely the double-flowered; of these, five varieties are now known in England, varying from pure white, through rose, to intense crimson.[64] One of these varieties, called the camellia-flowered, bears flowers above 2¼ inches in diameter, whilst those of the fruit-bearing kinds do not at most exceed 1¼ inch in diameter. The flowers of the double-flowered peaches have the singular property[65] of frequently producing double or treble fruit. Finally, there is good reason to believe that the peach is an almond profoundly modified; but whatever its origin may have been, there can be no doubt that it has yielded during the last eighteen centuries many varieties, some of them strongly characterised, belonging both to the nectarine and peach form.

Apricot (Prunus armeniaca).—It is commonly admitted that this tree is descended from a single species, now found wild in the Caucasian region.[66] On this view the varieties deserve notice, because they illustrate differences supposed by some botanists to be of specific value in the almond and plum. The best monograph on the apricot is by Mr. Thompson,[67] who describes seventeen varieties. We have seen that peaches and nectarines vary in a strictly parallel manner; and in the apricot, which forms a closely allied genus, we again meet with variations analogous to those of the peach, as well as to those of the plum. The varieties differ considerably in the shape of their leaves, which are either serrated or crenated, sometimes with ear-like appendages at their bases, and sometimes with glands on the petioles. The flowers are generally alike, but are small in the Masculine. The fruit varies much in size, shape, and in having the suture little pronounced or absent; in the skin being smooth, or downy, as in the orange-apricot; and in the flesh clinging to the stone, as in the last-mentioned kind, or in readily separating from it, as in the Turkey-apricot. In all these differences we see the closest analogy with the varieties of the peach and nectarine. In the stone we have more important differences, and these in the case of the plum have been esteemed of specific value: in some apricots the stone is almost spherical, in others much flattened, being either sharp in front or blunt at both ends, sometimes channelled along the back, or with a sharp ridge along both margins. In the Moorpark, and generally in the Hemskirke, the stone presents a singular character in being perforated, with a bundle of fibres passing through the perforation from end to end. The most constant and important character, according to Thompson, is whether the kernel is bitter or sweet: yet in this respect we have a graduated difference, for the kernel is very bitter in Shipley's apricot; in the Hemskirke less bitter than in some other kinds; slightly bitter in the Royal; and "sweet like a hazel-nut" in the Breda, Angoumois, and others. In the case of the almond, bitterness has been thought by some high authorities to indicate specific difference.

In N. America the Roman apricot endures "cold and unfavourable situations, where no other sort, except the Masculine, will succeed; and its blossoms bear quite a severe frost without injury."[68] According to Mr. Rivers,[69] seedling apricots deviate but little from the character of their race: in France the Alberge is constantly reproduced from seed with but little variation. In Ladakh, according to Moorcroft,[70] ten varieties of the apricot, very different from each other, are cultivated, and all are raised from seed, excepting one, which is budded.



Plum Stones.

Plums (Prunus insititia).—Formerly the sloe, *P. spinosa,* was thought to be the parent of all our plums; but now this honour is very commonly accorded to *P. insititia* or the bullace, which is found wild in the Caucasus and N.-Western India, and is naturalised in England.[71] It is not at all improbable, in accordance with some observations made by Mr. Rivers,[72] that both these forms, which some botanists rank as a single species, may be the parents of our domesticated plums. Another supposed parent-form, the *P. domestica,* is said to be found wild in the region of the Caucasus. Godron remarks[73] that the cultivated varieties may be divided into two main groups, which he supposes to be descended from two aboriginal stocks; namely, those with oblong fruit and stones pointed at both ends, having narrow separate petals and upright branches; and those with rounded fruit, with stones blunt at both ends, with rounded petals and spreading branches. From what we know of the variability of the flowers in the peach and of the diversified manner of growth in our various fruit-trees, it is difficult to lay much weight on these latter characters. With respect to the shape of the fruit, we have conclusive evidence that it is extremely variable: Downing[74] gives outlines of the plums of two seedlings, namely, the red and imperial gages, raised from the greengage; and the fruit of both is more elongated than that of the greengage. The latter has a very blunt broad stone, whereas the stone of the imperial gage is "oval and pointed at both ends." These trees also differ in their manner of growth: "the greengage is a very short-jointed, slow-growing tree, of spreading and rather dwarfish habit;" whilst its offspring, the imperial gage, "grows freely and rises rapidly, and has long dark shoots." The famous

Washington plum bears a globular fruit, but its offspring, the emerald drop, is nearly as much elongated as the most elongated plum figured by Downing, namely, Manning's prune. I have made a small collection of the stones of twenty-five kinds, and they graduate in shape from the bluntest into the sharpest kinds. As characters derived from seeds are generally of high systematic importance, I have thought it worth while to give drawings of the most distinct kinds in my small collection; and they may be seen to differ in a surprising manner in size, outline, thickness, prominence of the ridges, and state of surface. It deserves notice that the shape of the stone is not always strictly correlated with that of the fruit: thus the Washington plum is spherical and depressed at the pole, with a somewhat elongated stone, whilst the fruit of the Goliath is more elongated, but the stone less so, than in the Washington. Again, Denyer's Victoria and Goliath bear fruit closely resembling each other, but their stones are widely different. On the other hand, the Harvest and Black Margate plums are very dissimilar, yet include closely similar stones.

The varieties of the plum are numerous, and differ greatly in size, shape, quality, and colour,—being bright yellow, green, almost white, blue, purple, or red. There are some curious varieties, such as the double or Siamese, and the Stoneless plum: in the latter the kernel lies in a roomy cavity surrounded only by the pulp. The climate of North America appears to be singularly favourable for the production of new and good varieties; Downing describes no less than forty, of which seven of first-rate quality have been recently introduced into England.[75] Varieties occasionally arise having an innate adaptation for certain soils, almost as strongly pronounced as with natural species growing on the most distinct geological formations; thus in America the imperial gage, differently from almost all other kinds, "is peculiarly fitted for *dry light* soils where many sorts drop their fruit," whereas on rich heavy soils the fruit is often insipid.[76] My father could never succeed in making the Wine-Sour yield even a moderate crop in a sandy orchard near Shrewsbury, whilst in some parts of the same county and in its native Yorkshire it bears abundantly: one of my relations also repeatedly tried in vain to grow this variety in a sandy district in Staffordshire.

Mr. Rivers has given[77] a number of interesting facts, showing how truly many varieties can be propagated by seed. He sowed the stones of twenty bushels of the greengage for the sake of raising stocks, and closely observed the seedlings; all had the smooth shoots, the prominent buds, and the glossy leaves of the greengage, but the greater number had smaller leaves and thorns. There are two kinds of damson, one the Shropshire with downy shoots, and the other the Kentish with smooth shoots, and these differ but slightly in any other respect: Mr. Rivers sowed some bushels of the Kentish damson, and all the seedlings had smooth shoots, but in some the fruit was oval, in others round or roundish, and in a few the fruit was small, and, except in being sweet, closely resembled that of the wild sloe. Mr. Rivers gives several other striking instances of inheritance: thus, he raised eighty thousand seedlings from the common German Quetsche plum, and "not one could be found varying in the least, in foliage or habit."

Similar facts were observed with the Petite Mirabelle plum, yet this latter kind (as well as the Quetsche) is known to have yielded some well-established varieties; but, as Mr. Rivers remarks, they all belong to the same group with the Mirabelle.

Cherries (Prunus cerasus, avium, etc.).—Botanists believe that our cultivated cherries are descended from one, two, four, or even more wild stocks.[78] That there must be at least two parent species we may infer from the sterility of twenty hybrids raised by Mr. Knight from the morello fertilised by pollen of the Elton cherry; for these hybrids produced in all only five cherries, and one alone of these contained a seed.[79] Mr. Thompson[80] has classified the varieties in an apparently natural method in two main groups by characters taken from the flowers, fruit, and leaves; but some varieties which stand widely separate in this classification are quite fertile when crossed; thus Knight's Early Black cherries are the product of a cross between two such kinds.

Mr. Knight states that seedling cherries are more variable than those of any other fruit-tree.[81] In the Catalogue of the Horticultural Society for 1842 eighty varieties are enumerated. Some varieties present singular characters: thus, the flower of the Cluster cherry includes as many as twelve pistils, of which the majority abort; and they are said generally to produce from two to five or six cherries aggregated together and borne on a single peduncle. In the Ratafia cherry several flower-peduncles arise from a common peduncle, upwards of an inch in length. The fruit of Gascoigne's Heart has its apex produced into a globule or drop; that of the white Hungarian Gean has almost transparent flesh. The Flemish cherry is "a very odd-looking fruit," much flattened at the summit and base, with the latter deeply furrowed, and borne on a stout, very short footstalk. In the Kentish cherry the stone adheres so firmly to the footstalk, that it could be drawn out of the flesh; and this renders the fruit well fitted for drying. The Tobacco-leaved cherry, according to Sageret and Thompson, produces gigantic leaves, more than a foot and sometimes even eighteen inches in length, and half a foot in breadth. The weeping cherry, on the other hand, is valuable only as an ornament, and, according to Downing, is "a charming little tree, with slender, weeping branches, clothed with small, almost myrtle-like foliage." There is also a peach-leaved variety.

Sageret describes a remarkable variety, *le griottier de la Toussaint*, which bears at the same time, even as late as September, flowers and fruit of all degrees of maturity. The fruit, which is of inferior quality, is borne on long, very thin footstalks. But the extraordinary statement is made that all the leaf-bearing shoots spring from old flower-buds. Lastly, there is an important physiological distinction between those kinds of cherries which bear fruit on young or on old wood; but Sageret positively asserts that a Bigarreau in his garden bore fruit on wood of both ages.[82]

Apple (Pyrus malus).—The one source of doubt felt by botanists with respect to the parentage of the apple is whether, besides *P. malus*, two or three other closely allied wild forms, namely, *P. acerba* and *præcox* or *paradisiaca*, do not deserve to be ranked as distinct species. The *P. præcox* is supposed by some authors[83] to be the parent of the dwarf paradise stock, which, owing to the fibrous roots not penetrating deeply into the ground, is so largely used for grafting; but the paradise stocks, it is asserted,[84] cannot be propagated true by seed. The common wild crab varies considerably in England; but many of the varieties are believed to be escaped seedlings.[85] Every one knows the great difference in the manner of growth, in the foliage, flowers, and especially in the fruit, between the almost innumerable varieties of the apple. The pips or seeds (as I know by comparison) likewise differ considerably in shape, size, and colour. The fruit is adapted for eating or for cooking in various ways, and keeps for only a few weeks or for nearly two years. Some few kinds have the fruit covered with a powdery secretion, called bloom, like that on plums; and "it is extremely remarkable that this occurs almost exclusively among varieties cultivated in Russia."[86] Another Russian apple, the white Astracan, possesses the singular property of becoming transparent, when ripe, like some sorts of crabs. The *api étoilé* has five prominent ridges, hence its name; the *api noir* is nearly black: the *twin cluster pippin* often bears fruit joined in pairs.[87] The trees of the several sorts differ greatly in their periods of leafing and flowering; in my orchard the *Court Pendu Plat* produces leaves so late, that during several springs I thought that it was dead. The Tiffin apple scarcely bears a leaf when in full bloom; the Cornish crab, on the other hand, bears so many leaves at this period that the flowers can hardly be seen.[88] In some kinds the fruit ripens in mid-summer; in others, late in the autumn. These several differences in leafing, flowering, and fruiting, are not at all necessarily correlated; for, as Andrew Knight has remarked,[89] no one can judge from the early flowering of a new seedling, or from the early shedding or change of colour of the leaves, whether it will mature its fruit early in the season.

The varieties differ greatly in constitution. It is notorious that our summers are not hot enough for the Newtown Pippin,[90] which is the glory of the orchards near New York; and so it is with several varieties which we have imported from the Continent. On the other hand, our Court of Wick succeeds well under the severe climate of Canada. The *Caville rouge de Micoud* occasionally bears two crops during the same year. The Burr Knot is covered with small excrescences, which emit roots so readily that a branch with blossom-buds may be stuck in the ground, and will root and bear a few fruit even during the first year.[91] Mr. Rivers has recently described[92] some seedlings valuable from their roots running near the surface. One of these seedlings was remarkable from its extremely dwarfed size, "forming itself into a bush only a few inches in height." Many varieties are particularly liable to canker in certain soils. But perhaps the strangest constitutional peculiarity is that the Winter Majetin is not attacked by the mealy bug or coccus; Lindley[93] states that in an orchard in Norfolk infested with these insects the Majetin was quite free, though the stock on which it was grafted was affected: Knight makes a similar statement with respect to a cider apple, and adds that he only once saw these insects just above the stock, but that three days afterwards they entirely disappeared; this apple, however, was raised from a cross between the Golden Harvey and the Siberian Crab; and the latter, I believe, is considered by some authors as specifically distinct.

The famous St. Valery apple must not be passed over; the flower has a double calyx with ten divisions, and fourteen styles surmounted by conspicuous oblique stigmas, but is destitute of stamens or corolla. The fruit is constricted round the middle, and is formed of five seed-cells, surmounted by nine other cells.[94] Not being provided with stamens, the tree requires artificial fertilisation; and the girls of St. Valery annually go to "*faire ses pommes,*" each marking her own fruit with a ribbon; and as different pollen is used the fruit differs, and we here have an instance of the direct action of foreign pollen on the mother plant. These monstrous apples include, as we have seen, fourteen seed-cells; the pigeon-apple,[95] on the other hand, has only four, instead of, as with all common apples, five cells; and this certainly is a remarkable difference.

In the catalogue of apples published in 1842 by the Horticultural Society, 897 varieties are enumerated; but the differences between most of them are of comparatively little interest, as they are not strictly inherited. No one can raise, for instance, from the seed of the Ribston Pippin, a tree of the same kind; and it is said that the "Sister Ribston Pippin" was a white semi-transparent, sour-fleshed apple, or rather large crab.[96] Yet it was a mistake to suppose that with most varieties the characters are not to a certain extent inherited. In two lots of seedlings raised from two well-marked kinds, many worthless crab-like seedlings will appear, but it is now known that the two lots not only usually differ from each other, but resemble to a certain extent their parents. We see this indeed in the several sub-groups of Russetts, Sweetings, Codlins, Pearmains, Reinettes, etc.,[97] which are all believed, and many are known, to be descended from other varieties bearing the same names.

Pears (Pyrus communis).—I need say little on this fruit, which varies much in the wild state, and to an extraordinary degree when cultivated, in its fruit, flowers, and foliage. One of the most celebrated botanists in Europe, M. Decaisne, has carefully studied the many varieties;[98] although he formerly believed that they were derived from more than one species, he now thinks that all belong to one. He has arrived at this conclusion from finding in the several varieties a perfect gradation between the most extreme characters; so perfect is this gradation that he maintains it to be impossible to classify the varieties by any natural method. M. Decaisne raised many seedlings from four distinct kinds, and has carefully recorded the variations in each. Notwithstanding this extreme degree of variability, it is now positively known that many kinds reproduce by seed the leading characters of their race.[99]

Strawberries (Fragaria).—This fruit is remarkable on account of the number of species which have been cultivated, and from their rapid improvement within the last fifty or sixty years. Let any one compare the fruit of one of the largest varieties exhibited at our Shows with that of the wild wood strawberry, or, which will be a fairer comparison, with the somewhat larger fruit of the wild American Virginian Strawberry, and he will see what prodigies horticulture has effected.[100] The number of varieties has likewise increased in a surprisingly rapid manner. Only three kinds were known in France, in 1746, where this fruit was early cultivated. In 1766 five species had been introduced, the same which are now cultivated, but only five varieties of *Fragaria vesca*, with some sub-varieties, had been produced. At the present day the varieties of the several species are almost innumerable. The species consist of, firstly, the wood or Alpine cultivated strawberries, descended from *F. vesca*, a native of Europe and of North America. There are eight wild European varieties, as ranked by Duchesne, of *F. vesca*, but several of these are considered species by some botanists. Secondly, the green strawberries, descended from the European *F. collina*, and little cultivated in England. Thirdly, the Hautbois, from the European *F. elatior*. Fourthly, the Scarlets, descended from *F. virginiana*, a native of the whole breadth of North America. Fifthly, the Chili, descended from *F. chiloensis*, an inhabitant of the west coast of the temperate parts both of North and South America. Lastly, the pines or Carolinas (including the old Blacks), which have been ranked by most authors under the name of *F. grandiflora* as a distinct species, said to inhabit Surinam; but this is a manifest error. This form is considered by the highest authority, M. Gay, to be merely a strongly marked race of *F. chiloensis*.[101] These five or six forms have been ranked by most botanists as specifically distinct; but this may be doubted, for Andrew Knight,[102] who raised no less than 400 crossed strawberries, asserts that the *F. virginiana*, *chiloensis* and *grandiflora* "may be made to breed together indiscriminately," and he found, in accordance with the principle of analogous variation, "that similar varieties could be obtained from the seeds of any one of them."

Since Knight's time there is abundant and additional evidence[103] of the extent to which the American forms spontaneously cross. We owe indeed to such crosses most of our choicest existing varieties. Knight did not succeed in crossing the European wood-strawberry with the American Scarlet or with the Hautbois. Mr. Williams of Pitmaston, however, succeeded; but the hybrid offspring from the Hautbois, though fruiting well, never produced seed, with the exception of a single one, which reproduced the parent hybrid form.[104] Major R. Trevor Clarke informs me that he crossed two members of the Pine class (Myatt's B. Queen and Keen's Seedling) with the wood and hautbois, and that in each case he raised only a single seedling; one of these fruited, but was almost barren. Mr. W. Smith, of York, has raised similar hybrids with equally poor success.[105] We thus see[106] that the European and American species can with some difficulty be crossed; but it is improbable that hybrids sufficiently fertile to be worth cultivation will ever be thus produced. This fact is surprising, as these forms structurally are not widely distinct, and are sometimes connected in the districts where they grow wild, as I hear from Professor Asa Gray, by puzzling intermediate forms.

The energetic culture of the Strawberry is of recent date, and the cultivated varieties can in most cases be classed under some one of the above native stocks. As the American strawberries cross so freely and spontaneously, we can hardly doubt that they will ultimately become inextricably confused. We find, indeed, that horticulturists at present disagree under which class to rank some few of the varieties; and a writer in the 'Bon Jardinier' of 1840 remarks that formerly it was possible to class all of them under some one species, but that now this is quite impossible with the American forms, the new English varieties having completely filled up the gaps between them.[107] The blending together of two or more aboriginal forms, which there is every reason to believe has occurred with some of our anciently cultivated productions, we see now actually occurring with our strawberries.

The cultivated species offer some variations worth notice. The Black Prince, a seedling from Keen's Imperial (this latter being a seedling of a very white strawberry, the white Carolina), is remarkable from "its peculiar dark and polished surface, and from presenting an appearance entirely unlike that of any other kind."[108] Although the fruit in the different varieties differs so greatly in form, size, colour, and quality, the so-called seed (which corresponds with the whole fruit in the plum) with the exception of being more or less deeply embedded in the pulp, is, according to De Jonghe,[109] absolutely the same in all: and this no doubt may be accounted for by the seed being of no value, and consequently not having been subjected to selection. The strawberry is properly three-leaved, but in 1761 Duchesne raised a single-leaved variety of the European wood-strawberry, which Linnæus doubtfully raised to the rank of a species. Seedlings of this variety, like those of most varieties not fixed by long-continued selection, often revert to the ordinary form, or present intermediate states.[110] A variety raised by Mr. Myatt,[111] apparently belonging to one of the American forms presents a variation of an opposite nature, for it has five leaves; Godron and Lambertye also mention a five-leaved variety of *F. collina*.

The Red Bush Alpine strawberry (one of the *F. vesca* section) does not produce stolons or runners, and this remarkable deviation of structure is reproduced truly by seed. Another sub-variety, the White Bush Alpine, is similarly characterised, but when propagated by seed it often degenerates and produces plants with runners.[112] A strawberry of the American Pine section is also said to make but few runners.[113]

Much has been written on the sexes of strawberries; the true Hautbois properly bears the male and female organs on separate plants,[114] and was consequently named by Duchesne *dioica*; but it frequently produces hermaphrodites; and Lindley,[115] by propagating such plants by runners, at the same time destroying the males, soon raised a self-prolific stock. The other species often showed a tendency towards an imperfect separation of the sexes, as I have noticed with plants forced in a hot-house. Several English varieties, which in this country are free from any such tendency, when cultivated in rich soils under the climate of North America[116] commonly produce plants with separate sexes. Thus a whole acre of Keen's Seedlings in the United States has been observed to be almost sterile from the absence of male flowers; but the more general rule is, that the male plants overrun the females. Some members of the Cincinnati Horticultural Society, especially appointed to investigate this subject, report that "few varieties have the flowers perfect in both sexual organs," etc. The most successful cultivators in Ohio plant for every seven rows of "pistillata," or female plants, one row of hermaphrodites, which afford pollen for both kinds; but the hermaphrodites, owing to their expenditure in the production of pollen, bear less fruit than the female plants.

The varieties differ in constitution. Some of our best English kinds, such as Keen's Seedlings, are too tender for certain parts of North America, where other English and many American varieties succeed perfectly. That splendid fruit, the British Queen, can be cultivated but in few places either in England or France: but this apparently depends more on the nature of the soil than on the climate; a famous gardener says that "no mortal could grow the British Queen at Shrubland Park unless the whole nature of the soil was altered."[117] La Constantine is one of the hardiest kinds, and can withstand Russian winters, but it is easily burnt by the sun, so that it will not succeed in certain soils either in England or the United States.[118] The Filbert Pine Strawberry "requires more water than any other variety; and if the plants once suffer from drought, they will do little or no good afterwards."[119] Cuthill's Black Prince Strawberry evinces a singular tendency to mildew; no less than six cases have been recorded of this variety suffering severely, whilst other varieties growing close by, and treated in exactly the same manner, were not at all infested by this fungus.[120] The time of maturity differs much in the different varieties: some belonging to the wood or alpine section produce a succession of crops throughout the summer.

Gooseberry (Ribes grossularia).—No one, I believe, has hitherto doubted that all the cultivated kinds are sprung from the wild plant bearing this name, which is common in Central and Northern Europe; therefore it will be desirable briefly to specify all the points, though not very important, which have varied. If it be admitted that these differences are due to culture, authors perhaps will not be so ready to assume the existence of a large number of unknown wild parent-stocks for our other cultivated plants. The gooseberry is not alluded to by writers of the classical period. Turner mentions it in 1573, and Parkinson specifies eight varieties in 1629; the Catalogue of the Horticultural Society for 1842 gives 149 varieties, and the lists of the Lancashire nurserymen are said to include above 300 names.[121] In the 'Gooseberry Grower's Register' for 1862 I find that 243 distinct varieties have won prizes at various periods, so that a vast number must have been exhibited. No doubt the difference between many of the varieties is very small; but Mr. Thompson in classifying the fruit for the Horticultural Society found less confusion in the nomenclature of the gooseberry than of any other fruit, and he attributes this "to the great interest which the prize-growers have taken in detecting sorts with wrong names," and this shows that all the kinds, numerous as they are, can be recognised with certainty.

The bushes differ in their manner of growth, being erect, or spreading, or pendulous. The periods of leafing and flowering differ both absolutely and relatively to each other; thus the Whitesmith produces early flowers, which from not being protected by the foliage, as it is believed, continually fail to produce fruit.[122] The leaves vary in size, tint, and in depth of lobes; they are smooth, downy, or hairy on the upper surface. The branches are more or less downy or spinose; "the Hedgehog has probably derived its name from the singular bristly condition of its shoots and fruit." The branches of the wild gooseberry, I may remark, are smooth, with the exception of thorns at the bases of the buds. The thorns themselves are either very small, few and single, or very large and triple; they are sometimes reflexed and much dilated at their bases. In the different varieties the fruit varies in abundance, in the period of maturity, in hanging until shrivelled, and greatly in size, "some sorts having their fruit large during a very early period of growth, whilst others are small, until nearly ripe." The fruit varies also much in colour, being red, yellow, green, and white—the pulp of one dark-red gooseberry being tinged with yellow; in flavour; in being smooth or downy,—few, however, of the Red gooseberries, whilst many of the so-called Whites, are downy; or in being so spinose that one kind is called Henderson's Porcupine. Two kinds acquire when mature a powdery bloom on their fruit. The fruit varies in the thickness and veining of the skin, and, lastly, in shape, being spherical, oblong, oval, or obovate.[123]

I cultivated fifty-four varieties, and, considering how greatly the fruit differs, it was curious how closely similar the flowers were in all these kinds. In only a few I detected a trace of difference in the size or colour of the corolla. The calyx differed in a rather greater degree, for in some kinds it was much redder than in others; and in one smooth white gooseberry it was unusually red. The calyx also differed in the basal part being smooth or woolly, or covered with glandular hairs. It deserves notice, as being contrary to what might have been expected from the law of correlation, that a smooth red gooseberry had a remarkably hairy calyx. The flowers of the Sportsman are furnished with very large coloured bracteæ; and this is the most singular deviation of structure which I have observed. These same flowers also varied much in the number of the petals, and occasionally in the number of the stamens and pistils; so that they were semi-monstrous in structure, yet they produced plenty of fruit. Mr. Thompson remarks that in the Pastime gooseberry "extra bracts are often attached to the sides of the fruit."[124]

The most interesting point in the history of the gooseberry is the steady increase in the size of the fruit. Manchester is the metropolis of the fanciers, and prizes from five shillings to five or ten pounds are yearly given for the heaviest fruit. The 'Gooseberry Growers Register' is published annually; the earliest known copy is dated 1786, but it is certain that meetings for the adjudication of prizes were held some years previously.[125] The 'Register' for 1845 gives an account of 171 Gooseberry Shows, held in different places during that year; and this fact shows on how large a scale the culture has been carried on. The fruit of the wild gooseberry is said[126] to weigh about a quarter of an ounce or 5 dwts., that is, 120 grains; about the year 1786 gooseberries were exhibited weighing 10 dwts., so that the weight was then doubled; in 1817 26 dwts. 17 grs. was attained; there was no advance till 1825, when 31 dwts. 16 grs. was reached; in 1830 "Teazer" weighed 32 dwts. 13 grs.; in 1841 "Wonderful" weighed 32 dwts. 16

grs.; in 1844 "London" weighed 35 dwts. 12 grs., and in the following year 36 dwts. 16 grs.; and in 1852 in Staffordshire, the fruit of the same variety reached the astonishing weight of 37 dwts. 7 grs.[127] or 896 grs.; that is, between seven or eight times the weight of the wild fruit. I find that a small apple, 6½ inches in circumference, has exactly this same weight. The "London" gooseberry (which in 1852 had altogether gained 333 prizes) has, up to the present year of 1875, never reached a greater weight than that attained in 1852. Perhaps the fruit of the gooseberry has now reached the greatest possible weight, unless in the course of time some new and distinct variety shall arise.

This gradual, and on the whole steady increase of weight from the latter part of the last century to the year 1852, is probably in large part due to improved methods of cultivation, for extreme care is now taken; the branches and roots are trained, composts are made, the soil is mulched, and only a few berries are left on each bush;[128] but the increase no doubt is in main part due to the continued selection of seedlings which have been found to be more and more capable of yielding such extraordinary fruit. Assuredly the "Highwayman" in 1817 could not have produced fruit like that of the "Roaring Lion" in 1825; nor could the "Roaring Lion," though it was grown by many persons in many places, gain the supreme triumph achieved in 1852 by the "London" Gooseberry.

Walnut (Juglans regia).—This tree and the common nut belong to a widely different order from the foregoing fruits, and are therefore here noticed. The walnut grows wild on the Caucasus and in the Himalaya, where Dr. Hooker[129] found the fruit of full size, but "as hard as a hickory-nut." It has been found fossil, as M. de Saporta informs me, in the tertiary formation, of France.

In England the walnut presents considerable differences, in the shape and size of the fruit, in the thickness of the husk, and in the thinness of the shell; this latter quality has given rise to a variety called the thin-shelled, which is valuable, but suffers from the attacks of tit-mice.[130] The degree to which the kernel fills the shell varies much. In France there is a variety called the Grape or cluster-walnut, in which the nuts grow in "bunches of ten, fifteen, or even twenty together." There is another variety which bears on the same tree differently shaped leaves, like the heterophyllous hornbeam; this tree is also remarkable from having pendulous branches, and bearing elongated, large, thin-shelled nuts.[131] M. Cardan has minutely described[132] some singular physiological peculiarities in the June-leafing variety, which produces its leaves and flowers four or five weeks later than the common varieties; and although in August it is apparently in exactly the same state of forwardness as the other kinds, it retains its leaves and fruit much later in the autumn. These constitutional peculiarities are strictly inherited. Lastly, walnut-trees, which are properly monoicous, sometimes entirely fail to produce male flowers.[133]

Nuts (Corylus avellana).—Most botanists rank all the varieties under the same species, the common wild nut.[134] The husk, or involucre, differs greatly, being extremely short in Barr's Spanish, and extremely long in filberts, in which it is contracted so as to prevent the nut falling out. This kind of husk also protects the nut from birds, for titmice (*Parus*) have been observed [135] to pass over filberts, and attack cobs and common nuts growing in the same orchard. In the purple-filbert the husk is purple, and in the frizzled-filbert it is curiously laciniated; in the red-filbert the pellicle of the kernel is red. The shell is thick in some varieties, but is thin in Cosford's-nut, and in one variety is of a bluish colour. The nut itself differs much in size and shape, being ovate and compressed in filberts, nearly round and of great size in cobs and Spanish nuts, oblong and longitudinally striated in Cosford's, and obtusely four-sided in the Downton Square nut.

Cucurbitaceous plants.—These plants have been for a long period the opprobrium of botanists; numerous varieties have been ranked as species, and, what happens more rarely, forms which now must be considered as species have been classed as varieties. Owing to the admirable experimental researches of a distinguished botanist, M. Naudin,[136] a flood of light has recently been thrown on this group of plants. M. Naudin, during many years, observed and experimented on above 1200 living specimens, collected from all quarters of the world. Six species are now recognised in the genus Cucurbita; but three alone have been cultivated and concern us, namely, *C. maxima* and *pepo*, which include all pumpkins, gourds, squashes, and the vegetable marrow, and *C. moschata*. These three species are not known in a wild state; but Asa Gray[137] gives good reason for believing that some pumpkins are natives of N. America.

These three species are closely allied, and have the same general habit, but their innumerable varieties can always be distinguished, according to Naudin, by certain almost fixed characters; and what is still more important, when crossed they yield no seed, or only sterile seed; whilst the varieties spontaneously intercross with the utmost freedom. Naudin insists strongly (p. 15), that, though these three species have varied greatly in many characters, yet it has been in so closely an analogous manner that the varieties can he arranged in almost parallel series, as we have seen with the forms of wheat, with the two main races of the peach, and in other cases. Though some of the varieties are inconstant in character, yet others, when grown separately under uniform conditions of life, are, as Naudin repeatedly (pp. 6, 16, 35) urges, "douées d'une stabilité presque comparable à celle des espèces les mieux caractérisées." One variety, l'Orangin (pp. 43, 63), has such prepotency in transmitting its character, that when crossed with other varieties a vast majority of the seedlings come true. Naudin, referring (p. 47) to *C. pepo*, says that its races "ne different des espèces veritables qu'en ce qu'elles peuvent s'allier les unes aux autres par voie d'hybridité, sans que leur descendance perde la faculté de se perpétuer." If we were to trust to external differences alone, and give up the test of sterility, a multitude of species would have to be formed out of the varieties of these three species of Cucurbita. Many naturalists at the present day lay far too little stress, in my opinion, on the test of sterility; yet it is not improbable that distinct species of plants after a long course of cultivation and variation may have their mutual sterility eliminated, as we have every reason to believe has occurred with domesticated animals.

Nor, in the case of plants under cultivation, should we be justified in assuming that varieties never acquire a slight degree of mutual sterility, as we shall more fully see in a future chapter when certain facts are given on the high authority of Gärtner and Kölreuter.[138]

The forms of *C. pepo* are classed by Naudin under seven sections, each including subordinate varieties. He considers this plant as probably the most variable in the world. The fruit of one variety (pp. 33, 46) exceeds in value that of another by more than two thousand fold! When the fruit is of very large size, the number produced is few (p. 45); when of small size, many are produced. No less astonishing (p. 33) is the variation in the shape of the fruit, the typical form apparently is egg-like, but this becomes either drawn out into a cylinder, or shortened into a flat disc. We have also an almost infinite diversity in the colour and state of surface of the fruit, in the hardness both of the shell and of the flesh, and in the taste of the flesh, which is either extremely sweet, farinaceous, or slightly bitter. The seeds also differ in a slight degree in shape, and wonderfully in size (p. 34), namely, from six or seven to more than twenty-five millimètres in length.

In the varieties which grow upright or do not run and climb, the tendrils, though useless (p. 31), are either present or are represented by various semi-monstrous organs, or are quite absent. The tendrils are even absent in some running varieties in which the stems are much elongated. It is a singular fact that (p. 31) in all the varieties with dwarfed stems, the leaves closely resemble each other in shape.

Those naturalists who believe in the immutability of species often maintain that, even in the most variable forms, the characters which they consider of specific value are unchangeable. To give an example from a conscientious writer,[139] who, relying on the labours of M. Naudin, and referring to the species of Cucurbita, says, “au milieu de toutes les variations du fruit, les tiges, les feuilles, les calices, les corolles, les étamines restent invariables dans chacune d’elles.” Yet M. Naudin, in describing *Cucurbita pepo* (p. 30), says, “Ici, d’ailleurs, ce ne sont pas seulement les fruits qui varient, c’est aussi le feuillage et tout le port de la plante. Néanmoins, je crois qu’on la distinguera toujours facilement des deux autres espèces, si l’on veut ne pas perdre de vue les caractères différentiels que je m’efforce de faire ressortir. Ces caractères sont quelquefois peu marqués: il arrive meme que plusieurs d’entre eux s’effacent presque entièrement, mais ii en reste toujours quelques-uns qui remettent l’observateur sur la voie.” Now let it be noted what a difference, with regard to the immutability of the so-called specific characters this paragraph produces on the mind, from that above quoted from M. Godron.

I will add another remark: naturalists continually assert that no important organ varies; but in saying this they unconsciously argue in a vicious circle; for if an organ, let it be what it may, is highly variable, it is regarded as unimportant, and under a systematic point of view this is quite correct. But as long as constancy is thus taken as the criterion of importance, it will indeed be long before an important organ can be shown to be inconstant. The enlarged form of the stigmas, and their sessile position on the summit of the ovary, must be considered as important characters, and were used by Gasparini to separate certain pumpkins as a *distinct genus*; but Naudin says (p. 20), these parts have no constancy, and in the flowers of the Turban varieties of *C. maxima* they sometimes resume their ordinary structure. Again, in *C. maxima*, the carpels (p. 19) which form the turban project even as much as two-thirds of their length out of the receptacle, and this latter part is thus reduced to a sort of platform; but this remarkable structure occurs only in certain varieties, and graduates into the common form in which the carpels are almost entirely enveloped within the receptacle. In *C. moschata* the ovarium (p. 50) varies greatly in shape, being oval, nearly spherical, or cylindrical, more or less swollen in the upper part, or constricted round the middle, and either straight or curved. When the ovarium is short and oval the interior structure does not differ from that of *C. maxima* and *pepo*, but when it is elongated the carpels occupy only the terminal and swollen portion. I may add that in one variety of the cucumber (*Cucumis sativus*) the fruit regularly contains five carpels instead of three.[140] I presume that it will not be disputed that we here have instances of great variability in organs of the highest physiological importance, and with most plants of the highest classificatory importance.

Sageret[141] and Naudin found that the cucumber (*C. sativus*) could not be crossed with any other species of the genus; therefore no doubt it is specifically distinct from the melon. This will appear to most persons a superfluous statement; yet we hear from Naudin[142] that there is a race of melons, in which the fruit is so like that of the cucumber, "both externally and internally, that it is hardly possible to distinguish the one from the other except by the leaves." The varieties of the melon seem to be endless, for Naudin after six years' study had not come to the end of them: he divides them into ten sections, including numerous sub-varieties which all intercross with perfect ease.[143] Of the forms considered by Naudin to be varieties, botanists have made thirty distinct species! "and they had not the slightest acquaintance with the multitude of new forms which have appeared since their time." Nor is the creation of so many species at all surprising when we consider how strictly their characters are transmitted by seed, and how wonderfully they differ in appearance: "Mira est quidem foliorum et habitus diversitas, sed multo magis fructuum," says Naudin. The fruit is the valuable part, and this, in accordance with the common rule, is the most modified part. Some melons are only as large as small plums, others weigh as much as sixty-six pounds. One variety has a scarlet fruit! Another is not more than an inch in diameter, but sometimes more than a yard in length, "twisting about in all directions like a serpent." It is a singular fact that in this latter variety many parts of the plant, namely, the stems, the footstalks of the female flowers, the middle lobe of the leaves, and especially the ovarium, as well as the mature fruit, all show a strong tendency to become elongated. Several varieties of the melon are interesting from assuming the characteristic features of distinct species and even of distinct though allied genera: thus the serpent-melon has some resemblance to the fruit of *Trichosanthes anguina*; we have seen that other varieties closely resemble cucumbers; some Egyptian varieties have their seeds attached to a portion of the pulp, and this is characteristic of certain wild forms. Lastly, a variety of melon from Algiers is remarkable from announcing its maturity by “a spontaneous and almost sudden dislocation,” when deep cracks suddenly appear, and the fruit falls to pieces; and this occurs with the wild *C. momordica.* Finally, M. Naudin well remarks that this “extraordinary production of races and varieties by a single species and their permanence when not interfered with by crossing, are phenomena well calculated to cause reflection.”

USEFUL AND ORNAMENTAL TREES.

Trees deserve a passing notice on account of the numerous varieties which they present, differing in their precocity, in their manner of growth, their foliage, and bark. Thus of the common ash (*Fraxinus excelsior*) the catalogue of Messrs. Lawson of Edinburgh includes twenty-one varieties, some of which differ much in their bark; there is a yellow, a streaked reddish-white, a purple, a wart-barked and a fungous-barked variety.[144] Of hollies no less than eighty-four varieties are grown alongside each other in Mr. Paul’s nursery.[145] In the case of trees, all the recorded varieties, as far as I can find out, have been suddenly produced by one single act of variation. The length of time required to raise many generations, and the little value set on the fanciful varieties, explains how it is that successive modifications have not been accumulated by selection; hence, also, it follows that we do not here meet with sub-varieties subordinate to varieties, and these again subordinate to higher groups. On the Continent, however, where the forests are more carefully attended to than in England, Alph. De Candolle[146] says that there is not a forester who does not search for seeds from that variety which he esteems the most valuable.

Our useful trees have seldom been exposed to any great change of conditions; they have not been richly manured, and the English kinds grow under their proper climate. Yet in examining extensive beds of seedlings in nursery-gardens considerable differences may be generally observed in them; and whilst touring in England I have been surprised at the amount of difference in the appearance of the same species in our hedgerows and woods. But as plants vary so much in a truly wild state, it would be difficult for even a skilful botanist to pronounce whether, as I believe to be the case, hedgerow trees vary more than those growing in a primeval forest. Trees when planted by man in woods or hedges do not grow where they would naturally be able to hold their place against a host of competitors, and are therefore exposed to conditions not strictly natural: even this slight change would probably suffice to cause seedlings raised from such trees to be variable. Whether or not our half-wild English trees, as a general rule, are more variable than trees growing in their native forests, there can hardly be a doubt that they have yielded a greater number of strongly-marked and singular variations of structure.

In manner of growth, we have weeping or pendulous varieties of the willow, ash, elm, oak, and yew, and other trees; and this weeping habit is sometimes inherited, though in a singularly capricious manner. In the Lombardy poplar, and in certain fastigiate or pyramidal varieties of thorns, junipers, oaks, etc., we have an opposite kind of growth. The Hessian oak,[147] which is famous from its fastigiate habit and size, bears hardly any resemblance in general appearance to a common oak; "its acorns are not sure to produce plants of the same habit; some, however, turn out the same as the parent-tree." Another fastigiate oak is said to have been found wild in the Pyrenees, and this is a surprising circumstance; it generally comes so true by seed, that De Candolle considered it as specifically distinct.[148] The fastigiate Juniper (*J. suecica*) likewise transmits its character by seed.[149] Dr. Falconer informs me that in the Botanic Gardens at Calcutta the great heat caused apple-trees to become fastigiate; and we thus see the same result following from the effects of climate and from some unknown cause.[150]

In foliage we have variegated leaves which are often inherited; dark purple or red leaves, as in the hazel, barberry, and beech, the colour in these two latter trees being sometimes strongly and sometimes weakly inherited;[151] deeply-cut leaves; and leaves covered with prickles, as in the variety of the holly well called *ferox*, which is said to reproduce itself by seed.[152] In fact, nearly all the peculiar varieties evince a tendency, more or less strongly marked, to reproduce themselves by seed.[153] This is to a certain extent the case, according to Bosc,[154] with three varieties of the elm, namely, the broad-leafed, lime-leafed, and twisted elm, in which latter the fibres of the wood are twisted. Even with the heterophyllous hornbeam (*Carpinus betulus*), which bears on each twig leaves of two shapes, several plants raised from seed all retained "the same peculiarity."[155] I will add only one other remarkable case of variation in foliage, namely, the occurrence of two sub-varieties of the ash with simple instead of pinnated leaves, and which generally transmit their character by seed.[156] The occurrence, in trees belonging to widely different orders, of weeping and fastigiate varieties, and of trees bearing deeply cut, variegated, and purple leaves, shows that these deviations of structure must result from some very general physiological laws.

Differences in general appearance and foliage, not more strongly marked than those above indicated, have led good observers to rank as distinct species certain forms which are now known to be mere varieties. Thus, a plane-tree long cultivated in England was considered by almost every one as a North American species: but is now ascertained by old records, as I am informed by Dr. Hooker, to be a variety. So, again, the *Thuja pendula* or *filiformis* was ranked by such good observers as Lambert, Wallich, and others, as a true species; but it is now known that the original plants, five in number, suddenly appeared in a bed of seedlings, raised at Mr. Loddige's nursery, from *T. orientalis*; and Dr. Hooker has adduced excellent evidence that at Turin seeds of *T. pendula* have reproduced the parent form, *T. orientalis*.[157]

Every one must have noticed how certain individual trees regularly put forth and shed their leaves earlier or later than others of the same species. There is a famous horse-chestnut in the Tuileries which is named from leafing so much earlier than the others. There is also an oak near Edinburgh which retains its leaves to a very late period. These differences have been attributed by some authors to the nature of the soil in which the trees grow; but Archbishop Whately grafted an early thorn on a late one, and *vice versa*, and both grafts kept to their proper periods, which differed by about a fortnight, as if they still grew on their own stocks.[158] There is a Cornish variety of the elm which is almost an evergreen, and is so tender that the shoots are often killed by the frost; and the varieties of the Turkish oak (*Q. cerris*) may be arranged as deciduous, sub-evergreen, and evergreen.[159]

Scotch Fir (Pinus sylvestris).—I allude to this tree as it bears on the question of the greater variability of our hedgerow trees compared with those under strictly natural conditions. A well-informed writer[160] states that the Scotch fir presents few varieties in its native Scotch forests; but that it "varies much in figure and foliage, and in the size, shape, and colour of its cones, when several generations have been produced away from its native locality." There is little doubt that the highland and lowland varieties differ in the value of their timber, and that they can be propagated truly by seed; thus justifying Loudon's remark, that "a variety is often of as much importance as a species, and sometimes far more so."[161] I may mention one rather important point in which this tree occasionally varies; in the classification of the Coniferæ, sections are founded on whether two, three, or five leaves are included in the same sheath; the Scotch fir has properly only two leaves thus enclosed, but specimens have been observed with groups of three leaves in a sheath.[162] Besides these differences in the semi-cultivated Scotch fir, there are in several parts of Europe natural or geographical races, which have been ranked by some authors as distinct species.[163] Loudon[164] considers *P. pumilio*, with its several sub-varieties, as *mughus*, *nana*, etc., which differ much when planted in different soils, and only come "tolerably true from seed," as alpine varieties of the Scotch fir; if this were proved to be the case, it would be an interesting fact as showing that dwarfing from long exposure to a severe climate is to a certain extent inherited.

The *Hawthorn (Cratægus oxyacantha).* has varied much. Besides endless slighter variations in the form of the leaves, and in the size, hardness, fleshiness, and shape of the berries, Loudon[165] enumerates twenty-nine well-marked varieties. Besides those cultivated for their pretty flowers, there are others with golden-yellow, black, and whitish berries; others with woolly berries, and others with re-curved thorns. Loudon truly remarks that the chief reason why the hawthorn has yielded more varieties than most other trees, is that nurserymen select any remarkable variety out of the immense beds of seedlings which are annually raised for making hedges. The flowers of the hawthorn usually include from one to three pistils; but in two varieties, named monogyna and sibirica, there is only a single pistil; and d'Asso states that the common thorn in Spain is constantly in this state.[166] There is also a variety which is apetalous, or has its petals reduced to mere rudiments. The famous Glastonbury thorn flowers and leafs towards the end of December, at which time it bears berries produced from an earlier crop of flowers.[167] It is worth notice that several varieties of the hawthorn, as well as of the lime and juniper, are very distinct in their foliage and habit whilst young, but in the course of thirty or forty years become extremely like each other;[168] thus reminding us of the well-known fact that the deodar, the cedar of Lebanon, and that of the Atlas, are distinguished with the greatest ease whilst young, but with difficulty when old.

FLOWERS.

I shall not for several reasons treat the variability of plants which are cultivated for their flowers alone at any great length. Many of our favourite kinds in their present state are the descendants of two or more species crossed and commingled together, and this circumstance alone would render it difficult to detect the difference due to variation. For instance, our Roses, Petunias, Calceolarias, Fuchsias, Verbenas, Gladioli, Pelargoniums, etc., certainly have had a multiple origin. A botanist well acquainted with the parent-forms would probably detect some curious structural differences in their crossed and cultivated descendant; and he would certainly observe many new and remarkable constitutional peculiarities. I will give a few instances, all relating to the Pelargonium, and taken chiefly from Mr. Beck,[169] a famous cultivator of this plant: some varieties require more water than others; some are "very impatient of the knife if too greedily used in making cuttings;" some, when potted, scarcely "show a root at the outside of the ball of the earth;" one variety requires a certain amount of confinement in the pot to make it throw up a flower-stem; some varieties bloom well at the commencement of the season, others at the close; one variety is known,[170] which will stand "even pine-apple top and bottom heat, without looking any more drawn than if it had stood in a common greenhouse; and Blanche Fleur seems as if made on purpose for growing in winter, like many bulbs, and to rest all summer." These odd constitutional peculiarities would enable a plant in a state of nature to become adapted to widely different circumstances and climates.

Flowers possess little interest under our present point of view, because they have been almost exclusively attended to and selected for their beautiful colour, size, perfect outline, and manner of growth. In these particulars hardly one long-cultivated flower can be named which has not varied greatly. What does a florist care for the shape and structure of the organs of fructification, unless, indeed, they add to the beauty of the flower? When this is the case, flowers become modified in important points; stamens and pistils may be converted into petals, and additional petals may be developed, as in all double flowers. The process of gradual selection by which flowers have been rendered more and more double, each step in the process of conversion being inherited, has been recorded in several instances. In the so-called double flowers of the

Compositæ, the corollas of the central florets are greatly modified, and the modifications are likewise inherited. In the columbine (*Aquilegia vulgaris*) some of the stamens are converted into petals having the shape of nectaries, one neatly fitting into the other; but in one variety they are converted into simple petals.[171] In the "hose in hose" primulæ, the calyx becomes brightly coloured and enlarged so as to resemble a corolla; and Mr. W. Wooler informs me that this peculiarity is transmitted; for he crossed a common polyanthus with one having a coloured calyx,[172] and some of the seedlings inherited the coloured calyx during at least six generations. In the "hen-and-chicken" daisy the main flower is surrounded by a brood of small flowers developed from buds in the axils of the scales of the involucre. A wonderful poppy has been described, in which the stamens are converted into pistils; and so strictly was this peculiarity inherited that, out of 154 seedlings, one alone reverted to the ordinary and common type.[173] Of the cock's-comb (*Celosia cristata*), which is an annual, there are several races in which the flower-stem is wonderfully "fasciated" or compressed; and one has been exhibited[174] actually eighteen inches in breadth. Peloric races of *Gloxinia speciosa* and *Antirrhinum majus* can be propagated by seed, and they differ in a wonderful manner from the typical form both in structure and appearance.

A much more remarkable modification has been recorded by Sir William and Dr. Hooker[175] in *Begonia frigida*. This plant properly produces male and female flowers on the same fascicles; and in the female flowers the perianth is superior; but a plant at Kew produced, besides the ordinary flowers, others which graduated towards a perfect hermaphrodite structure; and in these flowers the perianth was inferior. To show the importance of this modification under a classificatory point of view, I may quote what Prof. Harvey says, namely, that had it "occurred in a state of nature, and had a botanist collected a plant with such flowers, he would not only have placed it in a distinct genus from Begonia, but would probably have considered it as the type of a new natural order." This modification cannot in one sense be considered as a monstrosity, for analogous structures naturally occur in other orders, as with Saxifragæ and Aristolochiaceæ. The interest of the case is largely added to by Mr. C. W. Crocker's observation that seedlings from the *normal* flowers produced plants which bore, in about the same proportion as the parent-plant, hermaphrodite flowers having inferior perianths. The hermaphrodite flowers fertilised with their own pollen were sterile.

If florists had attended to, selected, and propagated by seed other modifications of structure besides those which are beautiful, a host of curious varieties would certainly have been raised; and they would probably have transmitted their characters so truly that the cultivator would have felt aggrieved, as in the case of culinary vegetables, if his whole bed had not presented a uniform appearance. Florists have attended in some instances to the leaves of their plant, and have thus produced the most elegant and symmetrical patterns of white, red, and green, which, as in the case of the pelargonium, are sometimes strictly inherited.[176] Any one who will habitually examine highly-cultivated flowers in gardens and greenhouses will observe numerous deviations in structure; but most of these must be ranked as mere monstrosities, and are only so far interesting as showing how plastic the organisation becomes under high cultivation. From this point of view such works as Professor Moquin-Tandon's 'Tératologie' are highly instructive.

Roses.—These flowers offer an instance of a number of forms generally ranked as species, namely, *R. centifolia, gallica, alba, damascena, spinosissima, bracteata, indica, semperflorens, moschata,* etc., which have largely varied and been intercrossed. The genus Rosa is a notoriously difficult one, and, though some of the above forms are admitted by all botanists to be distinct species, others are doubtful; thus, with respect to the British forms, Babington makes seventeen, and Bentham only five species. The hybrids from some of the most distinct forms—for instance, from *R. indica,* fertilised by the pollen of *R. centifolia*—produce an abundance of seed; I state this on the authority of Mr. Rivers,[177] from whose work I have drawn most of the following statements. As almost all the aboriginal forms brought from different countries have been crossed and re-crossed, it is no wonder that Targioni-Tozzetti, in speaking of the common roses of the Italian gardens, remarks that "the native country and precise form of the wild type of most of them are involved in much uncertainty."[178] Nevertheless, Mr. Rivers in referring to *R. indica* (p. 68) says that the descendants of each group may generally be recognised by a close observer. The same author often speaks of roses as having been a little hybridised; but it is evident that in very many cases the differences due to variation and to hybridisation can now only be conjecturally distinguished.

The species have varied both by seed and by bud; such modified buds being often called by gardeners sports. In the following chapter I shall fully discuss this latter subject, and shall show that bud-variations can be propagated not only by grafting and budding, but often by seed. Whenever a new rose appears with any peculiar character, however produced, if it yields seed, Mr. Rivers (p. 4) fully expects it to become the parent-type of a new family. The tendency to vary is so strong in some kinds, as in the Village Maid (Rivers, p. 16), that when grown in different soils it varies so much in colour that it has been thought to form several distinct kinds. Altogether the number of kinds is very great: thus M. Desportes, in his Catalogue for 1829, enumerates 2562 as cultivated in France; but no doubt a large proportion of these are merely nominal.

It would be useless to specify the many points of difference between the various kinds, but some constitutional peculiarities may be mentioned. Several French roses (Rivers, p. 12) will not succeed in England; and an excellent horticulturist[179] remarks, that "Even in the same garden you will find that a rose that will do nothing under a south wall will do well under a north one. That is the case with Paul Joseph here. It grows strongly and blooms beautifully close to a north wall. For three years seven plants have done nothing under a south wall." Many roses can be forced, "many are totally unfit for forcing, among which is General Jacqueminot."[180] From the effects of crossing and variation Mr. Rivers enthusiastically anticipates (p. 87) that the day will come when all our roses, even moss-roses, will have evergreen foliage, brilliant and fragrant flowers, and the habit of blooming from June till November. "A distant view this seems, but perseverance in gardening will yet achieve wonders," as assuredly it has already achieved wonders.

It may be worth while briefly to give the well-known history of one class of roses. In 1793 some wild Scotch roses (*R. spinosissima*) were transplanted into a garden;[181] and one of these bore flowers slightly tinged with red, from which a plant was raised with semi-monstrous flowers, also tinged with red; seedlings from this flower were semi-double, and by continued selection, in about nine or ten years, eight sub-varieties were raised. In the course of less than twenty years these double Scotch roses had so much increased in number and kind, that twenty-six well-marked varieties, classed in eight sections, were described by Mr. Sabine. In 1841[182] it is said that three hundred varieties could be procured in the nursery-gardens near Glasgow; and these are described as blush, crimson, purple, red, marbled, two-coloured, white, and yellow, and as differing much in the size and shape of the flower.

Pansy or Heartsease (Viola tricolor, etc.).—The history of this flower seems to be pretty well known; it was grown in Evelyn's garden in 1687; but the varieties were not attended to till 1810-1812, when Lady Monke, together with Mr. Lee, the well-known nursery-man, energetically commenced their culture; and in the course of a few years twenty varieties could be purchased.[183] At about the same period, namely in 1813 or 1814, Lord Gambier collected some wild plants, and his gardener, Mr. Thomson, cultivated them, together with some common garden varieties, and soon effected a great improvement. The first great change was the conversion of the dark lines in the centre of the flower into a dark eye or centre, which at that period had never been seen, but is now considered one of the chief requisites of a first-rate flower. In 1835 a book entirely devoted to this flower was published, and four hundred named varieties were on sale. From these circumstances this plant seemed to me worth studying, more especially from the great contrast between the small, dull, elongated, irregular flowers of the wild pansy, and the beautiful, flat, symmetrical, circular, velvet-like flowers, more than two inches in diameter, magnificently and variously coloured, which are exhibited at our shows. But when I came to enquire more closely, I found that, though the varieties were so modern, yet that much confusion and doubt prevailed about their parentage. Florists believe that the varieties[184] are descended from several wild stocks, namely, *V. tricolor, lutea, grandiflora, amœna,* and *altaica*, more or less intercrossed. And when I looked to botanical works to ascertain whether these forms ought to be ranked as species, I found equal doubt and confusion. *Viola altaica* seems to be a distinct form, but what part it has played in the origin of our varieties I know not; it is said to have been crossed with *V. lutea. Viola amœna*[185] is now looked at by all botanists as a natural variety of *V. grandiflora*; and this and *V. sudetica* have been proved to be identical with *V. lutea.* The latter and *V. tricolor* (including its admitted variety *V. arvensis*) are ranked as distinct species by Babington, and likewise by M. Gay,[186] who has paid particular attention to the genus; but the specific distinction between *V. lutea* and *tricolor* is chiefly grounded on the one being strictly and the other not strictly perennial, as well as on some other slight and unimportant differences in the form of the stem and stipules. Bentham unites these two forms; and a high authority on such matters, Mr. H. C. Watson,[187] says that, "while *V. tricolor* passes into *V. arvensis* on the one side, it approximates so much towards *V. lutea* and *V. Curtisii* on the other side, that a distinction becomes scarcely more easy between them."

Hence, after having carefully compared numerous varieties, I gave up the attempt as too difficult for any one except a professed botanist. Most of the varieties present such inconstant characters, that when grown in poor soil, or when flowering out of their proper season, they produced differently coloured and much smaller flowers. Cultivators speak of this or that kind as being remarkably constant or true; but by this they do not mean, as in other cases, that the kind transmits its character by seed, but that the individual plant does not change much under culture. The principle of inheritance, however, does hold good to a certain extent even with the fleeting varieties of the Heartsease, for to gain good sorts it is indispensable to sow the seed of good sorts. Nevertheless, in almost every large seed-bed a few, almost wild seedlings reappear through reversion. On comparing the choicest varieties with the nearest allied wild forms, besides the difference in the size, outline, and colour of the flowers, the leaves sometimes differ in shape, as does the calyx occasionally in the length and breadth of the sepals. The differences in the form of the nectary more especially deserve notice; because characters derived from this organ have been much used in the discrimination of most of the species of Viola. In a large number of flowers compared in 1842 I found that in the greater number the nectary was straight; in others the extremity was a little turned upwards, or downwards, or inwards, so as to be completely hooked; in others, instead of being hooked, it was first turned rectangularly downwards, and then backwards and upwards; in others, the extremity was considerably enlarged; and lastly, in some the basal part was depressed, becoming, as usual, laterally compressed towards the extremity. In a large number of flowers, on the other hand, examined by me in 1856 from a nursery-garden in a different part of England, the nectary hardly varied at all. Now M. Gay says that in certain districts, especially in Auvergne, the nectary of the wild *V. grandiflora* varies in the manner just described. Must we conclude from this that the cultivated varieties first mentioned were all descended from *V. grandiflora*, and that the second lot, though having the same general appearance, were descended from *V. tricolor*, of which the nectary, according to M. Gay, is subject to little variation? Or is it not more probable that both these wild forms would be found under other conditions to vary in the same manner and degree, thus showing that they ought not to be ranked as specifically distinct?

The *Dahlia* has been referred to by almost every author who has written on the variation of plants, because it is believed that all the varieties are descended from a single species, and because all have arisen since 1802 in France, and since 1804 in England.[188] Mr. Sabine remarks that "it seems as if some period of cultivation had been required before the fixed qualities of the native plant gave way and began to sport into those changes which now so delight us."[189] The flowers have been greatly modified in shape from a flat to a globular form. Anemone and ranunculus-like races[190] which differ in the form and arrangement of the florets, have arisen; also dwarfed races, one of which is only eighteen inches in height. The seeds vary much in size. The petals are uniformly coloured or tipped or striped, and present an almost infinite diversity of tints. Seedlings of fourteen different colours[191] have been raised from the same plant; yet, as Mr. Sabine has remarked, "many of the seedlings follow their parents in colour." The period of flowering has been considerably hastened, and this has probably been effected by continued selection. Salisbury, writing 1808, says that they then flowered from September to November; in 1828 some new dwarf varieties began flowering in June;[192] and Mr. Grieve informs me that the dwarf purple Zelinda in his garden is in full bloom by the middle of June and sometimes even earlier. Slight constitutional differences have been observed between certain varieties: thus, some kinds succeed much better in one part of England than in another;[193] and it has been noticed that some varieties require much more moisture than others.[194]

Such flowers as the carnation, common tulip, and hyacinth, which are believed to be descended, each from a single wild form, present innumerable varieties, differing almost exclusively in the size, form, and colour of the flowers. These and some other anciently cultivated plants which have been long propagated by offsets, pipings, bulbs, etc., become so excessively variable, that almost each new plant raised from seed forms a new variety, "all of which to describe particularly," as old Gerarde wrote in 1597, "were to roll Sisyphus's stone, or to number the sands."

Hyacinth (Hyacinthus orientalis).—It may, however, be worth while to give a short account of this plant, which was introduced into England in 1596 from the Levant.[195] The petals of the original flower, says Mr. Paul, were narrow, wrinkled, pointed, and of a flimsy texture; now they are broad, smooth, solid, and rounded. The erectness, breadth, and length of the whole spike, and the size of the flowers, have all increased. The colours have been intensified and diversified. Gerarde, in 1597, enumerates four, and Parkinson, in 1629, eight varieties. Now the varieties are very numerous, and they were still more numerous a century ago. Mr. Paul remarks that "it is interesting to compare the Hyacinths of 1629 with those of 1864, and to mark the improvement. Two hundred and thirty-five years have elapsed since then, and this simple flower serves well to illustrate the great fact that the original forms of nature do not remain fixed and stationary, at least when brought under cultivation. While looking at the extremes, we must not, however, forget that there are intermediate stages which are for the most part lost to us. Nature will sometimes indulge herself with a leap, but as a rule her march is slow and gradual." He adds that the cultivator should have "in his mind an ideal of beauty, for the realisation of which he works with head and hand." We thus see how clearly Mr. Paul, an eminently successful cultivator of this flower, appreciates the action of methodical selection.

In a curious and apparently trustworthy treatise, published at Amsterdam[196] in 1768, it is stated that nearly 2,000 sorts were then known; but in 1864 Mr. Paul found only 700 in the largest garden at Haarlem. In this treatise it is said that not an instance is known of any one variety reproducing itself truly by seed: the white kinds, however, now[197] almost always yield white hyacinths, and the yellow kinds come nearly true. The hyacinth is remarkable from having given rise to varieties with bright blue, pink, and distinctly yellow flowers. These three primary colours do not occur in the varieties of any other species; nor do they often all occur even in the distinct species of the same genus. Although the several kinds of hyacinths differ but slightly from each other except in colour, yet each kind has its own individual character, which can be recognised by a highly educated eye; thus the writer of the Amsterdam treatise asserts (p. 43) that some experienced florists, such as the famous G. Voorhelm, seldom failed in a collection of above twelve hundred sorts to recognise each variety by the bulb alone! This same writer mentions some few singular variations: for instance, the hyacinth commonly produces six leaves, but there is one kind (p. 35) which scarcely ever has more than three leaves; another never more than five; whilst others regularly produce either seven or eight leaves. A variety, called la Coryphee, invariably produces (p. 116) two flower-stems, united together and covered by one skin. The flower-stem in another kind (p. 128) comes out of the ground in a coloured sheath, before the appearance of the leaves, and is consequently liable to suffer from frost. Another variety always pushes a second flower-stem after the first has begun to develop itself. Lastly, white hyacinths with red, purple, or violet centres (p. 129) are the most liable to rot. Thus, the hyacinth, like so many previous plants, when long cultivated and closely watched, is found to offer many singular variations.

In the two last chapters I have given in some detail the range of variation, and the history, as far as known, of a considerable number of plants, which have been cultivated for various purposes. But some of the most variable plants, such as Kidney-beans, Capsicum, Millets, Sorghum, etc., have been passed over; for botanists are not at all agreed which kinds ought to rank as species and which as varieties; and the wild parent-species are unknown.[198] Many plants long cultivated in tropical countries, such as the Banana, have produced numerous varieties; but as these have never been described with even moderate care, they are here also passed over. Nevertheless, a sufficient, and perhaps more than sufficient, number of cases have been given, so that the reader may be enabled to judge for himself on the nature and great amount of variation which cultivated plants have undergone.

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[2] Alph. De Candolle ‘Géograph. Bot.,’ p. 872; Dr. A. Targioni-Tozzetti in ‘Jour. Hort. Soc.,’ vol. ix. p. 133. For the fossil vine found by Dr. G.

Planchon *See* ‘Nat. Hist. Review,’ 1865, April, p. 224. *See also* the valuable works of M. de Saporta on the ‘Tertiary Plants of France.’

[3] Godron, ‘De l’Espèce,’ tom. ii. p. 100.

[4] *See* an account of M. Vibert’s experiments, by Alex. Jordan, in ‘Mém. de l’Acad. de Lyon,’ tom. ii. 185,2 p. 108.

[5] ‘Gardener’s Chronicle,’ 1864, p. 488.

[6] ‘Arbres Fruitiers,’ 1836, tom. ii. p. 290.

[7] Odart, ‘Ampelographie Universelle,’ 1849.

[8] M. Bouchardat, in ‘Comptes Rendus,’ Dec. 1st, 1851, quoted in ‘Gardener’s Chron.,’ 1852, p. 435. *See* also C. V. Riley on the manner in which some few of the varieties of the American Labruscan Vine escape the attacks of the Phylloxera: ‘Fourth Annual Report on the Insects of Missouri,’ 1872, p. 63, and ‘Fifth Report,’ 1873, p. 66.

[9] ‘Etudes sur les Maladies actuelles du Ver à Soie,’ 1859, p. 321.

[10] ‘Productive Resources of India,’ p. 130.

[11] ‘Traité du Citrus,’ 1811. ‘Teoria della Riproduzione Vegetale,’ 1816. I quote chiefly from this second work. In 1839 Gallesio published in folio ‘Gli Agrumi dei Giard. Bot. di Firenze,’ in which he gives a curious diagram of the supposed relationship of all the forms.

[12] Mr. Bentham, ‘Review of Dr. A. Targioni-Tozzetti, Journal of Hort. Soc.,’ vol. ix. p. 133.

[13] ‘Géograph. Bot.,’ p. 863.

[14] ‘Teoria della Riproduzione,’ pp. 52-57.

[15] Hooker’s ‘Bot. Misc.,’ vol. i. p. 302; vol. ii. p. 111.

[16] ‘Teoria della Riproduzione,’ p. 53.

[17] Gallesio, ‘Teoria della Riproduzione,’ p. 69.

[18] Ibid. p. 67.

[19] Gallesio, ‘Teoria della Riproduzione,’ pp. 75, 76.

[20] ‘Gardener’s Chronicle,’ 1841, p. 613.

[21] ‘Annales du Muséum,’ tom. xx. p. 188.

[22] ‘Géograph. Bot.,’ p. 882.

[23] ‘Transactions of Hort. Soc.,’ vol. iii. p. 1, and vol. iv. p. 396, and note to p. 370. A coloured drawing is given of this hybrid.

[24] ‘Gardener’s Chronicle,’ 1856, p. 532. A writer, it may be presumed Dr. Lindley, remarks on the perfect series which may be formed between the almond and the peach. Another high authority, Mr. Rivers, who has had such wide experience, strongly suspects (‘Gardener’s Chronicle,’ 1863, p. 27) that peaches, if left to a state of nature, would in the course of time retrograde into thick-fleshed almonds.

[25] ‘Journal of Hort. Soc.,’ vol. ix. p. 168.

[26] Whether this is the same variety as one lately mentioned (‘Gard. Chron.’ 1865, p. 1154) by M. Carrière under the name of *persica intermedia,* I know not; this variety is said to be intermediate in nearly all its characters between the almond and peach; it produces during successive years very different kinds of fruit.

[27] Quoted in ‘Gard. Chron.’ 1866, p. 800.

[28] Quoted in ‘Journal de La Soc. Imp. d’Horticulture,’ 1855, p. 238.

[29] ‘Teoria della Riproduzione Vegetale,’ 1816, p. 86.

[30] ‘Gardener’s Chronicle,’ 1862, p. 1195.

[31] Mr. Rivers, ‘Gardener’s Chron.,’ 1859, p. 774.

[32] Downing, ‘The Fruits of America,’ 1845, pp. 475, 489, 492, 494, 496. *See also* F. Michaux, ‘Travels in N. America’ (Eng. translat.), p. 228. For similar cases in France *See* Godron, ‘De l’Espèce,’ tom. ii. p. 97.

[33] Brickell’s ‘Nat. Hist. of N. Carolina,’ p. 102, and Downing’s ‘Fruit Trees,’ p. 505.

[34] ‘Gardener’s Chronicle,’ 1862, p. 1196.

[35] The peach and nectarine do not succeed equally well in the some soil: *See* Lindley’s ‘Horticulture,’ p. 351.

[36] Godron, ‘De l’Espèce,’ tom. ii., 1859, p. 97.

[37] ‘Transact. Hort. Soc.,’ vol. vi. p. 394.

[38] Downing’s ‘Fruit Trees,’ p. 502.

[39] ‘Gardener’s Chronicle,’ 1862, p. 1195.

[40] ‘Journal of Horticulture,’ Feb. 5th, 1866, p. 102.

[41] Mr. Rivers, in ‘Gardener’s ‘Chron.,’ 1859, p. 774, 1862, p. 1195; 1865, p. 1059; and ‘Journal of Hort.,’ 1866, p. 102.

[42] ‘Correspondence of Linnæus,’ 1821, pp. 7, 8, 70.

[43] ‘Transact. Hort. Soc.,’ vol. i. p. 103.

[44] Loudon’s ‘Gardener’s Mag.,’ 1826, vol. i. p. 471.

[45] Loudon’s ‘Gardener’s Mag.,’ 1828, p. 53.

[46] Ibid., 1830, p. 597.

[47] ‘Gardener’s Chronicle,’ 1841, p. 617.

[48] ‘Gardener’s Chronicle,’ 1844, p. 589.

[49] ‘Phytologist,’ vol. iv. p. 299.

[50] ‘Gardener’s Chron.,’ 1856, p. 531.

[51] Godron, ‘De l’Espèce,’ tom. ii. p. 97.

[52] ‘Gardener’s Chron.,’ 1856, p. 531.

[53] Alph. De Candolle, ‘Géograph. Bot.’ p. 886.

[54] Thompson, in Loudon’s ‘Encyclop. of Gardening,’ p. 911.

[55] ‘Catalogue of Fruit in Garden of Hort. Soc.,’ 1842, p. 105.

[56] Dr. A. Targioni-Tozzetti, ‘Journal Hort. Soc.,’ vol. ix. p. 167. Alph. de Candolle, ‘Géograph. Bot.,’ p. 885.

[57] ‘Transact. Hort. Soc.,’ vol. v. p. 554. *See also* Carrière, ‘Description et Class. des Variétés de Pêchers.’

[58] Loudon’s ‘Encyclop. of Gardening,’ p. 907.

[59] M. Carrière, in ‘Gard. Chron.,’ 1865, p. 1154.

[60] ‘Transact. Hort. Soc.,’ vol. iii. p. 332. *See also* ‘Gardener’s Chronicle,’ 1865, p. 271 to same effect. Also ‘Journal of Horticulture,’ Sept. 26th, 1865, p. 254.

[61] ‘Transact. Hort. Soc.,’ vol. iv. p. 512.

[62] ‘Journal of Horticulture,’ Sept. 8th, 1853 p. 188.

[63] ‘Transact. Hort. Soc.,’ vol. vi. p. 412.

[64] ‘Gardener’s Chronicle,’ 1857, p. 216.

[65] ‘Journal of Hort. Soc.,’ vol. ii. 283.

[66] Alph. de Candolle ‘Géograph. Bot.,’ p. 879.

[67] ‘Transact. Hort. Soc.’ (2nd series), vol. i. 1835, p. 56. *See also* ‘Cat. of Fruit in Garden of Hort. Soc.,’ 3rd edit. 1842.

[68] Downing, ‘The Fruits of America,’ 1845, p. 157: with respect to the Alberge apricot in France *See* p. 153.

[69] ‘Gardener’s Chronicle,’ 1863, p. 364.

[70] ‘Travels in the Himalayan Provinces,’ vol. i. 1841, p. 295.

[71] *See* an excellent discussion on this subject in Hewett C. Watson’s ‘Cybele Britannica,’ vol. iv. p. 80.

[72] ‘Gardener’s Chronicle,’ 1865, p. 27.

[73] ‘De l’Espèce,’ tom. ii. p. 94. On the parentage of our plums *see also* Alph. De Candolle ‘Géograph. Bot.,’ p. 878. Also Targioni-Tozzetti, ‘Journal Hort. Soc.,’ vol. ix. p. 164. Also Babington ‘Manual of Brit. Botany,’ 1851, p. 87.

[74] ‘Fruits of America,’ pp. 276, 278, 284, 310, 314. Mr. Rivers raised (‘Gard. Chron.,’ 1863, p. 27) from the Prune-pêche, which bears large, round, red plums on stout, robust shoots, a seedling which bears oval, smaller fruit on shoots that are so slender as to be almost pendulous.

[75] ‘Gardener’s Chronicle,’ 1855, p. 726.

[76] Downing’s ‘Fruit Trees,’ p. 278.

[77] ‘Gardener’s Chronicle,’ 1863, p. 27. Sageret, in his ‘Pomologie Phys.,’ p. 346, enumerates five kinds which can be propagated in France by seed: *see also* Downing’s ‘Fruit Trees of America,’ pp. 305, 312, etc.

[78] Compare Alph. De Candolle ‘Géograph. Bot.,’ p. 877; Bentham and Targioni-Tozzetti, in ‘Hort. Journal,’ vol. ix. p. 163; Godron, ‘De l’Espèce,’ tom. ii. p. 92.

[79] ‘Transact. Hort. Soc.,’ vol. v. 1824, p. 295.

[80] Ibid., second series, vol. i. 1835, p. 248.

[81] Ibid., vol. ii. p. 138.

[82] These several statements are taken from the four following works, which may, I believe, be trusted: Thompson, in ‘Hort. Transact.,’ *see* above; Sageret’s ‘Pomologie Phys.,’ 1830, pp. 358, 364, 367, 379; ‘Catalogue of the Fruit in the Garden of Hort. Soc.,’ 1842, pp. 57, 60; Downing, ‘The Fruits of America,’ 1845, pp. 189, 195, 200.

[83] Mr. Lowe states in his ‘Flora of Madeira’ (quoted in ‘Gard. Chron.,’ 1862, p. 215) that the *P. malus*, with its nearly sessile fruit, ranges farther south than the long-stalked *P. acerba*, which is entirely absent in Madeira, the Canaries, and apparently in Portugal. This fact supports the belief that these two forms deserve to be called species. But the characters separating them are of slight importance, and of a kind known to vary in other cultivated fruit-trees.

[84] *See* ‘Journ. of Hort. Tour, by Deputation of the Caledonian Hort. Soc.,’ 1823, p. 459.

[85] H. C. Watson, ‘Cybele Britannica,’ vol. i. p. 334.

[86] Loudon’s ‘Gardener’s Mag.,’ vol. vi., 1830, p. 83.

[87] *See* ‘Catalogue of Fruit in Garden of Hort. Soc.,’ 1842, and Downing’s ‘American Fruit Trees.’

[88] Loudon’s ‘Gardener’s Magazine,’ vol. iv., 1828, p. 112.

[89] ‘The Culture of the Apple,’ p. 43. Van Mons makes the same remark on the pear, ‘Arbres Fruitiers,’ tom. ii., 1836, p. 414.

[90] Lindley’s ‘Horticulture,’ p. 116. *See also* Knight on the Apple-Tree, in ‘Transact. of Hort. Soc.,’ vol. vi., p. 229.

[91] Transact. Hort. Soc.’ vol. i. 1812, p. 120.

[92] ‘Journal of Horticulture,’ March 13th, 1866, p. 194.

[93] ‘Transact. Hort. Soc.,’ vol. iv. p. 68. For Knight’s case *see* vol. vi. p. 547. When the *coccus* first appeared in this country it is said (vol. ii. p. 163) that it was more injurious to crab-stocks than to the apples grafted on them. The Majetin apple has been found equally free of the coccus at Melbourne in Australia (‘Gard. Chron.,’ 1871, p. 1065). The wood of this tree has been there analysed, and it is said (but the fact seems a strange one) that its ash contained over 50 per cent of lime, while that of the crab exhibited not quite 23 per cent. In Tasmania Mr. Wade (‘Transact. New Zealand Institute,’ vol. iv. 1871, p. 431) raised seedlings of the Siberian Bitter Sweet for stocks, and he found barely one per cent of them attacked by the coccus. Riley shows (‘Fifth Report on Insects of Missouri,’ 1873, p. 87) that in the United States some varieties of apples are highly attractive to the coccus and others very little so. Turning to a very different pest, namely, the caterpillar of a moth (*Carpocapsa pomonella*), Walsh affirms (‘The American Entomologist,’ April, 1869, p. 160) that the maiden-blush “is entirely exempt from apple-worms.” So, it is said, are some few other varieties; whereas others are “peculiarly subject to the attacks of this little pest.”

[94] ‘Mém. de La Soc. Linn. de Paris,’ tom. iii. 1825, p. 164; and Seringe ‘Bulletin Bot.’ 1830, p. 117.

[95] Gardener's Chronicle,' 1849, p. 24.

[96] R. Thompson, in 'Gardener's Chronicle,' 1850, p. 788.

[97] Sageret 'Pomologie Physiologique,' 1830, p. 263. Downing's 'Fruit Trees,' pp. 130, 134, 139, etc. Loudon's 'Gardener's Mag.' vol. viii. p. 317. Alexis Jordan, 'De l'Origine des diverses Variétés,' in 'Mém. de l'Acad. Imp. de Lyon,' tom. ii. 1852, pp. 95, 114. 'Gardener's Chronicle,' 1850, pp. 774, 788.

[98] 'Comptes Rendus,' July 6th, 1863.

[99] 'Gardener's Chronicle,' 1856, p. 804; 1857, p. 820; 1862, p. 1195.

[100] Most of the largest cultivated strawberries are the descendants of *F. grandiflora* or *chiloensis,* and I have seen no account of these forms in their wild state. Methuen's Scarlet (Downing, 'Fruits,' p. 527) has "immense fruit of the largest size," and belongs to the section descended from *F. virginiana;* and the fruit of this species, as I hear from Prof. A. Gray, is only a little larger than that of *F. vesca,* or our common wood-strawberry.

[101] 'Le Fraisier,' par le Comte L. de Lambertye, 1864, p. 50.

[102] 'Transact. Hort. Soc.,' vol. iii. 1820, p. 207.

[103] *See* an account by Prof. Decaisne, and by others in 'Gardener's Chronicle,' 1862, p. 335, and 1858, p. 172; and Mr. Barnet's paper in 'Hort. Soc. Transact.,' vol. vi. 1826, p. 170.

[104] 'Transact. Hort. Soc.,' vol. v. 1824, p. 294.

[105] 'Journal of Horticulture,' Dec. 30th, 1862, p. 779. *See also* Mr. Prince to the same effect, ibid., 1863, p. 418.

[106] For additional evidence *see* 'Journal of Horticulture,' Dec. 9th, 1862, p. 721.

[107] 'Le Fraisier,' par le Comte L. de Lambertye, pp. 221, 230.

[108] 'Transact. Hort. Soc.,' vol. vi. p. 200.

[109] 'Gardener's Chronicle,' 1858, p. 173.

[110] Godron 'De l'Espèce,' tom. i. p. 161.

[111] 'Gardener's Chronicle,' 1851, p. 440.

[112] F. Gloede in 'Gardener's Chronicle,' 1862, p. 1053.

[113] Downing's 'Fruits,' p. 532.

[114] Barnet, in 'Hort. Transact.,' vol. vi. p. 210.

[115] ‘Gardener’s Chronicle,’ 1847, p. 539.

[116] For the several statements with respect to the American strawberries *see* Downing, ‘Fruits,’ p. 524; ‘Gardener’s Chronicle,’ 1843, p. 188; 1847, p. 539; 1861, p. 717.

[117] Mr. D. Beaton, in ‘Cottage Gardener,’ 1860, p. 86. *See also* ‘Cottage Gardener,’ 1855, p. 88, and many other authorities. For the Continent, *see* F. Gloede, in ‘Gardener’s Chronicle,’ 1862, p. 1053.

[118] Rev. W. F. Radclyffe, in ‘Journal of Hort.,’ March 14th, 1865, p. 207.

[119] Mr. H. Doubleday in ‘Gardener’s Chronicle,’ 1862, p. 1101.

[120] ‘Gardener’s Chronicle,’ 1854, p. 254.

[121] Loudon’s ‘Encyclop. of Gardening,’ p. 930; and Alph. De Candolle ‘Géograph. Bot.,’ p. 910.

[122] Loudon’s ‘Gardener’s Magazine,’ vol. iv. 1828, p. 112.

[123] The fullest account of the gooseberry is given by Mr. Thompson in ‘Transact. Hort. Soc.,’ vol. i., 2nd series, 1835, p. 218, from which most of the foregoing facts are taken.

[124] ‘Catalogue of Fruits of Hort. Soc. Garden,’ 3rd edit., 1842.

[125] Mr. Clarkson of Manchester, on the Culture of the Gooseberry, in Loudon’s ‘Gardener’s Magazine,’ vol. iv. 1828, p. 482.

[126] Downing’s ‘Fruits of America,’ p. 213.

[127] ‘Gardener’s Chronicle,’ 1844, p. 811, where a table is given; and 1845, p. 819. For the extreme weights gained, *see* ‘Journal of Horticulture,’ July 26th, 1864, p. 61.

[128] Mr. Saul, of Lancaster, in Loudon’s ‘Gardener’s Mag.,’ vol. iii. 1828, p. 421; and vol. x. 1834, p. 42.

[129] ‘Himalayan Journals,’ 1854, vol. ii. p. 334. Moorcroft (‘Travels,’ vol. ii. p. 146) describes four varieties cultivated in Kashmir.

[130] ‘Gardener’s Chronicle,’ 1850, p. 723.

[131] Paper translated in Loudon’s ‘Gardener’s Mag.,’ 1829, vol. v. p. 202.

[132] Quoted in ‘Gardener’s Chronicle,’ 1849, p. 101.

[133] ‘Gardener’s Chronicle,’ 1847, pp. 541 and 558.

[134] The following details are taken from the ‘Catalogue of Fruits, 1842, in Garden of Hort. Soc.,’ p. 103; and from Loudon’s ‘Encyclop. of Gardening,’ p. 943.

[135] ‘Gardener’s Chronicle,’ 1860, p. 956.

[136] ‘Annales des Sc. Nat. Bot.,’ 4th series, vol. vi. 1856, p. 5.

[137] ‘American Journ. of Science,’ 2nd series, vol. xxiv. 1857, p. 442.

[138] Gärtner ‘Bastarderzeugung,’ 1849, s. 87, and s. 169 with respect to Maize; on Verbascum, ibid., s. 92 and 181; also his ‘Kenntniss der Befruchtung,’ s. 137. With respect to Nicotiana *see* Kölreuter ‘Zweite Forts.,’ 1764, s. 53; though this is a somewhat different case.

[139] ‘De l’Espèce,’ par M. Godron, tom. ii. p. 64.

[140] Naudin, in ‘Annal. des Sc. Nat.,’ 4th series, Bot. tom. xi. 1859, p. 28.

[141] ‘Mèmoire sur les Cucurbitacées,’ 1826, pp. 6, 24.

[142] ‘Flore des Serres,’ Oct. 1861, quoted in ‘Gardener’s Chronicle,’ 1861, p. 1135. I have often consulted and taken some facts from M. Naudin’s Memoir on Cucumis in ‘Annal. des Sc. Nat.,’ 4th series, Bot. tom. xi. 1859, p. 5.

[143] *See also* Sageret’s ‘Mémoire’ p. 7.

[144] Loudon’s ‘Arboretum et Fruticetum,’ vol. ii. p. 1217.

[145] ‘Gardener’s Chronicle,’ 1866, p. 1096.

[146] ‘Géograph. Bot.,’ p. 1096.

[147] ‘Gardener’s Chronicle,’ 1842, p. 36.

[148] Loudon’s ‘Arboretum et Fruticetum,’ vol. iii. p. 1731.

[149] Ibid., vol. iv. p. 2489.

[150] Godron (‘De l’Espèce’ tom. ii. p. 91) describes four varieties of Robinia remarkable from their manner of growth.

[151] ‘Journal of a Horticultural Tour, by Caledonian Hort. Soc.,’ 1823, p. 107. Alph. De Candolle, ‘Géograph. Bot.,’ p. 1083. Verlot, ‘Sur La Production des Variétés,’ 1865; p. 55 for the Barberry.

[152] Loudon’s ‘Arboretum et Fruticetum,’ vol. ii. p. 508.

[153] Verlot ‘Des Variétés,’ 1865, p. 92.

[154] Loudon’s ‘Arboretum et Fruticetum,’ vol. iii. p. 1376.

[155] ‘Gardener’s Chronicle,’ 1841, p. 687.

[156] Godron, ‘De l’Espèce,’ tom. ii. p. 89. In Loudon’s ‘Gardener’s Mag.,’ vol. xii. 1836, p. 371, a variegated bushy ash is described and figured, as having simple leaves; it originated in Ireland.

[157] ‘Gardener’s Chronicle,’ 1863, p. 575.

[158] Quoted from Royal Irish Academy in ‘Gardener’s Chronicle,’ 1841, p. 767.

[159] Loudon’s ‘Arboretum et Fruticetum:’ for Elm, *see* vol. iii. p. 1376; for Oak, p. 1846.

[160] ‘Gardener’s Chronicle,’ 1849, p. 822.

[161] ‘Arboretum et Fruticetum,’ vol. iv. p. 2150.

[162] ‘Gardener’s Chronicle,’ 1852, p. 693.

[163] *See* ‘Beiträge zur Kenntniss Europäischer Pinus-arten von Dr. Christ: Flora, 1864.’ He shows that in the Ober-Engadin *P. sylvestris* and *montana* are connected by intermediate links.

[164] ‘Arboretum et Fruticetum,’ vol. iv. pp. 2159 and 2189.

[165] Ibid., vol. ii. p. 830; Loudon’s ‘Gardener’s Mag.,’ vol. vi. 1830, p. 714.

[166] Loudon’s ‘Arboretum et Fruticetum,’ vol. ii. p. 834.

[167] Loudon’s ‘Gardener’s Mag.,’ vol. ix. 1833, p. 123.

[168] Ibid., vol. xi. 1835, p. 503.

[169] ‘Gardener’s Chronicle,’ 1845, p. 623.

[170] D. Beaton, in ‘Cottage Gardener,’ 1860, p. 377. *See also* Mr. Beck, on the habits of Queen Mab, in ‘Gardener’s Chronicle,’ 1845, p. 226.

[171] Moquin-Tandon, ‘Eléments de Tératologie,’ 1841, p. 213.

[172] *See also* ‘Cottage Gardener,’ 1860, p. 133.

[173] Quoted by Alph. de Candolle, ‘Bibl. Univ.,’ November 1862, p. 58.

[174] Knight, ‘Transact. Hort. Soc.,’ vol. iv. p. 322.

[175] ‘Botanical Magazine,’ tab. 5160, fig. 4; Dr. Hooker, in ‘Gardener’s Chronicle,’ 1860, p. 190; Prof. Harvey, in ‘Gardener’s Chronicle,’ 1860, p. 145; Mr. Crocker, in ‘Gardener’s Chronicle,’ 1861, p. 1092.

[176] Alph. de Candolle, 'Géograph. Bot.,' p. 1083; 'Gardener's Chronicle,' 1861, p. 433. The inheritance of the white and golden zones in Pelargonium largely depends on the nature of the soil. *See* D. Beaton, in 'Journal of Horticulture,' 1861, p. 64.

[177] 'Rose Amateur's Guide,' T. Rivers, 1837, p. 21.

[178] 'Journal Hort. Soc.,' vol. ix. 1855, p. 182.

[179] The Rev. W. F. Radclyffe, in 'Journal of Horticulture,' March 14th, 1865, p. 207.

[180] 'Gardener's Chronicle,' 1831, p. 46.

[181] Mr. Sabine, in 'Transact. Hort. Soc.,' vol. iv. p. 285.

[182] 'An Encyclop. of Plants,' by J. C. Loudon, 1841, p. 443.

[183] Loudon's 'Gardener's Magazine,' vol. xi. 1835, p. 427; also 'Journal of Horticulture,' April 14th, 1863, p. 275.

[184] Loudon's 'Gardener's Magazine,' vol. viii. p. 575: vol. ix. p. 689.

[185] Sir J. E. Smith, 'English Flora,' vol. i. p. 306. H. C. Watson, 'Cybele Britannica,' vol. i. 1847, p. 181.

[186] Quoted from 'Annales des Sciences,' in the Companion to the 'Bot. Mag.,' vol. i. 1835, p. 159.

[187] 'Cybele Britannica,' vol. i. p. 173. *See also* Dr. Herbert on the changes of colour in transplanted specimens, and on the natural variations of *V. grandiflora,* in 'Transact. Hort. Soc.,' vol. iv. p. 19.

[188] Salisbury, in 'Transact. Hort. Soc.,' vol. i. 1812, pp. 84, 92. A semi-double variety was produced in Madrid in 1790.

[189] 'Transact. Hort. Soc.,' vol. iii. 1820, p. 225.

[190] Loudon's 'Gardener's Mag.,' vol. vi. 1830, p. 77.

[191] Loudon's 'Encyclop. of Gardening,' p. 1035.

[192] 'Transact. Hort. Soc.,' vol. i. p. 91; and Loudon's 'Gardener's Mag.,' vol. iii. 1828, p. 179.

[193] Mr. Wildman, in 'Gardener's Chronicle,' 1843, p. 87. 'Cottage Gardener,' April 8th, 1856, p. 33.

[194] M. Faivre has given an interesting account of the successive variations of the Chinese primrose, since its introduction into Europe about the year 1820: 'Revue des Cours Scientifiques,' June, 1869, p. 428.

[195] The best and fullest account of this plant which I have met with is by a famous horticulturist, Mr. Paul, of Waltham, in the 'Gardener's Chronicle,' 1864, p. 342.

[196] 'Des Jacinthes, de leur Anatomie, Reproduction, et Culture,' Amsterdam, 1768.

[197] Alph. de Candolle, 'Géograph. Bot.,' p. 1082.

[198] Alph. De Candolle, 'Géograph. Bot.,' p. 983.

CHAPTER XI.
ON BUD-VARIATION, AND ON CERTAIN ANOMALOUS MODES OF REPRODUCTION AND VARIATION.

BUD-VARIATION IN THE PEACH, PLUM, CHERRY, VINE, GOOSEBERRY, CURRANT, AND BANANA, AS SHOWN BY THE MODIFIED FRUIT—IN FLOWERS: CAMELLIAS, AZALEAS, CHRYSANTHEMUMS, ROSES, ETC—ON THE RUNNING OF THE COLOUR IN CARNATIONS—BUD-VARIATIONS IN LEAVES—VARIATIONS BY SUCKERS, TUBERS, AND BULBS—ON THE BREAKING OF TULIPS—BUD-VARIATIONS GRADUATE INTO CHANGES CONSEQUENT ON CHANGED CONDITIONS OF LIFE—GRAFT-HYBRIDS—ON THE SEGREGATION OF THE PARENTAL CHARACTERS IN SEMINAL HYBRIDS BY BUD-VARIATION—ON THE DIRECT OR IMMEDIATE ACTION OF FOREIGN POLLEN ON THE MOTHER-PLANT—ON THE EFFECTS IN FEMALE ANIMALS OF A PREVIOUS IMPREGNATION ON THE SUBSEQUENT OFFSPRING—CONCLUSION AND SUMMARY

This chapter will be chiefly devoted to a subject in many respects important, namely, bud-variation. By this term I include all those sudden changes in structure or appearance which occasionally occur in full-grown plants in their flower-buds or leaf-buds. Gardeners call such changes "Sports;" but this, as previously remarked, is an ill-defined expression, as it has often been applied to strongly marked variations in seedling plants. The difference between seminal and bud reproduction is not so great as it at first appears; for each bud is in one sense a new and distinct individual; but such individuals are produced through the formation of various kinds of buds without the aid of any special apparatus, whilst fertile seeds are produced by the concourse of the two sexual elements. The modifications which arise through bud-variation can generally be propagated to any extent by grafting, budding, cuttings, bulbs, etc., and occasionally even by seed. Some few of our most beautiful and useful productions have arisen by bud-variation.

Bud-variations have as yet been observed only in the vegetable kingdom; but it is probable that if compound animals, such as corals, etc., had been subjected to a long course of domestication, they would have varied by buds; for they resemble plants in many respects. For instance, any new or peculiar character presented by a compound animal is propagated by budding, as occurs with differently coloured Hydras, and as Mr. Gosse has shown to be the case with a singular variety of a true coral. Varieties of the Hydra have also been grafted on other varieties, and have retained their character.

I will in the first place give all the cases of bud variations which I have been able to collect, and afterwards show their importance.[1] These cases prove that those authors who, like Pallas, attribute all variability to the crossing either of distinct races, or of distinct individuals belonging to the same race but somewhat different from each other, are in error; as are those authors who attribute all variability to the mere act of sexual union. Nor can we account in all cases for the appearance through bud-variation of new characters by the principle of reversion to long-lost characters. He who wishes to judge how far the conditions of life directly cause each particular variation ought to reflect well on the cases immediately to be given. I will commence with bud-variations, as exhibited in the fruit, and then pass on to flowers, and finally to leaves.

Peach (Amygdalus persica).—In the last chapter I gave two cases of a peach-almond and a double-flowered almond which suddenly produced fruit closely resembling true peaches. I have also given many cases of peach-trees producing buds, which, when developed into branches, have yielded nectarines. We have seen that no less than six named and several unnamed varieties of the peach have thus produced several varieties of nectarine. I have shown that it is highly improbable that all these peach-trees, some of which are old varieties, and have been propagated by the million, are hybrids from the peach and nectarine, and that it is opposed to all analogy to attribute the occasional production of nectarines on peach-trees to the direct action of pollen from some neighbouring nectarine-tree. Several of the cases are highly remarkable, because, firstly, the fruit thus produced has sometimes been in part a nectarine and in part a peach; secondly, because nectarines thus suddenly produced have reproduced themselves by seed; and thirdly, because nectarines are produced from peach-trees from seed as well as from buds. The seed of the nectarine, on the other hand, occasionally produces peaches; and we have seen in one instance that a nectarine-tree yielded peaches by bud-variation. As the peach is certainly the oldest or primary variety, the production of peaches from nectarines, either by seeds or buds, may perhaps be considered as a case of reversion. Certain trees have also been described as indifferently bearing peaches or nectarines, and this may be considered as bud-variation carried to an extreme degree.

The *grosse mignonne* peach at Montreuil produced "from a sporting branch" the *grosse mignonne tardive*, "a most excellent variety," which ripens its fruit a fortnight later than the parent tree, and is equally good.[2] This same peach has likewise produced by bud-variation the *early grosse mignonne*. Hunt's large tawny nectarine "originated from Hunt's small tawny nectarine, but not through seminal reproduction."[3]

Plums.—Mr. Knight states that a tree of the yellow magnum bonum plum, forty years old, which had always borne ordinary fruit, produced a branch which yielded red magnum bonums.[4] Mr. Rivers, of Sawbridgeworth, informs me (Jan. 1863) that a single tree out of 400 or 500 trees of the Early Prolific plum, which is a purple kind, descended from an old French variety bearing purple fruit, produced when about ten years old bright yellow plums; these differed in no respect except colour from those on the other trees, but were unlike any other known kind of yellow plum.[5]

Cherry (Prunus cerasus).—Mr. Knight has recorded (ibid.) the case of a branch of a May-Duke cherry, which, though certainly never grafted, always produced fruit, ripening later, and more oblong than the fruit on the other branches. Another account has been given of two May-Duke cherry-trees in Scotland, with branches bearing oblong and very fine fruit, which invariably ripened, as in Knight's case, a fortnight later than the other cherries.[6] M. Carrière gives (p. 37) numerous analogous cases, and one of the same tree bearing three kinds of fruit.

Grapes (Vitis vinifera).—The black or purple Frontignan in one case produced during two successive years (and no doubt permanently), spurs which bore white Frontignan grapes. In another case, on the same footstalk, the lower berries "were well-coloured black Frontignans; those next the stalk were white, with the exception of one black and one streaked berry;" and altogether there were fifteen black and twelve white berries on the same stalk. In another kind of grape, black and amber-coloured berries were produced in the same cluster.[7] Count Odart describes a variety which often bears on the same stalk small round and large oblong berries; though the shape of the berry is generally a fixed character.[8] Here is another striking case given on the excellent authority of M. Carrière:[9] "a black Hamburg grape (Frankenthal) was cut down, and produced three suckers; one of these was layered, and after a time produced much smaller berries, which always ripened at least a fortnight earlier than the others. Of the remaining two suckers, one produced every year fine grapes, whilst the other, although it set an abundance of fruit, matured only a few, and these of inferior quality."

Gooseberry (Ribes grossularia).—A remarkable case has been described by Dr. Lindley[10] of a bush which bore at the same time no less than four kinds of berries, namely, hairy and red,—smooth, small and red,—green,—and yellow tinged with buff; the two latter kinds had a different flavour from the red berries, and their seeds were coloured red. Three twigs on this bush grew close together; the first bore three yellow berries and one red; the second twig bore four yellow and one red; and the third four red and one yellow. Mr. Laxton also informs me that he has seen a Red Warrington gooseberry bearing both red and yellow fruit on the same branch.

Currant (Ribes rubrum).—A bush purchased as the Champagne, which is a variety that bears blush-coloured fruit intermediate between red and white, produced during fourteen years on separate branches and mingled on the same branch, berries of the red, white, and champagne kinds.[11] The suspicion naturally arises that this variety may have originated from a cross between a red and white variety, and that the above transformation may be accounted for by reversion to both parent-forms; but from the foregoing complex case of the gooseberry this view is doubtful. In France, a branch of a red-currant bush, about ten years old, produced near the summit five white berries) and lower down, amongst the red berries, one berry half red and half white.[12] Alexander Braun[13] also has often seen branches on white currant-trees bearing red berries.

Pear (Pyrus communis).—Dureau de la Malle states that the flowers on some trees of an ancient variety, the *doyenné galeux,* were destroyed by frost: other flowers appeared in July, which produced six pears; these exactly resembled in their skin and taste the fruit of a distinct variety, the *gros doyenne blanc*, but in shape were like the *bon-chrétien*: it was not ascertained whether this new variety could be propagated by budding or grafting. The same author grafted a *bon-chrétien* on a quince, and it produced, besides its proper fruit, an apparently new variety, of a peculiar form with thick and rough skin.[14]

Apple (Pyrus malus).—In Canada, a tree of the variety called Pound Sweet, produced,[15] between two of its proper fruit, an apple which was well russeted, small in size, different in shape, and with a short peduncle. As no russet apple grew anywhere near, this case apparently cannot be accounted for by the direct action of foreign pollen. M. Carrière (p. 38) mentions an analogous instance. I shall hereafter give cases of apple-trees which regularly produce fruit of two kinds, or half-and-half fruit; these trees are generally supposed, and probably with truth, to be of crossed parentage, and that the fruit reverts to both parent-forms.

Banana (Musa sapientium).—Sir R. Schomburgk states that he saw in St. Domingo a raceme on the Fig Banana which bore towards the base 125 fruits of the proper kind; and these were succeeded, as is usual, higher up the raceme, by barren flowers, and these by 420 fruits, having a widely different appearance, and ripening earlier than the proper fruit. The abnormal fruit closely resembled, except in being smaller, that of the *Musa chinensis* or *cavendishii,* which has generally been ranked as a distinct species.[16]

Flowers.—Many cases have been recorded of a whole plant, or single branch, or bud, suddenly producing flowers different from the proper type in colour, form, size, doubleness, or other character. Half the flower, or a smaller segment, sometimes changes colour.

Camellia.—The myrtle-leaved species (*C. myrtifolia*), and two or three varieties of the common species, have been known to produce hexagonal and imperfectly quadrangular flowers; and the branches producing such flowers have been propagated by grafting.[17] The Pompon variety often bears "four distinguishable kinds of flowers,—the pure white and the red-eyed, which appear promiscuously; the brindled pink and the rose-coloured, which may be kept separate with tolerable certainty by grafting from the branches that bear them." A branch, also, on an old tree of the rose-coloured variety has been seen to "revert to the pure white colour, an occurrence less common than the departure from it."[18]

Cratægus oxyacantha.—A dark pink hawthorn has been known to throw out a single tuft of pure white blossoms;[19] and Mr. A. Clapham, nurseryman, of Bedford, informs me that his father had a deep crimson thorn grafted on a white thorn, which during several years, always bore, high above the graft, bunches of white, pink and deep crimson flowers.

Azalea indica is well known often to produce new varieties by buds. I have myself seen several cases. A plant of *Azalea indica variegata* has been exhibited bearing a truss of flowers of A. ind. gledstanesii "as true as could possibly be produced, thus evidencing the origin of that fine variety." On another plant of *A. ind. variegata* a perfect flower of *A. ind. lateritia* was produced; so that both *gledstanesii* and *lateritia* no doubt originally appeared as sporting branches of *A. ind. variegata*.[20]

Hibiscus (Paritium tricuspis).—A seedling of this plant, when some years old, produced, at Saharunpore,[21] some branches "which bore leaves and flowers widely different from the normal form." "The abnormal leaf is much less divided, and not acuminated. The petals are considerably larger, and quite entire. There is also in the fresh state a conspicuous, large, oblong gland, full of a viscid secretion, on the back of each of the calycine segments." Dr. King, who subsequently had charge of these Gardens, informs me that a tree of *Paritium tricuspis* (probably the very same plant) growing there, had a branch buried in the ground, apparently by accident; and this branch changed its character wonderfully, growing like a bush, and producing flowers and leaves, resembling in shape those of another species, viz., *P. tiliaceum*. A small branch springing from this bush near the ground, reverted to the parent-form. Both forms were extensively propagated during several years by cuttings and kept perfectly true.

Althæa rosea.—A double yellow Hollyhock suddenly turned one year into a pure white single kind; subsequently a branch bearing the original double yellow flowers reappeared in the midst of the branches of the single white kind.[22]

Pelargonium.—These highly cultivated plants seem eminently liable to bud-variation. I will give only a few well-marked cases. Gärtner has seen[23] a plant of *P. zonale* with a branch having white edges, which remained constant for years, and bore flowers of a deeper red than usual. Generally speaking, such branches present little or no difference in their flowers: thus a writer[24] pinched off the leading shoot of a seedling *P. zonale,* and it threw out three branches, which differed in the size and colour of their leaves and stems; but on all three branches "the flowers were identical," except in being largest in the green-stemmed variety, and smallest in that with variegated foliage: these three varieties were subsequently propagated and distributed. Many branches, and some whole plants, of a variety called *compactum,* which bears orange-scarlet flowers, have been seen to produce pink flowers.[25] Hill's Hector, which is a pale red variety, produced a branch with lilac flowers, and some trusses with both red and lilac flowers. This apparently is a case of reversion, for Hill's Hector was a seedling from a lilac variety.[26] Here is a better case of reversion: a variety produced from a complicated cross, after having been propagated for five generations by seed, yielded by bud-variation three very distinct varieties which were undistinguishable from plants, "known to have been at some time ancestors of the plant in question."[27] Of all Pelargoniums, Rollisson's Unique seems to be the most sportive; its origin is not positively known, but is believed to be from a cross. Mr. Salter, of Hammersmith, states[28] that he has himself known this purple variety to produce the lilac, the rose-crimson or *conspicuum,* and the red or *coccineum* varieties; the latter has also produced the *rose d'amour*; so that altogether four varieties have originated by bud variation from Rollisson's Unique. Mr. Salter remarks that these four varieties "may now be considered as fixed, although they occasionally produce flowers of the original colour. This year *coccineum* has pushed flowers of three different colours, red, rose, and lilac, upon the same truss, and upon other trusses are flowers half red and half lilac." Besides these four varieties, two other scarlet Uniques are known to exist, both of which occasionally produce lilac flowers identical with Rollisson's Unique;[29] but one at least of these did not arise through bud-variation, but is believed to be a seedling from Rollisson's Unique.[30] There are, also, in the trade[31] two other slightly different varieties, of unknown origin, of Rollisson's Unique: so that altogether we have a curiously complex case of variation both by buds and seeds.[32] Here is a still more complex case: M. Rafarin states that a pale rose-coloured variety produced a branch bearing deep red flowers. "Cuttings were taken from this 'sport,' from which 20 plants were raised, which flowered in 1867, when it was found that scarcely two were alike." Some resembled the parent-form, some resembled the sport, some bore both kinds of flowers; and even some of the petals on the same flower were rose-coloured and others red.[33] An English wild plant, the *Geranium pratense,* when cultivated in a garden, has been seen to produce on the same plant both blue and white, and striped blue and white flowers.[34]

Chrysanthemum.—This plant frequently sports, both by its lateral branches and occasionally by suckers. A seedling raised by Mr. Salter has produced by bud-variation six distinct sorts, five different in colour and one in foliage, all of which are now fixed.[35] A variety called *cedo nulli* bears small yellow flowers, but habitually produces branches with white flowers; and a specimen was exhibited, which Prof. T. Dyer saw, before the Horticultural Society. The varieties which were first introduced from China were so excessively variable, "that it was extremely difficult to tell which was the original colour of the variety, and which was the sport." The same plant would produce one year only buff-coloured, and next year only rose-coloured flowers; and then would change again, or produce at the same time flowers of both colours. These fluctuating varieties are now all lost, and, when a branch sports into a new variety, it can generally be propagated and kept true; but, as Mr. Salter remarks, "every sport should be thoroughly tested in different soils before it can be really considered as fixed, as many have been known to run back when planted in rich compost; but when sufficient care and time are expended in proving, there will exist little danger of subsequent disappointment." Mr. Salter informs me that with all the varieties the commonest kind of bud-variation is the production of yellow flowers, and, as this is the primordial colour, these cases may be attributed to reversion. Mr. Salter has given me a list of seven differently coloured chrysanthemums, which have all produced branches with yellow flowers; but three of them have also sported into other colours. With any change of colour in the flower, the foliage generally changes in a corresponding manner in lightness or darkness.

Another Compositous plant, namely, Centauria cyanus, when cultivated in a garden, not unfrequently produces on the same root flowers of four different colours, viz., blue, white, dark-purple, and parti-coloured.[36] The flowers of Anthemis also vary on the same plant.[37]

Roses.—Many varieties of the Rose are known or are believed to have originated by bud-variation.[38] The common double moss-rose was imported into England from Italy about the year 1735.[39] Its origin is unknown, but from analogy it probably arose from the Provence rose (*R. centifolia*) by bud-variation; for the branches of the common moss-rose have several times been known to produce Provence roses, wholly or partially destitute of moss: I have seen one such instance, and several others have been recorded.[40] Mr. Rivers also informs me that he raised two or three roses of the Provence class from seed of the old single moss-rose;[41] and this latter kind was produced in 1807 by bud-variation from the common moss-rose. The white moss-rose was also produced in 1788 by an offset from the common red moss-rose: it was at first pale blush-coloured, but became white by continued budding. On cutting down the shoots which had produced this white moss-rose, two weak shoots were thrown up, and buds from these yielded the beautiful striped moss-rose. The common moss-rose has yielded by bud-variation, besides the old single red moss-rose, the old scarlet semi-double moss-rose, and the sage-leaf moss-rose, which "has a delicate shell-like form, and is of a beautiful blush colour; it is now (1852) nearly extinct."[42] A white moss-rose has been seen to bear a flower half white and half pink.[43] Although several moss-roses have thus certainly arisen by bud-variation, the greater number probably owe their origin to seed of moss-roses. For Mr. Rivers informs me that his seedlings from the old single moss-rose almost always produced moss-roses; and the old single moss-rose was, as we have seen, the product by bud-variation of the double moss-rose originally imported from Italy. That the original moss-rose was the product of bud-variation is probable, from the facts above given and from the de Meaux moss-rose (also a variety of *R. centifolia*)[44] having appeared as a sporting branch on the common rose de Meaux. Prof. Caspary has carefully described[45] the case of a six-year-old white moss-rose, which sent up several suckers, one of which was thorny, and produced red flowers, destitute of moss, exactly like those of the Provence rose (*R. centifolia*): another shoot bore both kinds of flowers, and in addition longitudinally striped flowers. As this white moss-rose had been grafted on the Provence rose, Prof. Caspary attributes the above changes to the influence of the stock; but from the facts already given, and from others to be given, bud-variation, with reversion, is probably a sufficient explanation.

Many other instances could be added of roses varying by buds. The white Provence rose apparently originated in this way.[46] M. Carrière states (p. 36) that he himself knows of five varieties thus produced by the Baronne Prévost. The double and highly-coloured Belladonna rose has produced by suckers both semi-double and almost single white roses;[47] whilst suckers from one of these semi-double white roses reverted to perfectly characterised Belladonnas. In St. Domingo, varieties of the China rose propagated by cuttings often revert after a year or two into the old China rose.[48] Many cases have been recorded of roses suddenly becoming striped or changing their character by segments: some plants of the Comtesse de Chabrillant, which is properly rose-coloured, were exhibited in 1862,[49] with crimson flakes on a rose ground. I have seen the Beauty of Billiard with a quarter and with half the flower almost white. 'The Austrian bramble *R. lutea* not rarely[50] produces branches with pure yellow flowers; and Prof. Henslow has seen exactly half the flower of a pure yellow, and I have seen narrow yellow streaks on a single petal, of which the rest was of the usual copper colour.

The following cases are highly remarkable. Mr. Rivers, as I am informed by him, possessed a new French rose with delicate smooth shoots, pale glaucous-green leaves, and semi-double pale flesh-coloured flowers striped with dark red; and on branches thus characterised there suddenly appeared in more than one instance, the famous old rose called the Baronne Prevost, with its stout thorny shoots, and immense, uniformly and richly coloured double flowers; so that in this case the shoots, leaves, and flowers, all at once changed their character by bud-variation. According to M. Verlot,[51] a variety called *Rosa cannabifolia*, which has peculiarly shaped leaflets, and differs from every member of the family in the leaves being opposite instead of alternate, suddenly appeared on a plant of *R. alba* in the gardens of the Luxembourg. Lastly, "a running shoot" was observed by Mr. H. Curtis[52] on the old Aimée Vibert Noisette, and he budded it on Celine; thus a climbing Aimée Vibert was first produced and afterwards propagated.

Dianthus.—It is quite common with the Sweet William (*D. barbatus*) to see differently coloured flowers on the same root; and I have observed on the same truss four differently coloured and shaded flowers. Carnations and pinks (*D.*

caryophyllus, etc.) occasionally vary by layers; and some kinds are so little certain in character that they are called by floriculturists “catch-flowers.”[53] Mr. Dickson has ably discussed the “running” of particoloured or striped carnations, and says it cannot be accounted for by the compost in which they are grown: “layers from the same clean flower would come part of them clean and part foul, even when subjected to precisely the same treatment; and frequently one flower alone appears influenced by the taint, the remainder coming perfectly clean.”[54] This running of the parti-coloured flowers apparently is a case of reversion by buds to the original uniform tint of the species.

I will briefly mention some other cases of bud-variation to show how many plants belonging to many orders have varied in their flowers; and many others might be added. I have seen on a snap-dragon (*Antirrhinum majus*) white, pink, and striped flowers on the same plant, and branches with striped flowers on a red-coloured variety. On a double stock (*Matthiola incana*) I have seen a branch bearing single flowers; and on a dingy-purple double variety of the wall-flower (*Cheiranthus cheiri*), a branch which had reverted to the ordinary copper colour. On other branches of the same plant, some flowers were exactly divided across the middle, one half being purple and the other coppery; but some of the smaller petals towards the centre of these same flowers were purple longitudinally streaked with coppery colour, or coppery streaked with purple. A Cyclamen[55] has been observed to bear white and pink flowers of two forms, the one resembling the Persicum strain, and the other the Coum strain. *Oenothera biennis* has been seen[56] bearing flowers of three different colours. The hybrid *Gladiolus colvilii* occasionally bears uniformly coloured flowers, and one case is recorded[57] of all the flowers on a plant thus changing colour. A Fuchsia has been seen[58] bearing two kinds of flowers. *Mirabilis jalapa* is eminently sportive, sometimes bearing on the same root pure red, yellow, and white flowers, and others striped with various combinations of these three colours.[59] The plants of the Mirabilis, which bear such extraordinarily variable flowers in most, probably in all, cases, owe their origin, as shown by Prof. Lecoq, to crosses between differently coloured varieties.

Leaves and Shoots.—Changes, through bud-variation, in fruits and flowers have hitherto been treated of; incidentally some remarkable modifications in the leaves and shoots of the rose and Paritium, and in a lesser degree in the foliage of the Pelargonium and Chrysanthemum, have been noticed. I will now add a few more cases of variation in leaf-buds. Verlot[60] states that on *Aralia trifoliata*, which properly has leaves with three leaflets, branches frequently appear bearing simple leaves of various forms; these can be propagated by buds or by grafting, and have given rise, as he states, to several nominal species.

With respect to trees, the history of but few of the many varieties with curious or ornamental foliage is known; but several probably have originated by bud-variation. Here is one case:—An old ash-tree (*Fraxinus excelsior*) in the grounds of Necton, as Mr. Mason states, “for many years has had one bough of a totally different character to the rest of the tree, or of any other ash-tree which I have seen; being short-jointed and densely covered with foliage." It was ascertained that this variety could be propagated by grafts.[61] The varieties of some trees with cut leaves, as the oak-leaved laburnum, the parsley-leaved vine, and especially the fern-leaved beech, are apt to revert by buds to the common forms.[62] The fern-like leaves of the beech sometimes revert only partially, and the branches display here and there sprouts bearing common leaves, fern-like, and variously shaped leaves. Such cases differ but little from the so-called heterophyllus varieties, in which the tree habitually bears leaves of various forms; but it is probable that most heterophyllous trees have originated as seedlings. There is a sub-variety of the weeping willow with leaves rolled up into a spiral coil; and Mr. Masters states that a tree of this kind kept true in his garden for twenty-five years, and then threw out a single upright shoot bearing flat leaves.[63]

I have often noticed single twigs and branches on beech and other trees with their leaves fully expanded before those on the other branches had opened; and as there was nothing in their exposure or character to account for this difference, I presume that they had appeared as bud-variations, like the early and late fruit-maturing varieties of the peach and nectarine.

Cryptogamic plants are liable to bud-variation, for fronds on the same fern often display remarkable deviations of structure. Spores, which are of the nature of buds, taken from such abnormal fronds, reproduce, with remarkable fidelity, the same variety, after passing through the sexual stage.[64]

With respect to colour, leaves often become by bud-variation zoned, blotched, or spotted with white, yellow, and red; and this occasionally occurs even with plants in a state of nature. Variegation, however, appears still more frequently in plants produced from seed; even the cotyledons or seed-leaves being thus affected.[65] There have been endless disputes whether variegation should be considered as a disease. In a future chapter we shall see that it is much influenced, both in the case of seedlings and of mature plants, by the nature of the soil. Plants which have become variegated as seedlings, generally transmit their character by seed to a large proportion of their progeny; and Mr. Salter has given me a list of eight genera in which this occurred.[66] Sir F. Pollock has given me more precise information: he sowed seed from a variegated plant of *Ballota nigra* which was found growing wild, and thirty per cent of the seedlings were variegated; seed from these latter being sown, sixty per cent came up variegated. When branches become variegated by bud-variation, and the variety is attempted to be propagated by seed, the seedlings are rarely variegated: Mr. Salter found this to be the case with plants belonging to eleven genera, in which the greater number of the seedlings proved to be green-leaved; yet a few were slightly variegated, or were quite white, but none were worth keeping. Variegated plants, whether originally produced from seeds or buds, can generally be propagated by budding, grafting, etc.; but all are apt to revert by bud-variation to their ordinary foliage. This tendency, however, differs much in the varieties of even the same species; for instance, the golden-striped variety of *Euonymus japonicus* "is very liable to run back to the green-leaved, while the silver-striped variety hardly ever changes."[67] I have seen a variety of the holly, with its leaves having a central yellow patch, which had everywhere partially reverted to the ordinary foliage, so that on the same small branch there were many twigs of both kinds. In the pelargonium, and in some other plants, variegation is generally accompanied by some degree of dwarfing, as is well exemplified in the "Dandy" pelargonium. When such dwarf varieties sport back by buds or suckers to the ordinary foliage, the dwarfed stature still remains.[68] It is remarkable that plants propagated from branches which have reverted from variegated to plain leaves[69] do not always (or never, as one observer asserts) perfectly resemble the original plain-leaved plant from which the variegated branch arose: it seems that a plant, in passing by bud-variation from plain leaves to variegated, and back again from variegated to plain, is generally in some degree affected so as to assume a slightly different aspect.

Bud-variation by Suckers, Tubers, and Bulbs.—All the cases hitherto given of bud-variation in fruits, flowers, leaves, and shoots, have been confined to buds on the stems or branches, with the exception of a few cases incidentally noticed of varying suckers in the rose, pelargonium, and chrysanthemum. I will now give a few instances of variation in subterranean buds, that is, by suckers, tubers, and bulbs; not that there is any essential difference between buds above and beneath the ground. Mr. Salter informs me that two variegated varieties of Phlox originated as suckers; but I should not have thought these worth mentioning, had not Mr. Salter found, after repeated trials, that he could not propagate them by "root-joints," whereas, the variegated *Tussilago farfara* can thus be safely propagated;[70] but this latter plant may have originated as a variegated seedling, which would account for its greater fixedness of character. The Barberry (*Berberis vulgaris*) offers an analogous case; there is a well-known variety with seedless fruit, which can be propagated by cuttings or layers; but suckers always revert to the common form, which produces fruit containing seeds.[71] My father repeatedly tried this experiment, and always with the same result. I may here mention that maize and wheat sometimes produce new varieties from the stock or root, as does the sugar-cane.[72]

Turning now to tubers: in the common Potato (*Solanum tuberosum*) a single bud or eye sometimes varies and produces a new variety; or, occasionally, and this is a much more remarkable circumstance, all the eyes in a tuber vary in the same manner and at the same time, so that the whole tuber assumes a new character. For instance, a single eye in a tuber of the old *Forty-fold potato*, which is a purple variety, was observed[73] to become white; this eye was cut out and planted separately, and the kind has since been largely propagated. *Kemp's potato* is properly white, but a plant in Lancashire produced two tubers which were red, and two which were white; the red kind was propagated in the usual manner by eyes, and kept true to its new colour, and, being found a more productive variety, soon became widely known under the name of *Taylor's forty-fold*.[74] The old *Forty-fold potato*, as already stated, is a purple variety; but a plant long cultivated on the same ground produced, not, as in the case above given, a single white eye, but a whole white tuber, which has since been propagated and keeps true.[75] Several cases have been recorded of large portions of whole rows of potatoes slightly changing their character.[76]

Dahlias propagated by tubers under the hot climate of St. Domingo vary much; Sir R. Schomburgk gives the case of the "Butterfly variety," which the second year produced on the same plant "double and single flowers; here white petals edged with maroon; there of a uniform deep maroon."[77] Mr. Bree also mentions a plant "which bore two different kinds of self-coloured flowers, as well as a third kind which partook of both colours beautifully intermixed."[78] Another case is described of a dahlia with purple flowers which bore a white flower streaked with purple.[79]

Considering how long and extensively many Bulbous plants have been cultivated, and how numerous are the varieties produced from seed, these plants have not perhaps varied so much by offsets,—that is, by the production of new bulbs,—as might have been expected. With the Hyacinth, however, several instances have been given by M. Carrière. A case also has been recorded of a blue variety which for three successive years gave offsets producing white flowers with a red centre.[80] Another hyacinth bore[81] on the same truss a perfectly pink and a perfectly blue flower. I have seen a bulb producing at the same time one stalk or truss with fine blue flowers, another with fine red flowers, and a third with blue flowers on one side and red on the other; several of the flowers being also longitudinally striped red and blue.

Mr. John Scott informs me that in 1862 *Imatophyllum miniatum,* in the Botanic Gardens of Edinburgh, threw up a sucker which differed from the normal form, in the leaves being two-ranked instead of four-ranked. The leaves were also smaller, with the upper surface raised instead of being channelled.

In the propagation of *Tulips,* seedlings are raised, called *selfs* or *breeders,* which, "consist of one plain colour on a white or yellow bottom. These, being cultivated on a dry and rather poor soil, become broken or variegated and produce new varieties. The time that elapses before they break varies from one to twenty years or more, and sometimes this change never takes place."[82] The broken or variegated colours which give value to all tulips are due to bud-variation; for although the Bybloemens and some other kinds have been raised from several distinct breeders, yet all the Baguets are said to have come from a single breeder or seedling. This bud-variation, in accordance with the views of MM. Vilmorin and Verlot,[83] is probably an attempt to revert to that uniform colour which is natural to the species. A tulip, however, which has already become broken, when treated with too strong manure, is liable to flush or lose by a second act of reversion its variegated colours. Some kinds, as Imperatrix Florum, are much more liable than others to flushing; and Mr. Dickson maintains[84] that this can no more be accounted for than the variation of any other plant. He believes that English growers, from care in choosing seed from broken flowers instead of from plain flowers, have to a certain extent diminished the tendency in flowers already broken to flushing or secondary reversion. *Iris xiphium,* according to M. Carrière (p. 65), behaves in nearly the same manner, as do so many tulips.

During two consecutive years all the early flowers in a bed of *Tigridia conchiflora*[85] resembled those of the old *T. pavonia*; but the later flowers assumed their proper colour of fine yellow, spotted with crimson. An apparently authentic account has been published[86] of two forms of Hemerocallis, which have been universally considered as distinct species, changing into each other; for the roots of the large-flowered tawny *H. fulva,* being divided and planted in a different soil and place, produced the small-flowered *H. flava,* as well as some intermediate forms. It is doubtful whether such cases as these latter, as well as the "flushing" of broken tulips and the "running" of particoloured carnations,—that is, their more or less complete return to a uniform tint,—ought to be classed under bud-variation, or ought to be retained for the chapter in which I treat of the direct action of the conditions of life on organic beings. These cases, however, have this much in bud-variation, that the change is effected through buds and not through seminal reproduction. But, on the other hand, there is this difference—that in ordinary cases of bud-variation, one bud alone changes, whilst in the foregoing cases all the buds on the same plant were modified together. With the potato, we have seen an intermediate case, for all the eyes in one tuber simultaneously changed their character.

I will conclude with a few allied cases, which may be ranked either under bud-variation, or under the direct action of the conditions of life. When the common Hepatica is transplanted from its native woods, the flowers change colour, even during the first year.[87] It is notorious that the improved varieties of the Heartsease (*Viola tricolor*), when transplanted, often produce flowers widely different in size, form, and colour: for instance, I transplanted a large uniformly-coloured dark purple variety, whilst in full flower, and it then produced much smaller, more elongated flowers, with the lower petals yellow; these were succeeded by flowers marked with large purple spots, and ultimately, towards the end of the same summer, by the original large dark purple flowers. The slight changes which some fruit-trees undergo from being grafted and regrafted on various stocks,[88] were considered by Andrew Knight[89] as closely allied to "sporting branches," or bud-variations. Again, we have the case of young fruit-trees changing their character as they grow old; seedling pears, for instance, lose with age their spines and improve in the flavour of their fruit. Weeping birch-trees, when grafted on the common variety, do not acquire a perfect pendulous habit until they grow old: on the other hand, I shall hereafter give the case of some weeping ashes which slowly and gradually assumed an upright habit of growth. All such changes, dependent on age, may be compared with the changes, alluded to in the last chapter, which many trees naturally undergo; as in the case of the Deodar and Cedar of Lebanon, which are unlike in youth, whilst they closely resemble each other in old age; and as with certain oaks, and with some varieties of the lime and hawthorn.[90]

Graft-hybrids.—Before giving a summary on Bud-variation I will discuss some singular and anomalous cases, which are more or less closely related to this same subject. I will begin with the famous case of Adam's laburnum or *Cytisus adami,* a form or hybrid intermediate between two very distinct species, namely, *C. laburnum* and *purpureus*, the common and purple laburnum; but as this tree has often been described, I will be as brief as I can.

Throughout Europe, in different soils and under different climates, branches on this tree have repeatedly and suddenly reverted to the two parent species in their flowers and leaves. To behold mingled on the same tree tufts of dingy-red, bright yellow, and purple flowers, borne on branches having widely different leaves and manner of growth, is a surprising sight. The same raceme sometimes bears two kinds of flowers; and I have seen a single flower exactly divided into halves, one side being bright yellow and the other purple; so that one half of the standard-petal was yellow and of larger size, and the other half purple and smaller. In another flower the whole corolla was bright yellow, but exactly half the calyx was purple. In another, one of the dingy-red wing-petals had a narrow bright yellow stripe on it; and lastly, in another flower, one of the stamens, which had become slightly foliaceous, was half yellow and half purple; so that the tendency to segregation of character or reversion affects even single parts and organs.[91] The most remarkable fact about this tree is that in its intermediate state, even when growing near both parent-species, it is quite sterile; but when the flowers become pure yellow or pure purple they yield seed. I believe that the pods from the yellow flowers yield a full complement of seed; they certainly yield a larger number. Two seedlings raised by Mr. Herbert from such seed[92] exhibited a purple tinge on the stalks of their flowers; but several seedlings raised by myself resembled in every character the common laburnum, with the exception that some of them had remarkably long racemes: these seedlings were perfectly fertile. That such purity of character and fertility should be suddenly reacquired from so hybridised and sterile a form is an astonishing phenomenon. The branches with purple flowers appear at first sight exactly to resemble those of *C. purpureus*; but on careful comparison I found that they differed from the pure species in the shoots being thicker, the leaves a little broader, and the flowers slightly shorter, with the corolla and calyx less brightly purple: the basal part of the standard-petal also plainly showed a trace of the yellow stain. So that the flowers, at least in this instance, had not perfectly recovered their true character; and in accordance with this, they were not perfectly fertile, for many of the pods contained no seed, some produced one, and very few contained as many as two seeds; whilst numerous pods on a tree of the pure *C. purpureus* in my garden contained three, four, and five fine seeds. The pollen, moreover, was very imperfect, a multitude of grains being small and shrivelled; and this is a singular fact; for, as we shall immediately see, the pollen-grains in the dingy-red and sterile flowers on the parent-tree, were, in external appearance, in a much better state, and included very few shrivelled grains. Although the pollen of the reverted purple flowers was in so poor a condition, the ovules were well formed, and the seeds, when mature, germinated freely with me. Mr. Herbert raised plants from seeds of the reverted purple flowers, and they differed a *very little* from the usual state of *C. purpureus*. Some which I raised in the same manner did not differ at all, either in the character of their flowers or of the whole bush, from the pure *C. purpureus*.

Prof. Caspary has examined the ovules of the dingy-red and sterile flowers in several plants of *C. adami* on the Continent,[93] and finds them generally monstrous. In three plants examined by me in England, the ovules were likewise monstrous, the nucleus varying much in shape, and projecting irregularly beyond the proper coats. The pollen grains, on the other hand, judging from their external appearance, were remarkably good, and readily protruded their tubes. By repeatedly counting, under the microscope, the proportional number of bad grains, Prof. Caspary ascertained that only 2·5 per cent were bad, which is a less proportion than in the pollen of three pure species of Cytisus in their cultivated state, viz., *C. purpureus*, *laburnum*, and *alpinus*. Although the pollen of *C. adami* is thus in appearance good, it does not follow, according to M. Naudin's observation[94] on Mirabilis, that it would be functionally effective. The fact of the ovules of *C. adami* being monstrous, and the pollen apparently sound, is all the more remarkable, because it is opposed to what usually occurs not only with most hybrids,[95] but with two hybrids in the same genus, namely in *C. purpureo-elongatus*, and *C. alpino-laburnum*. In both these hybrids, the ovules, as observed by Prof. Caspary and myself, were well-formed, whilst many of the pollen-grains were ill-formed; in the latter hybrid 20.3 per cent, and in the former no less than 84·8 per cent of the grains were ascertained by Prof. Caspary to be bad. This unusual condition of the male and female reproductive elements in *C. adami* has been used by Prof. Caspary as an argument against this plant being considered as an ordinary hybrid produced from seed; but we should remember that with hybrids the ovules have not been examined nearly so frequently as the pollen, and they may be much oftener imperfect than is generally supposed. Dr. E. Bornet, of Antibes, informs me (through Mr. J. Traherne Moggridge) that with hybrid Cisti the ovarium is frequently deformed, the ovules being in some cases quite absent, and in other cases incapable of fertilisation.

Several theories have been propounded to account for the origin of *C. adami*, and for the transformations which it undergoes. The whole case has been attributed by some authors to bud-variation; but considering the wide difference between *C. laburnum* and *purpureus*, both of which are natural species, and considering the sterility of the intermediate form, this view may be summarily rejected. We shall presently see that, with hybrid plants, two embryos differing in their characters may be developed within the same seed and cohere; and it has been supposed that *C. adami* thus originated. Many botanists maintain that *C. adami* is a hybrid produced in the common way by seed, and that it has reverted by buds to its two parent-forms. Negative results are not of much value; but Reisseck, Caspary, and myself, tried in vain to cross *C. laburnum* and *purpureus*; when I fertilised the former with pollen of the latter, I had the nearest approach to success, for pods were formed, but in sixteen days after the withering of the flowers, they fell off. Nevertheless, the belief that *C. adami* is a spontaneously produced hybrid between these two species is supported by the fact that such hybrids have arisen in this genus. In a bed of seedlings from *C. elongatus*, which grew near to *C. purpureus*, and was probably fertilised by it through the agency of insects (for these, as I know by experiment, play an important part in the fertilisation of the laburnum), the sterile hybrid *C. purpureo-elongatus* appeared.[96] Thus, also, Waterer's laburnum, the *C. alpino-laburnum*,[97] spontaneously appeared, as I am informed by Mr. Waterer, in a bed of seedlings.

On the other hand, we have a clear and distinct account given to Poiteau,[98] by M. Adam, who raised the plant, showing that *C. adami* is not an ordinary hybrid; but is what may be called a graft-hybrid, that is, one produced from the united cellular tissue of two distinct species. M. Adam inserted in the usual manner a shield of the bark of *C. purpureus* into a stock of *C. laburnum*; and the bud lay dormant, as often happens, for a year; the shield then produced many buds and shoots, one of which grew more upright and vigorous with larger leaves than the shoots of *C. purpureus*, and was consequently propagated. Now it deserves especial notice that these plants were sold by M. Adam, as a variety of *C. purpureus*, before they had flowered; and the account was published by Poiteau after the plants had flowered, but before they had exhibited their remarkable tendency to revert into the two parent species. So that there was no conceivable motive for falsification, and it is difficult to see how there could have been any error.[99] If we admit as true M. Adam's account, we must admit the extraordinary fact that two distinct species can unite by their cellular tissue, and subsequently produce a plant bearing leaves and sterile flowers intermediate in character between the scion and stock, and producing buds liable to reversion; in short, resembling in every important respect a hybrid formed in the ordinary way by seminal reproduction.

I will therefore give all the facts which I have been able to collect on the formation of hybrids between distinct species or varieties, without the intervention of the sexual organs. For if, as I am now convinced, this is possible, it is a most important fact, which will sooner or later change the views held by physiologists with respect to sexual reproduction. A sufficient body of facts will afterwards be adduced, showing that the segregation or separation of the characters of the two parent-forms by bud-variation, as in the case of *Cytisus adami*, is not an unusual though a striking phenomenon. We shall further see that a whole bud may thus revert, or only half, or some smaller segment.

The famous *bizzarria Orange* offers a strictly parallel case to that of *Cytisus adami*. The gardener who in 1644 in Florence raised this tree, declared that it was a seedling which had been grafted; and after the graft had perished, the stock sprouted and produced the bizzarria. Gallesio, who carefully examined several living specimens and compared them with the description given by the original describer, P. Nato,[100] states that the tree produces at the same time leaves, flowers, and fruit identical with the bitter orange and with the citron of Florence, and likewise compound fruit, with the two kinds either blended together, both externally and internally, or segregated in various ways. This tree can be propagated by cuttings, and retains its diversified character. The so-called trifacial orange of Alexandria and Smyrna[101] resembles in its general nature the bizzarria, and differs only in the orange being of the sweet kind; this and the citron are blended together in the same fruit, or are separately produced on the same tree; nothing is known of its origin. In regard to the bizzarria, many authors believe that it is a graft-hybrid; Gallesio, on the other hand, thinks that it is an ordinary hybrid, with the habit of partially reverting by buds to the two parent-forms; and we have seen that the species in this genus often cross spontaneously.

It is notorious that when the variegated Jessamine is budded on the common kind, the stock sometimes produces buds bearing variegated leaves: Mr. Rivers, as he informs me, has seen instances of this. The same thing occurs with the Oleander.[102] Mr. Rivers, on the authority of a trustworthy friend, states that some buds of a golden-variegated ash, which were inserted into common ashes, all died except one; but the ash-stocks were affected,[103] and produced, both above and below the points of insertion of the plates of bark bearing the dead buds, shoots which bore variegated leaves. Mr. J. Anderson Henry has communicated to me a nearly similar case: Mr. Brown, of Perth, observed many years ago, in a Highland glen, an ash-tree with yellow leaves; and buds taken from this tree were inserted into common ashes, which in consequence were affected, and produced the *Blotched Breadalbane Ash.* This variety has been propagated, and has preserved its character during the last fifty years. Weeping ashes, also, were budded on the affected stocks, and became similarly variegated. It has been repeatedly proved that several species of Abutilon, on which the variegated *A. thompsonii* has been grafted, become variegated.[104]

Many authors consider variegation as the result of disease; and the foregoing cases may be looked at as the direct result of the inoculation of a disease or some weakness. This has been almost proved to be the case by Morren in the excellent paper just referred to, who shows that even a leaf inserted by its footstalk into the bark of the stock is sufficient to communicate variegation to it, though the leaf soon perishes. Even fully formed leaves on the stock of Abutilon are sometimes affected by the graft and become variegated. Variegation is much influenced, as we shall hereafter see, by the nature of the soil in which the plants are grown; and it does not seem improbable that whatever change in the sap or tissues certain soils induce, whether or not called a disease, might spread from the inserted piece of bark to the stock. But a change of this kind cannot be considered to be of the nature of a graft-hybrid.

There is a variety of the hazel with dark-purple leaves, like those of the copper-beech: no one has attributed this colour to disease, and it apparently is only an exaggeration of a tint which may often be seen on the leaves of the common hazel. When this variety is grafted on the common hazel,[105] it sometimes colours, as has been asserted, the leaves below the graft; although negative evidence is not of much value, I may add that Mr. Rivers, who has possessed hundreds of such grafted trees, has never seen an instance.

Gärtner[106] quotes two separate accounts of branches of dark and white-fruited vines which had been united in various ways, such as being split longitudinally, and then joined, etc.; and these branches produced distinct bunches of grapes of the two colours, and other bunches with berries, either striped, or of an intermediate and new tint. Even the leaves in one case were variegated. These facts are the more remarkable because Andrew Knight never succeeded in raising variegated grapes by fertilising white kinds by pollen of dark kinds; though, as we have seen, he obtained seedlings with variegated fruits and leaves, by fertilising a white variety by the already variegated dark Aleppo grape. Gärtner attributes the above-quoted cases merely to bud-variation; but it is a strange coincidence that the branches which had been grafted in a peculiar manner should alone thus have varied; and H. Adorne de Tscharner positively asserts that he produced the described result more than once, and could do so at will, by splitting and uniting the branches in the manner described by him.

I should not have quoted the following case had not the author of ‘Des Jacinthes’[107] impressed me with the belief not only of his extensive knowledge, but of his truthfulness: he says that bulbs of blue and red hyacinths may be cut in two, and that they will grow together and throw up a united stem (and this I have myself seen) with flowers of the two colours on the opposite sides. But the remarkable point is, that flowers are sometimes produced with the two colours blended together, which makes the case closely analogous with that of the blended colours of the grapes on the united vine branches.

In the case of roses it is supposed that several graft-hybrids have been formed, but there is much doubt about these cases, owing to the frequency of ordinary bud-variations. The most trustworthy instance known to me is one, recorded by Mr. Poynter,[108] who assures me in a letter of the entire accuracy of the statement. *Rosa devoniensis* had been budded some years previously on a white Banksian rose; and from the much enlarged point of junction, whence the Devoniensis and Banksian still continued to grow, a third branch issued, which was neither pure Banksian nor pure Devoniensis, but partook of the character of both; the flowers resembled, but were superior in character to those of the variety called *Lamarque* (one of the Noisettes), while the shoots were similar in their manner of growth to those of the Banksian rose, with the exception that the longer and more robust shoots were furnished with prickles. This rose was exhibited before the Floral Committee of the Horticultural Society of London. Dr. Lindley examined it and concluded that it had certainly been produced by the mingling of *R. banksiæ* with some rose like *R. devoniensis*, “for while it was very greatly increased in vigour and in size of all the parts, the leaves were half-way between a Banksian and Tea-scented rose.” It appears that rose-growers were previously aware that the Banksian rose sometimes affects other roses. As Mr. Poynter’s new variety is intermediate in its fruit and foliage between the stock and scion, and as it arose from the point of junction between the two, it is very improbable that it owes its origin to mere bud-variation, independently of the mutual influence of the stock and scion.

Lastly, with respect to potatoes. Mr. R. Trail stated in 1867 before the Botanical Society of Edinburgh (and has since given me fuller information), that several years ago he cut about sixty blue and white potatoes into halves through the eyes or buds, and then carefully joined them, destroying at the same time the other eyes. Some of these united tubers produced white, and others blue tubers; some, however, produced tubers partly white and partly blue; and the tubers from about four or five were regularly mottled with the two colours. In these latter cases we may conclude that a stem had been formed by the union of the bisected buds, that is, by graft-hybridisation.

In the 'Botanische Zeitung' (May 16, 1868), Professor Hildebrand gives an account with a coloured figure, of his experiments on two varieties which were found during the same season to be constant in character, namely, a somewhat elongated rough-skinned red potato and a rounded smooth white one. He inserted buds reciprocally into both kinds, destroying the other buds. He thus raised two plants, and each of these produced a tuber intermediate in character between the two parent-forms. That from the red bud grafted into the white tuber, was at one end red and rough, as the whole tuber ought to have been if not affected; in the middle it was smooth with red stripes, and at the other end smooth and altogether white like that of the stock.

Mr. Taylor, who had received several accounts of potatoes having been grafted by wedge-shaped pieces of one variety inserted into another, though sceptical on the subject, made twenty-four experiments which he described in detail before the Horticultural Society.[109] He thus raised many new varieties, some like the graft or like the stock; others having an intermediate character. Several persons witnessed the digging up of the tubers from these graft-hybrids; and one of them, Mr. Jameson, a large dealer in potatoes, writes thus, "They were such a mixed lot, as I have never before or since seen. They were of all colours and shapes, some very ugly and some very handsome." Another witness says "some were round, some kidney, pink-eyed kidney, piebald, and mottled red and purple, of all shapes and sizes." Some of these varieties have been found valuable, and have been extensively propagated. Mr. Jameson took away a large piebald potato which he cut into five sets and propagated; these yielded round, white, red, and piebald potatoes.

Mr. Fitzpatrick followed a different plan;[110] he grafted together not the tubers but the young stems of varieties producing black, white, and red potatoes. The tubers borne by three of these twin or united plants were coloured in an extraordinary manner; one was almost exactly half black and half white, so that some persons on seeing it thought that two potatoes had been divided and rejoined; other tubers were half red and half white, or curiously mottled with red and white, or with red and black, according to the colours of the graft and stock.

The testimony of Mr. Fenn is of much value, as he is "a well known potato-grower" who has raised many new varieties by crossing different kinds in the ordinary manner. He considers it "demonstrated" that new, intermediate varieties can be produced by grafting the tubers, though he doubts whether such will prove valuable.[111] He made many trials and laid the results, exhibiting specimens, before the Horticultural Society. Not only were the tubers affected, some being smooth and white at one end and rough and red at the other, but the stems and leaves were modified in their manner of growth, colour and precocity. Some of these graft-hybrids after being propagated for three years still showed in their haulms their new character, different from that of the kind from which the eyes had been taken. Mr. Fenn gave twelve of the tubers of the third generation to Mr. Alex. Dean, who grew them, and was thus converted into a believer in graft-hybridisation, having previously been a complete sceptic. For comparison he planted the pure parent-forms alongside the twelve tubers; and found that many of the plants from the latter[112] were intermediate between the two parent-forms in precocity, in the tallness, uprightness, jointing, and robustness of the stems, and in the size and colour of the leaves.

Another experimentalist, Mr. Rintoul, grafted no less than fifty-nine tubers, which differed in shape (some being kidneys) in smoothness and colour,[113] and many of the plants thus raised "were intermediate in the tubers as well as in the haulms." He describes the more striking cases.

In 1871 I received a letter from Mr. Merrick, of Boston, U.S.A., who states that, "Mr. Fearing Burr, a very careful experimenter and author of a much valued book, 'The Garden Vegetables of America' has succeeded in producing distinctly mottled and most curious potatoes—evidently graft-hybrids, by inserting eyes from blue or red potatoes into the substance of white ones, after removing the eyes of the latter. I have seen the potatoes, and they are very curious."

We will now turn to the experiments made in Germany, since the publication of Prof. Hildebrand's paper. Herr Magnus relates[114] the results of numerous trials made by Herren Reuter and Lindemuth, both attached to the Royal Gardens of Berlin. They inserted the eyes of red potatoes into white ones, and *vice versa*. Many different forms partaking of the characters of the inserted bud and of the stock were thus obtained; for instance, some of the tubers were white with red eyes.

Herr Magnus also exhibited in the following year before the same Society (Nov. 19, 1872), the produce of grafts between black, white, and red potatoes, made by Dr. Neubert. These were made by uniting not the tubers but the young stems, as was done by Mr. Fitzpatrick. The result was remarkable, inasmuch as all the tubers thus produced were intermediate in character, though in a variable degree. Those between the black and the white or the red were the most striking in appearance. Some from between the white and red had one half of one colour and the other half of the other colour.

At the next meeting of the society Herr Magnus communicated the results of Dr. Heimann's experiments in grafting together the tubers of red Saxon, blue, and elongated white potatoes. The eyes were removed by a cylindrical instrument, and inserted into corresponding holes in other varieties. The plants thus produced yielded a great number of tubers, which were intermediate between the two parent-forms in shape, and in the colour both of the flesh and skin.

Herr Reuter experimented,[115] by inserting wedges of the elongated White Mexican potato into a Black Kidney potato. Both sorts are known to be very constant, and differ much not only in form and colour, but in the eyes of the Black Kidney being deeply sunk, whereas those of the White Mexican are superficial and of a different shape. The tubers produced by these hybrids were intermediate in colour and form; and some which resembled in form the graft, *i.e.* the Mexican, had eyes deeply sunk and of the same shape as in the stock or Black Kidney.

Any one who will attentively consider the abstract now given, of the experiments made by many observers in several countries, will, I think, be convinced that by grafting two varieties of the potato together in various ways, hybridised plants can be produced. It should be observed that several of the experimentalists are scientific horticulturists, and some of them potato-growers on a large scale, who, though beforehand sceptical, have been fully convinced of the possibility, even of the ease, of making graft-hybrids. The only way of escaping from this conclusion is to attribute all the many recorded cases to simple bud-variation. Undoubtedly the potato, as we have seen in this chapter, does sometimes, though not often, vary by buds; but it should be especially noted that it is experienced potato-growers, whose business it is to look out for new varieties, who have expressed unbounded astonishment at the number of new forms produced by graft-hybridisation. It may be argued that it is merely the operation of grafting, and not the union of two kinds, which causes so extraordinary an amount of bud-variation; but this objection is at once answered by the fact that potatoes are habitually propagated by the tubers being cut into pieces, and the sole difference in the case of graft-hybrids is that either a half or a smaller segment or a cylinder is placed in close opposition with the tissue of another variety. Moreover, in two cases, the young stems were grafted together, and the plants thus united yielded the same results as when the tubers were united. It is an argument of the greatest weight that when varieties are produced by simple bud-variation, they frequently present quite new characters; whereas in all the numerous cases above given, as Herr Magnus likewise insists, the graft-hybrids are intermediate in character between the two forms employed. That such a result should follow if the one kind did not affect the other is incredible.

Characters of all kinds are affected by graft hybridisation, in whatever way the grafting may have been effected. The plants thus raised yield tubers which partake of the widely different colours, form, state of surface, position and shape of the eye of the parents; and according to two careful observers they are also intermediate in certain constitutional peculiarities. But we should bear in mind that in all the varieties of the potato, the tubers differ much more than any other part.

The potato affords the best evidence of the possibility of the formation of graft-hybrids, but we must not overlook the account given of the origin of the famous *Cytisus* *adami* by M. Adam, who had no conceivable motive for deception, and the exactly parallel account of the origin of the Bizzarria orange, namely by graft-hybridisation. Nor must the cases be undervalued in which different varieties or species of vines, hyacinths and roses, have been grafted together, and have yielded intermediate forms. It is evident that graft-hybrids can be made much more easily with some plants, as the potato, than with others, for instance our common fruit trees; for these latter have been grafted by the million during many centuries, and though the graft is often slightly affected, it is very doubtful whether this may not be accounted for, merely by a more or less free supply of nutriment. Nevertheless, the cases above given seem to me to prove that under certain unknown conditions graft-hybridisation can be effected.

Herr Magnus asserts with much truth that graft-hybrids resemble in all respects seminal hybrids, including their great diversity of character. There is, however, a partial exception, inasmuch as the characters of the two parent forms are not often homogeneously blended together in graft-hybrids. They much more commonly appear in a segregated condition,—that is, in segments either at first, or subsequently through reversion. It would seem that the reproductive elements are not so completely blended by grafting as by sexual generation. But segregation of this kind occurs by no means rarely, as will be immediately shown, in seminal hybrids. Finally it must, I think, be admitted that we learn from the foregoing cases a highly important physiological fact, namely, that the elements that go to the production of a new being, are not necessarily formed by the male and female organs. They are present in the cellular tissue in such a state that they can unite without the aid of the sexual organs, and thus give rise to a new bud partaking of the characters of the two parent-forms.

On the segregation of the parental characters in seminal hybrids by bud-variation.—I will now give a sufficient number of cases to show that segregation of this kind, namely, by buds, may occur in ordinary hybrids raised from seed.

Hybrids were raised by Gärtner between *Tropæolum minus* and *majus*[116] which at first produced flowers intermediate in size, colour, and structure between their two parents; but later in the season some of these plants produced flowers in all respects like those of the mother-form, mingled with flowers still retaining the usual intermediate condition. A hybrid Cereus between *C. speciosissimus* and *phyllanthus,*[117] plants which are widely different in appearance, produced for the first three years angular, five-sided stems, and then some flat stems like those of *C. phyllanthus.* Kölreuter also gives cases of hybrid Lobelias and Verbascums, which at first produced flowers of one colour, and later in the season, flowers of a different colour.[118] Naudin[119] raised forty hybrids from *Datura lævis* fertilised by *D. stramonium*; and three of these hybrids produced many capsules, of which a half, or quarter, or lesser segment was smooth and of small size, like the capsule of the pure *D. lævis,* the remaining part being spinose and of larger size, like the capsule of the pure *D. stramonium*: from one of these composite capsules, plants perfectly resembling both parent-forms were raised.

Turning now to varieties. A *seedling* apple, conjectured to be of crossed parentage, has been described in France,[120] which bears fruit with one half larger than the other, of a red colour, acid taste, and peculiar odour; the other side being greenish-yellow and very sweet: it is said scarcely ever to include perfectly developed seed. I suppose that this is not the same tree as that which Gaudichaud[121] exhibited before the French institute, bearing on the same branch two distinct kinds of apples, one a *reinette rouge*, and the other like a *reinette canada jaunâtre*: this double-bearing variety can be propagated by grafts, and continues to produce both kinds; its origin is unknown. The Rev. J. D. La Touche sent me a coloured drawing of an apple which he brought from Canada, of which half, surrounding and including the whole of the calyx and the insertion of the foot-stalk, is green, the other half being brown and of the nature of the *pomme gris* apple, with the line of separation between the two halves exactly defined. The tree was a grafted one, and Mr. La Touche thinks that the branches which bore this curious apple sprung from the point of junction of the graft and stock: had this fact been ascertained, the case would probably have come into the class of graft-hybrids already given. But the branch may have sprung from the stock, which no doubt was a seedling.

Prof. H. Lecoq, who has made a great number of crossings between the differently coloured varieties of *Mirabilis jalapa*,[122] finds that in the seedlings the colours rarely combine, but form distinct stripes; or half the flower is of one colour and half of a different colour. Some varieties regularly bear flowers striped with yellow, white, and red; but plants of such varieties occasionally produce on the same root branches with uniformly coloured flowers of all three tints, and other branches with half-and-half coloured flowers, and others with marbled flowers. Gallesio[123] crossed reciprocally white and red carnations, and the seedlings were striped; but some of the striped plants also bore entirely white and entirely red flowers. Some of these plants produced one year red flowers alone, and in the following year striped flowers; or conversely, some plants, after having borne for two or three years striped flowers, would revert and bear exclusively red flowers. It may be worth mentioning that I fertilised the *Purple Sweet-pea (Lathyrus odoratus)* with pollen from the light-coloured *Painted Lady*: seedlings raised from the same pod were not intermediate in character, but perfectly resembled either parent. Later in the summer, the plants which had at first borne flowers identical with those of the *Painted Lady*, produced flowers streaked and blotched with purple; showing in these darker marks a tendency to reversion to the mother-variety. Andrew Knight[124] fertilised two white grapes with pollen of the Aleppo grape, which is darkly variegated both in its leaves and fruit. The result was that the young seedlings were not at first variegated, but all became variegated during the succeeding summer; besides this, many produced on the same plant bunches of grapes which were all black, or all white, or lead-coloured striped with white, or white dotted with minute black stripes; and grapes of all these shades could frequently be found on the same foot-stalk.

I will append a very curious case, not of bud-variation, but of two cohering embryos, different in character and contained within the same seed. A distinguished botanist, Mr. G. H. Thwaites,[125] states that a seed from *Fuchsia coccinea* fertilised by *F. fulgens,* contained two embryos, and was "a true vegetable twin." The two plants produced from the two embryos were "extremely different in appearance and character," though both resembled other hybrids of the same parentage produced at the same time. These twin plants "were closely coherent, below the two pairs of cotyledon-leaves, into a single cylindrical stem, so that they had subsequently the appearance of being branches on one trunk." Had the two united stems grown up to their full height, instead of dying, a curiously mixed hybrid would have been produced. A mongrel melon described by Sageret[126] may perhaps have thus originated; for the two main branches, which arose from two cotyledon-buds, produced very different fruit,—on the one branch like that of the paternal variety, and on the other branch like to a certain extent that of the maternal variety, the melon of China.

In most of these cases of crossed varieties, and in some of the cases of crossed species, the colours proper to both parents appeared in the seedlings, as soon as they first flowered, in the form of stripes or larger segments, or as whole flowers or fruit of different kinds borne on the same plant; and in this case the appearance of the two colours cannot strictly be said to be due to reversion, but to some incapacity of fusion. When, however, the later flowers or fruit produced during the same season, or during a succeeding year or generation, become striped or half-and-half, etc., the segregation of the two colours is strictly a case of reversion by bud-variation. Whether all the many recorded cases of striped flowers and fruit are due to previous hybridisation and reversion is by no means clear, for instance with peaches and nectarines, moss-roses, etc. In a future chapter I shall show that, with animals of crossed parentage, the same individual has been known to change its character during growth, and to revert to one of its parents which it did not at first resemble. Finally, from the various facts now given, there can be no doubt that the same individual plant, whether a hybrid or a mongrel, sometimes returns in its leaves, flowers, and fruit, either wholly or by segments, to both parent-forms.

On the direct or immediate action of the male element on the mother form.—Another remarkable class of facts must be here considered, firstly, because they have a high physiological importance, and secondly, because they have been supposed to account for some cases of bud-variation. I refer to the direct action of the male element, not in the ordinary way on the ovules, but on certain parts of the female plant, or in case of animals on the subsequent progeny of the female by a second male. I may premise that with plants the ovarium and the coats of the ovules are obviously parts of the female, and it could not have been anticipated that they would have been affected by the pollen of a foreign variety or species, although the development of the embryo, inside the embryonic sack, inside the ovule and ovarium, of course, depends on the male element.

Even as long ago as 1729 it was observed[127] that white and blue varieties of the Pea, when planted near each other, mutually crossed, no doubt through the agency of bees, and in the autumn blue and white peas were found within the same pods. Wiegmann made an exactly similar observation in the present century. The same result has followed several times when a variety with peas of one colour has been artificially crossed by a differently-coloured variety.[128] These statements led Gärtner, who was highly sceptical on the subject, carefully to try a long series of experiments: he selected the most constant varieties, and the result conclusively showed that the colour of the skin of the pea is modified when pollen of a differently coloured variety is used. This conclusion has since been confirmed by experiments made by the Rev. J. M. Berkeley.[129]

Mr. Laxton of Stamford, whilst making experiments on peas for the express purpose of ascertaining the influence of foreign pollen on the mother-plant, has recently[130] observed an important additional fact. He fertilised the Tall Sugar-pea, which bears very thin green pods, becoming brownish-white when dry, with pollen of the Purple-podded pea, which, as its name expresses, has dark-purple pods with very thick skin, becoming pale reddish purple when dry. Mr. Laxton has cultivated the tall sugar-pea during twenty years, and has never seen or heard of it producing a purple pod: nevertheless, a flower fertilised by pollen from the purple-pod yielded a pod clouded with purplish-red which Mr. Laxton kindly gave to me. A space of about two inches in length towards the extremity of the pod, and a smaller space near the stalk, were thus coloured. On comparing the colour with that of the purple pod, both pods having been first dried and then soaked in water, it was found to be identically the same; and in both the colour was confined to the cells lying immediately beneath the outer skin of the pod. The valves of the crossed pod were also decidedly thicker and stronger than those of the pods of the mother-plant, but this may possibly have been an accidental circumstance, for I know not how far their thickness is a variable character in the Tall Sugar-pea.

The peas of the Tall Sugar-pea, when dry, are pale greenish-brown, thickly covered with dots of dark purple so minute as to be visible only through a lens, and Mr. Laxton has never seen or heard of this variety producing a purple pea; but in the crossed pod one of the peas was of a uniform beautiful violet-purple tint, and a second was irregularly clouded with pale purple. The colour lies in the outer of the two coats which surround the pea. As the peas of the purple-podded variety when dry are of a pale greenish-buff, it would at first appear that this remarkable change of colour in the peas in the crossed pod could not have been caused by the direct action of the pollen of the purple-pod: but when we bear in mind that this latter variety has purple flowers, purple marks on its stipules, and purple pods; and that the Tall Sugar-pea likewise has purple flowers and stipules, and microscopically minute purple dots on the peas, we can hardly doubt that the tendency to the production of purple in both parents has in combination modified the colour of the peas in the crossed pod. After having examined these specimens, I crossed the same two varieties, and the peas in one pod but not the pods themselves, were clouded and tinted with purplish-red in a much more conspicuous manner than the peas in the uncrossed pods produced at the same time by the same plants. I may notice as a caution that Mr. Laxton sent me various other crossed peas slightly, or even greatly, modified in colour; but the change in these cases was due, as had been suspected by Mr. Laxton, to the altered colour of the cotyledons, seen through the transparent coats of the peas; and as the cotyledons are parts of the embryo, these cases are not in any way remarkable.

Turning now to the genus Matthiola. The pollen of one kind of stock sometimes affects the colour of the seeds of another kind, used as the mother-plant. I give the following case the more readily, as Gärtner doubted similar statements previously made with respect to the stock by other observers. A well-known horticulturist, Major Trevor Clarke, informs me[131] that the seeds of the large red-flowered *biennial* stock, *Matthiola annua* (*Cocardeau* of the French), are light brown, and those of the purple branching Queen stock (*M. incana*) are violet-black; and he found that, when flowers of the red stock were fertilised by pollen from the purple stock, they yielded about fifty per cent of *black* seeds. He sent me four pods from a red flowered plant, two of which had been fertilised by their own pollen, and they included pale brown seed; and two which had been crossed by pollen from the purple kind, and they included seeds all deeply tinged with black. These latter seeds yielded purple-flowered plants like their father; whilst the pale brown seeds yielded normal red-flowered plants; and Major Clarke, by sowing similar seeds, has observed on a greater scale the same result. The evidence in this case of the direct action of the pollen of one species on the colour of the seeds of another species appears to me conclusive.

Gallesio[132] fertilised the flowers of an orange with pollen from the lemon; and one fruit thus produced bore a longitudinal stripe of peel having the colour, flavour, and other characters of the lemon. Mr. Anderson[133] fertilised a green-fleshed melon with pollen from a scarlet-fleshed kind; in two of the fruits "a sensible change was perceptible: and four other fruits were somewhat altered both internally and externally." The seeds of the two first-mentioned fruits produced plants partaking of the good properties of both parents. In the United States, where Cucurbitaceæ are largely cultivated, it is the popular belief[134] that the fruit is thus directly affected hy foreign pollen; and I have received a similar statement with respect to the cucumber in England. It is believed that grapes have been thus affected in colour, size, and shape: in France a pale-coloured grape had its juice tinted by the pollen of the dark-coloured Teinturier; in Germany a variety bore berries which were affected by the pollen of two adjoining kinds; some of the berries being only partially affected or mottled.[135]

As long ago as 1751[136] it was observed that, when differently-coloured varieties of maize grew near each other, they mutually affected each other's seeds, and this is now a popular belief in the United States. Dr. Savi[137] tried the experiment with care: he sowed yellow and black-seeded maize together, and on the same ear some of the seeds were yellow, some black, and some mottled, the differently coloured seeds being arranged irregularly or in rows. Prof. Hildebrand has repeated the experiment[138] with the precaution of ascertaining that the mother-plant was true. A kind bearing yellow grains was fertilised with pollen of a kind having brown grains, and two ears produced yellow grains mingled with others of a dirty violet tint. A third ear had only yellow grains, but one side of the spindle was tinted of a reddish-brown; so that here we have the important fact of the influence of the foreign pollen extending to the axis. Mr. Arnold, in Canada, varied the experiment in an interesting manner: "a female flower was subjected first to the action of pollen from a yellow variety, and then to that from a white variety; the result was an ear, each grain of which was yellow below and white above."[139] With other plants it has occasionally been observed that the crossed offspring showed the influence of two kinds of pollen, but in this case the two kinds affected the mother-plant.

Mr. Sabine states[140] that he has seen the form of the nearly globular seed-capsule of *Amaryllis vittata* altered by the application of the pollen of another species, of which the capsule has gibbous angles. With an allied genus, a well-known botanist, Maximowicz, has described in detail the striking results of reciprocally fertilising *Lilium bulbiferum* and *davuricum* with each other's pollen. Each species produced fruit not like its own, but almost identical with that of the pollen-bearing species; but from an accident only the fruit of the latter species was carefully examined; the seeds were intermediate in the development of their wings.[141]

Fritz Müller fertilised *Cattleya leopoldi* with pollen of *Epidendron cinnabarinum*; and the capsules contained very few seeds; but these presented a most wonderful appearance, which, from the description given, two botanists, Hildebrand and Maximowicz, attribute to the direct action of the pollen of the Epidendron.[142]

Mr. J. Anderson Henry[143] crossed *Rhododendron dalhousiæ* with the pollen of *R. nuttallii*, which is one of the largest-flowered and noblest species of the genus. The largest pod produced by the former species, when fertilised with its own pollen, measured 1¼ inch in length and 1½ in girth; whilst three of the pods which had been fertilised by pollen of *R. nuttallii* measured 1-5/8 inch in length and no less than 2 inches in girth. Here the effect of the foreign pollen was apparently confined to increasing the size of the ovarium; but we must be cautious in assuming, as the following case shows, that size had been transferred from the male parent to the capsule of the female plant. Mr. Henry fertilised *Arabis blepharophylla* with pollen of *A. soyeri*, and the pods thus produced, of which he was so kind as to send me detailed measurements and sketches, were much larger in all their dimensions than those naturally produced by either the male or female parent-species. In a future chapter we shall see that the organs of vegetation in hybrid plants, independently of the character of either parent, are sometimes developed to a monstrous size; and the increased size of the pods in the foregoing cases may be an analogous fact. On the other hand, M. de Saporta informs me that an isolated female plant of *Pistacia vera* is very apt to be fertilised by the pollen of neighbouring plants of *P. terebinthus*, and in this case the fruits are only half their proper size, which he attributes to the influence of the pollen of *P. terebinthus.*

No case of the direct action of the pollen of one variety on another is better authenticated or more remarkable than that of the common apple. The fruit here consists of the lower part of the calyx and of the upper part of the flower-peduncle[144] in a metamorphosed condition, so that the effect of the foreign pollen has extended even beyond the limits of the ovarium. Cases of apples thus affected were recorded by Bradley in the early part of the last century; and other cases are given in old volumes of the 'Philosophical Transactions';[145] in one of these a Russeting apple and an adjoining kind mutually affected each other's fruit; and in another case a smooth apple affected a rough-coated kind. Another instance has been given[146] of two very different apple-trees growing close to each other, which bore fruit resembling each other, but only on the adjoining branches. It is, however, almost superfluous to adduce these or other cases, after that of the St. Valery apple, the flowers which, from the abortion of the stamens, do not produce pollen, but are fertilised by the girls of the neighbourhood with pollen of many kinds; and they bear fruit, "differing from one another in size, flavour, and colour, but resembling in character the hermaphrodite kinds by which they have been fertilised."[147]

I have now shown, on the authority of several excellent observers, in the case of plants belonging to widely different orders, that the pollen of one species or variety, when applied to the female of a distinct form, occasionally causes the coats of the seeds, the ovarium or fruit, including even the calyx and upper part of the peduncle of the apple, and the axis of the ear in maize, to be modified. Sometimes the whole ovarium or all the seeds are thus affected; sometimes only a certain number of the seeds, as in the case of the pea, or only a part of the ovarium, as with the striped orange, mottled grapes, and maize, is thus affected. It must not be supposed that any direct or immediate effect invariably follows the use of foreign pollen: this is far from being the case; nor is it known on what conditions the result depends. Mr. Knight[148] expressly states that he has never seen the fruit thus affected, though he crossed thousands of apple and other fruit-trees.

There is not the least reason to believe that a branch which has borne seed or fruit directly modified by foreign pollen is itself affected, so as afterwards to produce modified buds; such an occurrence, from the temporary connection of the flower with the stem, would be hardly possible. Hence, but very few, if any, of the cases of bud-variation in the fruit of trees, given in the early part of this chapter can be accounted for by the action of foreign pollen; for such fruits have commonly been propagated by budding or grafting. It is also obvious that changes of colour in flowers, which necessarily supervene long before they are ready for fertilisation, and changes in the shape or colour of leaves, when due to the appearance of modified buds, can have no relation to the action of foreign pollen.

The proofs of the action of foreign pollen on the mother-plant have been given in considerable detail, because this action, as we shall see in a future chapter, is of the highest theoretical importance, and because it is in itself a remarkable and apparently anomalous circumstance. That it is remarkable under a physiological point of view is clear, for the male element not only affects, in accordance with its proper function, the germ, but at the same time various parts of the mother-plant, in the same manner, as it affects the same part in the seminal offspring from the same two parents. We thus learn that an ovule is not indispensable for the reception of the influence of the male element. But this direct action of the male element is not so anomalous as it at first appears, for it comes into play in the ordinary fertilisation of many flowers. Gärtner gradually increased the number of pollen grains until he succeeded in fertilising a Malva, and has[149] proved that many grains are first expended in the development, or, as he expresses it, in the satiation, of the pistil and ovarium. Again, when one plant is fertilised by a widely distinct species, it often happens that the ovarium is fully and quickly developed without any seeds being formed; or the coats of the seeds are formed without any embryo being developed within. Prof. Hildebrand, also, has lately shown[150] that, in the normal fertilisation of several Orchideæ, the action of the plant's own pollen is necessary for the development of the ovarium; and that this development takes place not only long before the pollen-tubes have reached the ovules, but even before the placentæ and ovules have been formed; so that with these orchids the pollen acts directly on the ovarium. On the other hand, we must not overrate the efficacy of pollen in the case of hybridised plants, for an embryo may be formed and its influence excite the surrounding tissues of the mother-plant, and then perish at a very early age and be thus overlooked. Again, it is well known that with many plants the ovarium may be fully developed, though pollen be wholly excluded. Lastly, Mr. Smith, the late Curator at Kew (as I hear through Dr. Hooker), observed with an orchid, the *Bonatea speciosa*, the singular fact that the development of the ovarium could be effected by the mechanical irritation of the stigma. Nevertheless, from the number of the pollen-grains expended "in the satiation of the ovarium and pistil,"—from the generality of the formation of the ovarium and seed-coats in hybridised plants which produce no seeds,—and from Dr. Hildebrand's observations on orchids, we may admit that in most cases the swelling of the ovarium, and the formation of the seed-coats are at least aided, if not wholly caused, by the direct action of the pollen, independently of the intervention of the fertilised germ. Therefore, in the previously given cases we have only to believe in the further power of pollen, when applied to a distinct species or variety, to influence the shape, size, colour, texture, etc., of certain parts of the mother-plant.

Turning now to the animal kingdom. If we could imagine the same flower to yield seeds during successive years, then it would not be very surprising that a flower of which the ovarium had been modified by foreign pollen should next year produce, when self-fertilised, offspring modified by the previous male influence. Closely analogous cases have actually occurred with animals. In the case often quoted from Lord

Morton,[151] a nearly purely-bred Arabian chestnut mare bore a hybrid to a quagga; she was subsequently sent to Sir Gore Ouseley, and produced two colts by a black Arabian horse. These colts were partially dun-coloured, and were striped on the legs more plainly than the real hybrid, or even than the quagga. One of the two colts had its neck and some other parts of its body plainly marked with stripes. Stripes on the body, not to mention those on the legs, are extremely rare,—I speak after having long attended to the subject,—with horses of all kinds in Europe, and are almost unknown in the case of Arabians. But what makes the case still more striking is that in these colts the hair of the mane resembled that of the quagga, being short, stiff, and upright. Hence there can be no doubt that the quagga affected the character of the offspring subsequently begot by the black Arabian horse. Mr. Jenner Weir informs me of a strictly parallel case: his neighbour Mr. Lethbridge, of Blackheath, has a horse, bred by Lord Mostyn, which had previously borne a foal by a quagga. This horse is dun with a dark stripe down the back, faint stripes on the forehead between the eyes, plain stripes on the inner side of the fore-legs and rather more faint ones on the hind-legs, with no shoulder-stripe. The mane grows much lower on the forehead than in the horse, but not so low as in the quagga or zebra. The hoofs are proportionally longer than in the horse,—so much so that the farrier who first shod this animal, and knew nothing of its origin, said, "Had I not seen I was shoeing a horse, I should have thought I was shoeing a donkey."

With respect to the varieties of our domesticated animals, many similar and well-authenticated facts have been published,[152] and others have been communicated to me, plainly showing the influence of the first male on the progeny subsequently borne by the mother to other males. It will suffice to give a single instance, recorded in the 'Philosophical Transactions,' in a paper following that by Lord Morton: Mr. Giles put a sow of Lord Western's black and white Essex breed to a wild boar of a deep chestnut colour; and the "pigs produced partook in appearance of both boar and sow, but in some the chestnut colour of the boar strongly prevailed." After the boar had long been dead, the sow was put to a boar of her own black and white breed—a kind which is well known to breed very true and never to show any chestnut colour,—yet from this union the sow produced some young pigs which were plainly marked with the same chestnut tint as in the first litter. Similar cases have so frequently occurred, that careful breeders avoid putting a choice female of any animal to an inferior male, on account of the injury to her subsequent progeny which may be expected to follow.

Some physiologists have attempted to account for these remarkable results from a previous impregnation, by the imagination of the mother having been strongly affected; but it will hereafter be seen that there are very slight grounds for any such belief. Other physiologists attribute the result to the close attachment and freely intercommunicating blood-vessels between the modified embryo and mother. But the analogy from the action of foreign pollen on the ovarium, seed-coats, and other parts of the mother-plant, strongly supports the belief that with animals the male element acts directly on the female, and not through the crossed embryo. With birds there is no close connection between the embryo and mother; yet a careful observer, Dr. Chapuis, states[153] that with pigeons the influence of a first male sometimes makes itself perceived in the succeeding broods; but this statement requires confirmation.

Conclusion and Summary of the Chapter.—The facts given in the latter half of this chapter are well worthy of consideration, as they show us in how many extraordinary modes the union of one form with another may lead to the modification of the seminal offspring or of the buds, afterwards produced.

There is nothing surprising in the offspring of species or varieties crossed in the ordinary manner being modified; but the case of two plants within the same seed, which cohere and differ from each other, is curious. When a bud is formed after the cellular tissue of two species or two varieties have been united, and it partakes of the characters of both parents, the case is wonderful. But I need not here repeat what has been so lately said on this subject. We have also seen that in the case of plants the male element may affect in a direct manner the tissues of the mother, and with animals may lead to the modification of her future progeny. In the vegetable kingdom the offspring from a cross between two species or varieties, whether effected by seminal generation or by grafting, often revert, to a greater or less degree, in the first or in a succeeding generation, to the two parent-forms; and this reversion may affect the whole flower, fruit, or leaf-bud, or only the half or a smaller segment of a single organ. In some cases, however, such segregation of character apparently depends on an incapacity for union rather than on reversion, for the flowers or fruit which are first produced display by segments the characters of both parents. The various facts here given ought to be well considered by any one who wishes to embrace under a single point of view the many modes of reproduction by gemmation, division, and sexual union, the reparation of lost parts, variation, inheritance, reversion, and other such phenomena. Towards the close of the second volume I shall attempt to connect these facts together by the hypothesis of pangenesis.

In the early half of the present chapter I have given a long list of plants in which through bud-variation, that is, independently of reproduction by seed, the fruit has suddenly become modified in size, colour, flavour, hairiness, shape, and time of maturity; flowers have similarly changed in shape, colour, in being double, and greatly in the character of the calyx; young branches or shoots have changed in colour, in bearing spines and in habit of growth, as in climbing or in weeping; leaves have changed in becoming variegated, in shape, period of unfolding, and in their arrangement on the axis. Buds of all kinds, whether produced on ordinary branches or on subterranean stems, whether simple or much modified and supplied with a stock of nutriment, as in tubers and bulbs, are all liable to sudden variations of the same general nature.

In the list, many of the cases are certainly due to reversion to characters not acquired from a cross, but which were formerly present and have since been lost for a longer or shorter time;—as when a bud on a variegated plant produces plain leaves, or when the variously-coloured flowers of the Chrysanthemum revert to the aboriginal yellow tint. Many other cases included in the list are probably due to the plants being of crossed parentage, and to the buds reverting either completely or by segments to one of the two parent-forms.[154]

We may suspect that the strong tendency in the Chrysanthemum to produce by bud-variation differently-coloured flowers, results from the varieties having been at some time intentionally or accidentally crossed; and this is certainly the case with some kinds of Pelargonium. So it may be to a large extent with the bud-varieties of the Dahlia, and with the "broken colours" of Tulips. When, however, a plant reverts by bud-variation to its two parent forms, or to one of them, it sometimes does not revert perfectly, but assumes a somewhat new character,—of which fact, instances have been given, and Carrière gives[155] another in the cherry.

Many cases of bud-variation, however, cannot be attributed to reversion, but to so-called spontaneous variability, as is so common with cultivated plants raised from seed. As a single variety of the Chrysanthemum has produced by buds six other varieties, and as one variety of the gooseberry has borne at the same time four distinct kinds of fruit, it is scarcely possible to believe that all these variations are due to reversion. We can hardly believe, as remarked in a previous chapter, that all the many peaches which have yielded nectarine-buds are of crossed parentage. Lastly, in such cases as that of the moss-rose, with its peculiar calyx, and of the rose which bears opposite leaves, in that of the Imatophyllum, etc., there is no known natural species or variety from which the characters in question could have been derived by a cross. We must attribute all such cases to the appearance of absolutely new characters in the buds. The varieties which have thus arisen cannot be distinguished by any external character from seedlings; this is notoriously the case with the varieties of the Rose, Azalea, and many other plants. It deserves notice that all the plants which have yielded bud-variations have likewise varied greatly by seed.

The plants which have varied by buds belong to so many orders that we may infer that almost every plant would be liable to variation, if placed under the proper exciting conditions. These conditions, as far as we can judge, mainly depend on long-continued and high cultivation; for almost all the plants in the foregoing list are perennials, and have been largely propagated in many soils, under different climates, by cuttings, offsets, bulbs, tubers, and especially by budding or grafting. The instances of annuals varying by buds, or producing on the same plant differently coloured flowers, are comparatively rare: Hopkirk[156] has seen this with *Convolvulus tricolor*; and it is not uncommon with the Balsam and annual Delphinium. According to Sir R. Schomburgk, plants from the warmer temperate regions, when cultivated under the hot climate of St. Domingo, are eminently liable to bud-variation. I am informed by Mr. Sedgwick that moss-roses which have often been taken to Calcutta always there lose their mossiness; but change of climate is by no means a necessary contingent, as we see with the gooseberry, currant, and in many other cases. Plants living under their natural conditions are very rarely subject to bud-variation. Variegated leaves have, however, been observed under such circumstances; and I have given an instance of variation by buds on an ash-tree planted in ornamental grounds, but it is doubtful whether such a tree can be considered as living under strictly natural conditions. Gärtner has seen white and dark-red flowers produced from the same root of the wild *Achillea millefolium*; and Prof. Caspary has seen a completely wild *Viola lutea* bearing flowers of two different colours and sizes.[157]

As wild plants are so rarely liable to bud-variation, whilst highly cultivated plants long propagated by artificial means have yielded many varieties by this form of reproduction, we are led through a series such as the following,—namely, all the eyes in the same tuber of the potato varying in the same manner,—all the fruit on a purple plum-tree suddenly becoming yellow,—all the fruit on a double-flowered almond suddenly becoming peach like,—all the buds on grafted trees being in a very slight degree affected by the stock on which they have been worked,—all the flowers on a transplanted heartsease changing for a time in colour, size, and shape,—we are led by such a series to look at every case of bud-variation as the direct result of the conditions of life to which the plant has been exposed. On the other hand, plants of the same variety may be cultivated in two adjoining beds, apparently under exactly the same conditions, and those in the one bed, as Carrière insists,[158] will produce many bud-variations, and those in the other not a single one. Again, if we look to such cases as that of a peach-tree which, after having been cultivated by tens of thousands during many years in many countries, and after having annually produced millions of buds, all of which have apparently been exposed to precisely the same conditions, yet at last suddenly produces a single bud with its whole character greatly transformed, we are driven to the conclusion that the transformation stands in no *direct* relation to the conditions of life.

We have seen that varieties produced from seeds and from buds resemble each other so closely in general appearance that they cannot be distinguished. Just as certain species and groups of species, when propagated by seed, are more variable than other species or genera, so it is in the case of certain bud-varieties. Thus, the Queen of England Chrysanthemum has produced by this latter process no less than six, and Rollisson’s Unique Pelargonium four distinct varieties; moss-roses have also produced several other moss-roses. The Rosaceæ have varied by buds more than any other group of plants; but this may be in large part due to so many members having been long cultivated; but within this same group, the peach has often varied by buds, whilst the apple and pear, both grafted trees extensively cultivated, have afforded, as far as I can ascertain, extremely few instances of bud-variation.

The law of analogous variation holds good with varieties produced by buds, as with those produced from seed: more than one kind of rose has sported into a moss-rose; more than one kind of camellia has assumed an hexagonal form; and at least seven or eight varieties of the peach have produced nectarines.

The laws of inheritance seem to be nearly the same with seminal and bud-varieties. We know how commonly reversion comes into play with both, and it may affect the whole, or only segments of a leaf, flower, or fruit. When the tendency to reversion affects many buds on the same tree, it becomes covered with different kinds of leaves, flowers, or fruit; but there is reason to believe that such fluctuating varieties have generally arisen from seed. It is well known that, out of a number of seedling varieties, some transmit their character much more truly by seed than others; so with bud-varieties, some retain their character by successive buds more truly than others; of which instances have been given with two kinds of variegated Euonymus and with certain kinds of tulips and pelargoniums. Notwithstanding the sudden production of bud-varieties, the characters thus acquired are sometimes capable of transmission by seminal reproduction: Mr. Rivers has found that moss-roses generally reproduce themselves by seed; and the mossy character has been transferred by crossing from one species of rose to another. The Boston nectarine, which appeared as a bud-variation, produced by seed a closely allied nectarine. On the other hand, seedlings from some bud-variations have proved variable to an extreme degree.[159] We have also heard, on the authority of Mr. Salter, that seeds taken from a branch with leaves variegated through bud-variation, transmit this character very feebly; whilst many plants, which were variegated as seedlings, transmit variegation to a large proportion of their progeny.

Although I have been able to collect a good many cases of bud-variation, as shown in the previous lists, and might probably, by searching foreign horticultural works, have collected very many more cases, yet their total number is as nothing in comparison with that of seminal varieties. With seedlings raised from the more variable cultivated plants, the variations are almost infinitely numerous, but their differences are generally slight: only at long intervals of time a strongly marked modification appears. On the other hand, it is a singular and inexplicable fact that, when plants vary by buds, the variations, though they occur with comparative rarity, are often, or even generally, strongly pronounced. It struck me that this might perhaps be a delusion, and that slight changes often occurred in buds, but were overlooked or not recorded from being of no value. Accordingly, I applied to two great authorities on this subject, namely, to Mr. Rivers with respect to fruit-trees, and to Mr. Salter with respect to flowers. Mr. Rivers is doubtful, but does not remember having noticed very slight variations in fruit-buds. Mr. Salter informs me that with flowers such do occur, but, if propagated, they generally lose their new character in the following year; yet he concurs with me that bud-variations usually at once assume a decided and permanent character. We can hardly doubt that this is the rule, when we reflect on such cases as that of the peach, which has been so carefully observed, and of which such trifling seminal varieties have been propagated, yet this tree has repeatedly produced by bud-variation nectarines, and only twice (as far as I can learn) any other variety, namely, the Early and Late Grosse Mignonne peaches; and these differ from the parent-tree in hardly any character except the period of maturity.

To my surprise, I hear from Mr. Salter that he brings the principle of selection to bear on variegated plants propagated by buds, and has thus greatly improved and fixed several varieties. He informs me that at first a branch often produces variegated leaves on one side alone, and that the leaves are marked only with an irregular edging or with a few lines of white and yellow. To improve and fix such varieties, he finds it necessary to encourage the buds at the bases of the most distinctly marked leaves, and to propagate from them alone. By following with perseverance this plan during three or four successive seasons, a distinct and fixed variety can generally be secured.

Finally, the facts given in this chapter prove in how close and remarkable a manner the germ of a fertilised seed and the small cellular mass forming a bud, resemble each other in all their functions—in their power of inheritance with occasional reversion,—and in their capacity for variation of the same general nature, in obedience to the same laws. This resemblance, or rather identity of character, is shown in the most striking manner by the fact that the cellular tissue of one species or variety, when budded or grafted on another, may give rise to a bud having an intermediate character. We have seen that variability does not depend on sexual generation, though much more frequently its concomitant than of bud reproduction. We have seen that bud-variability is not solely dependent on reversion or atavism to long-lost characters, or to those formerly acquired from a cross, but appears often to be spontaneous. But when we ask ourselves what is the cause of any particular bud-variation, we are lost in doubt, being driven in some cases to look to the direct action of the external conditions of life as sufficient, and in other cases to feel a profound conviction that these have played a quite subordinate part, of not more importance than the nature of the spark which ignites a mass of combustible matter.

REFERENCES

[1] Since the publication of the first edition of this work, I have found that M. Carrière, *Chef des Pépinières au Mus. d'Hist. Nat.,* in his excellent Essay 'Production et Fixation des Variétés, 1865,' has given a list of bud-variations far more extensive than mine; but as these relate chiefly to cases occurring in France I have left my list as it stood, adding a few facts from M. Carrière and others. Any one who wishes to study the subject fully should refer to M. Carrière's Essay.

[2] 'Gardener's Chronicle,' 1854, p. 821.

[3] Lindley's 'Guide to Orchard,' as quoted in 'Gardener's Chronicle,' 1852, p. 821. For the *Early mignonne peach, see* 'Gardener's Chronicle,' 1864, p. 1251.

[4] 'Transact. Hort. Soc.,' vol. ii. p. 160.

[5] *See also* 'Gardener's Chronicle,' 1863, p. 27.

[6] ‘Gardener’s Chronicle,’ 1852, p. 821.

[7] ‘Gardener’s Chronicle,’ 1852, p. 629; 1856, p. 648; 1864, p. 986. Other cases are given by Braun ‘Rejuvenescence,’ in ‘Ray Soc. Bot. Mem.,’ 1853, p. 314.

[8] ‘Ampélographie,’ etc., 1849, p. 71.

[9] ‘Gardener’s Chronicle,’ 1866, p. 970.

[10] ‘Gardener’s Chronicle,’ 1855, pp. 597, 612.

[11] ‘Gardener’s Chronicle,’ 1842, p. 873; 1855, p. 646. In the ‘Chronicle,’ p. 876, Mr. P. Mackenzie states that the bush still continues to bear the three kinds of fruit, “although they have not been every year alike.”

[12] ‘Revue Horticole,’ quoted in ‘Gardener’s Chronicle,’ 1844, p. 87.

[13] ‘Rejuvenescence in Nature,’ ‘Bot. Memoirs Ray Soc.,’ 1853, p. 314.

[14] ‘Comptes Rendus,’ tom. xli. 1855, p. 804. The second case is given on the authority of Gaudichaud, ibid., tom. xxxiv. 1852, p. 748.

[15] This case is given in the ‘Gardener’s Chronicle,’ 1867, p. 403.

[16] ‘Journal of Proc. Linn. Soc.,’ vol ii. Botany, p. 131.

[17] ‘Gardener’s Chronicle,’ 1847, p. 207.

[18] Herbert, ‘Amaryllidaceæ,’ 1838, p. 369.

[19] ‘Gardener’s Chronicle,’ 1843, p. 391.

[20] Exhibited at Hort. Soc. London. Report in ‘Gardener’s Chronicle,’ 1844, p. 337.

[21] Mr. W. Bell ‘Bot. Soc. of Edinburgh,’ May, 1863.

[22] ‘Revue Horticole,’ quoted in ‘Gardener’s Chronicle,’ 1845, p. 475.

[23] ‘Bastarderzeugung,’ 1849, s. 76.

[24] ‘Journal of Horticulture,’ 1861, p. 336.

[25] W. P. Ayres, in ‘Gardener’s Chronicle,’ 1842, p. 791.

[26] W. P. Ayres, ibid.

[27] Dr. Maxwell Masters, ‘Pop. Science Review,’ July, 1872, p. 250.

[28] ‘Gardener’s Chronicle,’ 1861, p. 968.

[29] Ibid., 1861 p. 945.

[30] W. Paul, in 'Gardener's Chronicle,' 1861, p. 968.

[31] Ibid., p. 945.

[32] For other cases of bud-variation in this same variety, *see* 'Gardener's Chronicle,' 1861, pp. 578, 600, 925. For other distinct cases of bud-variation in the genus Pelargonium *see* 'Cottage Gardener,' 1860, p. 194.

[33] Dr. Maxwell Masters, 'Pop. Science Review,' July, 1872, p. 254.

[34] Rev. W. T. Bree, in Loudon's 'Gardener's Mag.,' vol. viii. 1832, p. 93.

[35] 'The Chrysanthemum: its History and Culture,' by J. Salter, 1865, p. 41, etc.

[36] Bree, in Loudon's 'Gardener's Mag.,' vol. viii. 1832, p. 93.

[37] Bronn 'Geschichte der Natur,' B. ii. s. 123.

[38] T. Rivers, 'Rose Amateur's Guide ' 1837 p. 4.

[39] Mr. Shailer, quoted in 'Gardener's Chronicle,' 1848 p. 759.

[40] 'Transact. Hort. Soc.,' vol. iv. 1822, p. 137; 'Gardener's Chronicle,' 1842, p. 422.

[41] *See also* Loudon's 'Arboretum,' vol. ii. p. 780.

[42] All these statements on the origin of the several varieties of the moss-rose are given on the authority of Mr. Shailer, who, together with his father, was concerned in their original propagation. *See* 'Gardener's Chronicle,' 1852, p. 759.

[43] 'Gardener's Chronicle,' 1845, p. 564.

[44] 'Transact. Hort. Soc.,' vol. ii. p. 242.

[45] 'Shriften der Phys. Oekon. Gesell. zu Königsberg,' Feb. 3rd, 1865, s. 4. *See also* Dr. Caspary's paper in 'Transactions of the Hort. Congress of Amsterdam,' 1865.

[46] 'Gardener's Chronicle,' 1852, p. 759.

[47] 'Transact. Hort. Soc.,' vol. ii. p. 242.

[48] Sir R. Schomburgk, 'Proc. Linn. Soc. Bot.,' vol. ii. p. 132.

[49] 'Gardener's Chronicle,' 1862, p. 619.

[50] Hopkirk's 'Flora Anomala,' 167.

[51] ‘Sur La Production et la Fixation des Variétés,’ 1865, p. 4.

[52] ‘Journal of Horticulture,’ March, 1865, p. 233.

[53] ‘Gardener’s Chronicle,’ 1843, p. 135.

[54] Ibid., 1842, p. 55.

[55] ‘Gardener’s Chronicle,’ 1867, p. 235.

[56] Gärtner ‘Bastarderzeugung,’ s. 305.

[57] Mr. D. Beaton, in ‘Cottage Gardener,’ 1860, p. 250.

[58] ‘Gardener’s Chronicle,’ 1850, p. 536.

[59] Braun, ‘Ray Soc. Bot. Mem.,’ 1853, p. 315; Hopkirk’s ‘Flora Anomala,’ p. 164; Lecoq ‘Géograph. Bot. de l’Europe,’ tom. iii. 1854, p. 405; and ‘De la Fécondation,’ 1862, p. 303.

[60] ‘Des Variétés,’ 1865, p. 5.

[61] W. Mason, in ‘Gardener’s Chronicle,’ 1843, p. 878.

[62] Alex. Braun, ‘Ray Soc. Bot. Mem.,’ 1853, p. 315; ‘Gardener’s Chronicle,’ 1841, p. 329.

[63] Dr. M. T. Masters, ‘Royal Institution Lecture,’ March 16th, 1860.

[64] *See* Mr. W. K. Bridgeman’s curious paper in ‘Annals and Mag. of Nat. Hist.,’ Dec. 1861; also Mr. J. Scott, ‘Bot. Soc. Edinburgh,’ June 12th, 1862.

[65] ‘Journal of Horticulture,’ 1861, p. 336; Verlot, ‘Des Variétés,’ p. 76.

[66] *See also* Verlot, ‘Des Variétés,’ p. 74.

[67] ‘Gardener’s Chronicle,’ 1844, p. 86.

[68] Ibid., 1861, p. 963.

[69] Ibid., 1861, p. 433; ‘Cottage Gardener,’ 1860, p. 2.

[70] M. Lemoine (quoted in ‘Gardener’s Chronicle,’ 1867, p. 74) has lately observed that the Symphytum with variegated leaves cannot be propagated by division of the roots. He also found that out of 500 plants of a Phlox with striped flowers, which had been propagated by root-division, only seven or eight produced striped flowers. *See also* on striped Pelargoniums, ‘Gardener’s Chronicle,’ 1867, p. 1000.

[71] Anderson’s ‘Recreations in Agriculture,’ vol. v. p. 152.

[72] For wheat, *see* ‘Improvement of the Cereals,’ by P. Shirreff, 1873, p. 47. For maize and sugar-cane, Carrière, ibid., pp. 40, 42. With respect to the sugar-cane Mr. J. Caldwell of Mauritius, says (‘Gardener’s Chronicle,’ 1874, p. 316) the Ribbon cane has here “sported into a perfectly green cane and a perfectly red cane from the same head. I verified this myself, and saw at least 200 instances in the same plantation, and the fact has completely upset all our preconceived ideas of the difference of colour being permanent. The conversion of a striped cane into a green cane was not uncommon, but the change into a red cane universally disbelieved, and that both events should occur in the same plant incredible. I find, however, in Fleischman’s ‘Report on Sugar Cultivation in Louisiana for 1848,’ by the American Patent Office, the circumstance is mentioned, but he says he never saw it himself.”

[73] ‘Gardener’s Chronicle,’ 1857, p. 662.

[74] ‘Gardener’s Chronicle,’ 1841, p. 814.

[75] Ibid., 1857, p. 613.

[76] Ibid., 1857, p. 679. *See also* Philips ‘Hist. of Vegetables,’ vol. ii. p. 91, for other and similar accounts.)

[77] ‘Journal of Proc. Linn. Soc.,’ vol. ii. Botany, p. 132.

[78] Loudon’s ‘Gardener’s Mag.,’ vol. viii. 1832, p. 94.

[79] ‘Gardener’s Chronicle,’ 1850, p. 536; and 1842, p. 729.

[80] ‘Des Jacinthes,’ etc., Amsterdam, 1768, p. 122.

[81] ‘Gardener’s Chronicle.’ 1845. p. 212.

[82] Loudon’s ‘Encyclopædia of Gardening,’ p. 1024.

[83] ‘Production des Variétés,’ 1865, p. 63.

[84] ‘Gardener’s Chronicle,’ 1841, p. 782; 1842, p. 55.

[85] ‘Gardener’s Chronicle,’ 1849. p. 565.

[86] ‘Transact. Lin. Soc.,’ vol. ii. p. 354.

[87] Godron, ‘De l’Espèce,’ tom. ii. p. 84.

[88] M. Carrière has lately described in the ‘Revue Horticole,’ (Dec. 1st, 1866, p. 457,) an extraordinary case. He twice inserted grafts of the *Aria vestita* on thorn-trees (*épines*) growing in pots; and the grafts, as they grew, produced shoots with bark, buds, leaves, petioles, petals, and flower-stalks, all widely different from those of the Aria. The grafted shoots were also much hardier, and flowered earlier, than those on the ungrafted Aria.

[89] ‘Transact. Hort. Soc.,’ vol. ii. p. 160.

[90] For the cases of oaks *see* Alph. De Candolle in ‘Bibl. Univers.,’ Geneva, Nov. 1862; for limes, etc., Loudon’s ‘Gard. Mag.,’ vol. xi. 1835, p. 503.

[91] For analogous facts, *see* Braun ‘Rejuvenescence,’ in ‘Ray Soc. Bot. Mem.,’ 1853, p. 320; and ‘Gardener’s Chronicle,’ 1842, p. 397; also Braun in ‘Sitzungsberichte der Ges. naturforschender Freunde,’ June, 1873, p. 63.

[92] ‘Journal of Hort. Soc.,’ vol. ii. 1847, p. 100.

[93] *See* ‘Transact. of Hort. Congress of Amsterdam,’ 1865; but I owe most of the following information to Prof. Caspary’s letters.

[94] ‘Nouvelles Archives du Muséum,’ tom. i. p. 143.

[95] *See* on this head, Naudin, ibid., p. 141.

[96] Braun, in ‘Bot. Mem. Ray. Soc.,’ 1853, p. 23.

[97] This hybrid has never been described. It is exactly intermediate in foliage, time of flowering, dark striæ at the base of the standard petal, hairiness of the ovarium, and in almost every other character, between *C. laburnum* and *alpinus*; but it approaches the former species more nearly in colour, and exceeds it in the length of the racemes. We have before seen that 20·3 per cent of its pollen-grains are ill-formed and worthless. My plant, though growing not above thirty or forty yards from both parent-species, during some seasons yielded no good seeds; but in 1866 it was unusually fertile, and its long racemes produced from one to occasionally even four pods. Many of the pods contained no good seeds, but generally they contained a single apparently good seed, sometimes two, and in one case three seeds. Some of these seeds germinated, and I raised two trees from them; one resembles the present form; the other has a remarkable dwarf character with small leaves, but has not yet flowered.

[98] ‘Annales de la Soc. de l’Hort. de Paris,’ tom. vii. 1830, p. 93.

[99] An account was given in the ‘Gardener’s Chronicle’ (1857, pp. 382, 400) of a common laburnum on which grafts of *C. purpureus* had been inserted, and which gradually assumed the character of *C. adami*; but I have little doubt that *C. adami* had been sold to the purchaser, who was not a botanist, in the place of *C. purpureus*. I have ascertained that this occurred in another instance.

[100] Gallesio, ‘Gli Agrumi dei Giard. Bot. Agrar. di. Firenze,’ 1839, p. 11. In his ‘Traité du Citrus,’ 1811, p. 146, he speaks as if the compound fruit consisted in part of a lemon, but this apparently was a mistake.

[101] ‘Gardener’s Chronicle,’ 1855, p. 628. *See also* Prof. Caspary in ‘Transact. Hort. Congress of Amsterdam,’ 1865.

[102] Gärtner (‘Bastarderzeugung,’ s. 611) gives many references on this subject.

[103] A nearly similar account was given by Brabley, in 1724, in his ‘Treatise on Husbandry,’ vol. i. p. 199.

[104] Morren, ‘Bull. de l’Acad. R. des Sciences de Belgique,’ 2de séries, tom. xxviii. 1869, p. 434. Also Magnus ‘Gesellschaft naturforschender Freunde, Berlin,’ Feb. 21st, 1871, p. 13; ibid., June 21st, 1870, and Oct. 17th, 1871. Also ‘Bot. Zeitung,’ Feb. 24th, 1871.

[105] Loudon’s ‘Arboretum,’ vol. iv. p. 2595.

[106] ‘Bastarderzeugung,’ s. 619.

[107] Amsterdam, 1768, p. 124.

[108] ‘Gardener’s Chronicle,’ 1860, p. 672, with a woodcut.

[109] *See* ‘Gardener’s Chronicle,’ 1869, p. 220.

[110] ‘Gardener’s Chronicle,’ 1869, p. 335.

[111] ‘Gardener’s Chronicle,’ 1869, p. 1018, with remarks by Dr. Masters on the adhesion of the united wedges. *See also* ibid., 1870, pp. 1277, 1283.

[112] ‘Gardener’s Chronicle,’ 1871, p. 837.

[113] ‘Gardener’s Chronicle,’ 1870, p. 1506.

[114] ‘Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin,’ Oct. 17th, 1871.

[115] Ibid., Nov. 17th, 1874. *See also* excellent remarks by Herr Magnus.

[116] ‘Bastarderzeugung,’ s. 549. It is, however, doubtful whether these plants should be ranked as species or varieties.

[117] Gärtner, ibid., s. 550.

[118] ‘Journal de Physique,’ tom. xxiii. 1873, p. 100. ‘Act. Acad. St. Petersburgh,’ 1781, part i. p. 249.

[119] ‘Nouvelles Archives du Muséum,’ tom. i. p. 49.

[120] L’Hermès, Jan. 14th, 1837, quoted in Loudon’s ‘Gardener’s Mag.,’ vol. xiii. p. 230.

[121] ‘Comptes Rendus,’ tom. xxxiv. 1852, p. 746.

[122] ‘Géograph. Bot. de l’Europe,’ tom. iii. 1854, p. 405; and ‘De la Fécondation,’ 1862, p. 302.

[123] ‘Traité du Citrus,’ 1811, p. 45.

[124] ‘Transact. Linn. Soc.,’ vol. ix. p. 268.

[125] ‘Annals and Mag. of Nat. Hist.,’ March, 1848.

[126] ‘Pomologie Physiolog.,’ 1830, p. 126.

[127] ‘Philosophical Transact.,’ vol. xliii. 1744-45, p. 525.

[128] Mr. Goss, ‘Transact. Hort. Soc.,’ vol. v. p. 234: and Gärtner, ‘Bastarderzeugung,’ 1849, ss. 81 and 499.

[129] ‘Gardener’s Chronicle,’ 1854, p. 404.

[130] Ibid., 1866, p. 900.

[131] *See also* a paper by this observer read before the International Hort. and Bot. Congress of London, 1866.

[132] ‘Traité du Citrus,’ p. 40.

[133] ‘Transact. Hort. Soc.,’ vol. iii. p. 318. *See also* vol. v. p. 65.

[134] Prof. Asa Gray, ‘Proc. Acad. Sc.,’ Boston, vol. iv. 1860, p. 21. I have received statements to the same effect from other persons in the United States.

[135] For the French case *see* ‘Journ. Hort. Soc.,’ vol. i. new series, 1866, p. 50. For Germany, *see* M. Jack quoted in Henfrey’s ‘Botanical Gazette,’ vol. i. p. 277. A case in England has recently been alluded to by the Rev. J. M. Berkeley before the Hort. Soc. of London.

[136] ‘Philosophical Transactions,’ vol. xlvii. 1751-52, p. 206.

[137] Gallesio, ‘Teoria della Riproduzione,’ 1816, p. 95.

[138] ‘Bot. Zeitung,’ May, 1868, p. 326.

[139] *See* Dr. J. Stockton-Hough, in ‘American Naturalist,’ Jan. 1874, p. 29.

[140] ‘Transact. Hort. Soc.,’ vol. v. p. 69.

[141] ‘Bull. de l’Acad. Imp. de St. Petersburg,’ tom. xvii. p. 275, 1872. The author gives references to those cases in the Solanaceæ of fruit affected by foreign pollen, but as it does not appear that the mother-plant was artificially fertilised, I have not entered into details.

[142] ‘Bot. Zeitung,’ Sept. 1868, p. 631. For Maximowicz’s judgment, *see* the paper last referred to.

[143] ‘Journal of Horticulture,’ Jan. 20th, 1863, p. 46.

[144] *See* on this head the high authority of Prof. Decaisne, in a paper translated in 'Journ. Hort. Soc.,' vol. i., new series, 1866, p. 48.

[145] Vol. xliii., 1744-45, p. 525; vol. xlv., 1747-48, p. 602.

[146] 'Transact. Hort. Soc.,' vol. v. pp. 65 and 68. *See also* Prof. Hildebrand, with a coloured figure, in 'Bot. Zeitung,' May 15th, 1868, p. 327. Puvis also has collected, 'De La Dégénération,' 1837, p. 36)several other instances; but it is not in all cases possible to distinguish between the direct action of foreign pollen and bud-variations.

[147] T. de Clermont-Tonnerre, in 'Mém. de la Soc. Linn. de Paris,' tom. iii. 1825, p. 164.

[148] 'Transact. of Hort. Soc.,' vol. v. p. 68.

[149] 'Beiträge zur Kenntniss der Befruchtung,' 1844, s. 347-351.

[150] 'Die Fruchtbildung der Orchideen, ein Beweis für die doppelte Wirkung des Pollens,' 'Botanische Zeitung,' No. 44 et seq., Oct. 30th, 1865; and Aug. 4th, 1865, s. 249.

[151] 'Philos. Transact.,' 1821, p. 20.

[152] Dr. Alex. Harvey on 'A remarkable Effect of Cross-breeding,' 1851. On the 'Physiology of Breeding,' by Mr. Reginald Orton, 1855. 'Intermarriage,' by Alex. Walker, 1837. 'L'Hérédité Naturelle,' by Dr. Prosper Lucas, tom. ii. p. 58. Mr. W. Sedgwick, in 'British and Foreign Medico-Chirurgical Review,' 1863, July, p. 183. Bronn, in his 'Geschichte der Natur,' 1843, B. ii. s. 127, has collected several cases with respect to mares, sows, and dogs. Mr. W. C. L. Martin ('History of the Dog,' 1845, p. 104) says he can personally vouch for the influence of the male parent on subsequent litters by other dogs. A French poet, Jacques Savary, who wrote in 1665 on dogs, was aware of this singular fact. Dr. Bowerbank has given us the following striking case:—A black, hairless Barbary bitch was first accidentally impregnated by a mongrel spaniel with long brown hair, and she produced five puppies, three of which were hairless and two covered with *short* brown hair. The next time she was put to a black, hairless Barbary dog; "but the mischief had been implanted in the mother, and again about half the litter looked like pure Barbarys, and the other half like the *short*-haired progeny of the first father." I have given in the text one case with pigs; an equally striking one has been recently published in Germany, 'Illust. Landwirth. Zeitung,' 1868, Nov. 17th, p. 143. It is worth notice that farmers in S. Brazil (as I hear from Fritz Müller), and at the C. of Good Hope (as I have heard from two trustworthy persons) are convinced that mares which have once borne mules, when subsequently put to horses, are extremely liable to produce colts, striped like a mule. Dr. Wilckens, of Pogarth, gives ('Jahrbuch Landwirthschaft,' ii. 1869, p. 325) a striking and analogous case. A merino ram, having two small lappets or flaps of skin on the neck, was in the winter of 1861-62 put to several Merino ewes, all of whom bore lambs with similar flaps on their necks. The ram was killed in the spring of 1862

and subsequently to his death the ewes were put to other Merino rams, and in 1863 to Southdown rams, none of whom ever have neck lappets: nevertheless, even as long afterwards as 1867, several of these ewes produced lambs bearing these appendages.

[153] ‘Le Pigeon Voyageur Belge,’ 1865, p. 59.

[154] It may be worth while to call attention to the several means by which flowers and fruit become striped or mottled. Firstly, by the direct action of the pollen of another variety or species, as in the cases given of oranges and maize. Secondly, in crosses of the first generation, when the colours of the two parents do not readily unite, as with Mirabilis and Dianthus. Thirdly, in crossed plants of a subsequent generation by reversion, through either bud or seminal generation. Fourthly, by reversion to a character not originally gained by a cross, but which had long been lost, as with white-flowered varieties, which we shall hereafter see often become striped with some other colour. Lastly, there are cases, as when peaches are produced with a half or quarter of the fruit like a nectarine, in which the change is apparently due to mere variation, through either bud or seminal generation.

[155] ‘Production des Variétés,’ p. 37.

[156] ‘Flora Anomala,’ p. 164.

[157] ‘Schriften der physisch-okon. Gesell. zu Königsberg,’ B. vi. Feb. 3rd, 1865, s. 4.

[158] ‘Production des Variétés,’ pp. 58, 70.

[159] Carrière, ‘Production des Variétés,’ p. 39.

CHAPTER XII.
INHERITANCE.

WONDERFUL NATURE OF INHERITANCE—PEDIGREES OF OUR DOMESTICATED ANIMALS—INHERITANCE NOT DUE TO CHANCE—TRIFLING CHARACTERS INHERITED—DISEASES INHERITED—PECULIARITIES IN THE EYE INHERITED—DISEASES IN THE HORSE—LONGEVITY AND VIGOUR—ASYMMETRICAL DEVIATIONS OF STRUCTURE—POLYDACTYLISM AND REGROWTH OF SUPERNUMERARY DIGITS AFTER AMPUTATION—CASES OF SEVERAL CHILDREN SIMILARLY AFFECTED FROM NON-AFFECTED PARENTS—WEAK AND FLUCTUATING INHERITANCE: IN WEEPING

TREES, IN DWARFNESS, COLOUR OF FRUIT AND FLOWERS—COLOUR OF HORSES—NON-INHERITANCE IN CERTAIN CASES—INHERITANCE OF STRUCTURE AND HABITS OVERBORNE BY HOSTILE CONDITIONS OF LIFE, BY INCESSANTLY RECURRING VARIABILITY, AND BY REVERSION—CONCLUSION.

The subject of inheritance is an immense one, and has been treated by many authors. One work alone, 'De l'Hérédité Naturelle' by Dr. Prosper Lucas, runs to the length of 1562 pages. We must confine ourselves to certain points which have an important bearing on the general subject of variation, both with domestic and natural productions. It is obvious that a variation which is not inherited throws no light on the derivation of species, nor is of any service to man, except in the case of perennial plants, which can be propagated by buds.

If animals and plants had never been domesticated, and wild ones alone had been observed, we should probably never have heard the saying, that "like begets like." The proposition would have been as self-evident as that all the buds on the same tree are alike, though neither proposition is strictly true. For, as has often been remarked, probably no two individuals are identically the same. All wild animals recognise each other, which shows that there is some difference between them; and when the eye is well practised, the shepherd knows each sheep, and man can distinguish a fellow-man out of millions on millions of other men. Some authors have gone so far as to maintain that the production of slight differences is as much a necessary function of the powers of generation, as the production of offspring like their parents. This view, as we shall see in a future chapter, is not theoretically probable, though practically it holds good. The saying that "like begets like" has, in fact, arisen from the perfect confidence felt by breeders, that a superior or inferior animal will generally reproduce its kind; but this very superiority or inferiority shows that the individual in question has departed slightly from its type.

The whole subject of inheritance is wonderful. When a new character arises, whatever its nature may be, it generally tends to be inherited, at least in a temporary and sometimes in a most persistent manner. What can be more wonderful than that some trifling peculiarity, not primordially attached to the species, should be transmitted through the male or female sexual cells, which are so minute as not to be visible to the naked eye, and afterwards through the incessant changes of a long course of development, undergone either in the womb or in the egg, and ultimately appear in the offspring when mature, or even when quite old, as in the case of certain diseases? Or again, what can be more wonderful than the well-ascertained fact that the minute ovule of a good milking cow will produce a male, from whom a cell, in union with an ovule, will produce a female, and she, when mature, will have large mammary glands, yielding an abundant supply of milk, and even milk of a particular quality? Nevertheless, the real subject of surprise is, as Sir H. Holland has well remarked,[1] not that a character should be inherited, but that any should ever fail to be inherited. In a future chapter, devoted to an hypothesis which I have termed pangenesis, an attempt will be made to show the means by which characters of all kinds are transmitted from generation to generation.

Some writers,[2] who have not attended to natural history, have attempted to show that the force of inheritance has been much exaggerated. The breeders of animals would smile at such simplicity; and if they condescended to make any answer, might ask what would be the chance of winning a prize if two inferior animals were paired together? They might ask whether the half-wild Arabs were led by theoretical notions to keep pedigrees of their horses? Why have pedigrees been scrupulously kept and published of the Shorthorn cattle, and more recently of the Hereford breed? Is it an illusion that these recently improved animals safely transmit their excellent qualities even when crossed with other breeds? have the Shorthorns, without good reason, been purchased at immense prices and exported to almost every quarter of the globe, a thousand guineas having been given for a bull? With greyhounds pedigrees have likewise been kept, and the names of such dogs, as Snowball, Major, etc., are as well known to coursers as those of Eclipse and Herod on the turf. Even with the Gamecock, pedigrees of famous strains were formerly kept, and extended back for a century. With pigs, the Yorkshire and Cumberland breeders "preserve and print pedigrees;" and to show how such highly-bred animals are valued, I may mention that Mr. Brown, who won all the first prizes for small breeds at Birmingham in 1850, sold a young sow and boar of his breed to Lord Ducie for 43 guineas; the sow alone was afterwards sold to the Rev. F. Thursby for 65 guineas; who writes, "She paid me very well, having sold her produce for 300 pounds, and having now four breeding sows from her."[3] Hard cash paid down, over and over again, is an excellent test of inherited superiority. In fact, the whole art of breeding, from which such great results have been attained during the present century, depends on the inheritance of each small detail of structure. But inheritance is not certain; for if it were, the breeder's art[4] would be reduced to a certainty, and there would be little scope left for that wonderful skill and perseverance shown by the men who have left an enduring monument of their success in the present state of our domesticated animals.

It is hardly possible, within a moderate compass, to impress on the mind of those who have not attended to the subject, the full conviction of the force of inheritance which is slowly acquired by rearing animals, by studying the many treatises which have been published on the various domestic animals, and by conversing with breeders. I will select a few facts of the kind, which, as far as I can judge, have most influenced my own mind. With man and the domestic animals, certain peculiarities have appeared in an individual, at rare intervals, or only once or twice in the history of the world, but have reappeared in several of the children and grandchildren. Thus Lambert, "the porcupine-man," whose skin was thickly covered with warty projections, which were periodically moulted, had all his six children and two grandsons similarly affected.[5] The face and body being covered with long hair, accompanied by deficient teeth (to which I shall hereafter refer), occurred in three successive generations in a Siamese family; but this case is not unique, as a woman[6] with a completely hairy face who was exhibited in London in 1663, and another instance has recently occurred. Colonel Hallam[7] has described a race of two-legged pigs, "the hinder extremities being entirely wanting;" and this deficiency was transmitted through three generations. In fact, all races presenting any remarkable peculiarity, such as solid-hoofed swine, Mauchamp sheep, niata cattle, etc., are instances of the long-continued inheritance of rare deviations of structure.

When we reflect that certain extraordinary peculiarities have thus appeared in a single individual out of many millions, all exposed in the same country to the same general conditions of life, and, again, that the same extraordinary peculiarity has sometimes appeared in individuals living under widely different conditions of life, we are driven to conclude that such peculiarities are not directly due to the action of the surrounding conditions, but to unknown laws acting on the organisation or constitution of the individual;—that their production stands in hardly closer relation to the conditions of life than does life itself. If this be so, and the occurrence of the same unusual character in the child and parent cannot be attributed to both having been exposed to the same unusual conditions, then the following problem is worth consideration, as showing that the result cannot be due, as some authors have supposed, to mere coincidence, but must be consequent on the members of the same family inheriting something in common in their constitution. Let it be assumed that, in a large population, a particular affection occurs on an average in one out of a million, so that the *à priori* chance that an individual taken at random will be so affected is only one in a million. Let the population consist of sixty millions, composed, we will assume, of ten million families, each containing six members. On these data, Professor Stokes has calculated for me that the odds will be no less than 8333 millions to 1 that in the ten million families there will not be even a single family in which one parent and two children will be affected by the peculiarity in question. But numerous instances could be given, in which several children have been affected by the same rare peculiarity with one of their parents; and in this case, more especially if the grandchildren be included in the calculation, the odds against mere coincidence become something prodigious, almost beyond enumeration.

In some respects the evidence of inheritance is more striking when we consider the reappearance of trifling peculiarities. Dr. Hodgkin formerly told me of an English family in which, for many generations, some members had a single lock differently coloured from the rest of the hair. I knew an Irish gentleman, who, on the right side of his head, had a small white lock in the midst of his dark hair: he assured me that his grandmother had a similar lock on the same side, and his mother on the opposite side. But it is superfluous to give instances; every shade of expression, which may often be seen alike in parents and children, tells the same story. On what a curious combination of corporeal structure, mental character, and training, handwriting depends! yet every one must have noted the occasional close similarity of the handwriting in father and son, although the father had not taught his son. A great collector of autographs assured me that in his collection there were several signatures of father and son hardly distinguishable except by their dates. Hofacker, in Germany, remarks on the inheritance of handwriting; and it has even been asserted that English boys when taught to write in France naturally cling to their English manner of writing; but for so extraordinary a statement more evidence is requisite.[8] Gait, gestures, voice, and general bearing are all inherited, as the illustrious Hunter and Sir A. Carlisle have insisted.[9] My father communicated to me some striking instances, in one of which a man died during the early infancy of his son, and my father, who did not see this son until grown up and out of health, declared that it seemed to him as if his old friend had risen from the grave, with all his highly peculiar habits and manners. Peculiar manners pass into tricks, and several instances could be given of their inheritance; as in the case, often quoted, of the father who generally slept on his back, with his right leg crossed over the left, and whose daughter, whilst an infant in the cradle, followed exactly the same habit, though an attempt was made to cure her.[10] I will give one instance which has fallen under my own observation, and which is curious from being a trick associated with a peculiar state of mind, namely, pleasureable emotion. A boy had the singular habit, when pleased, of rapidly moving his fingers parallel to each other, and, when much excited, of raising both hands, with the fingers still moving, to the sides of his face on a level with the eyes; when this boy was almost an old man, he could still hardly resist this trick when much pleased, but from its absurdity concealed it. He had eight children. Of these, a girl, when pleased, at the age of four and a half years, moved her fingers in exactly the same way, and what is still odder, when much excited, she raised both her hands, with her fingers still moving, to the sides of her face, in exactly the same manner as her father had done, and sometimes even still continued to do so when alone. I never heard of any one, excepting this one man and his little daughter, who had this strange habit; and certainly imitation was in this instance out of the question.

Some writers have doubted whether those complex mental attributes, on which genius and talent depend, are inherited, even when both parents are thus endowed. But he who will study Mr. Galton's able work on 'Hereditary Genius' will have its doubts allayed.

Unfortunately it matters not, as far as inheritance is concerned, how injurious a quality or structure may be if compatible with life. No one can read the many treatises[11] on hereditary disease and doubt this. The ancients were strongly of this opinion, or, as Ranchin expresses it, *Omnes Grœci, Arabes, et Latini in eo consentiunt.* A long catalogue could be given of all sorts of inherited malformations and of predisposition to various diseases. With gout, fifty per cent of the cases observed in hospital practice are, according to Dr. Garrod, inherited, and a greater percentage in private practice. Every one knows how often insanity runs in families, and some of the cases given by Mr. Sedgwick are awful,—as of a surgeon, whose brother, father, and four paternal uncles were all insane, the latter dying by suicide; of a Jew, whose father, mother, and six brothers and sisters were all mad; and in some other cases several members of the same family, during three or four successive generations, have committed suicide. Striking instances have been recorded of epilepsy, consumption, asthma, stone in the bladder, cancer, profuse bleeding from the slightest injuries, of the mother not giving milk, and of bad parturition being inherited. In this latter respect I may mention an odd case given by a good observer,[12] in which the fault lay in the offspring, and not in the mother: in a part of Yorkshire the farmers continued to select cattle with large hind-quarters, until they made a strain called "Dutch-buttocked," and "the monstrous size of the buttocks of the calf was frequently fatal to the cow, and numbers of cows were annually lost in calving."

Instead of giving numerous details on various inherited malformations and diseases, I will confine myself to one organ, that which is the most complex, delicate, and probably best-known in the human frame, namely, the eye, with its accessory parts.[13] To begin with the latter: I have received an account of a family in which one parent and the children are affected by drooping eyelids, in so peculiar a manner, that they cannot see without throwing their heads backwards. Mr. Wade, of Wakefield, has given me an analogous case of a man who had not his eyelids thus affected at birth, nor owed their state, as far as was known, to inheritance, but they began to droop whilst he was an infant after suffering from fits, and he has transmitted the affection to two out of his three children, as was evident in the photographs of the whole family sent to me together with this account. Sir A. Carlisle[14] specifies a pendulous fold to the eyelids, as inherited. "In a family," says Sir H. Holland,[15] "where the father had a singular elongation of the upper eyelid, seven or eight children were born with the same deformity; two or three other children having it not." Many persons, as I hear from Sir J. Paget, have two or three hairs in their eyebrows much longer than the others; and even so trifling a peculiarity as this certainly runs in families.

With respect to the eye itself, the highest authority in England, Mr. Bowman, has been so kind as to give me the following remarks on certain inherited imperfections. First, hypermetropia, or morbidly long sight: in this affection, the organ, instead of being spherical, is too flat from front to back, and is often altogether too small, so that the retina is brought too forward for the focus of the humours; consequently a convex glass is required for clear vision of near objects, and frequently even of distant ones. This state occurs congenitally, or at a very early age, often in several children of the same family, where one of the parents has presented it.[16] Secondly, myopia, or short-sight, in which the eye is egg-shaped and too long from front to back; the retina in this case lies behind the focus, and is therefore fitted to see distinctly only very near objects. This condition is not commonly congenital, but comes on in youth, the liability to it being well known to be transmissible from parent to child. The change from the spherical to the ovoidal shape seems the immediate consequence of something like inflammation of the coats, under which they yield, and there is ground for believing that it may often originate in causes acting on the individual affected,[17] and may thenceforward become transmissible. When both parents are myopic Mr. Bowman has observed the hereditary tendency in this direction to be heightened, and some of the children to be myopic at an earlier age or in a higher degree than their parents. Thirdly, squinting is a familiar example of hereditary transmission: it is frequently a result of such optical defects as have been above mentioned; but the more primary and uncomplicated forms of it are also sometimes in a marked degree transmitted in a family. Fourthly, *Cataract*, or opacity of the crystalline lens, is commonly observed in persons whose parents have been similarly affected, and often at an earlier age in the children than in the parents. Occasionally more than one child in a family is thus afflicted, one of whose parents or other relations, presents the senile form of the complaint. When cataract affects several members of a family in the same generation, it is often seen to commence at about the same age in each: *e.g.*, in one family several infants or young persons may suffer from it; in another, several persons of middle age. Mr. Bowman also informs me that he has occasionally seen, in several members of the same family, various defects in either the right or left eye; and Mr. White Cooper has often seen peculiarities of vision confined to one eye reappearing in the same eye in the offspring.[18]

The following cases are taken from an able paper by Mr. W. Sedgwick, and from Dr. Prosper Lucas.[19] Amaurosis, either congenital or coming on late in life, and causing total blindness, is often inherited; it has been observed in three successive generations. Congenital absence of the iris has likewise been transmitted for three generations, a cleft-iris for four generations, being limited in this latter case to the males of the family. Opacity of the cornea and congenital smallness of the eyes have been inherited. Portal records a curious case, in which a father and two sons were rendered blind, whenever the head was bent downwards, apparently owing to the crystalline lens, with its capsule, slipping through an unusually large pupil into the anterior chamber of the eye. Day-blindness, or imperfect vision under a bright light, is inherited, as is night-blindness, or an incapacity to see except under a strong light: a case has been recorded, by M. Cunier, of this latter defect having affected eighty-five members of the same family during six generations. The singular incapacity of distinguishing colours, which has been called *Daltonism*, is notoriously hereditary, and has been traced through five generations, in which it was confined to the female sex.

With respect to the colour of the iris: deficiency of colouring matter is well known to be hereditary in albinoes. The iris of one eye being of different colour from that of the other, and the iris being spotted, are cases which have been inherited. Mr. Sedgwick gives, in addition, on the authority of Dr. Osborne,[20] the following curious instance of strong inheritance: a family of sixteen sons and five daughters all had eyes "resembling in miniature the markings on the back of a tortoiseshell cat." The mother of this large family had three sisters and a brother all similarly marked, and they derived this peculiarity from their mother, who belonged to a family notorious for transmitting it to their posterity.

Finally, Dr. Lucas emphatically remarks that there is not one single faculty of the eye which is not subject to anomalies; and not one which is not subjected to the principle of inheritance. Mr. Bowman agrees with the general truth of this proposition; which of course does not imply that all malformations are necessarily inherited; this would not even follow if both parents were affected by an anomaly which in most cases was transmissible.

Even if no single fact had been known with respect to the inheritance of disease and malformations by man, the evidence would have been ample in the case of the horse. And this might have been expected, as horses breed much quicker than man, are matched with care, and are highly valued. I have consulted many works, and the unanimity of the belief by veterinaries of all nations in the transmission of various morbid tendencies is surprising. Authors who have had wide experience give in detail many singular cases, and assert that contracted feet, with the numerous contingent evils, of ring-bones, curbs, splints, spavin, founder and weakness of the front legs, roaring or broken and thick wind, melanosis, specific ophthalmia, and blindness (the great French veterinary Huzard going so far as to say that a blind race could soon be formed), crib-biting, jibbing and ill-temper, are all plainly hereditary. Youatt sums up by saying "there is scarcely a malady to which the horse is subject which is not hereditary;" and M. Bernard adds that the doctrine "that there is scarcely a disease which does not run in the stock, is gaining new advocates every day."[21] So it is in regard to cattle, with consumption, good and bad teeth, fine skin, etc. etc. But enough, and more than enough, has been said on disease. Andrew Knight, from his own experience, asserts that disease is hereditary with plants; and this assertion is endorsed by Lindley.[22]

Seeing how hereditary evil qualities are, it is fortunate that good health, vigour, and longevity are equally inherited. It was formerly a well-known practice, when annuities were purchased to be received during the life-time of a nominee, to search out a person belonging to a family of which many members had lived to extreme old age. As to the inheritance of vigour and endurance, the English race-horse offers an excellent instance. Eclipse begot 334, and King Herod 497 winners. A "cock-tail" is a horse not purely bred, but with only one-eighth, or one-sixteenth impure blood in his veins, yet very few instances have ever occurred of such horses having won a great race. They are sometimes as fleet for short distances as thoroughbreds, but as Mr. Robson, the great trainer, asserts, they are deficient in wind, and cannot keep up the pace. Mr. Lawrence also remarks, "perhaps no instance has ever occurred of a three-part-bred horse saving his *'distance'* in running two miles with thoroughbred racers." It has been stated by Cecil, that when unknown horses, whose parents were not celebrated, have unexpectedly won great races, as in the case of Priam, they can always be proved to be descended, on both sides, through many generations, from first-rate ancestors. On the Continent, Baron Cameronn challenges, in a German veterinary periodical, the opponents of the English race-horse to name one good horse on the Continent, which has not some English race-blood in his veins.[23]

With respect to the transmission of the many slight, but infinitely diversified characters, by which the domestic races of animals and plants are distinguished, nothing need be said; for the very existence of persistent races proclaims the power of inheritance.

A few special cases, however, deserve some consideration. It might have been anticipated, that deviations from the law of symmetry would not have been inherited. But Anderson[24] states that a rabbit produced in a litter a young animal having only one ear; and from this animal a breed was formed which steadily produced one-eared rabbits. He also mentions a bitch with a single leg deficient, and she produced several puppies with the same deficiency. From Hofacker's account,[25] it appears that a one-horned stag was seen in 1781 in a forest in Germany, in 1788 two, and afterwards, from year to year, many were observed with only one horn on the right side of the head. A cow lost a horn by suppuration,[26] and she produced three calves which had on the same side of the head, instead of a horn, a small bony lump attached merely to the skin; but we here encroach on the subject of inherited mutilations. A man who is left-handed, and a shell in which the spire turns in the wrong directions, are departures from the normal asymmetrical condition, and they are well-known to be inherited.

Polydactylism.—Supernumerary fingers and toes are eminently liable, as various authors have insisted, to be inherited. Polydactylism graduates[27] by multifarious steps from a mere cutaneous appendage, not including any bone, to a double hand. But an additional digit, supported on a metacarpal bone, and furnished with all the proper muscles, nerves, and vessels, is sometimes so perfect, that it escapes detection, unless the fingers are actually counted. Occasionally there are several supernumerary digits; but usually only one, making the total number six. This one may be attached to the inner or outer margin of the hand, representing either a thumb or little finger, the latter being the more frequent. Generally, through the law of correlation, both hands and both feet are similarly affected. Dr. Burt Wilder has tabulated[28] a large number of cases, and finds that supernumerary digits are more common on the hands than on the feet, and that men are affected oftener than women. Both these facts can be explained on two principles which seem generally to hold good; firstly, that of two parts, the more specialised one is the more variable, and the arm is more highly specialised than the leg; and secondly that male animals are more variable than females.

The presence of a greater number of digits than five is a great anomaly, for this number is not normally exceeded by any existing mammal, bird, or reptile. Nevertheless, supernumerary digits are strongly inherited; they have been transmitted through five generations; and in some cases, after disappearing for one, two, or even three generations, have reappeared through reversion. These facts are rendered, as Professor Huxley has observed, more remarkable from its being known in most cases that the affected person has not married one similarly affected. In such cases the child of the fifth generation would have only 1-32nd part of the blood of his first sedigitated ancestor. Other cases are rendered remarkable by the affection gathering force, as Dr. Struthers has shown, in each generation, though in each the affected person married one not affected; moreover, such additional digits are often amputated soon after birth, and can seldom have been strengthened by use. Dr. Struthers gives the following instance: in the first generation an additional digit appeared on one hand; in the second, on both hands; in the third, three brothers had both hands, and one of the brothers a foot affected; and in the fourth generation all four limbs were affected. Yet we must not over-estimate the force of inheritance. Dr. Struthers asserts that cases of non-inheritance and of the first appearance of additional digits in unaffected families are much more frequent than cases of inheritance. Many other deviations of structure, of a nature almost as anomalous as supernumerary digits, such as deficient phalanges,[29] thickened joints, crooked fingers, etc., are, in like manner, strongly inherited, and are equally subject to intermission, together with reversion, though in such cases there is no reason to suppose that both parents had been similarly affected.[30]

Additional digits have been observed in negroes as well as in other races of man, and in several of the lower animals, and have been inherited. Six toes have been described on the hind feet of the newt (*Salamandra cristata*), and are said to have occurred with the frog. It deserves notice, that the six-toed newt, though adult, preserved some of its larval characters; for part of the hyoidal apparatus, which is properly absorbed during the act of metamorphosis, was retained. It is also remarkable that in the case of man various structures in an embryonic or arrested state of development, such as a cleft-palate, bifid uterus, etc., are often accompanied by polydactylism.[31] Six toes on the hinder feet are known to have been inherited for three generations of cats. In several breeds of the fowl the hinder toe is double, and is generally transmitted truly, as is well shown when Dorkings are crossed with common four-toed breeds.[32] With animals which have properly less than five digits, the number is sometimes increased to five, especially on the front legs, though rarely carried beyond that number; but this is due to the development of a digit already existing in a more or less rudimentary state. Thus, the dog has properly four toes behind, but in the larger breeds a fifth toe is commonly, though not perfectly, developed. Horses, which properly have one toe alone fully developed with rudiments of the others, have been described with each foot bearing two or three small separate hoofs: analogous facts have been noticed with cows, sheep, goats, and pigs.[33]

There is a famous case described by Mr. White of a child, three years old, with a thumb double from the first joint. He removed the lesser thumb, which was furnished with a nail; but to his astonishment it grew again and reproduced a nail. The child was then taken to an eminent London surgeon, and the newly-grown thumb was removed by its socket-joint, but again it grew and reproduced a nail. Dr. Struthers mentions a case of the partial regrowth of an additional thumb, amputated when a child was three months old; and the late Dr. Falconer communicated to me an analogous instance. In the last edition of this work I also gave a case of the regrowth of a supernumerary little-finger after amputation; but having been informed by Dr. Bachmaier that several eminent surgeons expressed, at a meeting of the Anthropological Society of Munich, great doubt about my statements, I have made more particular inquiries. The full information thus gained, together with a tracing of the hand in its present state, has been laid before Sir J. Paget, and he has come to the conclusion that the degree of regrowth in this case is not greater than sometimes occurs with normal bones, especially with the humerus, when amputated at an early age. He further does not feel fully satisfied about the facts recorded by Mr. White. This being so, it is necessary for me to withdraw the view which I formerly advanced, with much hesitation, chiefly on the ground of the supposed regrowth of additional digits, namely, that their occasional development in man is a case of reversion to a lowly, organised progenitor provided with more than five digits.

I may here allude to a class of facts closely allied to, but somewhat different from, ordinary cases of inheritance. Sir H. Holland[34] states that brothers and sisters of the same family are frequently affected, often at about the same age, by the same peculiar disease, not known to have previously occurred in the family. He specifies the occurrence of diabetes in three brothers under ten years old; he also remarks that children of the same family often exhibit in common infantile diseases, the same peculiar symptoms. My father mentioned to me the case of four brothers who died between the ages of sixty and seventy, in the same highly peculiar comatose state. An instance has already been given of supernumerary digits appearing in four children out of six in a previously unaffected family. Dr. Devay states[35] that two brothers married two sisters, their first-cousins, none of the four nor any relation being an albino; but the seven children produced from this double marriage were all perfect albinoes. Some of these cases, as Mr. Sedgwick[36] has shown, are probably the result of reversion to a remote ancestor, of whom no record had been preserved; and all these cases are so far directly connected with inheritance that no doubt the children inherited a similar constitution from their parents, and, from being exposed to nearly similar conditions of life, it is not surprising that they should be affected in the same manner and at the same period of life.

Most of the facts hitherto given have served to illustrate the force of inheritance, but we must now consider cases grouped as well as the subject allows into classes, showing how feeble, capricious, or deficient the power of inheritance sometimes is. When a new peculiarity first appears, we can never predict whether it will be inherited. If both parents from their birth present the same peculiarity, the probability is strong that it will be transmitted to at least some of their offspring. We have seen that variegation is transmitted much more feebly by seed, taken from a branch which had become variegated through bud-variation, than from plants which were variegated as seedlings. With most plants the power of transmission notoriously depends on some innate capacity in the individual: thus Vilmorin[37] raised from a peculiarly coloured balsam some seedlings, which all resembled their parent; but of these seedlings some failed to transmit the new character, whilst others transmitted it to all their descendants during several successive generations. So again with a variety of the rose, two plants alone out of six were found by Vilmorin to be capable of transmitting the desired character; numerous analogous cases could be given.

The weeping or pendulous growth of trees is strongly inherited in some cases, and, without any assignable reason, feebly in other cases. I have selected this character as an instance of capricious inheritance, because it is certainly not proper to the parent-species, and because, both sexes being borne on the same tree, both tend to transmit the same character. Even supposing that there may have been in some instances crossing with adjoining trees of the same species, it is not probable that all the seedlings would have been thus affected. At Moccas Court there is a famous weeping oak; many of its branches "are 30 feet long, and no thicker in any part of this length than a common rope:" this tree transmits its weeping character, in a greater or less degree, to all its seedlings; some of the young oaks being so flexible that they have to be supported by props; others not showing the weeping tendency till about twenty years old.[38] Mr. Rivers fertilised, as he informs me, the flowers of a new Belgian weeping thorn (*Cratægus oxyacantha*) with pollen from a crimson not-weeping variety, and three young trees, "now six or seven years old, show a decided tendency to be pendulous, but as yet are not so much so as the mother-plant." According to Mr. MacNab,[39] seedlings from a magnificent weeping birch (*Betula alba*), in the Botanic Garden at Edinburgh, grew for the first ten or fifteen years upright, but then all became weepers like their parent. A peach with pendulous branches, like those of the weeping willow, has been found capable of propagation by seed.[40] Lastly, a weeping or rather a prostrate yew (*Taxus baccata*) was found in a hedge in Shropshire; it was a male, but one branch bore female flowers, and produced berries; these, being sown, produced seventeen trees all of which had exactly the same peculiar habit with the parent-tree.[41]

These facts, it might have been thought, would have been sufficient to render it probable that a pendulous habit would in all cases be strictly inherited. But let us look to the other side. Mr. MacNab[42] sowed seeds of the weeping beech (*Fagus sylvatica*), but succeeded in raising only common beeches. Mr. Rivers, at my request, raised a number of seedlings from three distinct varieties of weeping elm; and at least one of the parent-trees was so situated that it could not have been crossed by any other elm; but none of the young trees, now about a foot or two in height, show the least signs of weeping. Mr. Rivers formerly sowed above twenty thousand seeds of the weeping ash (*Fraxinus excelsior*), and not a single seedling was in the least degree pendulous: in Germany, M. Borchmeyer raised a thousand seedlings, with the same result. Nevertheless, Mr. Anderson, of the Chelsea Botanic Garden, by sowing seed from a weeping ash, which was found before the year 1780, in Cambridgeshire, raised several pendulous trees.[43] Professor Henslow also informs me that some seedlings from a female weeping ash in the Botanic Garden at Cambridge were at first a little pendulous, but afterwards became quite upright: it is probable that this latter tree, which transmits to a certain extent its pendulous habit, was derived by a bud from the same original Cambridgeshire stock; whilst other weeping ashes may have had a distinct origin. But the crowning case, communicated to me by Mr. Rivers, which shows how capricious is the inheritance of a pendulous habit, is that a variety of another species of ash (*F. lentiscifolia*), now about twenty years old, which was formerly pendulous, “has long lost this habit, every shoot being remarkably erect; but seedlings formerly raised from it were perfectly prostrate, the stems not rising more than two inches above the ground.” Thus the weeping variety of the common ash, which has been extensively propagated by buds during a long period, did not with Mr. Rivers, transmit its character to one seedling out of above twenty thousand; whereas the weeping variety of a second species of ash, which could not, whilst grown in the same garden, retain its own weeping character, transmitted to its character the pendulous habit in excess!

Many analogous facts could be given, showing how apparently capricious is the principle of inheritance. All the seedlings from a variety of the Barberry (*B. vulgaris*) with red leaves inherited the same character; only about one-third of the seedlings of the copper Beech (*Fagus sylvatica*) had purple leaves. Not one out of a hundred seedlings of a variety of the *Cerasus padus*, with yellow fruit, bore yellow fruit: one-twelfth of the seedlings of the variety of *Cornus mascula*, with yellow fruit, came true:[44] and lastly, all the trees raised by my father from a yellow-berried holly (*Ilex aquifolium*), found wild, produced yellow berries. Vilmorin[45] observed in a bed of *Saponaria calabrica* an extremely dwarf variety, and raised from it a large number of seedlings; some of these partially resembled their parent, and he selected their seed; but the grandchildren were not in the least dwarfed: on the other hand, he observed a stunted and bushy variety of *Tagetes signata* growing in the midst of the common varieties by which it was probably crossed; for most of the seedlings raised from this plant were intermediate in character, only two perfectly resembling their parent; but seed saved from these two plants reproduced the new variety so truly, that hardly any selection has since been necessary.

Flowers transmit their colour truly, or most capriciously. Many annuals come true: thus I purchased German seeds of thirty-four named sub-varieties of one *race* of ten-week stocks (*Matthiola annua*), and raised a hundred and forty plants, all of which, with the exception of a single plant, came true. In saying this, however, it must be understood that I could distinguish only twenty kinds out of the thirty-four named sub-varieties; nor did the colour of the flower always correspond with the name affixed to the packet; but I say that they came true, because in each of the thirty-six short rows every plant was absolutely alike, with the one single exception. Again, I procured packets of German seed of twenty-five named varieties of common and quilled asters, and raised a hundred and twenty-four plants; of these, all except ten were true in the above limited sense; and I considered even a wrong shade of colour as false.

It is a singular circumstance that white varieties generally transmit their colour much more truly than any other variety. This fact probably stands in close relation with one observed by Verlot,[46] namely, that flowers which are normally white rarely vary into any other colour. I have found that the white varieties of *Delphinium consolida* and of the Stock are the truest. It is, indeed, sufficient to look through a nurseryman's seed-list, to see the large number of white varieties which can be propagated by seed. The several coloured varieties of the sweet-pea (*Lathyrus odoratus*) are very true; but I hear from Mr. Masters, of Canterbury, who has particularly attended to this plant, that the white variety is the truest. The hyacinth, when propagated by seed, is extremely inconstant in colour, but "white hyacinths almost always give by seed white-flowered plants;"[47] and Mr. Masters informs me that the yellow varieties also reproduce their colour, but of different shades. On the other hand, pink and blue varieties, the latter being the natural colour, are not nearly so true: hence, as Mr. Masters has remarked to me, "we see that a garden variety may acquire a more permanent habit than a natural species;" but it should have been added, that this occurs under cultivation, and therefore under changed conditions.

With many flowers, especially perennials, nothing can be more fluctuating than the colour of the seedlings, as is notoriously the case with verbenas, carnations, dahlias, cinerarias, and others.[48] I sowed seed of twelve named varieties of Snapdragon (*Antirrhinum majus*), and utter confusion was the result. In most cases the extremely fluctuating colour of seedling plants is probably in chief part due to crosses between differently-coloured varieties during previous generations. It is almost certain that this is the case with the polyanthus and coloured primrose (*Primula veris* and *vulgaris*), from their reciprocally dimorphic structure;[49] and these are plants which florists speak of as never coming true by seed: but if care be taken to prevent crossing, neither species is by any means very inconstant, in colour; thus I raised twenty-three plants from a purple primrose, fertilised by Mr. J. Scott with its pollen, and eighteen came up purple of different shades, and only five reverted to the ordinary yellow colour: again, I raised twenty plants from a bright-red cowslip, similarly treated by Mr. Scott, and every one perfectly resembled its parent in colour, as likewise did, with the exception of a single plant, 72 grandchildren. Even with the most variable flowers, it is probable that each delicate shade of colour might be permanently fixed so as to be transmitted by seed, by cultivation in the same soil, by long-continued selection, and especially by the prevention of crosses. I infer this from certain annual larkspurs (*Delphinium consolida* and *ajacis*), of which common seedlings present a greater diversity of colour than any other plant known to me; yet on procuring seed of five named German varieties of *D. consolida,* only nine plants out of ninety-four were false; and the seedlings of six varieties of *D. ajacis* were true in the same manner and degree as with the stocks above described. A distinguished botanist maintains that the annual species of Delphinium are always self-fertilised; therefore I may mention that thirty-two flowers on a branch of *D. consolida,* enclosed in a net, yielded twenty-seven capsules, with an average of 17·2 seed in each; whilst five flowers, under the same net, which were artificially fertilised, in the same manner as must be effected by bees during their incessant visits, yielded five capsules with an average of 35·2 fine seed; and this shows that the agency of insects is necessary for the full fertility of this plant. Analogous facts could be given with respect to the crossing of many other flowers, such as carnations, etc., of which the varieties fluctuate much in colour.

As with flowers, so with our domesticated animals, no character is more variable than colour, and probably in no animal more so than with the horse. Yet, with a little care in breeding, it appears that races of any colour might soon be formed. Hofacker gives the result of matching two hundred and sixteen mares of four different colours with like-coloured stallions, without regard to the colour of their ancestors; and of the two hundred and sixteen colts born, eleven alone failed to inherit the colour of their parents: Autenrieth and Ammon assert that, after two generations, colts of a uniform colour are produced with certainty.[50]

In a few rare cases peculiarities fail to be inherited, apparently from the force of inheritance being too strong. I have been assured by breeders of the canary-bird that to get a good jonquil-coloured bird it does not answer to pair two jonquils, as the colour then comes out too strong, or is even brown; but this statement is disputed by other breeders. So again, if two crested canaries are paired, the young birds rarely inherit this character:[51] for in crested birds a narrow space of bare skin is left on the back of the head, where the feathers are up-turned to form the crest, and, when both parents are thus characterised, the bareness becomes excessive, and the crest itself fails to be developed. Mr. Hewitt, speaking of Laced Sebright Bantams, says[52] that, “why this should be so I know not, but I am confident that those that are best laced frequently produce offspring very far from perfect in their markings, whilst those exhibited by myself, which have so often proved successful, were bred from the union of heavily-laced birds with those that were scarcely sufficiently laced.”

It is a singular fact that, although several deaf-mutes often occur in the same family, and though their cousins and other relations are often in the same condition, yet their parents are rarely deaf-mutes. To give a single instance: not one scholar out of 148, who were at the same time in the London Institution, was the child of parents similarly affected. So again, when a male or female deaf-mute marries a sound person, their children are most rarely affected: in Ireland, out of 203 children thus produced one alone was mute. Even when both parents have been deaf-mutes, as in the case of forty-one marriages in the United States and of six in Ireland, only two deaf and dumb children were produced. Mr. Sedgwick,[53] in commenting on this remarkable and fortunate failure in the power of transmission in the direct line, remarks that it may possibly be owing to “excess having reversed the action of some natural law in development.” But it is safer in the present state of our knowledge to look at the whole case as simply unintelligible.

Although many congenital monstrosities are inherited, of which examples have already been given, and to which may be added the lately recorded case of the transmission during a century of hare-lip with a cleft-palate in the writer's own family,[54] yet other malformations are rarely or never inherited. Of these latter cases, many are probably due to injuries in the womb or egg, and would come under the head of non-inherited injuries or mutilations. With plants, a long catalogue of inherited monstrosities of the most serious and diversified nature could easily be given; and with plants, there is no reason to suppose that monstrosities are caused by direct injuries to the seed or embryo.

With respect to the inheritance of structures mutilated by injuries or altered by disease, it was until lately difficult to come to any definite conclusion. Some mutilations have been practised for a vast number of generations without any inherited result. Godron remarks[55] that different races of man have from time immemorial knocked out their upper incisors, cut off joints of their fingers, made holes of immense size through the lobes of their ears or through their nostrils, tatooed themselves, made deep gashes in various parts of their bodies, and there is no reason to suppose that these mutilations have ever been inherited.[56] Adhesions due to inflammation and pits from the small-pox (and formerly many consecutive generations must have been thus pitted) are not inherited. With respect to Jews, I have been assured by three medical men of the Jewish faith that circumcision, which has been practised for so many ages, has produced no inherited effect. Blumenbach, however, asserts[57] that Jews are often born in Germany in a condition rendering circumcision difficult, so that a name is given them signifying "born circumcised;" and Professor Preyer informs me that this is the case in Bonn, such children being considered the special favourites of Jehovah. I have also heard from Dr. A. Newman, of Guy's Hospital, of the grandson of a circumcised Jew, the father not having been circumcised, in a similar condition. But it is possible that all these cases may be accidental coincidence, for Sir J. Paget has seen five sons of a lady and one son of her sister with adherent prepuces; and one of these boys was affected in a manner "which might be considered like that commonly produced by circumcision;" yet there was no suspicion of Jewish blood in the family of these two sisters. Circumcision is practised by Mahomedans, but at a much later age than by Jews; and Dr. Riedel, Assistant Resident in North Celebes, writes to me that the boys there go naked until from six to ten years old; and he has observed that many of them, though not all, have their prepuces much reduced in length, and this he attributes to the inherited effects of the operation. In the vegetable kingdom oaks and other trees have borne galls from primeval times, yet they do not produce inherited excrescences; and many other such facts could be adduced.

Notwithstanding the above several negative cases, we now possess conclusive evidence that the effects of operations are sometimes inherited. Dr. Brown-Séquard[58] gives the following summary of his observations on guinea-pigs; and this summary is so important that I will quote the whole:—

“1st. Appearance of epilepsy in animals born of parents having been rendered epileptic by an injury to the spinal cord.

“2nd. Appearance of epilepsy also in animals born of parents having been rendered epileptic by the section of the sciatic nerve.

“3rd. A change in the shape of the ear in animals born of parents in which such a change was the effect of a division of the cervical sympathetic nerve.

“4th. Partial closure of the eyelids in animals born of parents in which that state of the eyelids had been caused either by the section of the cervical sympathetic nerve or the removal of the superior cervical ganglion.

“5th. Exophthalmia in animals born of parents in which an injury to the restiform body had produced that protrusion of the eyeball. This interesting fact I have witnessed a good many times, and I have seen the transmission of the morbid state of the eye continue through four generations. In these animals, modified by heredity, the two eyes generally protruded, although in the parents usually only one showed exophthalmia, the lesion having been made in most cases only on one of the corpora restiformia.

“6th. Hæmatoma and dry gangrene of the ears in animals born of parents in which these ear-alterations had been caused by an injury to the restiform body near the nib of the calamus.

“7th. Absence of two toes out of the three of the hind leg, and sometimes of the three, in animals whose parents had eaten up their hind-leg toes which had become anæsthetic from a section of the sciatic nerve alone, or of that nerve and also of the crural. Sometimes, instead of complete absence of the toes, only a part of one or two or three was missing in the young, although in the parent not only the toes but the whole foot was absent (partly eaten off, partly destroyed by inflammation, ulceration, or gangrene).

“8th. Appearance of various morbid states of the skin and hair of the neck and face in animals born of parents having had similar alterations in the same parts, as effects of an injury to the sciatic nerve.”

It should be especially observed that Brown-Séquard has bred during thirty years many thousand guinea-pigs from animals which had not been operated upon, and not one of these manifested the epileptic tendency. Nor has he ever seen a guinea-pig born without toes, which was not the offspring of parents which had gnawed off their own toes owing to the sciatic nerve having been divided. Of this latter fact thirteen instances were carefully recorded, and a greater number were seen; yet Brown-Séquard speaks of such cases as one of the rarer forms of inheritance. It is a still more interesting fact—

“That the sciatic nerve in the congenitally toeless animal has inherited the power of passing through all the different morbid states which have occurred in one of its parents from the time of the division till after its reunion with the peripheric end. It is not therefore simply the power of performing an action which is inherited, but the power of performing a whole series of actions, in a certain order.”

In most of the cases of inheritance recorded by Brown-Séquard only one of the two parents had been operated upon and was affected. He concludes by expressing his belief that "what is transmitted is the morbid state of the nervous system," due to the operation performed on the parents.

With the lower animals Dr. Prosper Lucas has collected a long list of inherited injuries. A few instances will suffice. A cow lost a horn from an accident with consequent suppuration, and she produced three calves which were hornless on the same side of the head. With the horse, there seems hardly a doubt that exostoses on the legs, caused by too much travelling on hard roads, are inherited. Blumenbach records the case of a man who had his little finger on the right hand almost cut off, and which in consequence grew crooked, and his sons had the same finger on the same hand similarly crooked. A soldier, fifteen years before his marriage, lost his left eye from purulent ophthalmia, and his two sons were microphthalmic on the same side.[59] In all cases in which a parent has had an organ injured on one side, and two or more of the offspring are born with the same organ affected on the same side, the chances against mere coincidence are almost infinitely great. Even when only a single child is born having exactly the same part of the body affected as that of his injured parent, the chances against coincidence are great; and Professor Rolleston has given me two such cases which have fallen under his own observation,—namely of two men, one of whom had his knee and the other his cheek severely cut, and both had children born with exactly the same spot marked or scarred. Many instances have been recorded of cats, dogs, and horses, which have had their tails, legs, etc., amputated or injured, producing offspring with the same parts ill-formed; but as it is not very rare for similar malformations to appear spontaneously, all such cases may be due to coincidence. It is, however, an argument on the other side that "under the old excise laws the shepherd-dog was only exempt from tax when without a tail, and for this reason it was always removed;"[60] and there still exist breeds of the shepherd-dog which are always born destitute of a tail. Finally, it must be admitted, more especially since the publication of Brown-Séquard's observations, that the effects of injuries, especially when followed by disease, or perhaps exclusively when thus followed, are occasionally inherited.[61]

Causes of Non-inheritance.

A large number of cases of non-inheritance are intelligible on the principle, that a strong tendency to inheritance does exist, but that it is overborne by hostile or unfavourable conditions of life. No one would expect that our improved pigs, if forced during several generations to travel about and root in the ground for their own subsistence, would transmit, as truly as they now do their short muzzles and legs, and their tendency to fatten. Dray-horses assuredly would not long transmit their great size and massive limbs, if compelled to live on a cold, damp mountainous region; we have indeed evidence of such deterioration in the horses which have run wild on the Falkland Islands. European dogs in India often fail to transmit their true character. Our sheep in tropical countries lose their wool in a few generations. There seems also to be a close relation between certain peculiar pastures and the inheritance of an enlarged tail in fat-tailed sheep, which form one of the most ancient breeds in the world. With plants, we have seen that tropical varieties of maize lose their proper character in the course of two or three generations, when cultivated in Europe; and conversely so it is with European varieties cultivated in Brazil. Our cabbages, which here come so true by seed, cannot form heads in hot countries. According to Carrière,[62] the purple-leafed beech and barberry transmit their character by seed far less truly in certain districts than in others. Under changed circumstances, periodical habits of life soon fail to be transmitted, as the period of maturity in summer and winter wheat, barley, and vetches. So it is with animals: for instance, a person, whose statement I can trust, procured eggs of Aylesbury ducks from that town, where they are kept in houses and are reared as early as possible for the London market; the ducks bred from these eggs in a distant part of England, hatched their first brood on January 24th, whilst common ducks, kept in the same yard and treated in the same manner, did not hatch till the end of March; and this shows that the period of hatching was inherited. But the grandchildren of these Aylesbury ducks completely lost their habit of early incubation, and hatched their eggs at the same time with the common ducks of the same place.

Many cases of non-inheritance apparently result from the conditions of life continually inducing fresh variability. We have seen that when the seeds of pears, plums, apples, etc., are sown, the seedlings generally inherit some degree of family likeness. Mingled with these seedlings, a few, and sometimes many, worthless, wild-looking plants commonly appear, and their appearance may be attributed to the principle of reversion. But scarcely a single seedling will be found perfectly to resemble the parent-form; and thus may be accounted for by constantly recurring variability induced by the conditions of life. I believe in this, because it has been observed that certain fruit-trees truly propagate their kind whilst growing on their own roots; but when grafted on other stocks, and by this process their natural state is manifestly affected, they produce seedlings which vary greatly, departing from the parental type in many characters.[63] Metzger, as stated in the ninth chapter, found that certain kinds of wheat brought from Spain and cultivated in Germany, failed during many years to reproduce themselves truly; but at last, when accustomed to their new conditions, they ceased to be variable,—that is, they became amenable to the power of inheritance. Nearly all the plants which cannot be propagated with any approach to certainty by seed, are kinds which have been long propagated by buds, cuttings, offsets, tubers, etc., and have in consequence been frequently exposed during what may be called their individual lives to widely diversified conditions of life. Plants thus propagated become so variable, that they are subject, as we have seen in the last chapter, even to bud-variation. Our domesticated animals, on the other hand, are not commonly exposed during the life of the individual to such extremely diversified conditions, and are not liable to such extreme variability; therefore they do not lose the power of transmitting most of their characteristic features. In the foregoing remarks on non-inheritance, crossed breeds are of course excluded, as their diversity mainly depends on the unequal development of character derived from either parent or their ancestors.

Conclusion.

It has been shown in the early part of this chapter how commonly new characters of the most diversified nature, whether normal or abnormal, injurious or beneficial, whether affecting organs of the highest or most trifling importance, are inherited. It is often sufficient for the inheritance of some peculiar character, that one parent alone should possess it, as in most cases in which the rarer anomalies have been transmitted. But the power of transmission is extremely variable. In a number of individuals descended from the same parents, and treated in the same manner, some display this power in a perfect manner, and in some it is quite deficient; and for this difference no reason can be assigned. The effects of injuries or mutilations are occasionally inherited; and we shall see in a future chapter that the long-continued use and disuse of parts produces an inherited effect. Even those characters which are considered the most fluctuating, such as colour, are with rare exceptions transmitted much more forcibly than is generally supposed. The wonder, indeed, in all cases is not that any character should be transmitted, but that the power of inheritance should ever fail. The checks to inheritance, as far as we know them, are, firstly, circumstances hostile to the particular character in question; secondly, conditions of life incessantly inducing fresh variability; and lastly, the crossing of distinct varieties during some previous generation, together with reversion or atavism-that is, the tendency in the child to resemble its grand-parents or more remote ancestors instead of its immediate parents. This latter subject will be discussed in the following chapter.

REFERENCES

[1] ‘Medical Notes and Reflections,’ 3rd edit., 1855, p. 267.

[2] Mr. Buckle, in his ‘History of Civilisation,’ expresses doubts on the subject, owing to the want of statistics. *See also* Mr. Bowen, Professor of Moral Philosophy, in ‘Proc. American Acad. of Sciences,’ vol. v. p. 102.

[3] For greyhounds, *see* Low’s ‘Domestic Animals of the British Islands,’ 1845, p. 721. For game-fowls, *see* ‘The Poultry Book,’ by Mr. Tegetmeier, 1866, p. 123. For pigs, *see* Mr. Sidney’s edition of ‘Youatt on the Pig,’ 1860, pp. 11, 22.

[4] ‘The Stud Farm,’ by Cecil, p. 39.

[5] ‘Philosophical Transactions,’ 1755, p. 23. I have seen only second-hand accounts of the two grandsons. Mr. Sedgwick, in a paper to which I shall

hereafter often refer, states that *four* generations were affected, and in each the males alone.

[6] Barbara Van Beck, figured, as I am informed by the Rev. W.D. Fox, in Woodburn's 'Gallery of Rare Portraits,' 1816, vol. ii.

[7] 'Proc. Zoolog. Soc.,' 1833, p. 16.

[8] Hofacker 'Ueber die Eigenschaften,' etc., 1828, s. 34. With respect to France, Report by Pariset in 'Comptes Rendus,' 1847, p. 592.

[9] Hunter, as quoted in Harlan's 'Med. Researches,' p. 530. Sir A. Carlisle, 'Phil. Transact.,' 1814, p. 94.

[10] Girou de Buzareingues, 'De la Génération,' p. 282. I have given an analogous case in my book on 'The Expression of the Emotions.'

[11] The works which I have read and found most useful are Dr. Prosper Lucas's great work, 'Traité de l'Hérédité Naturelle,' 1847; Mr. W. Sedgwick, in 'British and Foreign Medico-Chirurg. Review,' April and July, 1861, and April and July, 1863: Dr. Garrod on Gout is quoted in these articles. Sir Henry Holland, 'Medical Notes and Reflections,' 3rd edit., 1855. Piorry, 'De l'Hérédité dans les Maladies,' 1840. Adams, 'A Philosophical Treatise on Hereditary Peculiarities,' 2nd edit., 1815. Essay on 'Hereditary Diseases,' by Dr. J. Steinan, 1843. *See* Paget in 'Medical Times,' 1857, p. 192, on the Inheritance of Cancer; Dr. Gould, in 'Proc. of American Acad. of Sciences,' Nov. 8th, 1853, gives a curious case of hereditary bleeding in four generations. Harlan, 'Medical Researches,' p. 593.

[12] Marshall, quoted by Youatt in his work on Cattle, p. 284.

[13] Almost any other organ might have been selected. For instance Mr. J. Tomes, 'System of Dental Surgery,' 2nd edit., 1873, p. 114, gives many instances with teeth, and others have been communicated to me.

[14] 'Philosoph. Transact.,' 1814, p. 94.

[15] 'Medical Notes and Reflections,' 3rd edit., p. 33.

[16] This affection, as I hear from Mr. Bowman, has been ably described and spoken of as hereditary by Dr. Donders of Utrecht, whose work was published in English by the Sydenham Society in 1864.

[17] M. Giraud-Teulon has recently collected abundant statistical evidence, 'Revue des Cours Scientifiques,' Sept., 1870, p. 625, showing that short sight is due to the habit of viewing objects from a short distance, *c'est le travail assidu, de près.*

[18] Quoted by Mr. Herbert Spencer, 'Principles of Biology,' vol. i. p. 244.

[19] ‘British and Foreign Medico-Chirurg. Review,’ April, 1861, pp. 482-6; ‘L’Héréd. Nat.,’ tom. i. pp. 391-408.

[20] Dr. Osborne, Pres. of Royal College of Phys. in Ireland, published this case in the ‘Dublin Medical Journal,’ for 1835.

[21] These various statements are taken from the following works and papers:—Youatt on ‘The Horse,’ pp. 35, 220. Lawrence, ‘The Horse,’ p. 30. Karkeek, in an excellent paper in ‘Gard. Chronicle,’ 1853, p. 92. Mr. Burke, in ‘Journal of R. Agricul. Soc. of England,’ vol. v. p. 511. ‘Encyclop. of Rural Sports,’ p. 279. Girou de Buzareingues, ‘Philosoph. Phys.,’ p. 215. *See* following papers in ‘The Veterinary;’ Roberts in vol. ii. p. 144; M. Marrimpoey vol. ii. p. 387; Mr. Karkeek, vol. iv. p. 5; Youatt on Goitre in Dogs, vol. v. p. 483: Youatt in vol. vi. pp. 66, 348, 412; M. Bernard, vol. xi. p. 539; Dr. Samesreuther, on Cattle, in vol. xii. p. 181; Percivall, in vol. xiii. p. 47. With respect to blindness in horses *see also* a whole row of authorities in Dr. P. Lucas’s great work, tom. i. p. 399. Mr. Baker in ‘The Veterinary,’ vol. xiii. p. 721, gives a strong case of hereditary imperfect vision and of jibbing.

[22] Knight on ‘The Culture of the Apple and Pear,’ p. 34. Lindley’s ‘Horticulture,’ p. 180.

[23] These statements are taken from the following works in order:—Youatt on ‘The Horse,’ p. 48; Mr. Darvill, in ‘The Veterinary,’ vol. viii. p. 50. With respect to Robson, *see* ‘The Veterinary,’ vol. iii. p. 580; Mr. Lawrence on ‘The Horse,’ 1829, p. 9; ‘The Stud Farm,’ by Cecil, 1851; Baron Cameronn, quoted in ‘The Veterinary,’ vol. x. p. 500.

[24] ‘Recreations in Agriculture and Nat. Hist.,’ vol. i. p. 68.

[25] ‘Ueber die Eigenschaften,’ etc., 1828, s. 107.

[26] Bronn’s ‘Geschichte der Natur,’ Band ii. 2 s. 132.

[27] Vrolik has discussed this point at full length in a work published in Dutch, from which Sir J. Paget has kindly translated for me passages. *See, also,* Isidore Geoffroy St. Hilaire’s ‘Hist. des Anomalies,’ 1832, tom. i. p. 684.

[28] ‘Massachusetts Medical Society,’ vol. ii. No. 3; and ‘Proc. Boston Soc. of Nat. Hist.,’ vol. xiv. 1871, p. 154.

[29] Dr. J. W. Ogle gives a case of the inheritance of deficient phalanges during four generations. He adds references to various recent papers on inheritance, ‘Brit. and For. Med.-Chirurg. Review,’ April 1872.

[30] For these several statements, *see* Dr. Struthers ‘Edinburgh New Phil. Journal,’ July, 1863, especially on intermissions in the line of descent. Prof. Huxley, ‘Lectures on our Knowledge of Organic Nature,’ 1863, p. 97. With respect to inheritance, *see* Dr. Prosper Lucas, ‘L’Hérédité Nat.,’ tom. i. p.

325. Isid. Geoffroy, ‘Anom.,’ tom. i. p. 701. Sir A. Carlisle, in ‘Phil. Transact.,’ 1814, p. 94. A. Walker, on ‘Intermarriage,’ 1838, p. 140, gives a case of five generations; as does Mr. Sedgwick in ‘Brit. and Foreign Medico-Chirurg. Review,’ April, 1863, p. 462. On the inheritance of other anomalies in the extremities *see* Dr. H. Dobell, in vol. xlvi. of ‘Medico-Chirurg. Transactions,’ 1863; also Mr. Sedgwick in op. cit., April, 1863, p. 460. With respect to additional digits in the negro *see* Prichard, ‘Physical History of Mankind.’ Dr. Dieffenbach (‘Jour. Royal Geograph. Soc.,’ 1841, p. 208) says this anomaly is not uncommon with the Polynesians of the Chatham Islands; and I have heard of several cases with Hindus and Arabs.

[31] Meckel and Isid G. St. Hilaire insist on this fact. *See also* M. A. Roujou, ‘Sur quelques Analogies du Type Humain,’ p. 61; published, I believe, in the ‘Journal of the Anthropolog. Soc. of Paris,’ Jan. 1872.

[32] ‘The Poultry Chronicle,’ 1854, p. 559.

[33] The statements in this paragraph are taken from Isidore Geoffroy St. Hilaire, ‘Hist. des Anomalies,’ tom. i. pp. 688-693. Mr. Goodman gives, ‘Phil. Soc. of Cambridge,’ Nov. 25th, 1872, the case of a cow with three well developed toes on each hind limb, besides the ordinary rudiments; and her calf by an ordinary bull had extra digits. This calf also bore two calves having extra digits.

[34] ‘Medical Notes and Reflections,’ 1839, pp. 24, 34. *See also* Dr. P. Lucas, ‘L’Héréd. Nat.,’ tom. ii. p. 33.

[35] ‘Du Danger des Mariages Consanguins,’ 2nd edit., 1862, p. 103.

[36] ‘British and Foreign Medico-Chirurg. Review,’ July, 1863, pp. 183, 189.

[37] Verlot ‘La Product. des Variétés,’ 1865, p. 32.

[38] Loudon’s ‘Gardener’s Mag.,’ vol. xii. 1836, p. 368.

[39] Verlot, ‘La Product. des Variétés,’ 1865, p. 94.

[40] Bronn’s ‘Geschichte der Natur,’ B. ii. s. 121. Mr. Meehan makes a similar statement in ‘Proc. Nat. of Philadelphia,’ 1872, p. 235.

[41] Rev. W. A. Leighton, ‘Flora of Shropshire,’ p. 497; and Charlesworth, ‘Mag. of Nat. Hist.,’ vol. i. 1837, p. 30. I possess prostrate trees produced from these seeds.

[42] Verlot, op. cit., p. 93.

[43] For these several statements, *see* Loudon’s ‘Gard. Magazine,’ vol. x. 1834, pp. 408, 180; and vol. ix. 1833, p. 597.

[44] These statements are taken from Alph. De Candolle, ‘Bot. Géograph.,’ p. 1083.

[45] Verlot, op. cit., p. 38.

[46] Op. cit., p. 59.

[47] Alph. De Candolle, ‘Géograph. Bot.,’ p. 1082.

[48] *See* ‘Cottage Gardener,’ April 10th, 1860, p. 18, and Sept. 10th, 1861, p. 456; ‘Gardener’s Chronicle,’ 1845, p. 102.

[49] Darwin in ‘Journal of Proc. Linn. Soc. Bot.,’ 1862, p. 94.

[50] Hofacker, ‘Ueber die Eigenschaften,’ etc., s. 10.

[51] Bechstein, ‘Naturgesch. Deutschlands,’ B. iv. s. 462. Mr. Brent, a great breeder of canaries, informs me that he believes that these statements are correct.

[52] ‘The Poultry Book,’ by W. B. Tegetmeier, 1866, p. 245.

[53] ‘British and Foreign Med.-Chirurg. Review,’ July, 1861, pp. 200-204. Mr. Sedgwick has given such full details on this subject, with ample references, that I need refer to no other authorities.

[54] Mr. Sproule, in ‘British Medical Journal,’ April 18th, 1863.

[55] ‘De l’Espèce,’ tom. ii. 1859, p. 299.

[56] Nevertheless Mr. Wetherell states, ‘Nature,’ Dec. 1870, p. 168, that when he visited fifteen years ago the Sioux Indians, he was informed “by a physician, who has passed much of his time with these tribes, that sometimes a child was born with these marks. This was confirmed by the U.S. Government Indian Agent.”

[57] ‘Philosoph. Mag.,’ vol. iv. 1799, p. 5.

[58] ‘Proc. Royal Soc.,’ vol. x. p. 297. ‘Communication to the Brit. Assoc.,’ 1870. ‘The Lancet,’ Jan. 1875, p. 7. The extracts are from this last paper. It appears that Obersteiner, ‘Stricker’s Med. Jahrbücher,’ 1875, No. 2, has confirmed Brown-Séquard’s observations.

[59] This last case is quoted by Mr. Sedgwick in ‘British and Foreign Medico-Chirurg. Review,’ April, 1861, p. 484. For Blumenbach, *see* above-cited paper. *See also* Dr. P. Lucas, ‘Traité de l’Héréd. Nat.,’ tom. ii. p. 492. Also, ‘Transact. Linn. Soc.,’ vol. ix. p. 323. Some curious cases are given by Mr. Baker in the ‘Veterinary,’ vol. xiii. p. 723. Another curious case is given in the ‘Annales des Scienc. Nat.,’ 1st series, tom. xi. p. 324.

[60] ‘The Dog,’ by Stonehenge, 1867, p. 118.

[61] The Mot-mot habitually bites the barbs off the middle part of the two central tail-feathers, and as the barbs are congenitally somewhat reduced on the same part of these feathers, it seems extremely probable, as Mr. Salvin remarks (‘Proc. Zoolog. Soc.’ 1873, p. 429), that this is due to the inherited effects of long-continued mutilation.

[62] ‘Production et Fixation des Variétés,’ 1865, p. 72.

[63] Downing, ‘Fruits of America,’ p. 5: Sageret, ‘Pom. Phys.,’ pp. 43, 72.

CHAPTER XIII.
INHERITANCE *continued*—REVERSION OF ATAVISM.

DIFFERENT FORMS OF REVERSION—IN PURE OR UNCROSSED BREEDS, AS IN PIGEONS, FOWLS, HORNLESS CATTLE AND SHEEP, IN CULTIVATED PLANTS—REVERSION IN FERAL ANIMALS AND PLANTS—REVERSION IN CROSSED VARIETIES AND SPECIES—REVERSION THROUGH BUD-PROPAGATION, AND BY SEGMENTS IN THE SAME FLOWER OR FRUIT—IN DIFFERENT PARTS OF THE BODY IN THE SAME ANIMAL—THE ACT OF CROSSING A DIRECT CAUSE OF REVERSION, VARIOUS CASES OF, WITH INSTINCTS—OTHER PROXIMATE CAUSES OF REVERSION—LATENT CHARACTERS—SECONDARY SEXUAL CHARACTERS—UNEQUAL DEVELOPMENT OF THE TWO SIDES OF THE BODY—APPEARANCE WITH ADVANCING AGE OF CHARACTERS DERIVED FROM A CROSS—THE GERM, WITH ALL ITS LATENT CHARACTERS, A WONDERFUL OBJECT—MONSTROSITIES—PELORIC FLOWERS DUE IN SOME CASES TO REVERSION.

The great principle of inheritance to be discussed in this chapter has been recognised by agriculturists and authors of various nations, as shown by the scientific term *Atavism*, derived from atavus, an ancestor; by the English terms of *Reversion*, or *Throwing-back*; by the French *Pas-en-Arrière*; and by the German *Rückschlag*, or *Rückschritt.* When the child resembles either grandparent more closely than its immediate parents, our attention is not much arrested, though in truth the fact is highly remarkable; but when the child resembles some remote ancestor or some distant member in a collateral line,—and in the last case we must attribute this to the descent of all the members from a common progenitor,—we feel a just degree of astonishment. When one parent alone displays some newly-acquired and generally inheritable character, and the offspring do not inherit it, the cause may lie in the other parent having the power of prepotent transmission. But when both parents are similarly characterised, and the child does not, whatever the cause may be, inherit the character in question, but resembles its grandparents, we have one of the simplest cases of reversion. We continually see another and even more simple case of atavism, though not generally included under this head, namely, when the son more closely resembles his maternal than his paternal grand-sire in some male attribute, as in any peculiarity in the beard of man, the horns of the bull, the hackles or comb of the cock, or, as in certain diseases necessarily confined to the male sex; for as the mother cannot possess or exhibit such male attributes, the child must inherit them, through her blood, from his maternal grandsire.

The cases of reversion may be divided into two main classes which, however, in some instances, blend into one another; namely, first, those occurring in a variety or race which has not been crossed, but has lost by variation some character that it formerly possessed, and which afterwards reappears. The second class includes all cases in which an individual with some distinguishable character, a race, or species, has at some former period been crossed, and a character derived from this cross, after having disappeared during one or several generations, suddenly reappears. A third class, differing only in the manner of reproduction, might be formed to include all cases of reversion effected by means of buds, and therefore independent of true or seminal generation. Perhaps even a fourth class might be instituted, to include reversions by segments in the same individual flower or fruit, and in different parts of the body in the same individual animal as it grows old. But the two first main classes will be sufficient for our purpose.

Reversion to lost Characters by pure or uncrossed forms.—Striking instances of this first class of cases were given in the sixth chapter, namely, of the occasional reappearance, in variously-coloured breeds of the pigeon, of blue birds with all the marks characteristic of the wild *Columba livia*. Similar cases were given in the case of the fowl. With the common ass, as the legs of the wild progenitor are almost always striped, we may feel assured that the occasional appearance of such stripes in the domestic animal is a case of simple reversion. But I shall be compelled to refer again to these cases, and therefore here pass them over.

The aboriginal species from which our domesticated cattle and sheep are descended, no doubt possessed horns; but several hornless breeds are now well established. Yet in these—for instance, in Southdown sheep—"it is not unusual to find among the male lambs some with small horns." The horns, which thus occasionally reappear in other polled breeds, either "grow to the full size," or are curiously attached to the skin alone and hang "loosely down, or drop off."[1] The Galloways and Suffolk cattle have been hornless for the last 100 or 150 years, but a horned calf, with the horn often loosely attached, is occasionally produced.[2]

There is reason to believe that sheep in their early domesticated condition were "brown or dingy black;" but even in the time of David certain flocks were spoken of as white as snow. During the classical period the sheep of Spain are described by several ancient authors as being black, red, or tawny.[3] At the present day, notwithstanding the great care which is taken to prevent it, particoloured lambs and some entirely black are occasionally, or even frequently, dropped by our most highly improved and valued breeds, such as the Southdowns. Since the time of the famous Bakewell, during the last century, the Leicester sheep have been bred with the most scrupulous care; yet occasionally grey-faced, or black-spotted, or wholly black lambs appear.[4] This occurs still more frequently with the less improved breeds, such as the Norfolks.[5] As bearing on this tendency in sheep to revert to dark colours, I may state (though in doing so I trench on the reversion of crossed breeds, and likewise on the subject of prepotency) that the Rev. W. D. Fox was informed that seven white Southdown ewes were put to a so-called Spanish ram, which had two small black spots on his sides, and they produced thirteen lambs, all perfectly black. Mr. Fox believes that this ram belonged to a breed which he has himself kept, and which is always spotted with black and white; and he finds that Leicester sheep crossed by rams of this breed always produce black lambs: he has gone on recrossing these crossed sheep with pure white Leicesters during three successive generations, but always with the same result. Mr. Fox was also told by the friend from whom the spotted breed was procured, that he likewise had gone on for six or seven generations crossing with white sheep, but still black lambs were invariably produced.

Similar facts could be given with respect to tailless breeds of various animals. For instance, Mr. Hewitt[6] states that chickens bred from some rumpless fowls, which were reckoned so good that they won a prize at an exhibition, "in a considerable number of instances were furnished with fully developed tail-feathers." On inquiry, the original breeder of these fowls stated that, from the time when he had first kept them, they had often produced fowls furnished with tails; but that these latter would again reproduce rumpless chickens.

Analogous cases of reversion occur in the vegetable kingdom; thus "from seeds gathered from the finest cultivated varieties of Heartsease (*Viola tricolor*), plants perfectly wild both in their foliage and their flowers are frequently produced;"[7] but the reversion in this instance is not to a very ancient period, for the best existing varieties of the heartsease are of comparatively modern origin. With most of our cultivated vegetables there is some tendency to reversion to what is known to be, or may be presumed to be, their aboriginal state; and this would be more evident if gardeners did not generally look over their beds of seedlings, and pull up the false plants or "rogues" as they are called. It has already been remarked, that some few seedling apples and pears generally resemble, but apparently are not identical with, the wild trees from which they are descended. In our turnip[8] and carrot-beds a few plants often "break "—that is, flower too soon; and their roots are generally hard and stringy, as in the parent-species. By the aid of a little selection, carried on during a few generations, most of our cultivated plants could probably be brought back, without any great change in their conditions of life, to a wild or nearly wild condition: Mr. Buckman has effected this with the parsnip;[9] and Mr. Hewett C. Watson, as he informs me, selected, during three generations, "the most diverging plants of Scotch kail, perhaps one of the least modified varieties of the cabbage; and in the third generation some of the plants came very close to the forms now established in England about old castle-walls, and called indigenous."

Reversion in Animals and Plants which have run wild.—In the cases hitherto considered, the reverting animals and plants have not been exposed to any great or abrupt change in their conditions of life which could have induced this tendency; but it is very different with animals and plants which have become feral or run wild. It has been repeatedly asserted in the most positive manner by various authors, that feral animals and plants invariably return to their primitive specific type. It is curious on what little evidence this belief rests. Many of our domesticated animals could not subsist in a wild state; thus, the more highly improved breeds of the pigeon will not "field" or search for their own food. Sheep have never become feral, and would be destroyed by almost every beast of prey.[10] In several cases we do not know the aboriginal parent-species, and cannot possibly tell whether or not there has been any close degree of reversion. It is not known in any instance what variety was first turned out; several varieties have probably in some cases run wild, and their crossing alone would tend to obliterate their proper character. Our domesticated animals and plants, when they run wild, must always be exposed to new conditions of life, for, as Mr. Wallace[11] has well remarked, they have to obtain their own food, and are exposed to competition with the native productions. Under these circumstances, if our domesticated animals did not undergo change of some kind, the result would be quite opposed to the conclusions arrived at in this work. Nevertheless, I do not doubt that the simple fact of animals and plants becoming feral, does cause some tendency to reversion to the primitive state; though this tendency has been much exaggerated by some authors.

I will briefly run through the recorded cases. With neither horses nor cattle is the primitive stock known; and it has been shown in former chapters that they have assumed different colours in different countries. Thus the horses which have run wild in South America are generally brownish-bay, and in the East dun-coloured; their heads have become larger and coarser, and this may be due to reversion. No careful description has been given of the feral goat. Dogs which have run wild in various countries have hardly anywhere assumed a uniform character; but they are probably descended from several domestic races, and aboriginally from several distinct species. Feral cats, both in Europe and La Plata, are regularly striped; in some cases they have grown to an unusually large size, but do not differ from the domestic animal in any other character. When variously-coloured tame rabbits are turned out in Europe, they generally reacquire the colouring of the wild animal; there can be no doubt that this does really occur, but we should remember that oddly-coloured and conspicuous animals would suffer much from beasts of prey and from being easily shot; this at least was the opinion of a gentleman who tried to stock his woods with a nearly white variety; if thus destroyed, they would be supplanted by, instead of being transformed into, the common rabbit. We have seen that the feral rabbits of Jamaica, and especially of Porto Santo, have assumed new colours and other new characters. The best known case of reversion, and that on which the widely spread belief in its universality apparently rests, is that of pigs. These animals have run wild in the West Indies, South America, and the Falkland Islands, and have everywhere acquired the dark colour, the thick bristles, and great tusks of the wild boar; and the young have reacquired longitudinal stripes. But even in the case of the pig, Roulin describes the half-wild animals in different parts of South America as differing in several respects. In Louisiana the pig[12] has run wild, and is said to differ a little in form, and much in colour, from the domestic animal, yet does not closely resemble the wild boar of Europe. With pigeons and fowls,[13] it is not known what variety was first turned out, nor what character the feral birds have assumed. The guinea-fowl in the West Indies, when feral, seems to vary more than in the domesticated state.

With respect to plants run wild, Dr. Hooker[14] has strongly insisted on what slight evidence the common belief in their reversion to a primitive state rests. Godron[15] describes wild turnips, carrots, and celery; but these plants in their cultivated state hardly differ from their wild prototypes, except in the succulency and enlargement of certain parts,— characters which would certainly be lost by plants growing in poor soil and struggling with other plants. No cultivated plant has run wild on so enormous a scale as the cardoon (*Cynara cardunculus*) in La Plata. Every botanist who has seen it growing there, in vast beds, as high as a horse’s back, has been struck with its peculiar appearance; but whether it differs in any important point from the cultivated Spanish form, which is said not to be prickly like its American descendant, or whether it differs from the wild Mediterranean species, which is said not to be social (though this may be due merely to the nature of the conditions), I do not know.

Reversion to Characters derived from a Cross, in the case of Sub-varieties, Races, and Species.—When an individual having some recognisable peculiarity unites with another of the same sub-variety, not having the peculiarity in question, it often reappears in the descendants after an interval of several generations. Every one must have noticed, or heard from old people of children closely resembling in appearance or mental disposition, or in so small and complex a character as expression, one of their grandparents, or some more distant collateral relation. Very many anomalies of structure and diseases[16] of which instances have been given in the last chapter, have come into a family from one parent, and have reappeared in the progeny after passing over two or three generations. The following case has been communicated to me on good authority, and may, I believe, be fully trusted: a pointer-bitch produced seven puppies; four were marked with blue and white, which is so unusual a colour with pointers that she was thought to have played false with one of the greyhounds, and the whole litter was condemned; but the gamekeeper was permitted to save one as a curiosity. Two years afterwards a friend of the owner saw the young dog, and declared that he was the image of his old pointer-bitch Sappho, the only blue and white pointer of pure descent which he had ever seen. This led to close inquiry, and it was proved that he was the great-great-grandson of Sappho; so that, according to the common expression, he had only 1/16th of her blood in his veins. I may give one other instance, on the authority of Mr. R. Walker, a large cattle-breeder in Kincardineshire. He bought a black bull, the son of a black cow with white legs, white belly and part of the tail white; and in 1870 a calf the gr.-gr.-gr.-gr.-grandchild of this cow was born coloured in the same very peculiar manner; all the intermediate offspring having been black. In these cases there can hardly be a doubt that a character derived from a cross with an individual of the same variety reappeared after passing over three generations in the one case, and five in the other.

When two distinct races are crossed, it is notorious that the tendency in the offspring to revert to one or both parent-forms is strong, and endures for many generations. I have myself seen the clearest evidence of this in crossed pigeons and with various plants. Mr. Sidney[17] states that, in a litter of Essex pigs, two young ones appeared which were the image of the Berkshire boar that had been used twenty-eight years before in giving size and constitution to the breed. I observed in the farmyard at Betley Hall some fowls showing a strong likeness to the Malay breed, and was told by Mr. Tollet that he had forty years before crossed his birds with Malays; and that, though he had at first attempted to get rid of this strain, he had subsequently given up the attempt in despair, as the Malay character would reappear.

This strong tendency in crossed breeds to revert has given rise to endless discussions in how many generations after a single cross, either with a distinct breed or merely with an inferior animal, the breed may be considered as pure, and free from all danger of reversion. No one supposes that less than three generations suffices, and most breeders think that six, seven, or eight are necessary, and some go to still greater lengths.[18] But neither in the case of a breed which has been contaminated by a single cross, nor when, in the attempt to form an intermediate breed, half-bred animals have been matched together during many generations, can any rule be laid down how soon the tendency to reversion will be obliterated. It depends on the difference in the strength or prepotency of transmission in the two parent-forms, on their actual amount of difference, and on the nature of the conditions of life to which the crossed offspring are exposed. But we must be careful not to confound these cases of reversion to characters which were gained by a cross, with those under the first class, in which characters originally common to BOTH parents, but lost at some former period, reappear; for such characters may recur after an almost indefinite number of generations.

The law of reversion is as powerful with hybrids, when they are sufficiently fertile to breed together, or when they are repeatedly crossed with either pure parent-form, as in the case of mongrels. It is not necessary to give instances. With plants almost every one who has worked on this subject, from the time of Kölreuter to the present day, has insisted on this tendency. Gärtner has recorded some good instances; but no one has given more striking ones than Naudin.[19] The tendency differs in degree or strength in different groups, and partly depends, as we shall presently see, on whether the parent-plants have been long cultivated. Although the tendency to reversion is extremely general with nearly all mongrels and hybrids, it cannot be considered as invariably characteristic of them; it may also be mastered by long-continued selection; but these subjects will more properly be discussed in a future chapter on Crossing. From what we see of the power and scope of reversion, both in pure races, and when varieties or species are crossed, we may infer that characters of almost every kind are capable of reappearing after having been lost for a great length of time. But it does not follow from this that in each particular case certain characters will reappear; for instance, this will not occur when a race is crossed with another endowed with prepotency of transmission. Sometimes the power of reversion wholly fails, without our being able to assign any cause for the failure: thus it has been stated that in a French family in which 85 out of above 600 members, during six generations, had been subject to night-blindness, "there has not been a single example of this affection in the children of parents who were themselves free from it."[20]

Reversion through Bud-propagation—Partial Reversion, by segments in the same flower or fruit, or in different parts of the body in the same individual animal.—In the eleventh chapter many cases of reversion by buds, independently of seminal generation, were given—as when a leaf-bud on a variegated, a curled, or laciniated variety suddenly reassumes its proper character; or as when a Provence-rose appears on a moss-rose, or a peach on a nectarine-tree. In some of these cases only half the flower or fruit, or a smaller segment, or mere stripes, reassume their former character; and here we have reversion by segments. Vilmorin[21] has also recorded several cases with plants derived from seed, of flowers reverting by stripes or blotches to their primitive colours: he states that in all such cases a white or pale-coloured variety must first be formed, and, when this is propagated for a length of time by seed, striped seedlings occasionally make their appearance; and these can afterwards by care be multiplied by seed.

The stripes and segments just referred to are not due, as far as is known, to reversion to characters derived from a cross, but to characters lost by variation. These cases, however, as Naudin[22] insists in his discussion on disjunction of character, are closely analogous with those given in the eleventh chapter, in which crossed plants have been known to produce half-and-half or striped flowers and fruit, or distinct kinds of flowers on the same root resembling the two parent-forms. Many piebald animals probably come under this same head. Such cases, as we shall see in the chapter on Crossing, apparently result from certain characters not readily blending together, and, as a consequence of this incapacity for fusion, the offspring either perfectly resemble one of their two parents, or resemble one parent in one part, and the other parent in another part; or whilst young are intermediate in character, but with advancing age revert wholly or by segments to either parent-form, or to both. Thus, young trees of the *Cytisus* adami are intermediate in foliage and flowers between the two parent-forms; but when older the buds continually revert either partially or wholly to both forms. The cases given in the eleventh chapter on the changes which occurred during growth in crossed plants of Tropæolum, Cereus, Datura, and Lathyrus are all analogous. As, however, these plants are hybrids of the first generation, and as their buds after a time come to resemble their parents and not their grandparents, these cases do not at first appear to come under the law of reversion in the ordinary sense of the word; nevertheless, as the change is effected through a succession of bud-generations on the same plant, they may be thus included.

Analogous facts have been observed in the animal kingdom, and are more remarkable, as they occur in the same individual in the strictest sense, and not as with plants through a succession of bud-generations. With animals the act of reversion, if it can be so designated, does not pass over a true generation, but merely over the early stages of growth in the same individual. For instance, I crossed several white hens with a black cock, and many of the chickens were, during the first year, perfectly white, but acquired during the second year black feathers; on the other hand, some of the chickens which were at first black, became during the second year piebald with white. A great breeder[23] says, that a Pencilled Brahma hen which has any of the blood of the Light Brahma in her, will "occasionally produce a pullet well pencilled during the first year, but she will most likely moult brown on the shoulders and become quite unlike her original colours in the second year." The same thing occurs with light Brahmas if of impure blood. I have observed exactly similar cases with the crossed offspring from differently coloured pigeons. But here is a more remarkable fact: I crossed a turbit, which has a frill formed by the feathers being reversed on its breast, with a trumpeter; and one of the young pigeons thus raised at first showed not a trace of the frill, but, after moulting thrice, a small yet unmistakably distinct frill appeared on its breast. According to Girou[24] calves produced from a red cow by a black bull, or from a black cow by a red bull, are not rarely born red, and subsequently become black. I possess a dog, the daughter of a white terrier by a fox-coloured bulldog; as a puppy she was quite white, but when about six months old a black spot appeared on her nose, and brown spots on her ears. When a little older she was badly wounded on the back, and the hair which grew on the cicatrix was of a brown colour, apparently derived from her father. This is the more remarkable, as with most animals having coloured hair, that which grows on a wounded surface is white.

In the foregoing cases, the characters which with advancing age reappeared, were present in the immediately preceding generations; but characters sometimes reappear in the same manner after a much longer interval of time. Thus the calves of a hornless race of cattle which originated in Corrientes, though at first quite hornless, as they become adult sometimes acquire small, crooked, and loose horns; and these in succeeding years occasionally become attached to the skull.[25] White and black Bantams, both of which generally breed true, sometimes assume as they grow old a saffron or red plumage. For instance, a first-rate black bantam has been described, which during three seasons was perfectly black, but then annually became more and more red; and it deserves notice that this tendency to change, whenever it occurs in a bantam, "is almost certain to prove hereditary."[26] The cuckoo or blue-mottled Dorking cock, when old, is liable to acquire yellow or orange hackles in place of his proper bluish-grey hackles.[27] Now as *Gallus bankiva* is coloured red and orange, and as Dorking fowls and bantams are descended from this species, we can hardly doubt that the change which occasionally occurs in the plumage of these birds as their age advances, results from a tendency in the individual to revert to the primitive type.

Crossing as a direct cause of Reversion.—It has long been notorious that hybrids and mongrels often revert to both or to one of their parent-forms, after an interval of from two to seven or eight, or, according to some authorities, even a greater number of generations. But that the act of crossing in itself gives an impulse towards reversion, as shown by the reappearance of long-lost characters, has never, I believe, been hitherto proved. The proof lies in certain peculiarities, which do not characterise the immediate parents, and therefore cannot have been derived from them, frequently appearing in the offspring of two breeds when crossed, which peculiarities never appear, or appear with extreme rarity, in these same breeds, as long as they are precluded from crossing. As this conclusion seems to me highly curious and novel, I will give the evidence in detail.

My attention was first called to this subject, and I was led to make numerous experiments, by MM. Boitard and Corbie having stated that, when they crossed certain breeds of pigeons, birds coloured like the wild *C. livia*, or the common dovecote—namely, slaty-blue, with double black wing-bars, sometimes chequered with black, white loins, the tail barred with black, with the outer feathers edged with white,—were almost invariably produced. The breeds which I crossed, and the remarkable results attained, have been fully described in the sixth chapter. I selected pigeons belonging to true and ancient breeds, which had not a trace of blue or any of the above specified marks; but when crossed, and their mongrels recrossed, young birds were often produced, more or less plainly coloured slaty-blue, with some or all of the proper characteristic marks. I may recall to the reader's memory one case, namely, that of a pigeon, hardly distinguishable from the wild Shetland species, the grandchild of a red-spot, white fantail, and two black barbs, from any of which, when purely-bred, the production of a pigeon coloured like the wild *C. livia* would have been almost a prodigy.

I was thus led to make the experiments, recorded in the seventh chapter, on fowls. I selected long-established pure breeds, in which there was not a trace of red, yet in several of the mongrels feathers of this colour appeared; and one magnificent bird, the offspring of a black Spanish cock and white Silk hen, was coloured almost exactly like the wild *Gallus bankiva*. All who know anything of the breeding of poultry will admit that tens of thousands of pure Spanish and of pure white Silk fowls might have been reared without the appearance of a red feather. The fact, given on the authority of Mr.

Tegetmeier, of the frequent appearance, in mongrel fowls, of pencilled or transversely-barred feathers, like those common to many gallinaceous birds, is likewise apparently a case of reversion to a character formerly possessed by some ancient progenitor of the family. I owe to the kindness of this excellent observer the opportunity of inspecting some neck-hackles and tail-feathers from a hybrid between the common fowl and a very distinct species, the Gallus varius; and these feathers are transversely striped in a conspicuous manner with dark metallic blue and grey, a character which could not have been derived from either immediate parent.

I have been informed by Mr. B. P. Brent, that he crossed a white Aylesbury drake and a black so-called Labrador duck, both of which are true breeds, and he obtained a young drake closely like the mallard (*A. boschas*). Of the musk-duck (*Cairina moschata,* Linn.) there are two sub-breeds, namely, white and slate-coloured; and these I am informed breed true, or nearly true. But the Rev. W. D. Fox tells me that, by putting a white drake to a slate-coloured duck, black birds, pied with white, like the wild musk-duck, were always produced. I hear from Mr. Blyth that hybrids from the canary and gold-finch almost always have streaked feathers on their backs; and this streaking must be derived from the original wild canary.

We have seen in the fourth chapter, that the so-called Himalayan rabbit, with its snow-white body, black ears, nose, tail, and feet, breeds perfectly true. This race is known to have been formed by the union of two varieties of silver-grey rabbits. Now, when a Himalayan doe was crossed by a sandy-coloured buck, a silver-grey rabbit was produced; and this is evidently a case of reversion to one of the parent varieties. The young of the Himalayan rabbit are born snow-white, and the dark marks do not appear until some time subsequently; but occasionally young Himalayan rabbits are born of a light silver-grey, which colour soon disappears; so that here we have a trace of reversion, during an early period of life, to the parent varieties, independently of any recent cross.

In the third chapter it was shown that at an ancient period some breeds of cattle in the wilder parts of Britain were white with dark ears, and that the cattle now kept half wild in certain parks, and those which have run quite wild in two distant parts of the world, are likewise thus coloured. Now, an experienced breeder, Mr. J. Beasley, of Northamptonshire,[28] crossed some carefully selected West Highland cows with purely-bred shorthorn bulls. The bulls were red, red and white, or dark roan; and the Highland cows were all of a red colour, inclining to a light or yellow shade. But a considerable number of the offspring—and Mr. Beasley calls attention to this as a remarkable fact—were white, or white with red ears. Bearing in mind that none of the parents were white, and that they were purely-bred animals, it is highly probable that here the offspring reverted, in consequence of the cross, to the colour of some ancient and half-wild parent-breed. The following case, perhaps, comes under the same head: cows in their natural state have their udders but little developed, and do not yield nearly so much milk as our domesticated animals. Now there is some reason to believe[29] that cross-bred animals between two kinds, both of which are good milkers, such as Alderneys and Shorthorns, often turn out worthless in this respect.

In the chapter on the Horse reasons were assigned for believing that the primitive stock was striped and dun-coloured; and details were given, showing that in all parts of the world stripes of a dark colour frequently appear along the spine, across the legs, and on the shoulders, where they are occasionally double or treble, and even sometimes on the face and body of horses of all breeds and of all colours. But the stripes appear most frequently on the various kinds of duns. In foals they are sometimes plainly seen, and subsequently disappear. The dun-colour and the stripes are strongly transmitted when a horse thus characterised is crossed with any other; but I was not able to prove that striped duns are generally produced from the crossing of two distinct breeds, neither of which are duns, though this does sometimes occur.

The legs of the ass are often striped, and this may be considered as a reversion to the wild parent form, the *Equus tæniopus* of Abyssinia,[30] which is generally thus striped. In the domestic animal the stripes on the shoulder are occasionally double, or forked at the extremity, as in certain zebrine species. There is reason to believe that the foal is more frequently striped on the legs than the adult animal. As with the horse, I have not acquired any distinct evidence that the crossing of differently-coloured varieties of the ass brings out the stripes.

But now let us turn to the result of crossing the horse and ass. Although mules are not nearly so numerous in England as asses, I have seen a much greater number with striped legs, and with the stripes far more conspicuous than in either parent-form. Such mules are generally light-coloured, and might be called fallow-duns. The shoulder-stripe in one instance was deeply forked at the extremity, and in another instance was double, though united in the middle. Mr. Martin gives a figure of a Spanish mule with strong zebra-like marks on its legs,[31] and remarks that mules are particularly liable to be thus striped on their legs. In South America, according to Roulin,[32] such stripes are more frequent and conspicuous in the mule than in the ass. In the United States, Mr. Gosse,[33] speaking of these animals, says, “that in a great number, perhaps in nine out of every ten, the legs are banded with transverse dark stripes.”

Many years ago I saw in the Zoological Gardens a curious triple hybrid, from a bay mare, by a hybrid from a male ass and female zebra. This animal when old had hardly any stripes; but I was assured by the superintendent, that when young it had shoulder-stripes, and faint stripes on its flanks and legs. I mention this case more especially as an instance of the stripes being much plainer during youth than in old age.

As the zebra has such a conspicuously striped body and legs, it might have been expected that the hybrids from this animal and the common ass would have had their legs in some degree striped; but it appears from the figures given in Dr. Gray’s ‘Knowsley Gleanings’ and still more plainly from that given by Geoffroy and F. Cuvier,[34] that the legs are much more conspicuously striped than the rest of the body;

and this fact is intelligible only on the belief that the ass aids in giving, through the power of reversion, this character to its hybrid offspring.

The quagga is banded over the whole front part of its body like a zebra, but has no stripes on its legs, or mere traces of them. But in the famous hybrid bred by Lord Morton[35] from a chestnut, nearly purely-bred, Arabian mare, by a male quagga, the stripes were more strongly defined and darker than those on the legs of "the quagga." The mare was subsequently put to a black Arabian horse, and bore two colts, both of which, as formerly stated, were plainly striped on the legs, and one of them likewise had stripes on the neck and body.

The *Equus indicus*[36] is characterised by a spinal stripe, without shoulder or leg stripes; but traces of these latter stripes may occasionally be seen even in the adult[37] and Colonel S. Poole, who has had ample opportunities for observation, informs me that in the foal, when first born, the head and legs are often striped, but the shoulder-stripe is not so distinct as in the domestic ass; all these stripes, excepting that along the spine, soon disappear. Now a hybrid, raised at Knowsley[38] from a female of this species by a male domestic ass, had all four legs transversely and conspicuously striped, had three short stripes on each shoulder and had even some zebra-like stripes on its face! Dr. Gray informs me that he has seen a second hybrid of the same parentage, similarly striped.

From these facts we see that the crossing of the several equine species tends in a marked manner to cause stripes to appear on various parts of the body, especially on the legs. As we do not know whether the parent-form of the genus was striped, the appearance of the stripes can only hypothetically be attributed to reversion. But most persons, after considering the many undoubted cases of variously coloured marks reappearing by reversion in my experiments on crossed pigeons and fowls, will come to the same conclusion with respect to the horse-genus; and if so, we must admit that the progenitor of the group was striped on the legs, shoulders, face, and probably over the whole body, like a zebra.

Lastly, Professor Jaeger has given[39] a good case with pigs. He crossed the Japanese or masked breed with the common German breed, and the offspring were intermediate in character. He then re-crossed one of these mongrels with the pure Japanese, and in the litter thus produced one of the young resembled in all its characters a wild pig; it had a long snout and upright ears, and was striped on the back. It should be borne in mind that the young of the Japanese breed are not striped, and that they have a short muzzle and ears remarkably dependent.

A similar tendency to the recovery of long lost characters holds good even with the instincts of crossed animals. There are some breeds of fowls which are called "everlasting layers," because they have lost the instinct of incubation; and so rare is it for them to incubate that I have seen notices published in works on poultry, when hens of such breeds have taken to sit.[40] Yet the aboriginal species was of course a good incubator; and with birds in a state of nature hardly any instinct is so strong as this.

Now, so many cases have been recorded of the crossed offspring from two races, neither of which are incubators, becoming first-rate sitters, that the reappearance of this instinct must be attributed to reversion from crossing. One author goes so far as to say, "that a cross between two non-sitting varieties almost invariably produces a mongrel that becomes broody, and sits with remarkable steadiness."[41] Another author, after giving a striking example, remarks that the fact can be explained only on the principle that "two negatives make a positive." It cannot, however, be maintained that hens produced from a cross between two non-sitting breeds invariably recover their lost instinct, any more than that crossed fowls or pigeons invariably recover the red or blue plumage of their prototypes. Thus I raised several chickens from a Polish hen by a Spanish cock,—breeds which do not incubate,—and none of the young hens at first showed any tendency to sit; but one of them—the only one which was preserved—in the third year sat well on her eggs and reared a brood of chickens. So that here we have the reappearance with advancing age of a primitive instinct, in the same manner as we have seen that the red plumage of the *Gallus bankiva* is sometimes reacquired both by crossed and purely-bred fowls of various kinds as they grow old.

The parents of all our domesticated animals were of course aboriginally wild in disposition; and when a domesticated species is crossed with a distinct species, whether this is a domesticated or only a tamed animal, the hybrids are often wild to such a degree, that the fact is intelligible only on the principle that the cross has caused a partial return to a primitive disposition. Thus, the Earl of Powis formerly imported some thoroughly domesticated humped cattle from India, and crossed them with English breeds, which belong to a distinct species; and his agent remarked to me, without any question having been asked, how oddly wild the cross-bred animals were. The European wild boar and the Chinese domesticated pig are almost certainly specifically distinct: Sir F. Darwin crossed a sow of the latter breed with a wild Alpine boar which had become extremely tame, but the young, though having half-domesticated blood in their veins, were "extremely wild in confinement, and would not eat swill like common English pigs." Captain Hutton, in India, crossed a tame goat with a wild one from the Himalaya, and he remarked to me how surprisingly wild the offspring were. Mr. Hewitt, who has had great experience in crossing tame cock-pheasants with fowls belonging to five breeds, gives as the character of all "extraordinary wildness";[42] but I have myself seen one exception to this rule. Mr. S. J. Salter[43] who raised a large number of hybrids from a bantam-hen by *Gallus sonneratii*, states that "all were exceedingly wild." Mr. Waterton[44] bred some wild ducks from eggs hatched under a common duck, and the young were allowed to cross freely both amongst themselves and with the tame ducks; they were "half wild and half tame; they came to the windows to be fed, but still they had a wariness about them quite remarkable."

On the other hand, mules from the horse and ass are certainly not in the least wild, though notorious for obstinacy and vice. Mr. Brent, who has crossed canary-birds with many kinds of finches, has not observed, as he informs me, that the hybrids were in any way remarkably wild: but Mr. Jenner Weir who has had still greater experience, is of a directly opposite opinion. He remarks that the siskin is the tamest of finches, but its mules are as wild, when young, as newly caught birds, and are often lost through their continued efforts to escape. Hybrids are often raised between the common and musk duck, and I have been assured by three persons, who have kept these crossed birds, that they were not wild; but Mr. Garnett[45] observed that his hybrids were wild, and exhibited "migratory propensities" of which there is not a vestige in the common or musk duck. No case is known of this latter bird having escaped and become wild in Europe or Asia, except, according to Pallas, on the Caspian Sea; and the common domestic duck only occasionally becomes wild in districts where large lakes and fens abound. Nevertheless, a large number of cases have been recorded[46] of hybrids from these two ducks having been shot in a completely wild state, although so few are reared in comparison with purely-bred birds of either species. It is improbable that any of these hybrids could have acquired their wildness from the musk-duck having paired with a truly wild duck; and this is known not to be the case in North America; hence we must infer that they have reacquired, through reversion, their wildness, as well as renewed powers of flight.

These latter facts remind us of the statements, so frequently made by travellers in all parts of the world, on the degraded state and savage disposition of crossed races of man. That many excellent and kind-hearted mulattos have existed no one will dispute; and a more mild and gentle set of men could hardly be found than the inhabitants of the island of Chiloe, who consist of Indians commingled with Spaniards in various proportions. On the other hand, many years ago, long before I had thought of the present subject, I was struck with the fact that, in South America, men of complicated descent between Negroes, Indians, and Spaniards, seldom had, whatever the cause might be, a good expression.[47] Livingstone—and a more unimpeachable authority cannot be quoted,—after speaking of a half-caste man on the Zambesi, described by the Portuguese as a rare monster of inhumanity, remarks, "It is unaccountable why half-castes, such as he, are so much more cruel than the Portuguese, but such is undoubtedly the case." An inhabitant remarked to Livingstone, "God made white men, and God made black men, but the Devil made halfcastes."[48] When two races, both low in the scale, are crossed the progeny seems to be eminently bad. Thus the noble-hearted Humboldt, who felt no prejudice against the inferior races, speaks in strong terms of the bad and savage disposition of Zambos, or half-castes between Indians and Negroes; and this conclusion has been arrived at by various observers.[49] From these facts we may perhaps infer that the degraded state of so many half-castes is in part due to reversion to a primitive and savage condition, induced by the act of crossing, even if mainly due to the unfavourable moral conditions under which they are generally reared.

Summary on the proximate causes leading to Reversion.—When purely-bred animals or plants reassume long-lost characters,—when the common ass, for instance, is born with striped legs, when a pure race of black or white pigeons throws a slaty-blue bird, or when a cultivated heartsease with large and rounded flowers produces a seedling with small and elongated flowers,—we are quite unable to assign any proximate cause. When animals run wild, the tendency to reversion, which, though it has been greatly exaggerated, no doubt exists, is sometimes to a certain extent intelligible. Thus, with feral pigs, exposure to the weather will probably favour the growth of the bristles, as is known to be the case with the hair of other domesticated animals, and through correlation the tusks will tend to be redeveloped. But the reappearance of coloured longitudinal stripes on young feral pigs cannot be attributed to the direct action of external conditions. In this case, and in many others, we can only say that any change in the habits of life apparently favour a tendency, inherent or latent in the species, to return to the primitive state.

It will be shown in a future chapter that the position of flowers on the summit of the axis, and the position of seeds within the capsule, sometimes determine a tendency towards reversion; and this apparently depends on the amount of sap or nutriment which the flower-buds and seeds receive. The position, also, of buds, either on branches or on roots, sometimes determines, as was formerly shown, the transmission of the character proper to the variety, or its reversion to a former state.

We have seen in the last section that when two races or species are crossed there is the strongest tendency to the reappearance in the offspring of long-lost characters, possessed by neither parent nor immediate progenitor. When two white, or red, or black pigeons, of well-established breeds, are united, the offspring are almost sure to inherit the same colours; but when differently-coloured birds are crossed, the opposed forces of inheritance apparently counteract each other, and the tendency which is inherent in both parents to produce slaty-blue offspring becomes predominant. So it is in several other cases. But when, for instance, the ass is crossed with *E. indicus* or with the horse—animals which have not striped legs—and the hybrids have conspicuous stripes on their legs and even on their faces, all that can be said is, that an inherent tendency to reversion is evolved through some disturbance in the organisation caused by the act of crossing.

Another form of reversion is far commoner, indeed is almost universal with the offspring from a cross, namely, to the characters proper to either pure parent-form. As a general rule, crossed offspring in the first generation are nearly intermediate between their parents, but the grandchildren and succeeding generations continually revert, in a greater or lesser degree, to one or both of their progenitors. Several authors have maintained that hybrids and mongrels include all the characters of both parents, not fused together, but merely mingled in different proportions in different parts of the body; or, as Naudin[50] has expressed it, a hybrid is a living mosaic-work, in which the eye cannot distinguish the discordant elements, so completely are they intermingled. We can hardly doubt that, in a certain sense, this is true, as when we behold in a hybrid the elements of both species segregating themselves into segments in the same flower or fruit, by a process of self-attraction or self-affinity; this segregation taking place either by seminal or bud-propagation. Naudin further believes that the segregation of the two specific elements or essences is eminently liable to occur in the male and female reproductive matter; and he thus explains the almost universal tendency to reversion in successive hybrid generations. For this would be the natural result of the union of pollen and ovules, in both of which the elements of the same species had been segregated by self-affinity. If, on the other hand, pollen which included the elements of one species happened to unite with ovules including the elements of the other species, the intermediate or hybrid state would still be retained, and there would be no reversion. But it would, as I suspect, be more correct to say that the elements of both parent-species exist in every hybrid in a double state, namely, blended together and completely separate. How this is possible, and what the term specific essence or element may be supposed to express, I shall attempt to show in the chapter on the hypothesis of pangenesis.

But Naudin's view, as propounded by him, is not applicable to the reappearance of characters lost long ago by variation; and it is hardly applicable to races or species which, after having been crossed at some former period with a distinct form, and having since lost all traces of the cross, nevertheless occasionally yield an individual which reverts (as in the case of the great-great-grandchild of the pointer Sappho) to the crossing form. The most simple case of reversion, namely, of a hybrid or mongrel to its grandparents, is connected by an almost perfect series with the extreme case of a purely-bred race recovering characters which had been lost during many ages; and we are thus led to infer that all the cases must be related by some common bond.

Gärtner believed that only highly sterile hybrid plants exhibit any tendency to reversion to their parent-forms. This erroneous belief may perhaps be accounted for by the nature of the genera crossed by him, for he admits that the tendency differs in different genera. The statement is also directly contradicted by Naudin's observations, and by the notorious fact that perfectly fertile mongrels exhibit the tendency in a high degree,—even in a higher degree, according to Gärtner himself, than hybrids.[51]

Gärtner further states that reversions rarely occur with hybrid plants raised from species which have not been cultivated, whilst, with those which have been long cultivated, they are of frequent occurrence. This conclusion explains a curious discrepancy: Max Wichura[52] who worked exclusively on willows which had not been subjected to culture, never saw an instance of reversion; and he goes so far as to suspect that the careful Gartner had not sufficiently protected his hybrids from the pollen of the parent-species: Naudin, on the other hand, who chiefly experimented on cucurbitaceous and other cultivated plants, insists more strenuously than any other author on the tendency to reversion in all hybrids. The conclusion that the condition of the parent-species, as affected by culture, is one of the proximate causes leading to reversion, agrees well with the converse case of domesticated animals and cultivated plants being liable to reversion when they become feral; for in both cases the organisation or constitution must be disturbed, though in a very different way.[53]

Finally, we have seen that characters often reappear in purely-bred races without our being able to assign any proximate cause; but when they become feral this is either indirectly or directly induced by the change in their conditions of life. With crossed breeds, the act of crossing in itself certainly leads to the recovery of long-lost characters, as well as of those derived from either parent-form. Changed conditions, consequent on cultivation, and the relative position of buds, flowers, and seeds on the plant, all apparently aid in giving this same tendency. Reversion may occur either through seminal or bud generation, generally at birth, but sometimes only with an advance of age. Segments or portions of the individual may alone be thus affected. That a being should be born resembling in certain characters an ancestor removed by two or three, and in some cases by hundreds or even thousands of generations, is assuredly a wonderful fact. In these cases the child is commonly said to inherit such characters directly from its grandparent, or more remote ancestors. But this view is hardly conceivable. If, however, we suppose that every character is derived exclusively from the father or mother, but that many characters lie latent or dormant in both parents during a long succession of generations, the foregoing facts are intelligible. In what manner characters may be conceived to lie latent, will be considered in a future chapter to which I have lately alluded.

Latent Characters.—But I must explain what is meant by characters lying latent. The most obvious illustration is afforded by secondary sexual characters. In every female all the secondary male characters, and in every male all the secondary female characters, apparently exist in a latent state, ready to be evolved under certain conditions. It is well known that a large number of female birds, such as fowls, various pheasants, partridges, peahens, ducks, etc., when old or diseased, or when operated on, assume many or all of the secondary male characters of their species. In the case of the hen-pheasant this has been observed to occur far more frequently during certain years than during others.[54] A duck ten years old has been known to assume both the perfect winter and summer plumage of the drake.[55] Waterton,[56] gives a curious case of a hen which had ceased laying, and had assumed the plumage, voice, spurs, and warlike disposition of the cock; when opposed to an enemy she would erect her hackles and show fight. Thus every character, even to the instinct and manner of fighting, must have lain dormant in this hen as long as her ovaria continued to act. The females of two kinds of deer, when old, have been known to acquire horns; and, as Hunter has remarked, we see something of an analogous nature in the human species.

On the other hand, with male animals, it is notorious that the secondary sexual characters are more or less completely lost when they are subjected to castration. Thus, if the operation be performed on a young cock, he never, as Yarrell states, crows again; the comb, wattles, and spurs do not grow to their full size, and the hackles assume an intermediate appearance between true hackles and the feathers of the hen. Cases are recorded of confinement, which often affects the reproductive system, causing analogous results. But characters properly confined to the female are likewise acquired by the male; the capon takes to sitting on eggs, and will bring up chickens; and what is more curious, the utterly sterile male hybrids from the pheasant and the fowl act in the same manner, "their delight being to watch when the hens leave their nests, and to take on themselves the office of a sitter."[57] That admirable observer Reaumur[58] asserts that a cock, by being long confined in solitude and darkness, can be taught to take charge of young chickens; he then utters a peculiar cry, and retains during his whole life this newly acquired maternal instinct. The many well-ascertained cases of various male mammals giving milk shows that their rudimentary mammary glands retain this capacity in a latent condition.

We thus see that in many, probably in all cases, the secondary characters of each sex lie dormant or latent in the opposite sex, ready to be evolved under peculiar circumstances. We can thus understand how, for instance, it is possible for a good milking cow to transmit her good qualities through her male offspring to future generations; for we may confidently believe that these qualities are present, though latent, in the males of each generation. So it is with the game-cock, who can transmit his superiority in courage and vigour through his female to his male offspring; and with man it is known[59] that diseases, such as hydrocele, necessarily confined to the male sex, can be transmitted through the female to the grandson. Such cases as these offer, as was remarked at the commencement of this chapter, the simplest possible examples of reversion; and they are intelligible on the belief that characters common to the grandparent and grandchild of the same sex are present, though latent, in the intermediate parent of the opposite sex.

The subject of latent characters is so important, as we shall see in a future chapter, that I will give another illustration. Many animals have the right and left sides of their body unequally developed: this is well known to be the case with flat-fish, in which the one side differs in thickness and colour and in the shape of the fins, from the other, and during the growth of the young fish one eye is gradually twisted from the lower to the upper surface.[60] In most flat-fishes the left is the blind side, but in some it is the right; though in both cases reversed or "wrong fishes," are occasionally developed; and in *Platessa flesus* the right or left side is indifferently the upper one. With gasteropods or shell-fish, the right and left sides are extremely unlike; the far greater number of species are dextral, with rare and occasional reversals of development; and some few are normally sinistral; but certain species of Bulimus, and many Achatinellæ[61] are as often sinistral as dextral. I will give an analogous case in the great articulate kingdom: the two sides of Verruca[62] are so wonderfully unlike, that without careful dissection it is extremely difficult to recognise the corresponding parts on the opposite sides of the body; yet it is apparently a mere matter of chance whether it be the right or the left side that undergoes so singular amount of change. One plant is known to me[63] in which the flower, according as it stands on the one or other side of the spike, is unequally developed. In all the foregoing cases the two sides are perfectly symmetrical at an early period of growth. Now, whenever a species is as liable to be unequally developed on the one as on the other side, we may infer that the capacity for such development is present, though latent, in the undeveloped side. And as a reversal of development occasionally occurs in animals of many kinds, this latent capacity is probably very common.

The best yet simplest cases of characters lying dormant are, perhaps, those previously given, in which chickens and young pigeons, raised from a cross between differently coloured birds, are at first of one colour, but in a year or two acquire feathers of the colour of the other parent; for in this case the tendency to a change of plumage is clearly latent in the young bird. So it is with hornless breeds of cattle, some of which acquire small horns as they grow old. Purely bred black and white bantams, and some other fowls, occasionally assume, with advancing years, the red feathers of the parent-species. I will here add a somewhat different case, as it connects in a striking manner latent characters of two classes. Mr. Hewitt[64] possessed an excellent Sebright gold-laced bantam hen, which, as she became old, grew diseased in her ovaria, and assumed male characters. In this breed the males resemble the females in all respects except in their combs, wattles, spurs, and instincts; hence it might have been expected that the diseased hen would have assumed only those masculine characters which are proper to the breed, but she acquired, in addition, well-arched tail sickle-feathers quite a foot in length, saddle-feathers on the loins, and hackles on the neck,—ornaments which, as Mr. Hewitt remarks, "would be held as abominable in this breed." The Sebright bantam is known[65] to have originated about the year 1800 from a cross between a common bantam and a Polish fowl, recrossed by a hen-tailed bantam, and carefully selected; hence there can hardly be a doubt that the sickle-feathers and hackles which appeared in the old hen were derived from the Polish fowl or common bantam; and we thus see that not only certain masculine characters proper to the Sebright bantam, but other masculine characters derived from the first progenitors of the breed, removed by a period of above sixty years, were lying latent in this henbird, ready to be evolved as soon as her ovaria became diseased.

From these several facts it must be admitted that certain characters, capacities, and instincts, may lie latent in an individual, and even in a succession of individuals, without our being able to detect the least sign of their presence. When fowls, pigeons, or cattle of different colours are crossed, and their offspring change colour as they grow old, or when the crossed turbit acquired the characteristic frill after its third moult, or when rarely-bred bantams partially assume the red plumage of their prototype, we cannot doubt that these qualities were from the first present, though latent, in the individual animal, like the characters of a moth in the caterpillar. Now, if these animals had produced offspring before they had acquired with advancing age their new characters, nothing is more probable than that they would have transmitted them to some of their offspring, who in this case would in appearance have received such characters from their grand-parents or more distant progenitors. We should then have had a case of reversion, that is, of the reappearance in the child of an ancestral character, actually present, though during youth completely latent, in the parent; and this we may safely conclude is what occurs in all reversions to progenitors, however remote.

This view of the latency in each generation of all the characters which appear through reversion, is also supported by their actual presence in some cases during early youth alone, or by their more frequent appearance and greater distinctness at this age than during maturity. We have seen that this is often the case with the stripes on the legs and faces of the several species of the horse genus. The Himalayan rabbit, when crossed, sometimes produces offspring which revert to the parent silver-grey breed, and we have seen that in purely bred animals pale-grey fur occasionally reappears during early youth. Black cats, we may feel assured, would occasionally produce by reversion tabbies; and on young black kittens, with a pedigree[66] known to have been long pure, faint traces of stripes may almost always be seen which afterwards disappear. Hornless Suffolk cattle occasionally produce by reversion horned animals; and Youatt[67] asserts that even in hornless individuals "the rudiment of a horn may be often felt at an early age."

No doubt it appears at first sight in the highest degree improbable that in every horse of every generation there should be a latent capacity and tendency to produce stripes, though these may not appear once in a thousand generations; that in every white, black, or other coloured pigeon, which may have transmitted its proper colour during centuries, there should be a latent capacity in the plumage to become blue and to be marked with certain characteristic bars; that in every child in a six-fingered family there should be the capacity for the production of an additional digit; and so in other cases. Nevertheless, there is no more inherent improbability in this being the case than in a useless and rudimentary organ, or even in only a tendency to the production of a rudimentary organ, being inherited during millions of generations, as is well known to occur with a multitude of organic beings. There is no more inherent improbability in each domestic pig, during a thousand generations, retaining the capacity and tendency to develop great tusks under fitting conditions, than in the young calf having retained, for an indefinite number of generations rudimentary incisor teeth, which never protrude through the gums.

I shall give at the end of the next chapter a summary of the three preceding chapters; but as isolated and striking cases of reversion have here been chiefly insisted on, I wish to guard the reader against supposing that reversion is due to some rare or accidental combination of circumstances. When a character, lost during hundreds of generations, suddenly reappears, no doubt some such combination must occur; but reversions, to the immediately preceding generations may be constantly observed, at least, in the offspring of most unions. This has been universally recognised in the case of hybrids and mongrels, but it has been recognised simply from the difference between the united forms rendering the resemblance of the offspring to their grandparents or more remote progenitors of easy detection. Reversion is likewise almost invariably the rule, as Mr. Sedgwick has shown, with certain diseases. Hence we must conclude that a tendency to this peculiar form of transmission is an integral part of the general law of inheritance.

Monstrosities.—A large number of monstrous growths and of lesser anomalies are admitted by every one to be due to an arrest of development, that is, to the persistence of an embryonic condition. But many monstrosities cannot be thus explained; for parts of which no trace can be detected in the embryo, but which occur in other members of the same class of animals occasionally appear, and these may probably with truth be attributed to reversion. As, however, I have treated this subject as fully as I could in my 'Descent of Man' (ch. 1 2nd edition), I will not here recur to it.

When flowers which have normally an irregular structure become regular or peloric, the change is generally looked at by botanists as a return to the primitive state. But Dr. Maxwell Masters,[68] who has ably discussed this subject, remarks that when, for instance, all the sepals of a Tropæolum become green and of the same shape, instead of being coloured with one prolonged into a spur, or when all the petals of a Linaria become simple and regular, such cases may be due merely to an arrest of development; for in these flowers all the organs during their earliest condition are symmetrical, and, if arrested at this stage of growth, they would not become irregular. If, moreover, the arrest were to take place at a still earlier period of development, the result would be a simple tuft of green leaves; and no one probably would call this a case of reversion. Dr. Masters designates the cases first alluded to as regular peloria; and others, in which all the corresponding parts assume a similar form of irregularity, as when all the petals in a Linaria become spurred, as irregular peloria. We have no right to attribute these latter cases to reversion, until it can be shown that the parent-form, for instance, of the genus Linaria had had all its petals spurred; for a chance of this nature might result from the spreading of an anomalous structure, in accordance with the law, to be discussed in a future chapter, of homologous parts tending to vary in the same manner. But as both forms of peloria frequently occur on the same individual plant of the Linaria,[69] they probably stand in some close relation to one another. On the doctrine that peloria is simply the result of an arrest of development, it is difficult to understand how an organ arrested at a very early period of growth should acquire its full functional perfection;—how a petal, supposed to be thus arrested, should acquire its brilliant colours, and serve as an envelope to the flower, or a stamen produce efficient pollen; yet this occurs with many peloric flowers. That pelorism is not due to mere chance variability, but either to an arrest of development or to reversion, we may infer from an observation made by Ch. Morren[70] namely, that families which have irregular flowers often "return by these monstrous growths to their regular form; whilst we never see a regular flower realise the structure of an irregular one."

Some flowers have almost certainly become more or less completely peloric through reversion, as the following interesting case shows. *Corydalis tuberosa* properly has one of its two nectaries colourless, destitute of nectar, only half the size of the other, and therefore, to a certain extent, in a rudimentary state; the pistil is curved towards the perfect nectary, and the hood, formed of the inner petals, slips off the pistil and stamen in one direction alone, so that, when a bee sucks the perfect nectary, the stigma and stamens are exposed and rubbed against the insect's body. In several closely allied genera, as in Dielytra, etc., there are two perfect nectaries, the pistil is straight, and the hood slips off on either side, according as the bee sucks either nectary. Now, I have examined several flowers of *Corydalis tuberosa*, in which both nectaries were equally developed and contained nectar; in this we see only the redevelopment of a partially aborted organ; but with this redevelopment the pistil becomes straight, and the hood slips off in either direction, so that these flowers have acquired the perfect structure, so well adapted for insect agency, of Dielytra and its allies. We cannot attribute these coadapted modifications to chance, or to correlated variability; we must attribute them to reversion to a primordial condition of the species.

The peloric flowers of Pelargonium have their five petals in all respects alike, and there is no nectary so that they resemble the symmetrical flowers of the closely allied genus Geranium; but the alternate stamens are also sometimes destitute of anthers, the shortened filaments being left as rudiments, and in this respect they resemble the symmetrical flowers of the closely allied genus Erodium. Hence we may look at the peloric flowers of Pelargonium as having reverted to the state of some primordial form, the progenitor of the three closely related genera of Pelargonium, Geranium, and Erodium.

In the peloric form of *Antirrhinum majus*, appropriately called the "*Wonder*," the tubular and elongated flowers differ wonderfully from those of the common snapdragon; the calyx and the mouth of the corolla consist of six equal lobes, and include six equal instead of four unequal stamens. One of the two additional stamens is manifestly formed by the development of a microscopically minute papilla, which may be found at the base of the upper lip of the flower of the common snapdragons in the nineteen plants examined by me. That this papilla is a rudiment of a stamen was well shown by its various degrees of development in crossed plants between the common and the peloric Antirrhinum. Again, a peloric *Galeobdolon luteum*, growing in my garden, had five equal petals, all striped like the ordinary lower lip, and included five equal instead of four unequal stamens; but Mr. R. Keeley, who sent me this plant, informs me that the flowers vary greatly, having from four to six lobes to the corolla, and from three to six stamens.[71] Now, as the members of the two great families to which the Antirrhinum and Galeobdolon belong are properly pentamerous, with some of the parts confluent and others suppressed, we ought not to look at the sixth stamen and the sixth lobe to the corolla in either case as due to reversion, any more than the additional petals in double flowers in these same two families. But the case is different with the fifth stamen in the peloric Antirrhinum, which is produced by the redevelopment of a rudiment always present, and which probably reveals to us the state of the flower, as far as the stamens are concerned, at some ancient epoch. It is also difficult to believe that the other four stamens and the petals, after an arrest of development at a very early embryonic age, would have come to full perfection in colour, structure, and function, unless these organs had at some former period normally passed through a similar course of growth. Hence it appears to me probable that the progenitor of the genus Antirrhinum must at some remote epoch have included five stamens and borne flowers in some degree resembling those now produced by the peloric form. The conclusion that peloria is not a mere monstrosity, irrespective of any former state of the species, is supported by the fact that this structure is often strongly inherited, as in the case of the peloric Antirrhinum and Gloxinia and sometimes in that of the peloric *Corydalis solida*.[72]

Lastly I may add that many instances have been recorded of flowers, not generally considered as peloric, in which certain organs are abnormally augmented in number. As an increase of parts cannot be looked at as an arrest of development, nor as due to the redevelopment of rudiments, for no rudiments are present, and as these additional parts bring the plant into closer relationship with its natural allies, they ought probably to be viewed as reversions to a primordial condition.

These several facts show us in an interesting manner how intimately certain abnormal states are connected together; namely, arrests of development causing parts to become rudimentary or to be wholly suppressed,—the redevelopment of parts now in a more or less rudimentary condition,—the reappearance of organs of which not a vestige can be detected,—and to these may be added, in the case of animals, the presence during youth, and subsequent disappearance, of certain characters which occasionally are retained throughout life. Some naturalists look at all such abnormal structures as a return to the ideal state of the group to which the affected being belongs; but it is difficult to conceive what is meant to be conveyed by this expression. Other naturalists maintain, with greater probability and distinctness of view, that the common bond of connection between the several foregoing cases is an actual, though partial, return to the structure of the ancient progenitor of the group. If this view be correct, we must believe that a vast number of characters, capable of evolution, lie hidden in every organic being. But it would be a mistake to suppose that the number is equally great in all beings. We know, for instance, that plants of many orders occasionally become peloric; but many more cases have been observed in the Labiatæ and Scrophulariaceæ than in any other order; and in one genus of the Scrophulariaceæ, namely Linaria, no less than thirteen species have been described in this condition.[73] On this view of the nature of peloric flowers, and bearing in mind certain monstrosities in the animal kingdom, we must conclude that the progenitors of most plants and animals have left an impression, capable of redevelopment, on the germs of their descendants, although these have since been profoundly modified.

The fertilised germ of one of the higher animals, subjected as it is to so vast a series of changes from the germinal cell to old age,—incessantly agitated by what Quatrefages well calls the *tourbillon vital*,—is perhaps the most wonderful object in nature. It is probable that hardly a change of any kind affects either parent, without some mark being left on the germ. But on the doctrine of reversion, as given in this chapter, the germ becomes a far more marvellous object, for, besides the visible changes which it undergoes, we must believe that it is crowded with invisible characters, proper to both sexes, to both the right and left side of the body, and to a long line of male and female ancestors separated by hundreds or even thousands of generations from the present time: and these characters, like those written on paper with invisible ink, lie ready to be evolved whenever the organisation is disturbed by certain known or unknown conditions.

REFERENCES

[1] Youatt on Sheep, pp. 20, 234. The same fact of loose horns occasionally appearing in hornless breeds has been observed in Germany; Bechstein, 'Naturgesch. Deutschlands.' b. 1 s. 362.

[2] Youatt on Cattle, pp. 155, 174.

[3] Youatt on Sheep, 1838, pp. 17, 145.

[4] I have been informed of this fact through the Rev. W. D. Fox on the excellent authority of Mr. Wilmot: *see also* remarks on this subject in an article in the 'Quarterly Review,' 1849, p. 395.

[5] Youatt, pp. 19, 234.

[6] 'The Poultry Book,' by Mr. Tegetmeier, 1866, p. 231.

[7] Loudon's 'Gardener's Mag.,' vol. x., 1834, p. 396: a nurseryman, with much experience on this subject, has likewise assured me that this sometimes occurs.

[8] 'Gardener's Chronicle,' 1855, p. 777.

[9] Ibid., 1862, p. 721.

[10] Mr. Boner speaks ('Chamois-hunting,' 2nd edit., 1860, p. 92) of sheep often running wild in the Bavarian Alps; but, on making further inquiries at my request, he found that they are not able to establish themselves; they generally perish from the frozen snow clinging to their wool, and they have lost the skill necessary to pass over steep icy slopes. On one occasion two ewes survived the winter, but their lambs perished.

[11] *See* some excellent remarks on this subject by Mr. Wallace 'Journal Proc. Linn. Soc.,' 1858, vol. iii. p. 60.

[12] Dureau de la Malle 'Comptes Rendus,' tom. xli., 1855, p. 807. From the statements above given, the author concludes that the wild pigs of Louisiana are not descended from the European *Sus scrofa*.

[13] Capt. W. Allen, in his 'Expedition to the Niger,' states that fowls have run wild on the island of Annobon, and have become modified in form and voice. The account is so meagre and vague that it did not appear to me worth copying; but I now find that Dureau de la Malle ('Comptes Rendus,' tom.

xli., 1855, p. 690) advances this as a good instance of reversion to the primitive stock, and as confirmatory of a still more vague statement in classical times by Varro.

[14] ‘Flora of Australia,’ 1859, Introduct., p. ix.

[15] ‘De l’Espèce,’ tom. ii. pp. 54, 58, 60.

[16] Mr. Sedgwick gives many instances in the ‘British and Foreign Med.-Chirurg. Review,’ April and July, 1863, pp. 448, 188.

[17] In his edit. of ‘Youatt on the Pig,’ 1860, p. 27.

[18] Dr. P. Lucas, ‘Héréd. Nat.,’ tom. ii. pp. 314, 892: *see* a good practical article on the subject in ‘Gard. Chronicle,’ 1856, p. 620. I could add a vast number of references, but they would be superfluous.

[19] Kölreuter gives curious cases in his ‘Dritte Fortsetzung,’ 1766, ss. 53, 59; and in his well-known ‘Memoirs on Lavatera and Jalapa.’ Gärtner, ‘Bastarderzeugung,’ ss. 437, 441, etc. Naudin in his “Recherches sur l’Hybridité,” ‘Nouvelles Archives du Muséum,’ tom. i. p. 25.

[20] Quoted by Mr. Sedgwick in ‘Med.-Chirurg. Review,’ April, 1861, p. 485. Dr. H. Dobell in ‘Med.-Chirurg. Transactions,’ vol. xlvi., gives an analogous case in which, in a large family, fingers with thickened joints were transmitted to several members during five generations; but when the blemish once disappeared it never reappeared.

[21] Verlot ‘Des Variétés,’ 1865, p. 63.

[22] ‘Nouvelles Archives du Muséum,’ tom. i. p. 25. Alex. Braun (in his ‘Rejuvenescence,’ Ray Soc., 1853, p. 315) apparently holds a similar opinion.

[23] Mr. Teebay in ‘The Poultry Book,’ by Mr. Tegetmeier, 1866, p. 72.

[24] Quoted by Hofacker ‘Ueber die Eigenschaften,’ etc., s. 98.

[25] Azara, ‘Essais Hist. Nat. de Paraguay,’ tom. ii. 1801, p. 372.

[26] These facts are given on the high authority of Mr. Hewitt, in ‘The Poultry Book,’ by Mr. Tegetmeier, 1866, p. 248.

[27] ‘The Poultry Book,’ by Tegetmeier, 1866, p. 97.

[28] ‘Gardener’s Chron. and Agricultural Gazette,’ 1866, p. 528.

[29] Ibid., 1860, p. 343. I am glad to find that so experienced a breeder of cattle as Mr. Willoughby Wood, (‘Gard. Chron.’ 1869, p. 1216), admits my principle of a cross giving a tendency to reversion.

[30] Sclater in ‘Proc. Zoolog. Soc.,’ 1862, p. 163.

[31] ‘History of the Horse,’ p. 212.

[32] ‘Mém. présentés par divers Savans à l’Acad. Royale,’ tom. vi. 1835, p. 338.

[33] ‘Letters from Alabama,’ 1859, p. 280.

[34] ‘Hist. Nat. des Mammiferes,’ 1820, tom. i.

[35] ‘Philosoph. Transact.,’ 1821, p. 20.

[36] Sclater, in ‘Proc. Zoolog. Soc.,’ 1862, p. 163: this species is the Ghor-Khur of N.W. India, and has often been called the Hemionus of Pallas. *See also* Mr. Blyth’s excellent paper in ‘Journal of Asiatic Soc. of Bengal,’ vol. xviii., 1860, p. 229.

[37] Another species of wild ass, the true *E. hemionus* or *Kiang,* which ordinarily has no shoulder-stripes, is said occasionally to have them; and these, as with the horse and ass, are sometimes double: *see* Mr. Blyth in the paper just quoted and in ‘Indian Sporting Review,’ 1856, p. 320: and Col. Hamilton Smith in ‘Nat. Library, Horses,’ p. 318; and ‘Dict. Class. d’Hist. Nat.,’ tom. iii. p. 563.

[38] Figured in the ‘Gleanings from the Knowsley Menageries,’ by Dr. J. E. Gray.

[39] ‘Darwin’sche Theorie und ihre Stellung zu Moral und Religion,’ p. 85.

[40] Cases of both Spanish and Polish hens sitting are given in the ‘Poultry Chronicle,’ 1855, vol. iii. p. 477.

[41] ‘The Poultry Book,’ by Mr. Tegetmeier, 1866, pp. 119, 163. The author, who remarks on the two negatives (‘Journ. of Hort.,’ 1862, p. 325), states that two broods were raised from a Spanish cock and Silver-pencilled Hamburgh hen, neither of which are incubators, and no less than seven out of eight hens in these two broods “showed a perfect obstinacy in sitting.” The Rev. E. S. Dixon (‘Ornamental Poultry,’ 1848, p. 200) says that chickens reared from a cross between Golden and Black Polish fowls, are “good and steady birds to sit.” Mr. B. P. Brent informs me that he raised some good sitting hens by crossing Pencilled Hamburgh and Polish breeds. A cross-bred bird from a Spanish non-incubating cock and Cochin incubating hen is mentioned in the ‘Poultry Chronicle,’ vol. iii. p. 13, as an “exemplary mother.” On the other hand, an exceptional case is given in the ‘Cottage Gardener,’ 1860, p. 388, of a hen raised from a Spanish cock and black Polish hen which did not incubate.

[42] ‘The Poultry Book,’ by Tegetmeier, 1866, pp. 165, 167.

[43] ‘Natural History Review,’ 1863, April, p. 277.

[44] ‘Essays on Natural History,’ p. 917.

[45] As stated by Mr. Orton, in his ‘Physiology of Breeding,’ p. 12.

[46] M. E. de Selys-Longchamps refers (‘Bulletin Acad. Roy. de Bruxelles,’ tom. xii. No. 10) to more than seven of these hybrids shot in Switzerland and France. M. Deby asserts (‘Zoologist,’ vol. v., 1845-46, p. 1254) that several have been shot in various parts of Belgium and Northern France. Audubon (‘Ornitholog. Biography,’ vol. iii. p. 168), speaking of these hybrids, says that, in North America, they “now and then wander off and become quite wild.”

[47] ‘Journal of Researches,’ 1845, p. 71.

[48] ‘Expedition to the Zambesi,’ 1865, pp. 25, 150.

[49] Dr. P. Broca, on ‘Hybridity in the Genus Homo,’ Eng. translat., 1864, p. 39.

[50] ‘Nouvelles Archives du Muséum,’ tom. i. p. 151.

[51] ‘Bastarderzeugung,’ s. 582, 438, etc.

[52] ‘Die Bastardbefruchtung . . . der Weiden,’ 1865, s. 23. For Gärtner’s remarks on this head, *see* ‘Bastarderzeugung,’ s. 474, 582.

[53] Prof. Weismann, in his very curious essay on the different forms produced by the same species of butterfly at different seasons (‘Saison-Dimorphismus der Schmetterlinge,’ pp. 27, 28), has come to a similar conclusion, namely, that any cause which disturbs the organisation, such as the exposure of the cocoons to heat or even to much shaking, gives a tendency to reversion.

[54] Yarrell, ‘Phil. Transact.,’ 1827, p. 268; Dr. Hamilton, in ‘Proc. Zoolog. Soc.,’ 1862, p. 23.

[55] ‘Archiv. Skand. Beiträge zur Naturgesch.’ viii. s. 397-413.

[56] In his ‘Essays on Nat. Hist.,’ 1838, Mr. Hewitt gives analogous cases with hen-pheasants in ‘Journal of Horticulture,’ July 12, 1864, p. 37. Isidore Geoffroy Saint-Hilaire, in his ‘Essais de Zoolog. Gen.’ (‘suites a Buffon,’ 1842, pp. 496-513), has collected such cases in ten different kinds of birds. It appears that Aristotle was well aware of the change in mental disposition in old hens. The case of the female deer acquiring horns is given at p. 513.

[57] ‘Cottage Gardener,’ 1860, p. 379.

[58] ‘Art de faire Eclore,’ etc., 1749, tom. ii. p. 8.

[59] Sir H. Holland, ‘Medical Notes and Reflections,’ 3rd edit., 1855, p. 31.

[60] *See* Steenstrup on the ‘Obliquity of Flounders’: in ‘Annals and Mag. of Nat. Hist.’ May, 1865, p. 361. I have given an abstract of Malm’s

explanation of this wonderful phenomenon in the ‘Origin of Species’ 6th Edit. p. 186.

[61] Dr. E. von Martens, in ‘Annals and Mag. of Nat. Hist.’ March, 1866, p. 209.

[62] Darwin, ‘Balanidæ,’ Ray Soc., 1854, p. 499: *see also* the appended remarks on the apparently capricious development of the thoracic limbs on the right and left sides in the higher crustaceans.

[63] Mormodes ignea: Darwin, ‘Fertilisation of Orchids,’ 1862, p. 251.

[64] ‘Journal of Horticulture,’ July, 1864, p. 38. I have had the opportunity of examining these remarkable feathers through the kindness of Mr. Tegetmeier.

[65] ‘The Poultry Book,’ by Mr. Tegetmeier, 1866, p. 241.

[66] Carl Vogt, ‘Lectures on Man,’ Eng. translat., 1864, p. 411.

[67] ‘On Cattle,’ p. 174.

[68] ‘Natural Hist. Review,’ April, 1863, p. 258. *See also* his Lecture, Royal Institution, March 16, 1860. On same subject see Moquin-Tandon, ‘Eléments de Tératologie,’ 1841, pp. 184, 352. Dr. Peyritsch has collected a large number of very interesting cases, Sitzb. d. k. Akad. d. Wissensch.: Wien. b. LX. and especially b. LXVI., 1872, p. 125.

[69] Verlot, ‘Des Variétés,’ 1865, p. 89; Naudin, ‘Nouvelles Archives du Museum,’ tom. i. p. 137.

[70] In his discussion on some curious peloric Calceolarias, quoted in ‘Journal of Horticulture,’ Feb. 24, 1863, p. 152.

[71] For other cases of six divisions in peloric flowers of the Labiatæ and Scrophulariaceæ, *see* Moquin-Tandon, ‘Tératologie,’ p. 192.

[72] Godron, reprinted from the ‘Mémoires de l’Acad. de Stanislas,’ 1868.

[73] Moquin-Tandon, ‘Tératologie,’ p. 186.

CHAPTER XIV.
INHERITANCE *continued*—FIXEDNESS OF CHARACTER—PREPOTENCY—SEXUAL LIMITATION—CORRESPONDENCE OF AGE.

FIXEDNESS OF CHARACTER APPARENTLY NOT DUE TO ANTIQUITY OF INITANCE—PREPOTENCY OF

TRANSMISSION IN INDIVIDUALS OF THE SAME FAMILY, IN CROSSED BREEDS AND SPECIES; OFTEN STRONGER IN ONE SEX THAN THE OTHER; SOMETIMES DUE TO THE SAME CHARACTER BEING PRESENT AND VISIBLE IN ONE BREED AND LATENT IN THE OTHER—INHERITANCE AS LIMITED BY SEX—NEWLY-ACQUIRED CHARACTERS IN OUR DOMESTICATED ANIMALS OFTEN TRANSMITTED BY ONE SEX ALONE, SOMETIMES LOST BY ONE SEX ALONE—INHERITANCE AT CORRESPONDING PERIODS OF LIFE—THE IMPORTANCE OF THE PRINCIPLE WITH RESPECT TO EMBRYOLOGY; AS EXHIBITED IN DOMESTICATED ANIMALS: AS EXHIBITED IN THE APPEARANCE AND DISAPPEARANCE OF INHERITED DISEASES; SOMETIMES SUPERVENING EARLIER IN THE CHILD THAN IN THE PARENT—SUMMARY OF THE THREE PRECEDING CHAPTERS.

In the last two chapters the nature and force of Inheritance, the circumstances which interfere with its power, and the tendency to Reversion, with its many remarkable contingencies, were discussed. In the present chapter some other related phenomena will be treated of, as fully as my materials permit.

Fixedness of Character.

It is a general belief amongst breeders that the longer any character has been transmitted by a breed, the more fully it will continue to be transmitted. I do not wish to dispute the truth of the proposition that inheritance gains strength simply through long continuance, but I doubt whether it can be proved. In one sense the proposition is little better than a truism; if any character has remained constant during many generations, it will be likely to continue so, if the conditions of life remain the same. So, again, in improving a breed, if care be taken for a length of time to exclude all inferior individuals, the breed will obviously tend to become truer, as it will not have been crossed during many generations by an inferior animal. We have previously seen, but without being able to assign any cause, that, when a new character appears, it is occasionally from the first constant, or fluctuates much, or wholly fails to be transmitted. So it is with the aggregate of slight differences which characterise a new variety, for some propagate their kind from the first much truer than others. Even with plants multiplied by bulbs, layers, etc., which may in one sense be said to form parts of the same individual, it is well known that certain varieties retain and transmit through successive bud-generations their newly-acquired characters more truly than others. In none of these, nor in the following cases, does there appear to be any relation between the force with which a character is transmitted and the length of time during which it has been transmitted. Some varieties, such as white and yellow hyacinths and white sweet-peas, transmit their colours more faithfully than do the varieties which have retained their natural colour. In the Irish family, mentioned in the twelfth chapter, the peculiar tortoiseshell-like colouring of the eyes was transmitted far more faithfully than any ordinary colour. Ancon and Mauchamp sheep and niata cattle, which are all comparatively modern breeds, exhibit remarkably strong powers of inheritance. Many similar cases could be adduced.

As all domesticated animals and cultivated plants have varied, and yet are descended from aboriginally wild forms, which no doubt had retained the same character from an immensely remote epoch, we see that scarcely any degree of antiquity ensures a character being transmitted perfectly true. In this case, however, it may be said that changed conditions of life induce certain modifications, and not that the power of inheritance fails; but in every case of failure, some cause, either internal or external, must interfere. It will generally be found that the organs or parts which in our domesticated productions have varied, or which still continue to vary,—that is, which fail to retain their former state,—are the same with the parts which differ in the natural species of the same genus. As, on the theory of descent with modification, the species of the same genus have been modified since they branched off from a common progenitor, it follows that the characters by which they differ from one another have varied, whilst other parts of the organisation have remained unchanged; and it might be argued that these same characters now vary under domestication, or fail to be inherited, from their lesser antiquity. But variation in a state of nature seems to stand in some close relation with changed conditions of life, and characters which have already varied under such conditions would be apt to vary under the still greater changes consequent on domestication, independently of their greater or less antiquity.

Fixedness of character, or the strength of inheritance, has often been judged of by the preponderance of certain characters in the crossed offspring between distinct races; but prepotency of transmission here comes into play, and this, as we shall immediately see, is a very different consideration from the strength or weakness of inheritance.[1] It has often been observed that breeds of animals inhabiting wild and mountainous countries cannot be permanently modified by our improved breeds; and as these latter are of modern origin, it has been thought that the greater antiquity of the wilder breeds has been the cause of their resistance to improvement by crossing; but it is more probably due to their structure and constitution being better adapted to the surrounding conditions. When plants are first subjected to culture, it has been found that, during several generations, they transmit their characters truly, that is, do not vary, and this has been attributed to ancient characters being strongly inherited: but it may with equal or greater probability be consequent on changed conditions of life requiring a long time for their cumulative action. Notwithstanding these considerations, it would perhaps be rash to deny that characters become more strongly fixed the longer they are transmitted; but I believe that the proposition resolves itself into this,—that characters of all kinds, whether new or old, tend to be inherited, and that those which have already withstood all counteracting influences and been truly transmitted, will, as a general rule, continue to withstand them, and consequently be faithfully inherited.

Prepotency in the Transmission of Character.

When individuals, belonging to the same family, but distinct enough to be recognised, or when two well-marked races, or two species, are crossed, the usual result, as stated in the previous chapter, is, that the offspring in the first generation are intermediate between their parents, or resemble one parent in one part and the other parent in another part. But this is by no means the invariable rule; for in many cases it is found that certain individuals, races, and species, are prepotent in transmitting their likeness. This subject has been ably discussed by Prosper Lucas,[2] but is rendered extremely complex by the prepotency sometimes running equally in both sexes, and sometimes more strongly in one sex than in the other; it is likewise complicated by the presence of secondary sexual characters, which render the comparison of crossed breeds with their parents difficult.

It would appear that in certain families some one ancestor, and after him others in the same family, have had great power in transmitting their likeness through the male line; for we cannot otherwise understand how the same features should so often be transmitted after marriages with many females, as in the case of the Austrian Emperors; and so it was, according to Niebuhr, with the mental qualities of certain Roman families.[3] The famous bull Favourite is believed[4] to have had a prepotent influence on the shorthorn race. It has also been observed[5] with English racehorses that certain mares have generally transmitted their own character, whilst other mares of equally pure blood have allowed the character of the sire to prevail. A famous black greyhound, Bedlamite, as I hear from Mr. C. M. Brown "invariably got all his puppies black, no matter what was the colour of the bitch;" but then Bedlamite "had a preponderance of black in his blood, both on the sire and dam side."

The truth of the principle of prepotency comes out more clearly when distinct races are crossed. The improved Shorthorns, notwithstanding that the breed is comparatively modern, are generally acknowledged to possess great power in impressing their likeness on all other breeds; and it is chiefly in consequence of this power that they are so highly valued for exportation.[6] Godine has given a curious case of a ram of a goat-like breed of sheep from the Cape of Good Hope, which produced offspring hardly to be distinguished from himself, when crossed with ewes of twelve other breeds. But two of these half-bred ewes, when put to a merino ram, produced lambs closely resembling the merino breed. Girou de Buzareingues[7] found that of two races of French sheep the ewes of one, when crossed during successive generations with merino rams, yielded up their character far sooner than the ewes of the other race. Sturm and Girou have given analogous cases with other breeds of sheep and with cattle, the prepotency running in these cases through the male side; but I was assured on good authority in South America, that when niata cattle are crossed with common cattle, though the niata breed is prepotent whether males or females are used, yet that the prepotency is strongest through the female line. The Manx cat is tailless and has long hind legs; Dr. Wilson crossed a male Manx with common cats, and, out of twenty-three kittens, seventeen were destitute of tails; but when the female Manx was crossed by common male cats all the kittens had tails, though they were generally short and imperfect.[8]

In making reciprocal crosses between pouter and fantail pigeons, the pouter-race seemed to be prepotent through both sexes over the fantail. But this is probably due to weak power in the fantail rather than to any unusually strong power in the pouter, for I have observed that barbs also preponderate over fantails. This weakness of transmission in the fantail, though the breed is an ancient one, is said[9] to be general; but I have observed one exception to the rule, namely, in a cross between a fantail and laugher. The most curious instance known to me of weak power in both sexes is in the trumpeter pigeon. This breed has been well known for at least 130 years: it breeds perfectly true, as I have been assured by those who have long kept many birds: it is characterised by a peculiar tuft of feathers over the beak, by a crest on the head, by a singular coo quite unlike that of any other breed, and by much-feathered feet. I have crossed both sexes with turbits of two sub-breeds, with almond tumblers, spots, and runts, and reared many mongrels and recrossed them; and though the crest on the head and feathered feet were inherited (as is generally the case with most breeds), I have never seen a vestige of the tuft over the beak or heard the peculiar coo. Boitard and Corbié[10] assert that this is the invariable result of crossing trumpeters with other breeds: Neumeister,[11] however, states that in Germany mongrels have been obtained, though very rarely, which were furnished with the tuft and would trumpet: but a pair of these mongrels with a tuft, which I imported, never trumpeted. Mr. Brent states[12] that the crossed offspring of a trumpeter were crossed with trumpeters for three generations, by which time the mongrels had 7/8ths of this blood in their veins, yet the tuft over the beak did not appear. At the fourth generation the tuft appeared, but the birds though now having 15-16ths trumpeter’s blood still did not trumpet. This case well shows the wide difference between inheritance and prepotency; for here we have a well-established old race which transmits its characters faithfully, but which, when crossed with any other race, has the feeblest power of transmitting its two chief characteristic qualities.

I will give one other instance with fowls and pigeons of weakness and strength in the transmission of the same character to their crossed offspring. The Silk fowl breeds true, and there is reason to believe is a very ancient race; but when I reared a large number of mongrels from a Silk hen by a Spanish cock, not one exhibited even a trace of the so-called silkiness. Mr. Hewitt also asserts that in no instance are the silky feathers transmitted by this breed when crossed with any other variety. But three birds out of many raised by Mr. Orton from a cross between a silk cock and a bantam hen had silky feathers.[13] So that it is certain that this breed very seldom has the power of transmitting its peculiar plumage to its crossed progeny. On the other hand, there is a silk sub-variety of the fantail pigeon, which has its feathers in nearly the same state as in the Silk fowl: now we have already seen that fantails, when crossed, possess singularly weak power in transmitting their general qualities; but the silk sub-variety when crossed with any other small-sized race invariably transmits its silky feathers![14]

The well-known horticulturist, Mr. Paul, informs me that he fertilised the Black Prince hollyhock with pollen of the White Globe and the Lemonade and Black Prince hollyhocks reciprocally; but not one seedling from these three crosses inherited the black colour of the Black Prince. So, again, Mr. Laxton, who has had such great experience in crossing peas, writes to me that "whenever a cross has been effected between a white-blossomed and a purple-blossomed pea, or between a white-seeded and a purple-spotted, brown or maple-seeded pea, the offspring seems to lose nearly all the characteristics of the white-flowered and white-seeded varieties; and this result follows whether these varieties have been used as the pollen-bearing or seed-producing parents."

The law of prepotency comes into action when species are crossed, as with races and individuals. Gärtner has unequivocally shown[15] that this is the case with plants. To give one instance: when *Nicotiana paniculata* and *vincæflora* are crossed, the character of *N. paniculata* is almost completely lost in the hybrid; but if *N. quadrivalvis* be crossed with *N. vincæflora*, this latter species, which was before so prepotent, now in its turn almost disappears under the power of *N. quadrivalvis*. It is remarkable that the prepotency of one species over another in transmission is quite independent, as shown by Gärtner, of the greater or less facility with which the one fertilises the other.

With animals, the jackal is prepotent over the dog, as is stated by Flourens, who made many crosses between these animals; and this was likewise the case with a hybrid which I once saw between a jackal and a terrier. I cannot doubt, from the observations of Colin and others, that the ass is prepotent over the horse; the prepotency in this instance running more strongly through the male than through the female ass; so that the mule resembles the ass more closely than does the hinny.[16] The male pheasant, judging from Mr. Hewitt's descriptions,[17] and from the hybrids which I have seen, preponderates over the domestic fowl; but the latter, as far as colour is concerned, has considerable power of transmission, for hybrids raised from five differently coloured hens differed greatly in plumage. I formerly examined some curious hybrids in the Zoological Gardens, between the Penguin variety of the common duck and the Egyptian goose (*Anser ægyptiacus*); and although I will not assert that the domesticated variety preponderated over the natural species, yet it had strongly impressed its unnatural upright figure on these hybrids.

I am aware that such cases as the foregoing have been ascribed by various authors, not to one species, race, or individual being prepotent over the other in impressing its character on its crossed offspring, but to such rules as that the father influences the external characters and the mother the internal or vital organs. But the great diversity of the rules given by various authors almost proves their falseness. Dr. Prosper Lucas has fully discussed this point, and has shown[18] that none of the rules (and I could add others to those quoted by him) apply to all animals. Similar rules have been announced for plants, and have been proved by Gärtner[19] to be all erroneous. If we confine our view to the domesticated races of a single species, or perhaps even to the species of the same genus, some such rules may hold good; for instance, it seems that in reciprocally crossing various breeds of fowls the male generally gives colour;[20] but conspicuous exceptions have passed under my own eyes. It seems that the ram usually gives its peculiar horns and fleece to its crossed offspring, and the bull the presence or absence of horns.

In the following chapter on Crossing I shall have occasion to show that certain characters are rarely or never blended by crossing, but are transmitted in an unmodified state from either parent-form; I refer to this fact here because it is sometimes accompanied on the one side by prepotency, which thus acquires the false appearance of unusual strength. In the same chapter I shall show that the rate at which a species or breed absorbs and obliterates another by repeated crosses, depends in chief part on prepotency in transmission.

In conclusion, some of the cases above given,—for instance, that of the trumpeter pigeon,—prove that there is a wide difference between mere inheritance and prepotency. This latter power seems to us, in our ignorance, to act in most cases quite capriciously. The very same character, even though it be an abnormal or monstrous one, such as silky feathers, may be transmitted by different species, when crossed, either with prepotent force or singular feebleness. It is obvious, that a purely-bred form of either sex, in all cases in which prepotency does not run more strongly in one sex than the other, will transmit its character with prepotent force over a mongrelised and already variable form.[21] From several of the above-given cases we may conclude that mere antiquity of character does not by any means necessarily make it prepotent. In some cases prepotency apparently depends on the same character being present and visible in one of the two breeds which are crossed, and latent or invisible in the other breed; and in this case it is natural that the character which is potentially present in both breeds should be prepotent. Thus, we have reason to believe that there is a latent tendency in all horses to be dun-coloured and striped; and when a horse of this kind is crossed with one of any other colour, it is said that the offspring are almost sure to be striped. Sheep have a similar latent tendency to become dark-coloured, and we have seen with what prepotent force a ram with a few black spots, when crossed with white sheep of various breeds, coloured its offspring. All pigeons have a latent tendency to become slaty-blue, with certain characteristic marks, and it is known that, when a bird thus coloured is crossed with one of any other colour, it is most difficult afterwards to eradicate the blue tint. A nearly parallel case is offered by those black bantams which, as they grow old, develop a latent tendency to acquire red feathers. But there are exceptions to the rule:

hornless breeds of cattle possess a latent capacity to reproduce horns, yet when crossed with horned breeds they do not invariably produce offspring bearing horns.

We meet with analogous cases with plants. Striped flowers, though they can be propagated truly by seed, have a latent tendency to become uniformly coloured, but when once crossed by a uniformly coloured variety, they ever afterwards fail to produce striped seedlings.[22] Another case is in some respects more curious: plants bearing peloric flowers have so strong a latent tendency to reproduce their normally irregular flowers, that this often occurs by buds when a plant is transplanted into poorer or richer soil.[23] Now I crossed the peloric snapdragon (*Antirrhinum majus*), described in the last chapter, with pollen of the common form; and the latter, reciprocally, with peloric pollen. I thus raised two great beds of seedlings, and not one was peloric. Naudin[24] obtained the same result from crossing a peloric Linaria with the common form. I carefully examined the flowers of ninety plants of the crossed Antirrhinum in the two beds, and their structure had not been in the least affected by the cross, except that in a few instances the minute rudiment of the fifth stamen, which is always present, was more fully or even completely developed. It must not be supposed that this entire obliteration of the peloric structure in the crossed plants can be accounted for by any incapacity of transmission; for I raised a large bed of plants from the peloric Antirrhinum, artificially fertilised by its own pollen, and sixteen plants, which alone survived the winter, were all as perfectly peloric as the parent-plant. Here we have a good instance of the wide difference between the inheritance of a character and the power of transmitting it to crossed offspring. The crossed plants, which perfectly resembled the common snapdragon, were allowed to sow themselves, and out of a hundred and twenty-seven seedlings, eighty-eight proved to be common snapdragons, two were in an intermediate condition between the peloric and normal state, and thirty-seven were perfectly peloric, having reverted to the structure of their one grand-parent. This case seems at first sight to offer an exception to the rule just given, namely, that a character which is present in one form and latent in the other is generally transmitted with prepotent force when the two forms are crossed. For in all the Scrophulariaceæ, and especially in the genera Antirrhinum and Linaria, there is, as was shown in the last chapter, a strong latent tendency to become peloric; but there is also, as we have seen, a still stronger tendency in all peloric plants to reacquire their normal irregular structure. So that we have two opposed latent tendencies in the same plants. Now, with the crossed Antirrhinums the tendency to produce normal or irregular flowers, like those of the common Snapdragon, prevailed in the first generation; whilst the tendency to pelorism, appearing to gain strength by the intermission of a generation, prevailed to a large extent in the second set of seedlings. How it is possible for a character to gain strength by the intermission of a generation, will be considered in the chapter on pangenesis.

On the whole, the subject of prepotency is extremely intricate,—from its varying so much in strength, even in regard to the same character, in different animals,—from its running either equally in both sexes, or, as frequently is the case with animals, but not with plants, much stronger in one sex than the other,—from the existence of secondary sexual characters,—from the transmission of certain characters being limited, as we shall immediately see, by sex,—from certain characters not blending together,—and, perhaps, occasionally from the effects of a previous fertilisation on the mother. It is therefore not surprising that no one has hitherto succeeded in drawing up general rules on the subject of prepotency.

Inheritance as limited by Sex.

New characters often appear in one sex, and are afterwards transmitted to the same sex, either exclusively or in a much greater degree than to the other. This subject is important, because with animals of many kinds in a state of nature, both high and low in the scale, secondary sexual characters, not directly connected with the organs of reproduction, are conspicuously present. With our domesticated animals, characters of this kind often differ widely from those distinguishing the two sexes of the parent species; and the principle of inheritance, as limited by sex, explains how this is possible.

Dr. P. Lucas has shown[25] that when a peculiarity, in no manner connected with the reproductive organs, appears in either parent, it is often transmitted exclusively to the offspring of the same sex, or to a much greater number of them than of the opposite sex. Thus, in the family of Lambert, the horn-like projections on the skin were transmitted from the father to his sons and grandsons alone; so it has been with other cases of ichthyosis, with supernumerary digits, with a deficiency of digits and phalanges, and in a lesser degree with various diseases, especially with colour-blindness and the hæmorrhagic diathesis, that is, an extreme liability to profuse and uncontrollable bleeding from trifling wounds. On the other hand, mothers have transmitted, during several generations, to their daughters alone, supernumerary and deficient digits, colour-blindness and other peculiarities. So that the very same peculiarity may become attached to either sex, and be long inherited by that sex alone; but the attachment in certain cases is much more frequent to one than the other sex. The same peculiarities also may be promiscuously transmitted to either sex. Dr. Lucas gives other cases, showing that the male occasionally transmits his peculiarities to his daughters alone, and the mother to her sons alone; but even in this case we see that inheritance is to a certain extent, though inversely, regulated by sex. Dr. Lucas, after weighing the whole evidence, comes to the conclusion that every peculiarity tends to be transmitted in a greater or lesser degree to that sex in which it first appears. But a more definite rule, as I have elsewhere shown[26] generally holds good, namely, that variations which first appear in either sex at a late period of life, when the reproductive functions are active, tend to be developed in that sex alone; whilst variations which first appear early in life in either sex are commonly transmitted to both sexes. I am, however, far from supposing that this is the sole determining cause.

A few details from the many cases collected by Mr. Sedgwick,[27] may be here given. Colour-blindness, from some unknown cause, shows itself much oftener in males than in females; in upwards of two hundred cases collected by Mr. Sedgwick, nine-tenths related to men; but it is eminently liable to be transmitted through women. In the case given by Dr. Earle, members of eight related families were affected during five generations: these families consisted of sixty-one individuals, namely, of thirty-two males, of whom nine-sixteenths were incapable of distinguishing colour, and of twenty-nine females, of whom only one-fifteenth were thus affected. Although colour-blindness thus generally clings to the male sex, nevertheless, in one instance in which it first appeared in a female, it was transmitted during five generations to thirteen individuals, all of whom were females. The hæmorrhagic diathesis, often accompanied by rheumatism, has been known to affect the males alone during five generations, being transmitted, however, through the females. It is said that deficient phalanges in the fingers have been inherited by the females alone during ten generations. In another case, a man thus deficient in both hands and feet, transmitted the peculiarity to his two sons and one daughter; but in the third generation,—out of nineteen grandchildren, twelve sons had the family defect, whilst the seven daughters were free. In ordinary cases of sexual limitation, the sons or daughters inherit the peculiarity, whatever it may be, from their father or mother, and transmit it to their children of the same sex; but generally with the hæmorrhagic diathesis, and often with colour-blindness, and in some other cases, the sons never inherit the peculiarity directly from their fathers, but the daughters alone transmit the latent tendency, so that the sons of the daughters alone exhibit it. Thus the father, grandson, and great-great-grandson will exhibit a peculiarity,—the grandmother, daughter, and great-grand-daughter having transmitted it in a latent state. Hence we have, as Mr. Sedgwick remarks, a double kind of atavism or reversion; each grandson apparently receiving and developing the peculiarity from his grandfather, and each daughter apparently receiving the latent tendency from her grandmother.

From the various facts recorded by Dr. Prosper Lucas, Mr. Sedgwick, and others, there can be no doubt that peculiarities first appearing in either sex, though not in any way necessarily or invariably connected with that sex, strongly tend to be inherited by the offspring of the same sex, but are often transmitted in a latent state through the opposite sex.

Turning now to domesticated animals, we find that certain characters not proper to the parent species are often confined to, and inherited by, one sex alone; but we do not know the history of the first appearance of such characters. In the chapter on Sheep, we have seen that the males of certain races differ greatly from the females in the shape of their horns, these being absent in the ewes of some breeds; they differ also in the development of fat in the tail and in the outline of the forehead. These differences, judging from the character of the allied wild species, cannot be accounted for by supposing that they have been derived from distinct parent forms. There is, also, a great difference between the horns of the two sexes in one Indian breed of goats. The bull zebu is said to have a larger hump than the cow. In the Scotch deer-hound the two sexes differ in size more than in any other variety of the dog[28] and, judging from analogy, more than in the aboriginal parent-species. The peculiar colour called tortoise-shell is very rarely seen in a male cat; the males of this variety being of a rusty tint.

In various breeds of the fowl the males and females often differ greatly; and these differences are far from being the same with those which distinguish the two sexes of the parent-species, the *Gallus bankiva*; and consequently have originated under domestication. In certain sub-varieties of the Game race we have the unusual case of the hens differing from each other more than the cocks. In an Indian breed of a white colour shaded with black, the hens invariably have black skins, and their bones are covered by a black periosteum, whilst the cocks are never or most rarely thus characterised. Pigeons offer a more interesting case; for throughout the whole great family the two sexes do not often differ much; and the males and females of the parent-form, the *C. livia*, are undistinguishable: yet we have seen that with pouters the male has the characteristic quality of pouting more strongly developed than the female; and in certain sub-varieties the males alone are spotted or striated with black, or otherwise differ in colour. When male and female English carrier-pigeons are exhibited in separate pens, the difference in the development of the wattle over the beak and round the eyes is conspicuous. So that here we have instances of the appearance of secondary sexual characters in the domesticated races of a species in which such differences are naturally quite absent.

On the other hand, secondary sexual characters which belong to the species in a state of nature are sometimes quite lost, or greatly diminished, under domestication. We see this in the small size of the tusks in our improved breeds of the pig, in comparison with those of the wild boar. There are sub-breeds of fowls, in which the males have lost the fine-flowing tail-feathers and hackles; and others in which there is no difference in colour between the two sexes. In some cases the barred plumage, which in gallinaceous birds is commonly the attribute of the hen, has been transferred to the cock, as in the cuckoo sub-breeds. In other cases masculine characters have been partly transferred to the female, as with the splendid plumage of the golden-spangled Hamburgh hen, the enlarged comb of the Spanish hen, the pugnacious disposition of the Game hen, and as in the well-developed spurs which occasionally appear in the hens of various breeds. In Polish fowls both sexes are ornamented with a topknot, that of the male being formed of hackle-like feathers, and this is a new male character in the genus Gallus. On the whole, as far as I can judge, new characters are more apt to appear in the males of our domesticated animals than in the females,[29] and afterwards to be inherited exclusively or more strongly by the males. Finally, in accordance with the principle of inheritance as limited by sex, the preservation and augmentation of secondary sexual characters in natural species offers no especial difficulty, as this would follow through that form of selection which I have called sexual selection.

Inheritance at corresponding periods of Life.

This is an important subject. Since the publication of my 'Origin of Species' I have seen no reason to doubt the truth of the explanation there given of one of the most remarkable facts in biology, namely, the difference between the embryo and the adult animal. The explanation is, that variations do not necessarily or generally occur at a very early period of embryonic growth, and that such variations are inherited at a corresponding age. As a consequence of this the embryo, even after the parent-form has undergone great modification, is left only slightly modified; and the embryos of widely-different animals which are descended from a common progenitor remain in many important respects like one another and probably like their common progenitor. We can thus understand why embryology throws a flood of light on the natural system of classification, as this ought to be as far as possible genealogical. When the embryo leads an independent life, that is, becomes a larva, it has to be adapted to the surrounding conditions in its structure and instincts, independently of those of its parents; and the principle of inheritance at corresponding periods of life renders this possible.

This principle is, indeed, in one way so obvious that it escapes attention. We possess a number of races of animals and plants, which, when compared with one another and with their parent-forms, present conspicuous differences, both in their immature and mature states. Look at the seeds of the several kinds of peas, beans, maize, which can be propagated truly, and see how they differ in size, colour, and shape, whilst the full-grown plants differ but little. Cabbages, on the other hand, differ greatly in foliage and manner of growth, but hardly at all in their seeds; and generally it will be found that the differences between cultivated plants at different periods of growth are not necessarily closely connected together, for plants may differ much in their seeds and little when full-grown, and conversely may yield seeds hardly distinguishable, yet differ much when full-grown. In the several breeds of poultry, descended from a single species, differences in the eggs and chickens whilst covered with down, in the plumage at the first and subsequent moults, as well as in the comb and wattles, are all inherited. With man peculiarities in the milk and second teeth (of which I have received the details) are inheritable, and longevity is often transmitted. So again with our improved breeds of cattle and sheep, early maturity, including the early development of the teeth, and with certain breeds of fowl the early appearance of secondary sexual characters, all come under the same head of inheritance at corresponding periods.

Numerous analogous facts could be given. The silk-moth, perhaps, offers the best instance; for in the breeds which transmit their characters truly, the eggs differ in size, colour, and shape: the caterpillars differ, in moulting three or four times, in colour, even in having a dark-coloured mark like an eyebrow, and in the loss of certain instincts;—the cocoons differ in size, shape, and in the colour and quality of the silk; these several differences being followed by slight or barely distinguishable differences in the mature moth.

But it may be said that, if in the above cases a new peculiarity is inherited, it must be at the corresponding stage of development; for an egg or seed can resemble only an egg or seed, and the horn in a full-grown ox can resemble only a horn. The following cases show inheritance at corresponding periods more plainly, because they refer to peculiarities which might have supervened, as far as we can see, earlier or later in life, yet are inherited at the same period at which they first appeared.

In the Lambert family the porcupine-like excrescences appeared in the father and sons at the same age, namely, about nine weeks after birth.[30] In the extraordinary hairy family described by Mr. Crawfurd,[31] children were produced during three generations with hairy ears; in the father the hair began to grow over his body at six years old; in his daughter somewhat earlier, namely, at one year; and in both generations the milk teeth appeared late in life, the permanent teeth being afterwards singularly deficient. Greyness of hair at an unusually early age has been transmitted in some families. These cases border on diseases inherited at corresponding periods of life, to which I shall immediately refer.

It is a well-known peculiarity with almond-tumbler pigeons, that the full beauty and peculiar character of the plumage does not appear until the bird has moulted two or three times. Neumeister describes and figures a brace of pigeons in which the whole body is white except the breast, neck, and head; but in their first plumage all the white feathers have coloured edges. Another breed is more remarkable: its first plumage is black, with rusty-red wing-bars and a crescent-shaped mark on the breast; these marks then become white, and remain so during three or four moults; but after this period the white spreads over the body, and the bird loses its beauty.[32] Prize canary-birds have their wings and tail black: "this colour, however, is only retained until the first moult, so that they must be exhibited ere the change takes place. Once moulted, the peculiarity has ceased. Of course all the birds emanating from this stock have black wings and tails the first year."[33] A curious and somewhat analogous account has been given[34] of a family of wild pied rooks which were first observed in 1798, near Chalfont, and which every year from that date up to the period of the published notice, viz., 1837 "have several of their brood particoloured, black and white. This variegation of the plumage, however, disappears with the first moult; but among the next young families there are always a few pied ones." These changes of plumage, which are inherited at various corresponding periods of life in the pigeon, canary-bird, and rook, are remarkable, because the parent-species passes through no such change.

Inherited diseases afford evidence in some respects of less value than the foregoing cases, because diseases are not necessarily connected with any change in structure; but in other respects of more value, because the periods have been more carefully observed. Certain diseases are communicated to the child apparently by a process like inoculation, and the child is from the first affected; such cases may be here passed over. Large classes of diseases usually appear at certain ages, such as St. Vitus's dance in youth, consumption in early mid-life, gout later, and apoplexy still later; and these are naturally inherited at the same period. But even in diseases of this class, instances have been recorded, as with St. Vitus's dance, showing that an unusually early or late tendency to the disease is inheritable.[35] In most cases the appearance of any inherited disease is largely determined by certain critical periods in each person's life, as well as by unfavourable conditions. There are many other diseases, which are not attached to any particular period, but which certainly tend to appear in the child at about the same age at which the parent was first attacked. An array of high authorities, ancient and modern, could be given in support of this proposition. The illustrious Hunter believed in it; and Piorry[36] cautions the physician to look closely to the child at the period when any grave inheritable disease attacked the parent. Dr. Prosper Lucas,[37] after collecting facts from every source, asserts that affections of all kinds, though not related to any particular period of life, tend to reappear in the offspring at whatever period of life they first appeared in the progenitor.

As the subject is important, it may be well to give a few instances, simply as illustrations, not as proof; for proof, recourse must be had to the authorities above quoted. Some of the following cases have been selected for the sake of showing that, when a slight departure from the rule occurs, the child is affected somewhat earlier in life than the parent. In the family of Le Compte blindness was inherited through three generations, and no less than twenty-seven children and grandchildren were all affected at about the same age; their blindness in general began to advance about the fifteenth or sixteenth year, and ended in total deprivation of sight at the age of about twenty-two.[38] In another case a father and his four children all became blind at twenty-one years old; in another, a grandmother grew blind at thirty-five, her daughter at nineteen, and three grandchildren at the ages of thirteen and eleven.[39] So with deafness, two brothers, their father and paternal grandfather, all became deaf at the age of forty.[40]

Esquirol gives several striking instances of insanity coming on at the same age, as that of a grandfather, father, and son, who all committed suicide near their fiftieth year. Many other cases could be given, as of a whole family who became insane at the age of forty.[41] Other cerebral affections sometimes follow the same rule,—for instance, epilepsy and apoplexy. A woman died of the latter disease when sixty-three years old; one of her daughters at forty-three, and the other at sixty-seven: the latter had twelve children, who all died from tubercular meningitis.[42] I mention this latter case because it illustrates a frequent occurrence, namely, a change in the precise nature of an inherited disease, though still affecting the same organ.

Asthma has attacked several members of the same family when forty years old, and other families during infancy. The most different diseases, such as angina pectoris, stone in the bladder, and various affections of the skin, have appeared in successive generations at nearly the same age. The little finger of a man began from some unknown cause to grow inwards, and the same finger in his two sons began at the same age to bend inwards in a similar manner. Strange and inexplicable neuralgic affections have caused parents and children to suffer agonies at about the same period of life.[43]

I will give only two other cases, which are interesting as illustrating the disappearance as well as the appearance of disease at the same age. Two brothers, their father, their paternal uncles, seven cousins, and their paternal grandfather, were all similarly affected by a skin-disease, called pityriasis versicolor; "the disease, strictly limited to the males of the family (though transmitted through the females), usually appeared at puberty, and disappeared at about the age of forty or forty-five years." The second case is that of four brothers, who when about twelve years old suffered almost every week from severe headaches, which were relieved only by a recumbent position in a dark room. Their father, paternal uncles, paternal grandfather, and granduncles all suffered in the same way from headaches, which ceased at the age of fifty-four or fifty-five in all those who lived so long. None of the females of the family were affected.[44]

It is impossible to read the foregoing accounts, and the many others which have been recorded, of diseases coming on during three or even more generations in several members of the same family at the same age, especially in the case of rare affections in which the coincidence cannot be attributed to chance, and to doubt that there is a strong tendency to inheritance in disease at corresponding periods of life. When the rule fails, the disease is apt to come on earlier in the child than in the parent; the exceptions in the other direction being very much rarer. Dr. Lucas[45] alludes to several cases of inherited diseases coming on at an earlier period. I have already given one striking instance with blindness during three generations; and Mr. Bowman remarks that this frequently occurs with cataract. With cancer there seems to be a peculiar liability to earlier inheritance: Sir J. Paget, who has particularly attended to this subject, and tabulated a large number of cases, informs me that he believes that in nine cases out of ten the later generation suffers from the disease at an earlier period than the previous generation. He adds, "In the instances in which the opposite relation holds, and the members of later generations have cancer at a later age than their predecessors, I think it will be found that the non-cancerous parents have lived to extreme old ages." So that the longevity of a non-affected parent seems to have the power of influencing the fatal period in the offspring; and we thus apparently get another element of complexity in inheritance.

The facts, showing that with certain diseases the period of inheritance occasionally or even frequently advances, are important with respect to the general descent-theory, for they render it probable that the same thing would occur with ordinary modifications of structure. The final result of a long series of such advances would be the gradual obliteration of characters proper to the embryo and larva, which would thus come to resemble more and more closely the mature parent-form. But any structure which was of service to the embryo or larva would be preserved by the destruction at this stage of growth of each individual which manifested any tendency to lose its proper character at too early an age.

Finally, from the numerous races of cultivated plants and domestic animals, in which the seeds or eggs, the young or old, differ from one another and from those of the parent-species;—from the cases in which new characters have appeared at a particular period, and afterwards been inherited at the same period;—and from what we know with respect to disease, we must believe in the truth of the great principle of inheritance at corresponding periods of life.

Summary of the three preceding Chapters.—Strong as is the force of inheritance, it allows the incessant appearance of new characters. These, whether beneficial or injurious,—of the most trifling importance, such as a shade of colour in a flower, a coloured lock of hair, or a mere gesture,—or of the highest importance, as when affecting the brain, or an organ so perfect and complex as the eye,—or of so grave a nature as to deserve to be called a monstrosity,—or so peculiar as not to occur normally in any member of the same natural class,—often inherited by man, by the lower animals, and plants. In numberless cases it suffices for the inheritance of a peculiarity that one parent alone should be thus characterised. Inequalities in the two sides of the body, though opposed to the law of symmetry, may be transmitted. There is ample evidence that the effects of mutilations and of accidents, especially or perhaps exclusively when followed by disease, are occasionally inherited. There can be no doubt that the evil effects of the long-continued exposure of the parent to injurious conditions are sometimes transmitted to the offspring. So it is, as we shall see in a future chapter, with the effects of the use and disuse of parts, and of mental habits. Periodical habits are likewise transmitted, but generally, as it would appear, with little force.

Hence we are led to look at inheritance as the rule, and non-inheritance as the anomaly. But this power often appears to us in our ignorance to act capriciously, transmitting a character with inexplicable strength or feebleness. The very same peculiarity, as the weeping habit of trees, silky feathers, etc., may be inherited either firmly or not at all by different members of the same group, and even by different individuals of the same species, though treated in the same manner. In this latter case we see that the power of transmission is a quality which is merely individual in its attachment. As with single characters, so it is with the several concurrent slight differences which distinguish sub-varieties or races; for of these, some can be propagated almost as truly as species, whilst others cannot be relied on. The same rule holds good with plants, when propagated by bulbs, offsets, etc., which in one sense still form parts of the same individual, for some varieties retain or inherit through successive bud-generations their character far more truly than others.

Some characters not proper to the parent-species have certainly been inherited from an extremely remote epoch, and may therefore be considered as firmly fixed. But it is doubtful whether length of inheritance in itself gives fixedness of character; though the chances are obviously in favour of any character which has long been transmitted true or unaltered still being transmitted true as long as the conditions of life remain the same. We know that many species, after having retained the same character for countless ages, whilst living under their natural conditions, when domesticated have varied in the most diversified manner, that is, have failed to transmit their original form; so that no character appears to be absolutely fixed. We can sometimes account for the failure of inheritance by the conditions of life being opposed to the development of certain characters; and still oftener, as with plants cultivated by grafts and buds, by the conditions causing new and slight modifications incessantly to appear. In this latter case it is not that inheritance wholly fails, but that new characters are continually superadded. In some few cases, in which both parents are similarly characterised, inheritance seems to gain so much force by the combined action of the two parents, that it counteracts its own power, and a new modification is the result.

In many cases the failure of the parents to transmit their likeness is due to the breed having been at some former period crossed; and the child takes after his grandparent or more remote ancestor of foreign blood. In other cases, in which the breed has not been crossed, but some ancient character has been lost through variation, it occasionally reappears through reversion, so that the parents apparently fail to transmit their own likeness. In all cases, however, we may safely conclude that the child inherits all its characters from its parents, in whom certain characters are latent, like the secondary sexual characters of one sex in the other. When, after a long succession of bud-generations, a flower or fruit becomes separated into distinct segments, having the colours or other attributes of both parent-forms, we cannot doubt that these characters were latent in the earlier buds, though they could not then be detected, or could be detected only in an intimately commingled state. So it is with animals of crossed parentage, which with advancing years occasionally exhibit characters derived from one of their two parents, of which not a trace could at first be perceived. Certain monstrosities, which resemble what naturalists call the typical form of the group in question, apparently come under the same law of reversion. It is assuredly an astonishing fact that the male and female sexual elements, that buds, and even full-grown animals, should retain characters, during several generations in the case of crossed breeds, and during thousands of generations in the case of pure breeds, written as it were in invisible ink, yet ready at any time to be evolved under certain conditions.

What these conditions precisely are, we do not know. But any cause which disturbs the organisation or constitution seems to be sufficient. A cross certainly gives a strong tendency to the reappearance of long-lost characters, both corporeal and mental. In the case of plants, this tendency is much stronger with those species which have been crossed after long cultivation and which therefore have had their constitutions disturbed by this cause as well as by crossing, than with species which have always lived under their natural conditions and have then been crossed. A return, also, of domesticated animals and cultivated plants to a wild state favours reversion; but the tendency under these circumstances has been much exaggerated.

When individuals of the same family which differ somewhat, and when races or species are crossed, the one is often prepotent over the other in transmitting its character. A race may possess a strong power of inheritance, and yet when crossed, as we have seen with trumpeter-pigeons, yield to the prepotency of every other race. Prepotency of transmission may be equal in the two sexes of the same species, but often runs more strongly in one sex. It plays an important part in determining the rate at which one race can be modified or wholly absorbed by repeated crosses with another. We can seldom tell what makes one race or species prepotent over another; but it sometimes depends on the same character being present and visible in one parent, and latent or potentially present in the other.

Characters may first appear in either sex, but oftener in the male than in the female, and afterwards be transmitted to the offspring of the same sex. In this case we may feel confident that the peculiarity in question is really present though latent in the opposite sex! hence the father may transmit through his daughter any character to his grandson; and the mother conversely to her granddaughter. We thus learn, and the fact is an important one, that transmission and development are distinct powers. Occasionally these two powers seem to be antagonistic, or incapable of combination in the same individual; for several cases have been recorded in which the son has not directly inherited a character from his father, or directly transmitted it to his son, but has received it by transmission through his non-affected mother, and transmitted it through his non-affected daughter. Owing to inheritance being limited by sex, we see how secondary sexual characters may have arisen under nature; their preservation and accumulation being dependent on their service to either sex.

At whatever period of life a new character first appears, it generally remains latent in the offspring until a corresponding age is attained, and then is developed. When this rule fails, the child generally exhibits the character at an earlier period than the parent. On this principle of inheritance at corresponding periods, we can understand how it is that most animals display from the germ to maturity such a marvellous succession of characters.

Finally, though much remains obscure with respect to Inheritance, we may look at the following laws as fairly well established. Firstly, a tendency in every character, new and old, to be transmitted by seminal and bud generation, though often counteracted by various known and unknown causes. Secondly, reversion or atavism, which depends on transmission and development being distinct powers: it acts in various degrees and manners through both seminal and bud generation. Thirdly, prepotency of transmission, which may be confined to one sex, or be common to both sexes. Fourthly, transmission, as limited by sex, generally to the same sex in which the inherited character first appeared; and this in many, probably most cases, depends on the new character having first appeared at a rather late period of life. Fifthly, inheritance at corresponding periods of life, with some tendency to the earlier development of the inherited character. In these laws of Inheritance, as displayed under domestication, we see an ample provision for the production, through variability and natural selection, of new specific forms.

REFERENCES

[1] *See* Youatt on Cattle, pp. 92, 69, 78, 88, 163; and Youatt on Sheep, p. 325. Also Dr. Lucas 'L'Héréd. Nat.,' tom. ii. p. 310.

[2] 'Héréd. Nat.,' tom. ii. pp. 112-120.

[3] Sir H. Holland, 'Chapters on Mental Physiology,' 1852, p. 234.

[4] 'Gardener's Chronicle,' 1860, p. 270.

[5] Mr. N. H. Smith, 'Observations on Breeding,' quoted in 'Encyclop. of Rural Sports,' p. 278.

[6] Quoted by Bronn, 'Geshichte der Natur,' b. ii. s. 170. *See* Sturm, 'Ueber Racen,' 1825, s. 104-107. For the niata cattle, *see* my 'Journal of Researches,' 1845, p. 146.

[7] Lucas, 'L'Hérédite Nat.,' tom. ii. p. 112.

[8] Mr. Orton, 'Physiology of Breeding,' 1855, p. 9.

[9] Boitard and Corbié, 'Les Pigeons,' 1824, p. 224.

[10] 'Les Pigeons,' pp. 168, 198.

[11] 'Das Ganze,' etc., 1837, s. 39.

[12] 'The Pigeon Book,' p. 46.

[13] 'Physiology of Breeding,' p. 22; Mr. Hewitt, in 'The Poultry Book,' by Tegetmeier, 1866, p. 224.

[14] Boitard and Corbié, 'Les Pigeons,' 1824, p. 226.

[15] 'Bastarderzeugung,' s. 256, 290, etc. Naudin ('Nouvelles Archives du Muséum,' tom. i. p. 149) gives a striking instance of prepotency in *Datura stramonium* when crossed with two other species.

[16] Flourens, 'Longévité Humaine,' p. 144, on crossed jackals. With respect to the difference between the mule and the hinny I am aware that this has generally been attributed to the sire and dam transmitting their characters differently; but Colin, who has given in his 'Traité Phys. Comp.,' tom. ii. pp. 537-539, the fullest description which I have met with of these reciprocal hybrids, is strongly of opinion that the ass preponderates in both crosses, but in an unequal degree. This is likewise the conclusion of Flourens, and of Bechstein in his 'Naturgeschichte Deutschlands,' b. i. s. 294. The tail of the hinny is much more like that of the horse than is the tail of the mule, and this is generally accounted for by the males of both species transmitting with greater power this part of their structure; but a compound hybrid which I saw in the Zoological Gardens, from a mare by a hybrid ass-zebra, closely resembled its mother in its tail.

[17] Mr. Hewitt, who has had such great experience in raising these hybrids says ('Poultry Book,' by Mr. Tegetmeier, 1866, pp. 165-167) that in all, the head was destitute of wattles, comb, and ear-lappets; and all closely resembled the pheasant in the shape of the tail and general contour of the body. These hybrids were raised from hens of several breeds by a cock-pheasant; but another hybrid, described by Mr. Hewitt, was raised from a hen-pheasant, by a silver-laced Bantam cock, and this possessed a rudimental comb and wattles.

[18] 'L'Héréd. Nat.' tom. ii. 2 book ii. ch. i.

[19] 'Bastarderzeugung,' s. 264-266. Naudin ('Nouvelles Archives du Muséum,' tom. i. p. 148) has arrived at a similar conclusion.

[20] 'Cottage Gardener,' 1856, pp. 101, 137.

[21] *See* some remarks on this head with respect to sheep by Mr. Wilson, in 'Gardener's Chronicle,' 1863, p. 15. Many striking instances of this result are given by M. Malingié-Nouel ('Journ. R. Agricult. Soc.,' vol. xiv. 1853, p. 220) with respect to crosses between English and French sheep. He found that he obtained the desired influence of the English breeds by crossing intentionally mongrelised French breeds with pure English breeds.

[22] Verlot, 'Des Variétés,' 1865, p. 66.

[23] Moquin-Tandon, 'Tératologie,' p. 191.

[24] 'Nouvelles Archives du Muséum,' tom. i. p. 137.

[25] 'L'Héréd. Nat.,' tom. ii. pp. 137-165. *See also* Mr. Sedgwick's four memoirs, immediately to be referred to.

[26] 'Descent of Man,' 2nd edit., p. 32.

[27] On Sexual Limitation in Hereditary Diseases, 'Brit. and For. Med.-Chirurg. Review,' April 1861, p. 477; July, p. 198; April 1863, p. 445; and July, p. 159. Also in 1867, 'On the influence of Age in Hereditary Disease.'

[28] W. Scrope, 'Art of Deer Stalking,' p. 354.

[29] I have given in my 'Descent of Man' (2nd edit. p. 223) sufficient evidence that male animals are usually more variable than the females.

[30] Prichard, 'Phys. Hist. of Mankind,' 1851, vol. i. p. 349.

[31] 'Embassy to the Court of Ava,' vol. i. p. 320. The third generation is described by Capt. Yule in his 'Narrative of the Mission to the Court of Ava,' 1855, p. 94.

[32] 'Das Ganze der Taubenzucht,' 1837, s. 24, tab. iv., fig. 2; s. 21, tab. i., fig. 4.

[33] Kidd's 'Treatise on the Canary,' p. 18.

[34] Charlesworth, 'Mag. of Nat. Hist.,' vol. i. 1837, p. 167.

[35] Dr. Prosper Lucas, 'Héréd. Nat.,' tom. ii. p. 713.

[36] 'L'Héréd. dans les Maladies,' 1840, p. 135. For Hunter, *see* Harlan's 'Med. Researches,' p. 530.

[37] 'L'Héréd. Nat.,' tom. ii. p. 850.

[38] Sedgwick, 'Brit. and For. Med.-Chirurg. Review,' April, 1861, p. 485. In some accounts the number of children and grandchildren is given as 37; but this seems to be an error judging from the paper first published in the 'Baltimore Med. and Phys. Reg.' 1809, of which Mr. Sedgwick has been so kind as to send me a copy.

[39] Prosper Lucas, 'Héréd. Nat.,' tom. i. p. 400.

[40] Sedgwick, ibid., July, 1861, p. 202.

[41] Piorry, p. 109; Prosper Lucas, tom. ii. p. 759.

[42] Prosper Lucas, tom. ii. p. 748.

[43] Prosper Lucas, tom. iii. pp. 678, 700, 702; Sedgwick, ibid., April, 1863, p. 449, and July, 1863, p. 162. Dr. J. Steinan 'Essay on Hereditary Disease,' 1843, pp. 27, 34.

[44] These cases are given by Mr. Sedgwick on the authority of Dr. H. Stewart, in 'Med.-Chirurg. Review,' April, 1863, pp. 449, 477.

[45] 'Héréd. Nat.,' tom. ii. p. 852.

CHAPTER XV.
ON CROSSING.

FREE INTERCROSSING OBLITERATES THE DIFFERENCES BETWEEN ALLIED BREEDS—WHEN THE NUMBERS OF TWO COMMINGLING BREEDS ARE UNEQUAL, ONE ABSORBS THE OTHER—THE RATE OF ABSORPTION DETERMINED BY PREPOTENCY OF TRANSMISSION, BY THE CONDITIONS OF LIFE, AND BY NATURAL SELECTION—ALL ORGANIC BEINGS OCCASIONALLY INTERCROSS; APPARENT EXCEPTIONS—ON CERTAIN CHARACTERS

INCAPABLE OF FUSION; CHIEFLY OR EXCLUSIVELY THOSE WHICH HAVE SUDDENLY APPEARED IN THE INDIVIDUAL—ON THE MODIFICATION OF OLD RACES, AND THE FORMATION OF NEW RACES BY CROSSING—SOME CROSSED RACES HAVE BRED TRUE FROM THEIR FIRST PRODUCTION—ON THE CROSSING OF DISTINCT SPECIES IN RELATION TO THE FORMATION OF DOMESTIC RACES.

In the two previous chapters, when discussing reversion and prepotency, I was necessarily led to give many facts on crossing. In the present chapter I shall consider the part which crossing plays in two opposed directions,—firstly, in obliterating characters, and consequently in preventing the formation of new races; and secondly, in the modification of old races, or in the formation of new and intermediate races, by a combination of characters. I shall also show that certain characters are incapable of fusion.

The effects of free or uncontrolled breeding between the members of the same variety or of closely allied varieties are important; but are so obvious that they need not be discussed at much length. It is free intercrossing which chiefly gives uniformity, both under nature and under domestication, to the individuals of the same species or variety, when they live mingled together and are not exposed to any cause inducing excessive variability. The prevention of free crossing, and the intentional matching of individual animals, are the corner-stones of the breeder's art. No man in his senses would expect to improve or modify a breed in any particular manner, or keep an old breed true and distinct, unless he separated his animals. The killing of inferior animals in each generation comes to the same thing as their separation. In savage and semi-civilised countries, where the inhabitants have not the means of separating their animals, more than a single breed of the same species rarely or never exists. In former times, even in the United States, there were no distinct races of sheep, for all had been mingled together.[1] The celebrated agriculturist Marshall[2] remarks that "sheep that are kept within fences, as well as shepherded flocks in open countries, have generally a similarity, if not a uniformity, of character in the individuals of each flock;" for they breed freely together, and are prevented from crossing with other kinds; whereas in the unenclosed parts of England the unshepherded sheep, even of the same flock, are far from true or uniform, owing to various breeds having mingled and crossed. We have seen that the half-wild cattle in each of the several British parks are nearly uniform in character; but in the different parks, from not having mingled and crossed during many generations, they differ to a certain small extent.

We cannot doubt that the extraordinary number of varieties and sub-varieties of the pigeon, amounting to at least one hundred and fifty, is partly due to their remaining, differently from other domesticated birds, paired for life once matched. On the other hand, breeds of cats imported into this country soon disappear, for their nocturnal and rambling habits render it hardly possible to prevent free crossing. Rengger[3] gives an interesting case with respect to the cat in Paraguay: in all the distant parts of the kingdom it has assumed, apparently from the effects of the climate, a peculiar character, but near the capital this change has been prevented, owing, as he asserts, to the native animal frequently crossing with cats imported from Europe. In all cases like the foregoing, the effects of an occasional cross will be augmented by the increased vigour and fertility of the crossed offspring, of which fact evidence will hereafter be given; for this will lead to the mongrels increasing more rapidly than the pure parent-breeds.

When distinct breeds are allowed to cross freely, the result will be a heterogeneous body; for instance, the dogs in Paraguay are far from uniform, and can no longer be affiliated to their parent-races.[4] The character which a crossed body of animals will ultimately assume must depend on several contingencies,—namely, on the relative members of the individuals belonging to the two or more races which are allowed to mingle; on the prepotency of one race over the other in the transmission of character; and on the conditions of life to which they are exposed. When two commingled breeds exist at first in nearly equal numbers, the whole will sooner or later become intimately blended, but not so soon, both breeds being equally favoured in all respects, as might have been expected. The following calculation[5] shows that this is the case: if a colony with an equal number of black and white men were founded, and we assume that they marry indiscriminately, are equally prolific, and that one in thirty annually dies and is born; then "in 65 years the number of blacks, whites, and mulattoes would be equal. In 91 years the whites would be 1-10th, the blacks 1-10th, and the mulattoes, or people of intermediate degrees of colour, 8-10ths of the whole number. In three centuries not 1-100th part of the whites would exist."

When one of two mingled races exceed the other greatly in number, the latter will soon be wholly, or almost wholly, absorbed and lost.[6] Thus European pigs and dogs have been largely introduced in the islands of the Pacific Ocean, and the native races have been absorbed and lost in the course of about fifty or sixty years;[7] but the imported races no doubt were favoured. Rats may be considered as semi-domesticated animals. Some snake-rats (*Mus alexandrinus*) escaped in the Zoological Gardens of London "and for a long time afterwards the keepers frequently caught cross-bred rats, at first half-breds, afterwards with less of the character of the snake-rat, till at length all traces of it disappeared."[8] On the other hand, in some parts of London, especially near the docks, where fresh rats are frequently imported, an endless variety of intermediate forms may be found between the brown, black, and snake rat, which are all three usually ranked as distinct species.

How many generations are necessary for one species or race to absorb another by repeated crosses has often been discussed;[9] and the requisite number has probably been much exaggerated. Some writers have maintained that a dozen or score, or even more generations, are necessary; but this in itself is improbable, for in the tenth generation there would be only 1-1024th part of foreign blood in the offspring. Gärtner found,[10] that with plants, one species could be made to absorb another in from three to five generations, and he believes that this could always be effected in from six to seven generations. In one instance, however, Kolreuter[11] speaks of the offspring of *Mirabilis vulgaris,* crossed during eight successive generations by *M. longiflora,* as resembling this latter species so closely, that the most scrupulous observer could detect "vix aliquam notabilem differentiam" or, as he says, he succeeded, "ad plenariam fere transmutationem." But this expression shows that the act of absorption was not even then absolutely complete, though these crossed plants contained only the 1-256th part of *M. vulgaris.* The conclusions of such accurate observers as Gärtner and Kölreuter are of far higher worth than those made without scientific aim by breeders. The most precise account which I have met with is given by Stonehenge[12] and is illustrated by photographs. Mr. Hanley crossed a greyhound bitch with a bulldog; the offspring in each succeeding generation being recrossed with first-rate greyhounds. As Stonehenge remarks, it might naturally be supposed that it would take several crosses to get rid of the heavy form of the bulldog; but Hysterics, the gr-gr-granddaughter of a bulldog, showed no trace whatever of this breed in external form. She and all of the same litter, however, were "remarkably deficient in stoutness, though fast as well as clever." I believe clever refers to skill in turning. Hysterics was put to a son of Bedlamite, "but the result of the fifth cross is not as yet, I believe, more satisfactory than that of the fourth." On the other hand, with sheep, Fleischmann[13] shows how persistent the effects of a single cross may be: he says "that the original coarse sheep (of Germany) have 5500 fibres of wool on a square inch; grades of the third or fourth Merino cross produced about 8000, the twentieth cross 27,000, the perfect pure Merino blood 40,000 to 48,000." So that common German sheep crossed twenty times successively with Merino did not by any means acquire wool as fine as that of the pure breed. But in all cases, the rate of absorption will depend largely on the conditions of life being favourable to any particular character; and we may suspect that there would be a constant tendency to degeneration in the wool of Merinos under the climate of Germany, unless prevented by careful selection; and thus perhaps the foregoing remarkable case may be explained. The rate of absorption must also depend on the amount of distinguishable difference between the two forms which are crossed, and especially, as Gärtner insists, on prepotency of transmission in the one form over the other. We have seen in the last chapter that one of two French breeds of sheep yielded up its character, when crossed with Merinos, very much more slowly than the other; and the common German sheep referred to by Fleischmann may be in this respect analogous. In all cases there will be more or less liability to reversion during many subsequent generations, and it is this fact which has probably led authors to maintain that a score or more of generations are requisite for one race to absorb another. In considering the final result of the commingling of two or more breeds, we must not forget that the act of crossing in itself tends to bring back long-lost characters not proper to the immediate parent-forms.

With respect to the influence of the conditions of life on any two breeds which are allowed to cross freely, unless both are indigenous and have long been accustomed to the country where they live, they will, in all probability, be unequally affected by the conditions, and this will modify the result. Even with indigenous breeds, it will rarely or never occur that both are equally well adapted to the surrounding circumstances; more especially when permitted to roam freely, and not carefully tended, as is generally the case with breeds allowed to cross. As a consequence of this, natural selection will to a certain extent come into action, and the best fitted will survive, and this will aid in determining the ultimate character of the commingled body.

How long a time it would require before such a crossed body of animals would assume a uniform character within a limited area, no one can say; that they would ultimately become uniform from free intercrossing, and from the survival of the fittest, we may feel assured; but the characters thus acquired would rarely or never, as may be inferred from the previous considerations, be exactly intermediate between those of the two parent-breeds. With respect to the very slight differences by which the individuals of the same sub-variety, or even of allied varieties, are characterised, it is obvious that free crossing would soon obliterate such small distinctions. The formation of new varieties, independently of selection, would also thus be prevented; except when the same variation continually recurred from the action of some strongly predisposing cause. We may therefore conclude that free crossing has in all cases played an important part in giving uniformity of character to all the members of the same domestic race and of the same natural species, though largely governed by natural selection and by the direct action of the surrounding conditions.

On the possibility of all organic beings occasionally intercrossing.—But it may be asked, can free crossing occur with hermaphrodite animals and plants? All the higher animals, and the few insects which have been domesticated, have separate sexes, and must inevitably unite for each birth. With respect to the crossing of hermaphrodites, the subject is too large for the present volume, but in the 'Origin of Species' I have given a short abstract of the reasons which induce me to believe that all organic beings occasionally cross, though perhaps in some cases only at long intervals of time.[14] I will merely recall the fact that many plants, though hermaphrodite in structure, are unisexual in function;—such as those called by C.K. Sprengel *dichogamous,* in which the pollen and stigma of the same flower are matured at different periods; or those called by me *reciprocally dimorphic,* in which the flower's own pollen is not fitted to fertilise its own stigma; or again, the many kinds in which curious mechanical contrivances exist, effectually preventing self-fertilisation. There are, however, many hermaphrodite plants which are not in any way specially constructed to favour intercrossing, but which nevertheless commingle almost as freely as animals with separated sexes. This is the case with cabbages, radishes, and onions, as I know from having experimented on them:

even the peasants of Liguria say that cabbages must be prevented “from falling in love” with each other. In the orange tribe, Gallesio[15] remarks that the amelioration of the various kinds is checked by their continual and almost regular crossing. So it is with numerous other plants.

On the other hand, some cultivated plants rarely or never intercross, for instance, the common pea and sweet-pea (*Lathyrus odoratus*); yet their flowers are certainly adapted for cross fertilisation. The varieties of the tomato and aubergine (*Solanum*) and the pimenta (*Pimenta vulgaris?*) are said[16] never to cross, even when growing alongside one another. But it should be observed that these are all exotic plants, and we do not know how they would behave in their native country when visited by the proper insects. With respect to the common pea, I have ascertained that it is rarely crossed in this country owing to premature fertilisation. There exist, however, some plants which under their natural conditions appear to be always self-fertilised, such as the Bee Ophrys (*Ophrys apifera*) and a few other Orchids; yet these plants exhibit the plainest adaptations for cross-fertilisation. Again, some few plants are believed to produce only closed flowers, called cleistogene, which cannot possibly be crossed. This was long thought to be the case with the *Leersia oryzoides,*[17] but this grass is now known occasionally to produce perfect flowers, which set seed.

Although some plants, both indigenous and naturalised, rarely or never produce flowers, or if they flower never produce seeds, yet no one doubts that phanerogamic plants are adapted to produce flowers, and the flowers to produce seed. When they fail, we believe that such plants under different conditions would perform their proper function, or that they formerly did so, and will do so again. On analogous grounds, I believe that the flowers in the above specified anomalous cases which do not now intercross, either would do so occasionally under different conditions, or that they formerly did so—the means for affecting this being generally still retained—and will again intercross at some future period, unless indeed they become extinct. On this view alone, many points in the structure and action of the reproductive organs in hermaphrodite plants and animals are intelligible,—for instance, the fact of the male and female organs never being so completely enclosed as to render access from without impossible. Hence we may conclude that the most important of all the means for giving uniformity to the individuals of the same species, namely, the capacity of occasionally intercrossing, is present, or has been formerly present, with all organic beings, except, perhaps, some of the lowest.

On certain Characters not blending.—When two breeds are crossed their characters usually become intimately fused together; but some characters refuse to blend, and are transmitted in an unmodified state either from both parents or from one. When grey and white mice are paired, the young are piebald, or pure white or grey, but not of an intermediate tint; so it is when white and common collared turtle-doves are paired. In breeding Game fowls, a great authority, Mr. J. Douglas, remarks, “I may here state a strange fact: if you cross a black with a white game, you get birds of both breeds of the clearest colour.” Sir R. Heron crossed during many years white, black, brown, and fawn-coloured Angora rabbits, and never once got these colours mingled in the same animal, but often all four colours in the same litter.[18] From cases like these, in which the colours of the two parents are transmitted quite separately to the offspring, we have all sorts of gradations, leading to complete fusion. I will give an instance: a gentleman with a fair complexion, light hair but dark eyes, married a lady with dark hair and complexion: their three children have very light hair, but on careful search about a dozen black hairs were found scattered in the midst of the light hair on the heads of all three.

When turnspit dogs and ancon sheep, both of which have dwarfed limbs, are crossed with common breeds, the offspring are not intermediate in structure, but take after either parent. When tailless or hornless animals are crossed with perfect animals, it frequently, but by no means invariably, happens that the offspring are either furnished with these organs in a perfect state, or are quite destitute of them. According to Rengger, the hairless condition of the Paraguay dog is either perfectly or not at all transmitted to its mongrel offspring; but I have seen one partial exception in a dog of this parentage which had part of its skin hairy, and part naked, the parts being distinctly separated as in a piebald animal. When Dorking fowls with five toes are crossed with other breeds, the chickens often have five toes on one foot and four on the other. Some crossed pigs raised by Sir R. Heron between the solid-hoofed and common pig had not all four feet in an intermediate condition, but two feet were furnished with properly divided, and two with united hoofs.

Analogous facts have been observed with plants: Major Trevor Clarke crossed the little, glabrous-leaved, annual stock (Matthiola), with pollen of a large, red-flowered, rough-leaved, biennial stock, called *cocardeau* by the French, and the result was that half the seedlings had glabrous and the other half rough leaves, but none had leaves in an intermediate state. That the glabrous seedlings were the product of the rough-leaved variety, and not accidentally of the mother-plant’s own pollen, was shown by their tall and strong habit of growth.[19] in the succeeding generations raised from the rough-leaved crossed seedlings, some glabrous plants appeared, showing that the glabrous character, though incapable of blending with and modifying the rough leaves, was all the time latent in this family of plants. The numerous plants formerly referred to, which I raised from reciprocal crosses between the peloric and common Antirrhinum, offer a nearly parallel case; for in the first generation all the plants resembled the common form, and in the next generation, out of one hundred and thirty-seven plants, two alone were in an intermediate condition, the others perfectly resembling either the peloric or common form. Major Trevor Clarke also fertilised the above-mentioned red-flowered stock with pollen from the purple Queen stock, and about half the seedlings scarcely differed in habit, and not at all in the red colour of the flower, from the mother-plant, the other half bearing blossoms of a rich purple, closely like those of the paternal plant. Gärtner crossed many white and yellow-flowered species and varieties of Verbascum;

and these colours were never blended, but the offspring bore either pure white or pure yellow blossoms; the former in the larger proportion.[20] Dr. Herbert raised many seedlings, as he informed me, from Swedish turnips crossed by two other varieties, and these never produced flowers of an intermediate tint, but always like one of their parents. I fertilised the purple sweet-pea (*Lathyrus odoratus*), which has a dark reddish-purple standard-petal and violet-coloured wings and keel, with pollen of the painted lady sweet-pea, which has a pale cherry-coloured standard, and almost white wings and keel; and from the same pod I twice raised plants perfectly resembling both sorts; the greater number resembling the father. So perfect was the resemblance, that I should have thought there had been some mistake, if the plants which were at first identical with the paternal variety, namely, the painted-lady, had not later in the season produced, as mentioned in a former chapter, flowers blotched and streaked with dark purple. I raised grandchildren and great-grandchildren from these crossed plants, and they continued to resemble the painted-lady, but during later generations became rather more blotched with purple, yet none reverted completely to the original mother-plant, the purple sweet-pea. The following case is slightly different, but still shows the same principle: Naudin[21] raised numerous hybrids between the yellow *Linaria vulgaris* and the purple *L. purpurea*, and during three successive generations the colours kept distinct in different parts of the same flower.

From cases such as the foregoing, in which the offspring of the first generation perfectly resemble either parent, we come by a small step to those cases in which differently coloured flowers borne on the same root resemble both parents, and by another step to those in which the same flower or fruit is striped or blotched with the two parental colours, or bears a single stripe of the colour or other characteristic quality of one of the parent-forms. With hybrids and mongrels it frequently or even generally happens that one part of the body resembles more or less closely one parent and another part the other parent; and here again some resistence to fusion, or, what comes to the same thing, some mutual affinity between the organic atoms of the same nature, apparently comes into play, for otherwise all parts of the body would be equally intermediate in character. So again, when the offspring of hybrids or mongrels, which are themselves nearly intermediate in character, revert either wholly or by segments to their ancestors, the principle of the affinity of similar, or the repulsion of dissimilar atoms, must come into action. To this principle, which seems to be extremely general, we shall recur in the chapter on pangenesis.

It is remarkable, as has been strongly insisted upon by Isidore Geoffroy St. Hilaire in regard to animals, that the transmission of characters without fusion occurs very rarely when species are crossed; I know of one exception alone, namely, with the hybrids naturally produced between the common and hooded crow (*Corvus corone* and *cornix*), which, however, are closely allied species, differing in nothing except colour. Nor have I met with any well-ascertained cases of transmission of this kind, even when one form is strongly prepotent over another, when two races are crossed which have been slowly formed by man's selection, and therefore resemble to a certain extent natural species. Such cases as puppies in the same litter closely resembling two distinct breeds, are probably due to superfoetation,—that is, to the influence of two fathers. All the characters above enumerated, which are transmitted in a perfect state to some of the offspring and not to others,— such as distinct colours, nakedness of skin, smoothness of leaves, absence of horns or tail, additional toes, pelorism, dwarfed structure, etc.,—have all been known to appear suddenly in individual animals and plants. From this fact, and from the several slight, aggregated differences which distinguish domestic races and species from one another, not being liable to this peculiar form of transmission, we may conclude that it is in some way connected with the sudden appearance of the characters in question.

On the Modification of old Races and the Formation of new Races by Crossing.—We have hitherto chiefly considered the effects of crossing in giving uniformity of character; we must now look to an opposite result. There can be no doubt that crossing, with the aid of rigorous selection during several generations, has been a potent means in modifying old races, and in forming new ones. Lord Orford crossed his famous stud of greyhounds once with the bulldog, in order to give them courage and perseverance. Certain pointers have been crossed, as I hear from the Rev. W. D. Fox, with the foxhound, to give them dash and speed. Certain strains of Dorking fowls have had a slight infusion of Game blood; and I have known a great fancier who on a single occasion crossed his turbit-pigeons with barbs, for the sake of gaining greater breadth of beak.

In the foregoing cases breeds have been crossed once, for the sake of modifying some particular character; but with most of the improved races of the pig, which now breed true, there have been repeated crosses,—for instance, the improved Essex owes its excellence to repeated crosses with the Neapolitan, together probably with some infusion of Chinese blood.[22] So with our British sheep: almost all the races, except the Southdown, have been largely crossed; "this, in fact, has been the history of our principal breeds."[23] To give an example, the "Oxfordshire Downs" now rank as an established breed.[24] They were produced about the year 1830 by crossing "Hampshire and in some instances Southdown ewes with Cotswold rams:" now the Hampshire ram was itself produced by repeated crosses between the native Hampshire sheep and Southdowns; and the long-woolled Cotswold were improved by crosses with the Leicester, which latter again is believed to have been a cross between several long-woolled sheep. Mr. Spooner, after considering the various cases which have been carefully recorded, concludes, "that from a judicious pairing of cross-bred animals it is practicable to establish a new breed." On the continent the history of several crossed races of cattle and of other animals has been well ascertained. To give one instance: the King of Wurtemburg, after twenty-five years' careful breeding, that is, after six or seven generations, made a new breed of cattle from a cross between a Dutch and a Swiss breed, combined with other breeds.[25] The Sebright bantam, which breeds as true as any other kind of fowl, was formed about sixty years ago by a complicated cross.[26] Dark Brahmas, which are believed by some fanciers to constitute a distinct species, were undoubtedly formed[27] in the United States, within a recent period, by a cross between Chittagongs and Cochins. With plants there is little doubt that the Swede-turnip originated from a cross; and the history of a variety of wheat, raised from two very distinct varieties, and which after six years' culture presented an even sample, has been recorded on good authority.[28]

Until lately, cautious and experienced breeders, though not averse to a single infusion of foreign blood, were almost universally convinced that the attempt to establish a new race, intermediate between two widely distinct races, was hopeless "they clung with superstitious tenacity to the doctrine of purity of blood, believing it to be the ark in which alone true safety could be found."[29] Nor was this conviction unreasonable: when two distinct races are crossed, the offspring of the first generation are generally nearly uniform in character; but even this sometimes fails to be the case, especially with crossed dogs and fowls, the young of which from the first are sometimes much diversified. As cross-bred animals are generally of large size and vigorous, they have been raised in great numbers for immediate consumption. But for breeding they are found utterly useless; for though they may themselves be uniform in character, they yield during many generations astonishingly diversified offspring. The breeder is driven to despair, and concludes that he will never form an intermediate race. But from the cases already given, and from others which have been recorded, it appears that patience alone is necessary; as Mr. Spooner remarks, "nature opposes no barrier to successful admixture; in the course of time, by the aid of selection and careful weeding, it is practicable to establish a new breed." After six or seven generations the hoped-for result will in most cases be obtained; but even then an occasional reversion, or failure to keep true, may be expected. The attempt, however, will assuredly fail if the conditions of life be decidedly unfavourable to the characters of either parent-breed.[30]

Although the grandchildren and succeeding generations of cross-bred animals are generally variable in an extreme degree, some curious exceptions to the rule have been observed both with crossed races and species. Thus Boitard and Corbié[31] assert that from a Pouter and a Runt "a Cavalier will appear, which we have classed amongst pigeons of pure race, because it transmits all its qualities to its posterity." The editor of the 'Poultry Chronicle'[32] bred some bluish fowls from a black Spanish cock and a Malay hen; and these remained true to colour "generation after generation." The Himalayan breed of rabbits was certainly formed by crossing two sub-varieties of the silver-grey rabbit; although it suddenly assumed its present character, which differs much from that of either parent-breed, yet it has ever since been easily and truly propagated. I crossed some Labrador and Penguin ducks, and recrossed the mongrels with Penguins; afterwards most of the ducks reared during three generations were nearly uniform in character, being brown with a white crescentic mark on the lower part of the breast, and with some white spots at the base of the beak; so that by the aid of a little selection a new breed might easily have been formed. With regard to crossed varieties of plants, Mr. Beaton[33] remarks that "Melville's extraordinary cross between the Scotch kale and an early cabbage is as true and genuine as any on record;" but in this case no doubt selection was practised. Gärtner[34] has given five cases of hybrids, in which the progeny kept constant; and hybrids between *Dianthus armeria* and *deltoides* remained true and uniform to the tenth generation. Dr. Herbert likewise showed me a hybrid from two species of Loasa which from its first production had kept constant during several generations.

We have seen in the first chapter, that the several kinds of dogs are almost certainly descended from more than one species, and so it is with cattle, pigs and some other domesticated animals. Hence the crossing of aboriginally distinct species probably came into play at an early period in the formation of our present races. From Rutimeyer's observations there can be little doubt that this occurred with cattle; but in most cases one form will probably have absorbed and obliterated the other, for it is not likely that semi-civilised men would have taken the necessary pains to modify by selection their commingled, crossed, and fluctuating stock. Nevertheless, those animals which were best adapted to their conditions of life would have survived through natural selection; and by this means crossing will often have indirectly aided in the formation of primeval domesticated breeds. Within recent times, as far as animals are concerned, the crossing of distinct species has done little or nothing towards the formation or modification of our races. It is not yet known whether the several species of silk-moth which have been recently crossed in France will yield permanent races. With plants which can be multiplied by buds and cuttings, hybridisation has done wonders, as with many kinds of Roses, Rhododendrons, Pelargoniums, Calceolarias, and Petunias. Nearly all these plants can be propagated by seed, most of them freely; but extremely few or none come true by seed.

Some authors believe that crossing is the chief cause of variability,—that is, of the appearance of absolutely new characters. Some have gone so far as to look at it as the sole cause; but this conclusion is disproved by the facts given in the chapter on Bud-variation. The belief that characters not present in either parent or in their ancestors frequently originate from crossing is doubtful; that they occasionally do so is probable; but this subject will be more conveniently discussed in a future chapter on the causes of Variability.

A condensed summary of this and of the three following chapters, together with some remarks on Hybridism, will be given in the nineteenth chapter.

REFERENCES

[1] 'Communications to the Board of Agriculture,' vol. i. p. 367.

[2] 'Review of Reports, North of England,' 1808, p. 200.

[3] 'Säugethiere von Paraguay,' 1830, s. 212.

[4] Rengger, 'Säugethiere,' etc., s. 154.

[5] White, 'Regular Gradation in Man,' p. 146.

[6] Dr. W. F. Edwards, in his 'Caractères Physiolog. des Races Humaines,' p. 24, first called attention to this subject, and ably discussed it.

[7] Rev. D. Tyerman and Bennett, 'Journal of Voyages,' 1821-1829, vol. i. p. 300.

[8] Mr. S. J. Salter, 'Journal Linn. Soc.,' vol. vi., 1862, p. 71.

[9] Sturm, 'Ueber Racen, etc.,' 1825, s. 107. Bronn, 'Geschichte der Natur,' b. ii. s. 170, gives a table of the proportions of blood after successive crosses. Dr. P. Lucas, 'L'Hérédité Nat.,' tom. ii. p. 308.

[10] 'Bastarderzeugung,' s. 463, 470.

[11] 'Nova Acta Petrop.,' 1794, p. 393: *see also* previous volume.

[12] 'The Dog,' 1867, pp. 179-184.

[13] As quoted in the 'True Principles of Breeding,' by C. H. Macknight and Dr. H. Madden, 1865, p. 11.

[14] With respect to plants, an admirable essay on this subject (Die Geschlechter-Vertheilung bei den Pflanzen: 1867) has been published by Dr. Hildebrand, who arrives at the same general conclusions as I have done. Various other treatises have since appeared on the same subject, more especially by Hermann Müller and Delpino.

[15] 'Teoria della Riproduzione Vegetal,' 1816, p. 12.

[16] Verlot 'Des Variétés,' 1865, p. 72.

[17] Duval Jouve, 'Bull. Soc. Bot. de France,' tom. x., 1863, p. 194. With respect to the perfect flowers setting seed, *see* Dr. Ascherson in 'Bot. Zeitung,' 1864, p. 350.

[18] Extract of a letter from Sir R. Heron, 1838, given me by Mr. Yarrell. With respect to mice, *see* 'Annal. des Sc. Nat.,' tom. i. p. 180; and I have heard of other similar cases. For turtle-doves Boitard and Corbié, 'Les Pigeons,' etc., p. 238. For the Game fowl, 'The Poultry Book,' 1866, p. 128. For crosses of tailless fowls *see* Bechstein, 'Naturges. Deutsch.' b. iii. s. 403. Bronn, 'Geschichte der Natur,' b. ii. s. 170, gives analogous facts with horses. On the hairless condition of crossed South American dogs, *see* Rengger, 'Säugethiere von Paraguay,' s. 152; but I saw in the Zoological Gardens mongrels, from a similar cross, which were hairless, quite hairy, or hairy in patches, that is, piebald with hair. For crosses of

Dorking and other fowls, *see* ‘Poultry Chronicle,’ vol. ii. p. 355. About the crossed pigs, extract of letter from Sir R. Heron to Mr. Yarrell. For other cases, *see* P. Lucas ‘L’Héréd. Nat.’ tom. i. p. 212.

[19] ‘Internat. Hort. and Bot. Congress of London,’ 1866.

[20] ‘Bastarderzeugung,’ s. 307. Kölreuter (‘Dritte Fortsetszung,’ s. 34, 39), however, obtained intermediate tints from similar crosses in the genus Verbascum. With respect to the turnips, *see* Herbert’s ‘Amaryllidaceæ,’ 1837, p. 370.

[21] ‘Nouvelles Archives du Muséum,’ tom. i. p. 100.

[22] Richardson, ‘Pigs,’ 1847, pp. 37, 42; S. Sidney’s edition of ‘Youatt on the Pig,’ 1860, p. 3.

23[] *See* Mr. W. C. Spooner’s excellent paper on Cross-Breeding, ‘Journal Royal Agricult. Soc.,’ vol. xx., part ii.: *see also* an equally good article by Mr. Ch. Howard, in ‘Gardener’s Chronicle,’ 1860, p. 320.

[24] ‘Gardener’s Chronicle,’ 1857, pp. 649, 652.

[25] ‘Bulletin de la Soc. d’Acclimat.,’ 1862, tom. ix. p. 463. *See also* for other cases MM. Moll and Gayot, ‘Du Bœuf,’ 1860, p. 32.

[26] ‘Poultry Chronicle,’ vol. ii., 1854, p. 36.

[27] ‘The Poultry Book,’ by W. B. Tegetmeier, 1866, p. 58.

[28] ‘Gardener’s Chronicle,’ 1852, p. 765.

[29] Spooner, in ‘Journal Royal Agricult. Soc.,’ vol. xx., part ii.

[30] *See* Colin’s ‘Traité de Phys. Comp. des Animaux Domestiques,’ tom. ii. p. 536, where this subject is well treated.

[31] ‘Les Pigeons,’ p. 37.

[32] Vol. i., 1854, p. 101.

[33] ‘Cottage Gardener,’ 1856, p. 110.

[34] ‘Bastarderzeugung,’ s. 553.

CHAPTER XVI.
CAUSES WHICH INTERFERE WITH THE FREE CROSSING OF VARIETIES—INFLUENCE OF DOMESTICATION ON FERTILITY.

DIFFICULTIES IN JUDGING OF THE FERTILITY OF VARIETIES WHEN CROSSED. VARIOUS CAUSES WHICH KEEP VARIETIES DISTINCT, AS THE PERIOD OF BREEDING AND SEXUAL PREFERENCE—VARIETIES OF WHEAT SAID TO BE STERILE WHEN CROSSED—VARIETIES OF MAIZE, VERBASCUM, HOLLYHOCK, GOURDS, MELONS, AND TOBACCO, RENDERED IN SOME DEGREE MUTUALLY STERILE—DOMESTICATION ELIMINATES THE TENDENCY TO STERILITY NATURAL TO SPECIES WHEN CROSSED—ON THE INCREASED FERTILITY OF UNCROSSED ANIMALS AND PLANTS FROM DOMESTICATION AND CULTIVATION.

The domesticated races of both animals and plants, when crossed, are, with extremely few exceptions, quite prolific,—in some cases even more so than the purely-bred parent-races. The offspring, also, raised from such crosses are likewise, as we shall see in the following chapter, generally more vigorous and fertile than their parents. On the other hand, species when crossed, and their hybrid offspring, are almost invariably in some degree sterile; and here there seems to exist a broad and insuperable distinction between races and species. The importance of this subject as bearing on the origin of species is obvious; and we shall hereafter recur to it.

It is unfortunate how few precise observations have been made on the fertility of mongrel animals and plants during several successive generations. Dr. Broca[1] has remarked that no one has observed whether, for instance, mongrel dogs, bred inter se, are indefinitely fertile; yet, if a shade of infertility be detected by careful observation in the offspring of natural forms when crossed, it is thought that their specific distinction is proved. But so many breeds of sheep, cattle, pigs, dogs, and poultry, have been crossed and recrossed in various ways, that any sterility, if it had existed, would from being injurious almost certainly have been observed. In investigating the fertility of crossed varieties many sources of doubt occur. Whenever the least trace of sterility between two plants, however closely allied, was observed by Kolreuter, and more especially by Gärtner, who counted the exact number of seed in each capsule, the two forms were at once ranked as distinct species; and if this rule be followed, assuredly it will never be proved that varieties when crossed are in any degree sterile. We have formerly seen that certain breeds of dogs do not readily pair together; but no observations have been made whether, when paired, they produce the full number of young, and whether the latter are perfectly fertile *inter se*; but, supposing that some degree of sterility were found to exist, naturalists would simply infer that these breeds were descended from aboriginally distinct species; and it would be scarcely possible to ascertain whether or not this explanation was the true one.

The Sebright Bantam is much less prolific than any other breed of fowls, and is descended from a cross between two very distinct breeds, recrossed by a third sub-variety. But it would be extremely rash to infer that the loss of fertility was in any manner connected with its crossed origin, for it may with more probability be attributed either to long-continued close interbreeding, or to an innate tendency to sterility correlated with the absence of hackles and sickle tail-feathers.

Before giving the few recorded cases of forms, which must be ranked as varieties, being in some degree sterile when crossed, I may remark that other causes sometimes interfere with varieties freely intercrossing. Thus they may differ too greatly in size, as with some kinds of dogs and fowls: for instance, the editor of the 'Journal of Horticulture, etc.'[2] says that he can keep Bantams with the larger breeds without much danger of their crossing, but not with the smaller breeds, such as Games, Hamburghs, etc. With plants a difference in the period of flowering serves to keep varieties distinct, as with the various kinds of maize and wheat: thus Colonel Le Couteur[3] remarks, "the Talavera wheat, from flowering much earlier than any other kind, is sure to continue pure." In different parts of the Falkland Islands the cattle are breaking up into herds of different colours; and those on the higher ground, which are generally white, usually breed, as I am informed by Sir J. Sulivan, three months earlier than those on the lowland; and this would manifestly tend to keep the herds from blending.

Certain domestic races seem to prefer breeding with their own kind; and this is a fact of some importance, for it is a step towards that instinctive feeling which helps to keep closely allied species in a state of nature distinct. We have now abundant evidence that, if it were not for this feeling, many more hybrids would be naturally produced than in this case. We have seen in the first chapter that the alco dog of Mexico dislikes dogs of other breeds; and the hairless dog of Paraguay mixes less readily with the European races, than the latter do with each other. In Germany the female Spitz-dog is said to receive the fox more readily than will other dogs; a female Australian Dingo in England attracted the wild male foxes. But these differences in the sexual instinct and attractive power of the various breeds may be wholly due to their descent from distinct species. In Paraguay the horses have much freedom, and an excellent observer[4] believes that the native horses of the same colour and size prefer associating with each other, and that the horses which have been imported from Entre Rios and Banda Oriental into Paraguay likewise prefer associating together. In Circassia six sub-races of the horse have received distinct names; and a native proprietor of rank[5] asserts that horses of three of these races, whilst living a free life, almost always refuse to mingle and cross, and will even attack one another.

It has been observed, in a district stocked with heavy Lincolnshire and light Norfolk sheep, that both kinds; though bred together, when turned out, "in a short time separate to a sheep;" the Lincolnshires drawing off to the rich soil, and the Norfolks to their own dry light soil; and as long as there is plenty of grass, "the two breeds keep themselves as distinct as rooks and pigeons." In this case different habits of life tend to keep the races distinct. On one of the Faroe islands, not more than half a mile in diameter, the half-wild native black sheep are said not to have readily mixed with the imported white sheep. It is a more curious fact that the semi-monstrous ancon sheep of modern origin "have been observed to keep together, separating themselves from the rest of the flock, when put into enclosures with other sheep."[6] With respect to fallow-deer, which live in a semi-domesticated condition, Mr. Bennett[7] states that the dark and pale coloured herds, which have long been kept together in the Forest of Dean, in High Meadow Woods, and in the New Forest, have never been known to mingle: the dark-coloured deer, it may be added, are believed to have been first brought by James I. from Norway, on account of their greater hardiness. I imported from the island of Porto Santo two of the feral rabbits, which differ, as described in the fourth chapter, from common rabbits; both proved to be males, and, though they lived during some years in the Zoological Gardens, the superintendent, Mr. Bartlett, in vain endeavoured to make them breed with various tame kinds; but whether this refusal to breed was due to any change in the instinct, or simply to their extreme wildness, or whether confinement had rendered them sterile, as often occurs, cannot be determined.

Whilst matching for the sake of experiment many of the most distinct breeds of pigeons, it frequently appeared to me that the birds, though faithful to their marriage vow, retained some desire after their own kind. Accordingly I asked Mr. Wicking, who has kept a larger stock of various breeds together than any man in England, whether he thought that they would prefer pairing with their own kind, supposing that there were males and females enough of each; and he without hesitation answered that he was convinced that this was the case. It has often been noticed that the dovecote pigeon seems to have an actual aversion towards the several fancy breeds[8] yet all have certainly sprung from a common progenitor. The Rev. W. D. Fox informs me that his flocks of white and common Chinese geese kept distinct.

These facts and statements, though some of them are incapable of proof, resting only on the opinion of experienced observers, show that some domestic races are led by different habits of life to keep to a certain extent separate, and that others prefer coupling with their own kind, in the same manner as species in a state of nature, though in a much less degree.

With respect to sterility from the crossing of domestic races, I know of no well-ascertained case with animals. This fact, seeing the great difference in structure between some breeds of pigeons, fowls, pigs, dogs, etc., is extraordinary, in contrast with the sterility of many closely allied natural species when crossed; but we shall hereafter attempt to show that it is not so extraordinary as it at first appears. And it may be well here to recall to mind that the amount of external difference between two species is not a safe guide for predicting whether or not they will breed together,—some closely allied species when crossed being utterly sterile, and others which are extremely unlike being moderately fertile. I have said that no case of sterility in crossed races rests on satisfactory evidence; but here is one which at first seems trustworthy. Mr. Youatt[9] and a better authority cannot be quoted, states, that formerly in Lancashire crosses were frequently made between longhorn and shorthorn cattle; the first cross was excellent, but the produce was uncertain; in the third or fourth generation the cows were bad milkers; “in addition to which, there was much uncertainty whether the cows would conceive; and full one-third of the cows among some of these half-breds failed to be in calf.” This at first seems a good case: but Mr. Wilkinson states,[10] that a breed derived from this same cross was actually established in another part of England; and if it had failed in fertility, the fact would surely have been noticed. Moreover, supposing that Mr. Youatt had proved his case, it might be argued that the sterility was wholly due to the two parent-breeds being descended from primordially distinct species.

In the case of plants Gärtner states that he fertilised thirteen heads (and subsequently nine others) on a dwarf maize bearing yellow seed[11] with pollen of a tall maize having red seed; and one head alone produced good seed, but only five in number. Though these plants are monœcious, and therefore do not require castration, yet I should have suspected some accident in the manipulation, had not Gärtner expressly stated that he had during many years grown these two varieties together, and they did not spontaneously cross; and this, considering that the plants are monoecious and abound with pollen, and are well known generally to cross freely, seems explicable only on the belief that these two varieties are in some degree mutually infertile. The hybrid plants raised from the above five seeds were intermediate in structure, extremely variable, and perfectly fertile.[12] In like manner Prof. Hildebrand[13] could not succeed in fertilising the female flowers of a plant bearing brown grains with pollen from a certain kind bearing yellow grains; although other flowers on the same plant, which were fertilised with their own pollen, yielded good seed. No one, I believe, even suspects that these varieties of maize are distinct species; but had the hybrids been in the least sterile, no doubt Gärtner would at once have so classed them. I may here remark, that with undoubted species there is not necessarily any close relation between the sterility of a first cross and that of the hybrid offspring. Some species can be crossed with facility, but produce utterly sterile hybrids; others can be crossed with extreme difficulty, but the hybrids when produced are moderately fertile. I am not aware, however, of any instance quite like this of the maize, namely, of a first cross made with difficulty, but yielding perfectly fertile hybrids.[14]

The following case is much more remarkable, and evidently perplexed Gärtner, whose strong wish it was to draw a broad line of distinction between species and varieties. In the genus Verbascum, he made, during eighteen years, a vast number of experiments, and crossed no less than 1085 flowers and counted their seeds. Many of these experiments consisted in crossing white and yellow varieties of both *V. lychnitis* and *V. blattaria* with nine other species and their hybrids. That the white and yellow flowered plants of these two species are really varieties, no one has doubted; and Gärtner actually raised in the case of both species one variety from the seed of the other. Now in two of his works[15] he distinctly asserts that crosses between similarly-coloured flowers yield more seed than between dissimilarly-coloured; so that the yellow-flowered variety of either species (and conversely with the white-flowered variety), when crossed with pollen of its own kind, yields more seed than when crossed with that of the white variety; and so it is when differently coloured species are crossed. The general results may be seen in the Table at the end of his volume. In one instance he gives[16] the following details; but I must premise that Gärtner, to avoid exaggerating the degree of sterility in his crosses, always compares the *maximum* number obtained from a cross with the *average* number naturally given by the pure mother-plant. The white variety of *V. lychnitis*, naturally fertilised by its own pollen, gave from an *average* of twelve capsules ninety-six good seeds in each; whilst twenty flowers fertilised with pollen from the yellow variety of this same species, gave as the *maximum* only eighty-nine good seeds; so that we have the proportion of 1000 to 908, according to Gärtner's usual scale. I should have thought it possible that so small a difference in fertility might have been accounted for by the evil effects of the necessary castration; but Gärtner shows that the white variety of *V. lychnitis*, when fertilised first by the white variety of *V. blattaria*, and then by the yellow variety of this species, yielded seed in the proportion of 622 to 438; and in both these cases castration was performed. Now the sterility which results from the crossing of the differently coloured varieties of the same species, is fully as great as that which occurs in many cases when distinct species are crossed. Unfortunately Gärtner compared the results of the first unions alone, and not the sterility of the two sets of hybrids produced from the white variety of *V. lychnitis* when fertilised by the white and yellow varieties of *V. blattaria*, for it is probable that they would have differed in this respect.

Mr. J. Scott has given me the results of a series of experiments on Verbascum, made by him in the Botanic Gardens of Edinburgh.[17] He repeated some of Gärtner's experiments on distinct species, but obtained only fluctuating results, some confirmatory, the greater number contradictory; nevertheless these seem hardly sufficient to overthrow the conclusion arrived at by Gärtner from experiments tried on a larger scale. Mr. Scott also experimented on the relative fertility of unions between similarly and dissimilarly-coloured varieties of the same species. Thus he fertilised six flowers of the yellow variety of *V. lychnitis* by its own pollen, and obtained six capsules; and calling, for the sake of comparison, the average number of good seed in each of their capsules one hundred, he found that this same yellow variety, when fertilised by the white variety, yielded from seven capsules an average of ninety-four seed. On the same principle, the white variety of *V. lychnitis* by its own pollen (from six capsules), and by the pollen of the yellow variety (eight capsules), yielded seed in the proportion of 100 to 82. The yellow variety of *V. thapsus* by its own pollen (eight capsules), and by that of the white variety (only two capsules), yielded seed in the proportion of 100 to 94. Lastly, the white variety of *V. blattaria* by its own pollen (eight capsules), and by that of the yellow variety (five capsules), yielded seed in the proportion of 100 to 79. So that in every case the unions of similarly-coloured varieties of the same species were more fertile than the unions of dissimilarly-coloured varieties; when all the cases are grouped together, the difference of fertility is as 100 to 86. Some additional trials were made, and altogether thirty-six similarly-coloured unions yielded thirty-five good capsules; whilst thirty-five dissimilarly-coloured unions yielded only twenty-six good capsules. Besides the foregoing experiments, the purple *V. phœniceum* was crossed by a rose-coloured and a white variety of the same species; these two varieties were also crossed together, and these several unions yielded less seed than *V. phœniceum* by its own pollen. Hence it follows from Mr. Scott's experiments, that in the genus Verbascum the similarly and dissimilarly-coloured varieties of the same species behave, when crossed, like closely allied but distinct species.[18]

This remarkable fact of the sexual affinity of similarly-coloured varieties, as observed by Gärtner and Mr. Scott, may not be of very rare occurrence; for the subject has not been attended to by others. The following case is worth giving, partly to show how difficult it is to avoid error. Dr. Herbert[19] has remarked that variously-coloured double varieties of the Hollyhock (*Althea rosea*) may be raised with certainty by seed from plants growing close together. I have been informed that nurserymen who raise seed for sale do not separate their plants; accordingly I procured seed of eighteen named varieties; of these, eleven varieties produced sixty-two plants all perfectly true to their kind; and seven produced forty-nine plants, half of which were true and half false. Mr. Masters of Canterbury has given me a more striking case; he saved seed from a great bed of twenty-four named varieties planted in closely adjoining rows, and each variety reproduced itself truly with only sometimes a shade of difference in tint. Now in the hollyhock the pollen, which is abundant, is matured and nearly all shed before the stigma of the same flower is ready to receive it;[20] and as bees covered with pollen incessantly fly from plant to plant, it would appear that adjoining varieties could not escape being crossed. As, however, this does not occur, it appeared to me probable that the pollen of each variety was prepotent on its own stigma over that of all other varieties, but I have no evidence on this point. Mr. C. Turner of Slough, well known for his success in the cultivation of this plant, informs me that it is the doubleness of the flowers which prevents the bees gaining access to the pollen and stigma; and he finds that it is difficult even to cross them artificially. Whether this explanation will fully account for varieties in close proximity propagating themselves so truly by seed, I do not know.

The following cases are worth giving, as they relate to monoecious forms, which do not require, and consequently cannot have been injured by, castration. Girou de Buzareingues crossed what he designates three varieties of gourd,[21] and asserts that their mutual fertilisation is less easy in proportion to the difference which they present. I am aware how imperfectly the forms in this group were until recently known; but Sageret,[22] who ranked them according to their mutual fertility, considers the three forms above alluded to as varieties, as does a far higher authority, namely, M. Naudin.[23] Sageret[24] has observed that certain melons have a greater tendency, whatever the cause may be, to keep true than others; and M. Naudin, who has had such immense experience in this group, informs me that he believes that certain varieties intercross more readily than others of the same species; but he has not proved the truth of this conclusion; the frequent abortion of the pollen near Paris being one great difficulty. Nevertheless, he has grown close together, during seven years, certain forms of Citrullus, which, as they could be artificially crossed with perfect facility and produced fertile offspring, are ranked as varieties; but these forms when not artificially crossed kept true. Many other varieties, on the other hand, in the same group cross with such facility, as M. Naudin repeatedly insists, that without being grown far apart they cannot be kept in the least true.

Another case, though somewhat different, may be here given, as it is highly remarkable, and is established on excellent evidence. Kolreuter minutely describes five varieties of the common tobacco[25] which were reciprocally crossed, and the offspring were intermediate in character and as fertile as their parents: from this fact Kolreuter inferred that they are really varieties; and no one, as far as I can discover, seems to have doubted that such is the case. He also crossed reciprocally these five varieties with *N. glutinosa*, and they yielded very sterile hybrids; but those raised from the *var. perennis*, whether used as the father or mother plant, were not so sterile as the hybrids from the four other varieties.[26] So that the sexual capacity of this one variety has certainly been in some degree modified, so as to approach in nature that of *N. glutinosa*.[27]

These facts with respect to plants show that in some few cases certain varieties have had their sexual powers so far modified, that they cross together less readily and yield less seed than other varieties of the same species. We shall presently see that the sexual functions of most animals and plants are eminently liable to be affected by the conditions of life to which they are exposed; and hereafter we shall briefly discuss the conjoint bearing of this fact, and others, on the difference in fertility between crossed varieties and crossed species.

Domestication eliminates the tendency to Sterility which is general with Species when crossed.

This hypothesis was first propounded by Pallas,[28] and has been adopted by several authors. I can find hardly any direct facts in its support; but unfortunately no one has compared, in the case of either animals or plants, the fertility of anciently domesticated varieties, when crossed with a distinct species, with that of the wild parent-species when similarly crossed. No one has compared, for instance, the fertility of *Gallus bankiva* and of the domesticated fowl, when crossed with a distinct species of Gallus or Phasianus; and the experiment would in all cases be surrounded by many difficulties. Dureau de la Malle, who has so closely studied classical literature, states[29] that in the time of the Romans the common mule was produced with more difficulty than at the present day;

but whether this statement may be trusted I know not. A much more important, though somewhat different, case is given by M. Groenland,[30] namely, that plants, known from their intermediate character and sterility to be hybrids between Ægilops and wheat, have perpetuated themselves under culture since 1857, *with a rapid but varying increase of fertility in each generation*. In the fourth generation the plants, still retaining their intermediate character, had become as fertile as common cultivated wheat.

The indirect evidence in favour of the Pallasian doctrine appears to me to be extremely strong. In the earlier chapters I have shown that our various breeds of the dog are descended from several wild species; and this probably is the case with sheep. There can be no doubt that the Zebu or humped Indian ox belongs to a distinct species from European cattle: the latter, moreover, are descended from two forms, which may be called either species or races. We have good evidence that our domesticated pigs belong to at least two specific types, *S. scrofa* and *indicus*. Now a widely extended analogy leads to the belief that if these several allied species, when first reclaimed, had been crossed, they would have exhibited, both in their first unions and in their hybrid offspring, some degree of sterility. Nevertheless, the several domesticated races descended from them are now all, as far as can be ascertained, perfectly fertile together. If this reasoning be trustworthy, and it is apparently sound, we must admit the Pallasian doctrine that long-continued domestication tends to eliminate that sterility which is natural to species when crossed in their aboriginal state.

On increased Fertility from Domestication and Cultivation.

Increased fertility from domestication, without any reference to crossing, may be here briefly considered. This subject bears indirectly on two or three points connected with the modification of organic beings. As Buffon long ago remarked,[31] domestic animals breed oftener in the year and produce more young at a birth than wild animals of the same species; they, also, sometimes breed at an earlier age. The case would hardly have deserved further notice, had not some authors lately attempted to show that fertility increases and decreases in an inverse ratio with the amount of food. This strange doctrine has apparently arisen from individual animals when supplied with an inordinate quantity of food, and from plants of many kinds when grown on excessively rich soil, as on a dunghill, becoming sterile: but to this latter point I shall have occasion presently to return. With hardly an exception, our domesticated animals, which have been long habituated to a regular and copious supply of food, without the labour of searching for it, are more fertile than the corresponding wild animals. It is notorious how frequently cats and dogs breed, and how many young they produce at a birth. The wild rabbit is said generally to breed four times yearly, and to produce each time at most six young; the tame rabbit breeds six or seven times yearly, producing each time from four to eleven young; and Mr. Harrison Weir tells me of a case of eighteen young having been produced at a birth, all of which survived. The ferret, though generally so closely confined, is more prolific than its supposed wild prototype. The wild sow is remarkably prolific; she often breeds twice in the year, and bears from four to eight and sometimes even twelve young; but the domestic sow regularly breeds twice a year, and would breed oftener if permitted; and a sow that produces less than eight at a birth "is worth little, and the sooner she is fattened for the butcher the better." The amount of food affects the fertility of the same individual: thus sheep, which on mountains never produce more than one lamb at a birth, when brought down to lowland pastures frequently bear twins. This difference apparently is not due to the cold of the higher land, for sheep and other domestic animals are said to be extremely prolific in Lapland. Hard living, also, retards the period at which animals conceive; for it has been found disadvantageous in the northern islands of Scotland to allow cows to bear calves before they are four years old.[32]

Birds offer still better evidence of increased fertility from domestication: the hen of the wild *Gallus bankiva* lays from six to ten eggs, a number which would be thought nothing of with the domestic hen. The wild duck lays from five to ten eggs; the tame one in the course of the year from eighty to one hundred. The wild grey-lag goose lays from five to eight eggs; the tame from thirteen to eighteen, and she lays a second time; as Mr. Dixon has remarked, "high-feeding, care, and moderate warmth induce a habit of prolificacy which becomes in some measure hereditary." Whether the semi-domesticated dovecote pigeon is more fertile than the wild rock-pigeon, C. livia, I know not; but the more thoroughly domesticated breeds are nearly twice as fertile as dovecotes: the latter, however, when caged and highly fed, become equally fertile with house pigeons. I hear from Judge Caton that the wild turkey in the United States does not breed when a year old, as the domesticated turkeys there invariably do. The peahen alone of domesticated birds is rather more fertile, according to some accounts, when wild in its native Indian home, than in Europe when exposed to our much colder climate.[33]

With respect to plants, no one would expect wheat to tiller more, and each ear to produce more grain, in poor than in rich soil; or to get in poor soil a heavy crop of peas or beans. Seeds vary so much in number that it is difficult to estimate them; but on comparing beds of carrots in a nursery garden with wild plants, the former seemed to produce about twice as much seed. Cultivated cabbages yielded thrice as many pods by measure as wild cabbages from the rocks of South Wales. The excess of berries produced by the cultivated asparagus in comparison with the wild plant is enormous. No doubt many highly cultivated plants, such as pears, pineapples, bananas, sugar-cane, etc., are nearly or quite sterile; and I am inclined to attribute this sterility to excess of food and to other unnatural conditions; but to this subject I shall recur.

In some cases, as with the pig, rabbit, etc., and with those plants which are valued for their seed, the direct selection of the more fertile individuals has probably much increased their fertility; and in all cases this may have occurred indirectly, from the better chance of some of the numerous offspring from the more fertile individuals having been preserved. But with cats, ferrets, and dogs, and with plants like carrots, cabbages, and asparagus, which are not valued for their prolificacy, selection can have played only a subordinate part; and their increased fertility must be attributed to the more favourable conditions of life under which they have long existed.

REFERENCES

[1] 'Journal de Physiolog.,' tom. ii., 1859, p. 385.

[2] Dec. 1863, p. 484.

[3] On 'The Varieties of Wheat,' p. 66.

[4] Rengger, 'Säugethiere von Paraguay,' s. 336.

[5] *See* a memoir by MM. Lherbette and De Quatrefages, in 'Bull. Soc. d'Acclimat.,' tom. viii., July, 1861, p. 312.

[6] For the Norfolk sheep, *see* Marshall's 'Rural Economy of Norfolk,' vol. ii. p. 136. *See* Rev. L. Landt's 'Description of Faroe,' p. 66. For the ancon sheep, *see* 'Phil. Transact.,' 1813, p. 90.

[7] White's 'Nat. Hist. of Selbourne,' edited by Bennett, p. 39. With respect to the origin of the dark-coloured deer, *see* 'Some Account of English Deer Parks,' by E. P. Shirley, Esq.

[8] 'The Dovecote,' by the Rev. E. S. Dixon, p. 155; Bechstein, 'Naturgesch. Deutschlands,' b. iv., 1795, s. 17.

[9] 'Cattle,' p. 202.

[10] Mr. J. Wilkinson, in 'Remarks addressed to Sir J. Sebright,' 1820, p. 38.

[11] 'Bastarderzeugung,' s. 87, 169. *See also* the Table at the end of volume.

[12] 'Bastarderzeugung,' s. 87, 577.

[13] 'Bot. Zeitung,' 1868, p. 327.

[14] Mr. Shirreff formerly thought ('Gard. Chron.,' 1858, p. 771) that the offspring from a cross between certain varieties of wheat became sterile in the fourth generation; but he now admits ('Improvement of the Cereals,' 1873) that this was an error.

[15] 'Kenntniss der Befruchtung,' s. 137; 'Bastarderzeugung,' s. 92, 181. On raising the two varieties from seed, *see* s. 307.

[16] 'Bastarderzeugung,' s. 216.

[17] The results have since been published in 'Journ. Asiatic Soc. of Bengal,' 1867, p. 145.

[18] The following facts, given by Kölreuter in his ‘Dritte Fortsetzung,’ ss. 34, 39, appear at first sight strongly to confirm Mr. Scott’s and Gärtner’s statements; and to a certain limited extent they do so. Kölreuter asserts, from innumerable observations, that insects incessantly carry pollen from one species and variety of Verbascum to another; and I can confirm this assertion; yet he found that the white and yellow varieties of *Verbascum lychnitis* often grew wild mingled together: moreover, he cultivated these two varieties in considerable numbers during four years in his garden, and they kept true by seed; but when he crossed them, they produced flowers of an intermediate tint. Hence it might have been thought that both varieties must have a stronger elective affinity for the pollen of their own variety than for that of the other; this elective affinity, I may add of each species for its own pollen (Kölreuter, ‘Dritte Forts.’ s. 39, and Gärtner, ‘Bastarderz.,’ *passim*) being a perfectly well-ascertained power. But the force of the foregoing facts is much lessened by Gärtner’s numerous experiments, for, differently from Kölreuter, he never once got (‘Bastarderz.,’ s. 307) an intermediate tint when he crossed the yellow and white flowered varieties of Verbascum. So that the fact of the white and yellow varieties keeping true to their colour by seed does not prove that they were not mutually fertilised by the pollen carried by insects from one to the other.

[19] ‘Amaryllidaceæ,’ 1837, p. 366. Gärtner has made a similar observation.

[20] Kölreuter first observed this fact, ‘Mém. de l’Acad. de St. Petersburg,’ vol. iii. p. 127. *See also* C. K. Sprengel, ‘Das Entdeckte Geheimniss,’ s. 345.

[21] Namely, Barbarines, Pastissons, Giraumous: ‘Annal. des Sc. Nat.’ tom. xxx., 1833, pp. 398 and 405.

[22] ‘Mémoire sur les Cucurbitaceæ,’ 1826, pp. 46, 55.

[23] ‘Annales des Sc. Nat.,’ 4th series, tom. vi. M. Naudin considers these forms as undoubtedly varieties of *Cucurbita pepo.*

[24] ‘Mém. Cucurb.,’ p. 8.

[25] ‘Zweite Forts.,’ s. 53, namely, *Nicotiana major vulgaris;* (2) *perennis;* (3) *transylvanica;* (4) a sub-var. of the last; (5) *major latifol. fl. alb.*

[26] Kölreuter was so much struck with this fact that he suspected that a little pollen of *N. glutinosa* in one of his experiments might have accidentally got mingled with that of *var. perennis,* and thus aided its fertilising power. But we now know conclusively from Gärtner (‘Bastarderz.,’ s. 34, 43) that the pollen of two species never acts *conjointly* on a third species; still less will the pollen of a distinct species, mingled with a plant’s own pollen, if the latter be present in sufficient quantity, have any effect. The sole effect of mingling two kinds of pollen is to produce in the same capsule seeds which yield plants, some taking after the one and some after the other parent.

[27] Mr. Scott has made some observations on the absolute sterility of a purple and white primrose (*Primula vulgaris*) when fertilised by pollen from the common primrose ('Journal of Proc. of Linn. Soc.,' vol. viii., 1864, p. 98); but these observations require confirmation. I raised a number of purple-flowered long-styled seedlings from seed kindly sent me by Mr. Scott, and, though they were all in some degree sterile, they were much more fertile with pollen taken from the common primrose than with their own pollen. Mr. Scott has likewise described a red equal-styled cowslip (*P. veris*, ibid. p. 106), which was found by him to be highly sterile when crossed with the common cowslip; but this was not the case with several equal-styled red seedlings raised by me from his plant. This variety of the cowslip presents the remarkable peculiarity of combining male organs in every respect like those of the short-styled form, with female organs resembling in function and partly in structure those of the long-styled form; so that we have the singular anomaly of the two forms combined in the same flower. Hence it is not surprising that these flowers should be spontaneously self-fertile in a high degree.

[28] 'Act. Acad. St. Petersburg,' 1780, part ii. pp. 84, 100.

[29] 'Annales des Sc. Nat.' tom. xxi. (1st series), p. 61.

[30] 'Bull. Bot. Soc. de France,' Dec. 27th, 1861, tom. viii. p. 612.

[31] Quoted by Isid. Geoffroy St. Hilaire 'Hist. Naturelle Générale,' tom. iii. p. 476. Since this MS. has been sent to press a full discussion on the present subject has appeared in Mr. Herbert Spencer's 'Principles of Biology,' vol. ii., 1867, p. 457 *et seq.*

[32] For cats and dogs, etc., *see* Bellingeri in 'Annal. des Sc. Nat.,' 2nd series, Zoolog. tom. xii. p. 155. For ferrets, Bechstein, 'Naturgeschichte Deutschlands,' b. i. 1801, s. 786, 795. For rabbits, ditto, s. 1123, 1131; and Bronn's 'Geschichte der Natur.,' b. ii. s. 99. For mountain sheep, ditto, s. 102. For the fertility of the wild sow, *see* Bechstein 'Naturgesch. Deutschlands,' b. i., 1801, s. 534; for the domestic pig, Sidney's edit. of Youatt on the Pig, 1860, p. 62. With respect to Lapland, *see* Acerbi's 'Travels to the North Cape,' Eng. translat., vol. ii. p. 222. About the Highland cows, *see* Hogg on Sheep, p. 263.

[33] For the eggs of *Gallus bankiva, see* Blyth, in 'Annals and Mag. of Nat. Hist.,' 2nd series, vol. i., 1848, p. 456. For wild and tame ducks, Macgillivray, 'British Birds,' vol. v. p. 37; and 'Die Enten,' s. 87. For wild geese, L. Lloyd, 'Scandinavian Adventures,' vol. ii. 1854, p. 413; and for tame geese, 'Ornamental Poultry,' by Rev. E. S. Dixon, p. 139. On the breeding of Pigeons, Pistor, 'Das Ganze der Taubenzucht,' 1831, s. 46; and Boitard and Corbié 'Les Pigeons,' p. 158. With respect to peacocks, according to Temminck ('Hist. Nat. Gén. des Pigeons,' etc., 1813, tom. ii. p. 41), the hen lays in India even as many as twenty eggs; but according to Jerdon and another writer (quoted in Tegetmeier's 'Poultry Book,' 1866, pp. 280, 282), she there lays only from four to nine or ten eggs: in England she

is said, in the 'Poultry Book,' to lay five or six, but another writer says from eight to twelve eggs.

CHAPTER XVII.
ON THE GOOD EFFECTS OF CROSSING, AND ON THE EVIL EFFECTS OF CLOSE INTERBREEDING.

DEFINITION OF CLOSE INTERBREEDING—AUGMENTATION OF MORBID TENDENCIES—GENERAL EVIDENCE OF THE GOOD EFFECTS DERIVED FROM CROSSING, AND ON THE EVIL EFFECTS FROM CLOSE INTERBREEDING—CATTLE, CLOSELY INTERBRED; HALF-WILD CATTLE LONG KEPT IN THE SAME PARKS—SHEEP—FALLOW-DEER—DOGS, RABBITS, PIGS—MAN, ORIGIN OF HIS ABHORRENCE OF INCESTUOUS MARRIAGES—FOWLS—PIGEONS—HIVE-BEES—PLANTS, GENERAL CONSIDERATIONS ON THE BENEFITS DERIVED FROM CROSSING—MELONS, FRUIT-TREES, PEAS, CABBAGES, WHEAT, AND FOREST-TREES—ON THE INCREASED SIZE OF HYBRID PLANTS, NOT EXCLUSIVELY DUE TO THEIR STERILITY—ON CERTAIN PLANTS WHICH EITHER NORMALLY OR ABNORMALLY ARE SELF-IMPOTENT, BUT ARE FERTILE, BOTH ON THE MALE AND FEMALE SIDE, WHEN CROSSED WITH DISTINCT INDIVIDUALS EITHER OF THE SAME OR ANOTHER SPECIES—CONCLUSION.

The gain in constitutional vigour, derived from an occasional cross between individuals of the same variety, but belonging to distinct families, or between distinct varieties, has not been so largely or so frequently discussed, as have the evil effects of too close interbreeding. But the former point is the more important of the two, inasmuch as the evidence is more decisive. The evil results from close interbreeding are difficult to detect, for they accumulate slowly, and differ much in degree with different species; whilst the good effects which almost invariably follow a cross are from the first manifest. It should, however, be clearly understood that the advantage of close interbreeding, as far as the retention of character is concerned, is indisputable, and often outweighs the evil of a slight loss of constitutional vigour. In relation to the subject of domestication, the whole question is of some importance, as too close interbreeding interferes with the improvement of old races. It is important as indirectly bearing on

Hybridism; and possibly on the extinction of species, when any form has become so rare that only a few individuals remain within a confined area. It bears in an important manner on the influence of free intercrossing, in obliterating individual differences, and thus giving uniformity of character to the individuals of the same race or species; for if additional vigour and fertility be thus gained, the crossed offspring will multiply and prevail, and the ultimate result will be far greater than otherwise would have occurred. Lastly, the question is of high interest, as bearing on mankind. I shall therefore discuss this subject at full length. As the facts which prove the evil effects of close interbreeding are more copious, though less decisive, than those on the good effects of crossing, I shall, under each group of beings, begin with the former.

There is no difficulty in defining what is meant by a cross; but this is by no means easy in regard to "breeding in and in" or "too close interbreeding," because, as we shall see, different species of animals are differently affected by the same degree of interbreeding. The pairing of a father and daughter, or mother and son, or brothers and sisters, if carried on during several generations, is the closest possible form of interbreeding. But some good judges, for instance Sir J. Sebright, believe that the pairing of a brother and sister is much closer than that of parents and children; for when the father is matched with his daughter he crosses, as is said, with only half his own blood. The consequences of close interbreeding carried on for too long a time, are, as is generally believed, loss of size, constitutional vigour, and fertility, sometimes accompanied by a tendency to malformation. Manifest evil does not usually follow from pairing the nearest relations for two, three, or even four generations; but several causes interfere with our detecting the evil—such as the deterioration being very gradual, and the difficulty of distinguishing between such direct evil and the inevitable augmentation of any morbid tendencies which may be latent or apparent in the related parents. On the other hand, the benefit from a cross, even when there has not been any very close interbreeding, is almost invariably at once conspicuous. There is good reason to believe, and this was the opinion of that most experienced observer Sir J. Sebright,[1] that the evil effects of close interbreeding may be checked or quite prevented by the related individuals being separated for a few generations and exposed to different conditions of life. This conclusion is now held by many breeders; for instance Mr. Carr[2] remarks, it is a well-known "fact that a change of soil and climate effects perhaps almost as great a change in the constitution as would result from an infusion of fresh blood." I hope to show in a future work that consanguinity by itself counts for nothing, but acts solely from related organisms generally having a similar constitution, and having been exposed in most cases to similar conditions.

That any evil directly follows from the closest interbreeding has been denied by many persons; but rarely by any practical breeder; and never, as far as I know, by one who has largely bred animals which propagate their kind quickly. Many physiologists attribute the evil exclusively to the combination and consequent increase of morbid tendencies common to both parents; and that this is an active source of mischief there can be no doubt. It is unfortunately too notorious that men and various domestic animals endowed with a wretched constitution, and with a strong hereditary disposition to disease, if not actually ill, are fully capable of procreating their kind. Close interbreeding, on the other hand, often induces sterility; and this indicates something quite distinct from the augmentation of morbid tendencies common to both parents. The evidence immediately to be given convinces me that it is a great law of nature, that all organic beings profit from an occasional cross with individuals not closely related to them in blood; and that, on the other hand, long-continued close interbreeding is injurious.

Various general considerations have had much influence in leading me to this conclusion; but the reader will probably rely more on special facts and opinions. The authority of experienced observers, even when they do not advance the grounds of their belief, is of some little value. Now almost all men who have bred many kinds of animals and have written on the subject, such as Sir J. Sebright, Andrew Knight, etc.,[3] have expressed the strongest conviction on the impossibility of long-continued close interbreeding. Those who have compiled works on agriculture, and have associated much with breeders, such as the sagacious Youatt, Low, etc., have strongly declared their opinion to the same effect. Prosper Lucas, trusting largely to French authorities, has come to a similar conclusion. The distinguished German agriculturist Hermann von Nathusius, who has written the most able treatise on this subject which I have met with, concurs; and as I shall have to quote from this treatise, I may state that Nathusius is not only intimately acquainted with works on agriculture in all languages, and knows the pedigrees of our British breeds better than most Englishmen, but has imported many of our improved animals, and is himself an experienced breeder.

Evidence of the evil effects of close interbreeding can most readily be acquired in the case of animals, such as fowls, pigeons, etc., which propagate quickly, and, from being kept in the same place, are exposed to the same conditions. Now I have inquired of very many breeders of these birds, and I have hitherto not met with a single man who was not thoroughly convinced that an occasional cross with another strain of the same sub-variety was absolutely necessary. Most breeders of highly improved or fancy birds value their own strain, and are most unwilling, at the risk, in their opinion, of deterioration, to make a cross. The purchase of a first-rate bird of another strain is expensive, and exchanges are troublesome; yet all breeders, as far as I can hear, excepting those who keep large stocks at different places for the sake of crossing, are driven after a time to take this step.

Another general consideration which has had great influence on my mind is, that with all hermaphrodite animals and plants, which it might have been thought would have perpetually fertilised themselves and been thus subjected for long ages to the closest interbreeding, there is not a single species, as far as I can discover, in which the structure ensures self-fertilisation. On the contrary, there are in a multitude of cases, as briefly stated in the fifteenth chapter, manifest adaptations which favour or inevitably lead to an occasional cross between one hermaphrodite and another of the same species; and these adaptive structures are utterly purposeless, as far as we can see, for any other end.

With *Cattle* there can be no doubt that extremely close interbreeding may be long carried on advantageously with respect to external characters, and with no manifest evil as far as constitution is concerned. The case of Bakewell's Longhorns, which were closely interbred for a long period, has often been quoted; yet Youatt says[4] the breed "had acquired a delicacy of constitution inconsistent with common management," and "the propagation of the species was not always certain." But the Shorthorns offer the most striking case of close interbreeding; for instance, the famous bull Favourite (who was himself the offspring of a half-brother and sister from Foljambe) was matched with his own daughter, granddaughter, and great-granddaughter; so that the produce of this last union, or the great-great-granddaughter, had 15-16ths, or 93·75 per cent of the blood of Favourite in her veins. This cow was matched with the bull Wellington, having 62·5 per cent of Favourite blood in his veins, and produced Clarissa; Clarissa was matched with the bull Lancaster, having 68·75 of the same blood, and she yielded valuable offspring.[5] Nevertheless Collings, who reared these animals, and was a strong advocate for close breeding, once crossed his stock with a Galloway, and the cows from this cross realised the highest prices. Bates's herd was esteemed the most celebrated in the world. For thirteen years he bred most closely in and in; but during the next seventeen years, though he had the most exalted notion of the value of his own stock, he thrice infused fresh blood into his herd: it is said that he did this, not to improve the form of his animals, but on account of their lessened fertility. Mr. Bates's own view, as given by a celebrated breeder,[6] was, that "to breed in-and-in from a bad stock was ruin and devastation; yet that the practice may be safely followed within certain limits when the parents so related are descended from first-rate animals." We thus see that there has been much close interbreeding with Shorthorns; but Nathusius, after the most careful study of their pedigrees, says that he can find no instance of a breeder who has strictly followed this practice during his whole life. From this study and his own experience, he concludes that close interbreeding is necessary to ennoble the stock; but that in effecting this the greatest care is necessary, on account of the tendency to infertility and weakness. It may be added, that another high authority[7] asserts that many more calves are born cripples from Shorthorns than from other and less closely interbred races of cattle.

Although by carefully selecting the best animals (as Nature effectually does by the law of battle) close interbreeding may be long carried on with cattle, yet the good effects of a cross between almost any two breeds is at once shown by the greater size and vigour of the offspring; as Mr. Spooner writes to me, "crossing distinct breeds certainly improves cattle for the butcher." Such crossed animals are of course of no value to the breeder; but they have been raised during many years in several parts of England to be slaughtered;[8] and their merit is now so fully recognised, that at fat-cattle shows a separate class has been formed for their reception. The best fat ox at the great show at Islington in 1862 was a crossed animal.

The half-wild cattle, which have been kept in British parks probably for 400 or 500 years, or even for a longer period, have been advanced by Culley and others as a case of long-continued interbreeding within the limits of the same herd without any consequent injury. With respect to the cattle at Chillingham, the late Lord Tankerville owned that they were bad breeders.[9] The agent, Mr. Hardy, estimates (in a letter to me, dated May, 1861) that in the herd of about fifty the average number annually slaughtered, killed by fighting, and dying, is about ten, or one in five. As the herd is kept up to nearly the same average number, the annual rate of increase must be likewise about one in five. The bulls, I may add, engage in furious battles, of which battles the present Lord Tankerville has given me a graphic description, so that there will always be rigorous selection of the most vigorous males. I procured in 1855 from Mr. D. Gardner, agent to the Duke of Hamilton, the following account of the wild cattle kept in the Duke's park in Lanarkshire, which is about 200 acres in extent. The number of cattle varies from sixty-five to eighty; and the number annually killed (I presume by all causes) is from eight to ten; so that the annual rate of increase can hardly be more than one in six. Now in South America, where the herds are half-wild, and therefore offer a nearly fair standard of comparison, according to Azara the natural increase of the cattle on an estancia is from one-third to one-fourth of the total number, or one in between three and four and this, no doubt, applies exclusively to adult animals fit for consumption. Hence the half-wild British cattle which have long interbred within the limits of the same herd are relatively far less fertile. Although in an unenclosed country like Paraguay there must be some crossing between the different herds, yet even there the inhabitants believe that the occasional introduction of animals from distant localities is necessary to prevent "degeneration in size and diminution of fertility."[10] The decrease in size from ancient times in the Chillingham and Hamilton cattle must have been prodigious, for Professor Rütimeyer has shown that they are almost certainly the descendants of the gigantic *Bos primigenius.* No doubt this decrease in size may be largely attributed to less favourable conditions of life; yet animals roaming over large parks, and fed during severe winters, can hardly be considered as placed under very unfavourable conditions.

With *Sheep* there has often been long-continued interbreeding within the limits of the same flock; but whether the nearest relations have been matched so frequently as in the case of Shorthorn cattle, I do not know. The Messrs. Brown during fifty years have never infused fresh blood into their excellent flock of Leicesters. Since 1810 Mr. Barford has acted on the same principle with the Foscote flock. He asserts that half a century of experience has convinced him that when two nearly related animals are quite sound in constitution, in-and-in breeding does not induce degeneracy; but he adds that he "does not pride himself on breeding from the nearest affinities." In France the Naz flock has been bred for sixty years without the introduction of a single strange ram.[11] Nevertheless, most great breeders of sheep have protested against close interbreeding prolonged for too great a length of time.[12] The most celebrated of recent breeders, Jonas Webb, kept five separate families to work on, thus "retaining the requisite distance of relationship between the sexes";[13] and what is probably of greater importance, the separate flocks will have been exposed to somewhat different conditions.

Although by the aid of careful selection the near interbreeding of sheep may be long continued without any manifest evil, yet it has often been the practice with farmers to cross distinct breeds to obtain animals for the butcher, which plainly shows that good of some kind is derived from this practice. We have excellent evidence on this head from Mr. S. Druce,[14] who gives in detail the comparative numbers of four pure breeds and of a cross-breed which can be supported on the same ground, and he gives their produce in fleece and carcase. A high authority, Mr. Pusey, sums up the result in money value during an equal length of time, namely (neglecting shillings), for Cotswolds 248*l.*, for Leicesters 223*l.*, for Southdowns 204*l.*, for Hampshire Downs 264*l.*, and for the crossbred 293*l.* A former celebrated breeder, Lord Somerville, states that his half-breeds from Ryelands and Spanish sheep were larger animals than either the pure Ryelands or pure Spanish sheep. Mr. Spooner concludes his excellent Essay on Crossing by asserting that there is a pecuniary advantage in judicious cross-breeding, especially when the male is larger than the female.[15]

As some of our British parks are ancient, it occurred to me that there must have been long-continued close interbreeding with the fallow-deer (*Cervus dama*) kept in them; but on inquiry I find that it is a common practice to infuse new blood by procuring bucks from other parks. Mr. Shirley,[16] who has carefully studied the management of deer, admits that in some parks there has been no admixture of foreign blood from a time beyond the memory of man. But he concludes "that in the end the constant breeding in-and-in is sure to tell to the disadvantage of the whole herd, though it may take a very long time to prove it; moreover, when we find, as is very constantly the case, that the introduction of fresh blood has been of the very greatest use to deer, both by improving their size and appearance, and particularly by being of service in removing the taint of 'rickback,' if not of other diseases, to which deer are sometimes subject when the blood has not been changed, there can, I think, be no doubt but that a judicious cross with a good stock is of the greatest consequence, and is indeed essential, sooner or later, to the prosperity of every well-ordered park."

Mr. Meynell's famous foxhounds have been adduced, as showing that no ill effects follow from close interbreeding; and Sir J. Sebright ascertained from him that he frequently bred from father and daughter, mother and son, and sometimes even from brothers and sisters. With greyhounds also there has been much close interbreeding, but the best breeders agree that it may be carried too far.[17] But Sir J. Sebright declares,[18] that by breeding in-and-in, by which he means matching brothers and sisters, he has actually seen the offspring of strong spaniels degenerate into weak and diminutive lapdogs. The

Rev. W. D. Fox has communicated to me the case of a small lot of bloodhounds, long kept in the same family, which had become very bad breeders, and nearly all had a bony enlargement in the tail. A single cross with a distinct strain of bloodhounds restored their fertility, and drove away the tendency to malformation in the tail. I have heard the particulars of another case with bloodhounds, in which the female had to be held to the male. Considering how rapid is the natural increase of the dog, it is difficult to understand the large price of all highly improved breeds, which almost implies long-continued close interbreeding, except on the belief that this process lessens fertility and increases liability to distemper and other diseases. A high authority, Mr. Scrope, attributes the rarity and deterioration in size of the Scotch deerhound (the few individuals formerly existing throughout the country being all related) in large part to close interbreeding.

With all highly-bred animals there is more or less difficulty in getting them to procreate quickly, and all suffer much from delicacy of constitution. A great judge of rabbits[19] says, "the long-eared does are often too highly bred or forced in their youth to be of much value as breeders, often turning out barren or bad mothers." They often desert their young, so that it is necessary to have nurse-rabbits, but I do not pretend to attribute all these evil results to close interbreeding.[20]

With respect to *Pigs* there is more unanimity amongst breeders on the evil effects of close interbreeding than, perhaps, with any other large animal. Mr. Druce, a great and successful breeder of the Improved Oxfordshires (a crossed race), writes, "without a change of boars of a different tribe, but of the same breed, constitution cannot be preserved." Mr. Fisher Hobbs, the raiser of the celebrated Improved Essex breed, divided his stock into three separate families, by which means he maintained the breed for more than twenty years, "by judicious selection from the *three distinct families*."[21] Lord Western was the first importer of a Neapolitan boar and sow. "From this pair he bred in-and-in, until the breed was in danger of becoming extinct, a sure result (as Mr. Sidney remarks) of in-and-in breeding." Lord Western then crossed his Neapolitan pigs with the old Essex, and made the first great step towards the Improved Essex breed. Here is a more interesting case. Mr. J. Wright, well known as a breeder, crossed[22] the same boar with the daughter, granddaughter, and great-granddaughter, and so on for seven generations. The result was, that in many instances the offspring failed to breed; in others they produced few that lived; and of the latter many were idiotic, without sense, even to suck, and when attempting to move could not walk straight. Now it deserves especial notice, that the two last sows produced by this long course of interbreeding were sent to other boars, and they bore several litters of healthy pigs. The best sow in external appearance produced during the whole seven generations was one in the last stage of descent; but the litter consisted of this one sow. She would not breed to her sire, yet bred at the first trial to a stranger in blood. So that, in Mr. Wright's case, long-continued and extremely close interbreeding did not affect the external form or merit of the young; but with many of them the general constitution and mental powers, and especially the reproductive functions, were seriously affected.

Nathusius gives[23] an analogous and even more striking case: he imported from England a pregnant sow of the large Yorkshire breed, and bred the product closely in-and-in for three generations: the result was unfavourable, as the young were weak in constitution, with impaired fertility. One of the latest sows, which he esteemed a good animal, produced, when paired with her own uncle (who was known to be productive with sows of other breeds), a litter of six, and a second time a litter of only five weak young pigs. He then paired this sow with a boar of a small black breed, which he had likewise imported from England; this boar, when matched with sows of his own breed, produced from seven to nine young. Now, the sow of the large breed, which was so unproductive when paired with her own uncle, yielded to the small black boar, in the first litter twenty-one, and in the second litter eighteen young pigs; so that in one year she produced thirty-nine fine young animals!

As in the case of several other animals already mentioned, even when no injury is perceptible from moderately close interbreeding, yet, to quote the words of Mr. Coate (who five times won the annual gold medal of the Smithfield Club Show for the best pen of pigs), "Crosses answer well for profit to the farmer, as you get more constitution and quicker growth; but for me, who sell a great number of pigs for breeding purposes, I find it will not do, as it requires many years to get anything like purity of blood again."[24]

Almost all the animals as yet mentioned are gregarious, and the males must frequently pair with their own daughters, for they expel the young males as well as all intruders, until forced by old age and loss of strength to yield to some stronger male. It is therefore not improbable that gregarious animals may have been rendered less susceptible than non-social species to the evil consequences of close interbreeding, so that they may be enabled to live in herds without injury to their offspring. Unfortunately we do not know whether an animal like the cat, which is not gregarious, would suffer from close interbreeding in a greater degree than our other domesticated animals. But the pig is not, as far as I can discover, strictly gregarious, and we have seen that it appears eminently liable to the evil effects of close interbreeding. Mr. Huth, in the case of the pig, attributes (Chapter XXIV) these effects to their having been "cultivated most for their fat," or to the selected individuals having had a weak constitution; but we must remember that it is great breeders who have brought forward the above cases, and who are far more familiar than ordinary men can be, with the causes which are likely to interfere with the fertility of their animals.

The effects of close interbreeding in the case of man is a difficult subject, on which I will say but little. It has been discussed by various authors under many points of view.[25] Mr. Tylor[26] has shown that with widely different races in the most distant quarters of the world, marriages between relations—even between distant relations—

have been strictly prohibited. There are, however, many exceptions to the rule, which are fully given by Mr. Huth.[27] It is a curious problem how these prohibitions arose during early and barbarous times. Mr. Tylor is inclined to attribute them to the evil effects of consanguineous marriages having been observed; and he ingeniously attempts to explain some apparent anomalies in the prohibition not extending equally to the relations on the male and female side. He admits, however, that other causes, such as the extension of friendly alliances, may have come into play. Mr. W. Adam, on the other hand, concludes that related marriages are prohibited and viewed with repugnance, from the confusion which would thus arise in the descent of property, and from other still more recondite reasons. But I cannot accept these views, seeing that incest is held in abhorrence by savages such as those of Australia and South America,[28] who have no property to bequeath, or fine moral feelings to confuse, and who are not likely to reflect on distant evils to their progeny. According to Mr. Huth the feeling is the indirect result of exogamy, inasmuch as when this practice ceased in any tribe and it became endogamous, so that marriages were strictly confined to the same tribe, it is not unlikely that a vestige of the former practice would still be retained, so that closely-related marriages would be prohibited. With respect to exogamy itself Mr. MacLennan believes that it arose from a scarcity of women, owing to female infanticide, aided perhaps by other causes.

It has been clearly shown by Mr. Huth that there is no instinctive feeling in man against incest any more than in gregarious animals. We know also how readily any prejudice or feeling may rise to abhorrence, as shown by Hindus in regard to objects causing defilement. Although there seems to be no strong inherited feeling in mankind against incest, it seems possible that men during primeval times may have been more excited by strange females than by those with whom they habitually lived; in the same manner as according to Mr. Cupples,[29] male deerhounds are inclined towards strange females, while the females prefer dogs with whom they have associated. If any such feeling formerly existed in man, this would have led to a preference for marriages beyond the nearest kin, and might have been strengthened by the offspring of such marriages surviving in greater numbers, as analogy would lead us to believe would have occurred.

Whether consanguineous marriages, such as are permitted in civilised nations, and which would not be considered as close interbreeding in the case of our domesticated animals, cause any injury will never be known with certainty until a census is taken with this object in view. My son, George Darwin, has done what is possible at present by a statistical investigation,[30] and he has come to the conclusion, from his own researches and those of Dr. Mitchell, that the evidence as to any evil thus caused is conflicting, but on the whole points to the evil being very small.

Birds.—In the case of the *Fowl* a whole array of authorities could be given against too close interbreeding. Sir J. Sebright positively asserts that he made many trials, and that his fowls, when thus treated, became long in the legs, small in the body, and bad breeders.[31] He produced the famous Sebright Bantams by complicated crosses, and by breeding in-and-in; and since his time there has been much close interbreeding with these animals; and they are now notoriously bad breeders. I have seen Silver Bantams, directly descended from his stock, which had become almost as barren as hybrids; for not a single chicken had been that year hatched from two full nests of eggs. Mr. Hewitt says that with these Bantams the sterility of the male stands, with rare exceptions, in the closest relation with their loss of certain secondary male characters: he adds, "I have noticed, as a general rule, that even the slightest deviation from feminine character in the tail of the male Sebright—say the elongation by only half an inch of the two principal tail feathers—brings with it improved probability of increased fertility."[32]

Mr. Wright states[33] that Mr. Clark, "whose fighting-cocks were so notorious, continued to breed from his own kind till they lost their disposition to fight, but stood to be cut up without making any resistance, and were so reduced in size as to be under those weights required for the best prizes; but on obtaining a cross from Mr. Leighton, they again resumed their former courage and weight." It should be borne in mind that game-cocks before they fought were always weighed, so that nothing was left to the imagination about any reduction or increase of weight. Mr. Clark does not seem to have bred from brothers and sisters, which is the most injurious kind of union; and he found, after repeated trials, that there was a greater reduction in weight in the young from a father paired with his daughter, than from a mother with her son. I may add that Mr. Eyton of Eyton, the well-known ornithologist, who is a large breeder of Grey Dorkings, informs me that they certainly diminish in size, and become less prolific, unless a cross with another strain is occasionally obtained. So it is with Malays, according to Mr. Hewitt, as far as size is concerned.[34]

An experienced writer[35] remarks that the same amateur, as is well known, seldom long maintains the superiority of his birds; and this, he adds, undoubtedly is due to all his stock "being of the same blood;" hence it is indispensable that he should occasionally procure a bird of another strain. But this is not necessary with those who keep a stock of fowls at different stations. Thus, Mr. Ballance, who has bred Malays for thirty years, and has won more prizes with these birds than any other fancier in England, says that breeding in-and-in does not necessarily cause deterioration; "but all depends upon how this is managed. My plan has been to keep about five or six distinct runs, and to rear about two hundred or three hundred chickens each year, and select the best birds from each run for crossing. I thus secure sufficient crossing to prevent deterioration."[36]

We thus see that there is almost complete unanimity with poultry-breeders that, when fowls are kept at the same place, evil quickly follows from interbreeding carried on to an extent which would be disregarded in the case of most quadrupeds. Moreover, it is a generally received opinion that cross-bred chickens are the hardiest and most easily reared.[37] Mr. Tegetmeier, who has carefully attended to poultry of all breeds, says[38] that Dorking hens, allowed to run with Houdan or Crevecœur cocks, "produce in the early spring chickens that for size, hardihood, early maturity, and fitness for the market, surpass those of any pure breed that we have ever raised." Mr. Hewitt gives it as a general rule with fowls, that crossing the breed increases their size. He makes this remark after stating that hybrids from the pheasant and fowl are considerably larger than either progenitor: so again, hybrids from the male golden pheasant and female common pheasant "are of far larger size than either parent-bird."[39] To this subject of the increased size of hybrids I shall presently return.

With *Pigeons*, breeders are unanimous, as previously stated, that it is absolutely indispensable, notwithstanding the trouble and expense thus caused, occasionally to cross their much-prized birds with individuals of another strain, but belonging, of course, to the same variety. It deserves notice that, when size is one of the desired characters, as with pouters[40] the evil effects of close interbreeding are much sooner perceived than when small birds, such as short-faced tumblers, are valued. The extreme delicacy of the high fancy breeds, such as these tumblers and improved English carriers, is remarkable; they are liable to many diseases, and often die in the egg or during the first moult; and their eggs have generally to be hatched under foster-mothers. Although these highly-prized birds have invariably been subjected to much close interbreeding, yet their extreme delicacy of constitution cannot perhaps be thus fully explained. Mr. Yarrell informed me that Sir J. Sebright continued closely interbreeding some owl-pigeons, until from their extreme sterility he as nearly as possible lost the whole family. Mr. Brent[41] tried to raise a breed of trumpeters, by crossing a common pigeon, and recrossing the daughter, granddaughter, great-granddaughter, and great-great-granddaughter, with the same male trumpeter, until he obtained a bird with 15/16 of trumpeter's blood; but then the experiment failed, for "breeding so close stopped reproduction." The experienced Neumeister[42] also asserts that the offspring from dovecotes and various other breeds are "generally very fertile and hardy birds:" so again MM. Boitard and Corbié,[43] after forty-five years' experience, recommend persons to cross their breeds for amusement; for, if they fail to make interesting birds, they will succeed under an economical point of view, "as it is found that mongrels are more fertile than pigeons of pure race."

I will refer only to one other animal, namely, the Hive-bee, because a distinguished entomologist has advanced this as a case of inevitable close interbreeding. As the hive is tenanted by a single female, it might have been thought that her male and female offspring would always have bred together, more especially as bees of different hives are hostile to each other; a strange worker being almost always attacked when trying to enter another hive. But Mr. Tegetmeier has shown[44] that this instinct does not apply to drones, which are permitted to enter any hive; so that there is no *à priori* improbability of a queen receiving a foreign drone. The fact of the union invariably and necessarily taking place on the wing, during the queen's nuptial flight, seems to be a special provision against continued interbreeding. However this may be, experience has shown, since the introduction of the yellow-banded Ligurian race into Germany and England, that bees freely cross: Mr. Woodbury, who introduced Ligurian bees into Devonshire, found during a single season that three stocks, at distances of from one to two miles from his hives, were crossed by his drones. In one case the Ligurian drones must have flown over the city of Exeter, and over several intermediate hives. On another occasion several common black queens were crossed by Ligurian drones at a distance of from one to three and a half miles.[45]

Plants.

When a single plant of a new species is introduced into any country, if propagated by seed, many individuals will soon be raised, so that if the proper insects be present there will be crossing. With newly-introduced trees or other plants not propagated by seed we are not here concerned. With old-established plants it is an almost universal practice occasionally to make exchanges of seed, by which means individuals which have been exposed to different conditions of life,—and this, as we have seen with animals, diminishes the evil from close interbreeding,—will occasionally be introduced into each district.

With respect to individuals belonging to the same sub-variety, Gärtner, whose accuracy and experience exceeded that of all other observers, states[46] that he has many times observed good effects from this step, especially with exotic genera, of which the fertility is somewhat impaired, such as Passiflora, Lobelia, Fuchsia. Herbert also says,[47] "I am inclined to think that I have derived advantage from impregnating the flower from which I wished to obtain seed with pollen from another individual of the same variety, or at least from another flower, rather than with its own." Again, Professor Lecoq ascertained that crossed offspring are more vigorous and robust than their parents.[48]

General statements of this kind, however, can seldom be fully trusted: I therefore began a long series of experiments, continued for about ten years, which will I think conclusively show the good effects of crossing two distinct plants of the same variety, and the evil effects of long-continued self-fertilisation. A clear light will thus be thrown on such questions, as why flowers are almost invariably constructed so as to permit, or favour, or necessitate the union of two individuals. We shall clearly understand why monœcious and dioecious,—why dichogamous, dimorphic and trimorphic plants exist, and many other such cases. I intend soon to publish an account of these experiments, and I can here give only a few cases in illustration. The plan which I followed was to grow plants in the same pot, or in pots of the same size, or close together in the open ground; carefully to exclude insects; and then to fertilise some of the flowers with pollen from the same flower, and others on the same plant with pollen from a distinct but adjoining plant. In many of these experiments, the crossed plants yielded much more seed than the self-fertilised plants; and I have never seen the reversed case. The self-fertilised and crossed seeds thus obtained were allowed to germinate in the same glass vessel on damp sand; and as the seeds germinated, they were planted in pairs on opposite sides of the same pot, with a superficial partition between them, and were placed so as to be equally exposed to the light. In other cases the self-fertilised and crossed seeds were simply sown on opposite sides of the same small pot. I have, in short, followed different plans, but in every case have taken all the precautions which I could think of, so that the two lots should be equally favoured. The growth of the plants raised from the crossed and self-fertilised seed, were carefully observed from their germination to maturity, in species belonging to fifty-two genera; and the difference in their growth, and in withstanding unfavourable conditions, was in most cases manifest and strongly marked. It is of importance that the two lots of seed should be sown or planted on opposite sides of the same pot, so that the seedlings may struggle against each other; for if sown separately in ample and good soil, there is often but little difference in their growth.

I will briefly describe two of the first cases observed by me. Six crossed and six self-fertilised seeds of *Ipomoea purpurea,* from plants treated in the manner above described, were planted as soon as they had germinated, in pairs on opposite sides of two pots, and rods of equal thickness were given them to twine up. Five of the crossed plants grew from the first more quickly than the opposed self-fertilised plants; the sixth, however, was weakly and was for a time beaten, but at last its sounder constitution prevailed and it shot ahead of its antagonist. As soon as each crossed plant reached the top of its seven-foot rod its fellow was measured, and the result was that, when the crossed plants were seven feet high the self-fertilised had attained the average height of only five feet four and a half inches. The crossed plants flowered a little before, and more profusely than the self-fertilised plants. On opposite sides of another *small* pot a large number of crossed and self-fertilised seeds were sown, so that they had to struggle for bare existence; a single rod was given to each lot: here again the crossed plants showed from the first their advantage; they never quite reached the summit of the seven-foot rod, but relatively to the self-fertilised plants their average height was as seven feet to five feet two inches. The experiment was repeated during several succeeding generations, treated in exactly the same manner, and with nearly the same result. In the second generation, the crossed plants, which were again crossed, produced 121 seed-capsules, whilst the self-fertilised, again self-fertilised, produced only 84 capsules.

Some flowers of the *Mimulus luteus* were fertilised with their own pollen, and others were crossed with pollen from distinct plants growing in the same pot. The seeds were thickly sown on opposite sides of a pot. The seedlings were at first equal in height; but when the young crossed plants were half an inch, the self-fertilised plants were only a quarter of an inch high. But this degree of inequality did not last, for, when the crossed plants were four and a half inches high, the self-fertilised were three inches, and they retained the same relative difference till their growth was complete. The crossed plants looked far more vigorous than the uncrossed, and flowered before them; they produced also a far greater number of capsules. As in the former case, the experiment was repeated during several succeeding generations. Had I not watched these plants of

Mimulus and Ipomoea during their whole growth, I could not have believed it possible, that a difference apparently so slight as that of the pollen being taken from the same flower, or from a distinct plant growing in the same pot, could have made so wonderful a difference in the growth and vigour of the plants thus produced. This, under a physiological point of view, is a most remarkable phenomenon.

With respect to the benefit derived from crossing distinct varieties, plenty of evidence has been published. Sageret[49] repeatedly speaks in strong terms of the vigour of melons raised by crossing different varieties, and adds that they are more easily fertilised than common melons, and produce numerous good seed. Here follows the evidence of an English gardener:[50] "I have this summer met with better success in my cultivation of melons, in an unprotected state, from the seeds of hybrids (*i.e.* mongrels) obtained by cross impregnation, than with old varieties. The offspring of three different hybridisations (one more especially, of which the parents were the two most dissimilar varieties I could select) each yielded more ample and finer produce than any one of between twenty and thirty established varieties."

Andrew Knight[51] believed that his seedlings from crossed varieties of the apple exhibited increased vigour and luxuriance; and M. Chevreul[52] alludes to the extreme vigour of some of the crossed fruit-trees raised by Sageret.

By crossing reciprocally the tallest and shortest peas, Knight[53] says: "I had in this experiment a striking instance of the stimulative effects of crossing the breeds; for the smallest variety, whose height rarely exceeded two feet, was increased to six feet: whilst the height of the large and luxuriant kind was very little diminished." Mr. Laxton gave me seed-peas produced from crosses between four distinct kinds; and the plants thus raised were extraordinarily vigorous, being in each case from one to two or three feet taller than the parent-forms growing close alongside them.

Wiegmann[54] made many crosses between several varieties of cabbage; and he speaks with astonishment of the vigour and height of the mongrels, which excited the amazement of all the gardeners who beheld them. Mr. Chaundy raised a great number of mongrels by planting together six distinct varieties of cabbage. These mongrels displayed an infinite diversity of character; "But the most remarkable circumstance was, that, while all the other cabbages and borecoles in the nursery were destroyed by a severe winter, these hybrids were little injured, and supplied the kitchen when there was no other cabbage to be had."

Mr. Maund exhibited before the Royal Agricultural Society[55] specimens of crossed wheat, together with their parent varieties; and the editor states that they were intermediate in character, "united with that greater vigour of growth, which it appears, in the vegetable as in the animal world, is the result of a first cross." Knight also crossed several varieties of wheat,[56] and he says "that in the years 1795 and 1796, when almost the whole crop of corn in the island was blighted, the varieties thus obtained, and these only, escaped in this neighbourhood, though sown in several different soils and situations."

Here is a remarkable case: M. Clotzsch[57] crossed *Pinus sylvestris* and *nigricans, Quercus robur* and *pedunculata, Alnus glutinosa* and *incana, Ulmus campestris* and *effusa*; and the cross-fertilised seeds, as well as seeds of the pure parent-trees, were all sown at the same time and in the same place. The result was, that after an interval of eight years, the hybrids were one-third taller than the pure trees!

The facts above given refer to undoubted varieties, excepting the trees crossed by Clotzsch, which are ranked by various botanists as strongly-marked races, sub-species, or species. That true hybrids raised from entirely distinct species, though they lose in fertility, often gain in size and constitutional vigour, is certain. It would be superfluous to quote any facts; for all experimenters, Kolreuter, Gärtner, Herbert, Sageret, Lecoq, and Naudin, have been struck with the wonderful vigour, height, size, tenacity of life, precocity, and hardiness of their hybrid productions. Gärtner[58] sums up his conviction on this head in the strongest terms. Kölreuter[59] gives numerous precise measurements of the weight and height of his hybrids in his comparison with measurements of both parent-forms; and speaks with astonishment of their "*statura portentosa,*" their "*ambitus vastissimus ac altitudo valde conspicua.*" Some exceptions to the rule in the case of very sterile hybrids have, however, been noticed by Gärtner and Herbert; but the most striking exceptions are given by Max Wichura[60] who found that hybrid willows were generally tender in constitution, dwarf, and short-lived.

Kolreuter explains the vast increase in the size of the roots, stems, etc., of his hybrids, as the result of a sort of compensation due to their sterility, in the same way as many emasculated animals are larger than the perfect males. This view seems at first sight extremely probable, and has been accepted by various authors;[61] but Gärtner[62] has well remarked that there is much difficulty in fully admitting it; for with many hybrids there is no parallelism between the degree of their sterility and their increased size and vigour. The most striking instances of luxuriant growth have been observed with hybrids which were not sterile in any extreme degree. In the genus Mirabilis, certain hybrids are unusually fertile, and their extraordinary luxuriance of growth, together with their enormous roots[63] have been transmitted to their progeny. The result in all cases is probably in part due to the saving of nutriment and vital force through the sexual organs acting imperfectly or not at all, but more especially to the general law of good being derived from a cross. For it deserves especial attention that mongrel animals and plants, which are so far from being sterile that their fertility is often actually augmented, have, as previously shown, their size, hardiness, and constitutional vigour generally increased. It is not a little remarkable that an accession of vigour and size should thus arise under the opposite contingencies of increased and diminished fertility.

It is a perfectly well ascertained fact[64] that hybrids invariably breed with either pure parent, and not rarely with a distinct species, more readily than with one another.

Herbert is inclined to explain even this fact by the advantage derived from a cross; but Gärtner more justly accounts for it by the pollen of the hybrid, and probably its ovules, being in some degree vitiated, whereas the pollen and ovules of both pure parents and of any third species are sound. Nevertheless, there are some well-ascertained and remarkable facts, which, as we shall presently see, show that a cross by itself undoubtedly tends to increase or re-establish the fertility of hybrids.

The same law, namely, that the crossed offspring both of varieties and species are larger than the parent-forms, holds good in the most striking manner with hybrid animals as well as with mongrels. Mr. Bartlett, who has had such large experience says, “Among all hybrids of vertebrated animals there is a marked increase of size.” He then enumerates many cases with mammals, including monkeys, and with various families of birds.[65]

On certain Hermaphrodite Plants which, either normally or abnormally, require to be fertilised by pollen from a distinct individual or species.

The facts now to be given differ from the foregoing, as self-sterility is not here the result of long-continued close interbreeding. These facts are, however, connected with our present subject, because a cross with a distinct individual is shown to be either necessary or advantageous. Dimorphic and trimorphic plants, though they are hermaphrodites, must be reciprocally crossed, one set of forms by the other, in order to be fully fertile, and in some cases to be fertile in any degree. But I should not have noticed these plants, had it not been for the following cases given by Dr. Hildebrand:—[66]

Primula sinensis is a reciprocally dimorphic species: Dr. Hildebrand fertilised twenty-eight flowers of both forms, each by pollen of the other form, and obtained the full number of capsules containing on an average 42·7 seed per capsule; here we have complete and normal fertility. He then fertilised forty-two flowers of both forms with pollen of the same form, but taken from a distinct plant, and all produced capsules containing on an average only 19·6 seed. Lastly, and here we come to our more immediate point, he fertilised forty-eight flowers of both forms with pollen of the same form and taken from the same flower, and now he obtained only thirty-two capsules, and these contained on an average 18·6 seed, or one less per capsule than in the former case. So that, with these illegitimate unions, the act of impregnation is less assured, and the fertility slightly less, when the pollen and ovules belong to the same flower, than when belonging to two distinct individuals of the same form. Dr. Hildebrand has recently made analogous experiments on the long-styled form of *Oxalis rosea*, with the same result.[67]

It has recently been discovered that certain plants, whilst growing in their native country under natural conditions, cannot be fertilised with pollen from the same plant. They are sometimes so utterly self-impotent, that, though they can readily be fertilised by the pollen of a distinct species or even distinct genus, yet, wonderful as is the fact, they never produce a single seed by their own pollen. In some cases, moreover, the plant's own pollen and stigma mutually act on each other in a deleterious manner. Most of the facts to be given relate to orchids, but I will commence with a plant belonging to a widely different family.

Sixty-three flowers of *Corydalis cava*, borne on distinct plants, were fertilised by Dr. Hildebrand[68] with pollen from other plants of the same species; and fifty-eight capsules were obtained, including on an average 4.5 seed in each. He then fertilised sixteen flowers produced by the same raceme, one with another, but obtained only three capsules, one of which alone contained any good seeds, namely, two in number. Lastly, he fertilised twenty-seven flowers, each with its own pollen; he left also fifty-seven flowers to be spontaneously fertilised, and this would certainly have ensued if it had been possible, for the anthers not only touch the stigma, but the pollen-tubes were seen by Dr. Hildebrand to penetrate it; nevertheless these eighty-four flowers did not produce a single seed-capsule! This whole case is highly instructive, as it shows how widely different the action of the same pollen is, according as it is placed on the stigma of the same flower, or on that of another flower on the same raceme, or on that of a distinct plant.

With exotic Orchids several analogous cases have been observed, chiefly by Mr. John Scott.[69] *Oncidium sphacelatum* has effective pollen, for Mr. Scott fertilised two distinct species with it; the ovules are likewise capable of impregnation, for they were readily fertilised by the pollen of *O. divaricatum*; nevertheless, between one and two hundred flowers fertilised by their own pollen did not produce a single capsule, though the stigmas were penetrated by the pollen-tubes. Mr. Robertson Munro, of the Royal Botanic Gardens of Edinburgh, also informs me (1864) that a hundred and twenty flowers of this same species were fertilised by him with their own pollen, and did not produce a capsule, but eight flowers, fertilised by the pollen of *O. divaricatum*, produced four fine capsules: again, between two and three hundred flowers of *O. divaricatum*, fertilised by their own pollen, did not set a capsule, but twelve flowers fertilised by *O. flexuosum* produced eight fine capsules: so that here we have three utterly self-impotent species, with their male and female organs perfect, as shown by their mutual fertilisation. In these cases fertilisation was effected only by the aid of a distinct species. But, as we shall presently see, distinct plants, raised from seed, of *Oncidium flexuosum*, and probably of the other species, would have been perfectly capable of fertilising each other, for this is the natural process. Again, Mr. Scott found that the pollen of a plant of *O. microchilum* was effective, for with it he fertilised two distinct species; he found its ovules good, for they could be fertilised by the pollen of one of these species, and by the pollen of a distinct plant of *O. microchilum*; but they could not be fertilised by pollen of the same plant, though the pollen-tubes penetrated the stigma. An analogous case has been recorded by M. Rivière[70] with two plants of *O. cavendishianum*, which were both self-sterile, but reciprocally fertilised each other. All these cases refer to the genus Oncidium, but Mr. Scott found that *Maxillaria atro-*

rubens was "totally insusceptible of fertilisation with its own pollen," but fertilised, and was fertilised by, a widely distinct species, viz. *M. squalens.*

As these orchids had been grown under unnatural conditions in hot-houses, I concluded that their self-sterility was due to this cause. But Fritz Müller informs me that at Desterro, in Brazil, he fertilised above one hundred flowers of the above-mentioned *Oncidium flexuosum,* which is there endemic, with its own pollen, and with that taken from distinct plants: all the former were sterile, whilst those fertilised by pollen from any *other plant* of the same species were fertile. During the first three days there was no difference in the action of the two kinds of pollen: that placed on stigma of the same plant separated in the usual manner into grains, and emitted tubes which penetrated the column, and the stigmatic chamber shut itself; but only those flowers which had been fertilised by pollen taken from a distinct plant produced seed-capsules. On a subsequent occasion these experiments were repeated on a large scale with the same result. Fritz Müller found that four other endemic species of Oncidium were in like manner utterly sterile with their own pollen, but fertile with that from any other plant: some of them likewise produced seed-capsules when impregnated with pollen of widely distinct genera, such as Cyrtopodium, and Rodriguezia. *Oncidium crispum,* however, differs from the foregoing species in varying much in its self-sterility; some plants producing fine pods with their own pollen, others failing to do so in two or three instances, Fritz Müller observed that the pods produced by pollen taken from a distinct flower on the same plant, were larger than those produced by the flower's own pollen. In *Epidendrum cinnabarinum,* an orchid belonging to another division of the family, fine pods were produced by the plant's own pollen, but they contained by weight only about half as much seed as the capsules which had been fertilised by pollen from a distinct plant, and in one instance from a distinct species; moreover, a very large proportion, and in some cases nearly all the seeds produced by the plant's own pollen, were destitute of an embryo. Some self-fertilised capsules of a Maxillaria were in a similar state.

Another observation made by Fritz Müller is highly remarkable, namely, that with various orchids the plant's own pollen not only fails to impregnate the flower, but acts on the stigma, and is acted on, in an injurious or poisonous manner. This is shown by the surface of the stigma in contact with the pollen, and by the pollen itself becoming in from three to five days dark brown, and then decaying. The discoloration and decay are not caused by parasitic cryptograms, which were observed by Fritz Müller in only a single instance. These changes are well shown by placing on the same stigma, at the same time, the plant's own pollen and that from a distinct plant of the same species, or of another species, or even of another and widely remote genus. Thus, on the stigma of *Oncidium flexuosum,* the plant's own pollen and that from a distinct plant were placed side by side, and in five days' time the latter was perfectly fresh, whilst the plant's own pollen was brown. On the other hand, when the pollen of a distinct plant of the *Oncidium flexuosum* and of the *Epidendrum zebra (nov. spec.?)* were placed together on the same stigma, they behaved in exactly the same manner, the grains separating, emitting tubes, and penetrating the stigma, so that the two pollen-masses, after an interval of eleven days, could not be distinguished except by the difference of their caudicles, which, of course, undergo no change. Fritz Müller has, moreover, made a large number of crosses between orchids belonging to distinct species and genera, and he finds that in all cases when the flowers are not fertilised their footstalks first begin to wither; and the withering slowly spreads upwards until the germens fall off, after an interval of one or two weeks, and in one instance of between six and seven weeks; but even in this latter case, and in most other cases, the pollen and stigma remained in appearance fresh. Occasionally, however, the pollen becomes brownish, generally on the external surface, and not in contact with the stigma, as is invariably the case when the plant's own pollen is applied.

Fritz Müller observed the poisonous action of the plant's own pollen in the above-mentioned *Oncidium flexuosum, O. unicorne, pubes (?),* and in two other unnamed species. Also in two species of Rodriguezia, in two of Notylia, in one of Burlingtonia, and of a fourth genus in the same group. In all these cases, except the last, it was proved that the flowers were, as might have been expected, fertile with pollen from a distinct plant of the same species. Numerous flowers of one species of Notylia were fertilised with pollen from the same raceme; in two days' time they all withered, the germens began to shrink, the pollen-masses became dark brown, and not one pollen-grain emitted a tube. So that in this orchid the injurious action of the plant's own pollen is more rapid than with *Oncidium flexuosum.* Eight other flowers on the same raceme were fertilised with pollen from a distinct plant of the same species: two of these were dissected, and their stigmas were found to be penetrated by numberless pollen-tubes; and the germens of the other six flowers became well developed. On a subsequent occasion many other flowers were fertilised with their own pollen, and all fell off dead in a few days; whilst some flowers on the same raceme which had been left simply unfertilised adhered and long remained fresh. We have seen that in cross-unions between extremely distinct orchids the pollen long remains undecayed; but Notylia behaved in this respect differently; for when its pollen was placed on the stigma of *Oncidium flexuosum,* both the stigma and pollen quickly became dark brown, in the same manner as if the plant's own pollen had been applied.

Fritz Müller suggests that, as in all these cases the plant's own pollen is not only impotent (thus effectually preventing self-fertilisation), but likewise prevents, as was ascertained in the case of the Notylia and *Oncidium flexuosum,* the action of subsequently applied pollen from a distinct individual, it would be an advantage to the plant to have its own pollen rendered more and more deleterious; for the germens would thus quickly be killed, and dropping off, there would be no further waste in nourishing a part which ultimately could be of no avail.

The same naturalist found in Brazil three plants of a Bignonia growing near together. He fertilised twenty-nine flowerets on one of them with their own pollen, and they did not set a single capsule. Thirty flowers were then fertilised with pollen from a distinct plant, one of the three, and they yielded only two capsules. Lastly, five flowers were fertilised with pollen from a fourth plant growing at a distance, and all five produced capsules. Fritz Müller thinks that the three plants which grew near one another were probably seedlings from the same parent, and that from being closely related, they acted very feebly on one another. This view is extremely probable, for he has since shown in a remarkable paper,[71] that in the case of some Brazilian species of Abutilon, which are self-sterile, and between which he raised some complex hybrids, that these, if near relatives, were much less fertile *inter se*, than when not closely related.

We now come to cases closely analogous with those just given, but different in so far that only certain individuals of the species are self-sterile. This self-impotence does not depend on the pollen or ovules being in an unfit state for fertilisation, for both have been found effective in union with other plants of the same or of a distinct species. The fact of plants having acquired so peculiar a constitution, that they can be fertilised more readily by the pollen of a distinct species than by their own, is exactly the reverse of what occurs with all ordinary species. For in the latter the two sexual elements of the same individual plant are of course capable of freely acting on each other; but are so constituted that they are more or less impotent when brought into union with the sexual elements of a distinct species, and produce more or less sterile hybrids.

Gärtner experimented on two plants of *Lobelia fulgens*, brought from separate places, and found[72] that their pollen was good, for he fertilised with it *L. cardinalis* and *syphilitica*; their ovules were likewise good, for they were fertilised by the pollen of these same two species; but these two plants of *L. fulgens* could not be fertilised by their own pollen, as can generally be effected with perfect ease with this species. Again, the pollen of a plant of *Verbascum nigrum* grown in a pot was found by Gärtner[73] capable of fertilising *V. lychnitis* and *V. austriacum*; the ovules could be fertilised by the pollen of *V. thapsus*; but the flowers could not be fertilised by their own pollen. Kölreuter, also,[74] gives the case of three garden plants of *Verbascum phœniceum,* which bore during two years many flowers; these he fertilised successfully with the pollen of no less than four distinct species, but they produced not a seed with their own apparently good pollen; subsequently these same plants, and others raised from seed, assumed a strangely fluctuating condition, being temporarily sterile on the male or female side, or on both sides, and sometimes fertile on both sides; but two of the plants were perfectly fertile throughout the summer.

With *Reseda odorata* I have found certain individuals quite sterile with their own pollen, and so it is with the indigenous *Reseda lutea*. The self-sterile plants of both species were perfectly fertile when crossed with pollen from any other individual of the same species. These observations will hereafter be published in another work, in which I shall also show that seeds sent to me by Fritz Müller produced by plants of *Eschscholtzia californica* which were quite self-sterile in Brazil, yielded in this country plants which were only slightly self-sterile.

It appears[75] that certain flowers on certain plants of *Lilium candidum* can be fertilised more freely by pollen from a distinct individual than by their own. So, again, with the varieties of the potato. Tinzmann,[76] who made many trials with this plant, says that pollen from another variety sometimes "exerts a powerful influence, and I have found sorts of potatoes which would not bear seed from impregnation with the pollen of their own flowers would bear it when impregnated with other pollen." It does not, however, appear to have been proved that the pollen which failed to act on the flower's own stigma was in itself good.

In the genus Passiflora it has long been known that several species do not produce fruit, unless fertilised by pollen taken from distinct species: thus, Mr. Mowbray[77] found that he could not get fruit from *P. alata* and *racemosa* except by reciprocally fertilising them with each other's pollen; and similar facts have been observed in Germany and France.[78] I have received two accounts of *P. quadrangularis* never producing fruit from its own pollen, but doing so freely when fertilised in one case with the pollen of *P. cœrulea,* and in another case with that of *P. edulis.* But in three other cases this species fruited freely when fertilised with its own pollen; and the writer in one case attributed the favourable result to the temperature of the house having been raised from 5° to 10° Fahr. above the former temperature, after the flowers were fertilised.[79] With respect to *P. laurifolia,* a cultivator of much experience has recently remarked[80] that the flowers "must be fertilised with the pollen of *P. cœrulea,* or of some other common kind, as their own pollen will not fertilise them." But the fullest details on this subject have been given by Messrs. Scott and Robertson Munro:[81] plants of *Passiflora racemosa, cœrulea,* and *alata* flowered profusely during many years in the Botanic Gardens of Edinburgh, and, though repeatedly fertilised with their own pollen, never produced any seed; yet this occurred at once with all three species when they were crossed together in various ways. In the case of *P. cœrulea* three plants, two of which grew in the Botanic Gardens, were all rendered fertile, merely by impregnating each with pollen of one of the others. The same result was attained in the same manner with *P. alata,* but with only one plant out of three. As so many self-sterile species of Passiflora have been mentioned, it should be stated that the flowers of the annual *P. gracilis* are nearly as fertile with their own pollen as with that from a distinct plant; thus sixteen flowers spontaneously self-fertilised produced fruit, each containing on an average 21·3 seed, whilst fruit from fourteen crossed flowers contained 24·1 seed.

Returning to *P. alata,* I have received (1866) some interesting details from Mr. Robertson Munro. Three plants, including one in England, have already been mentioned which were inveterately self-sterile, and Mr. Munro informs me of several others which, after repeated trials during many years, have been found in the same predicament. At some other places, however, this species fruits readily when fertilised with its own pollen. At Taymouth Castle there is a plant which was formerly grafted by Mr. Donaldson on a distinct species, name unknown, and ever since the operation it has produced fruit in abundance by its own pollen; so that this small and unnatural change in the state of this plant has restored its self-fertility! Some of the seedlings from the Taymouth Castle plant were found to be not only sterile with their own pollen, but with each other's pollen, and with the pollen of distinct species. Pollen from the Taymouth plant failed to fertilise certain plants of the same species, but was successful on one plant in the Edinburgh Botanic Gardens. Seedlings were raised from this latter union, and some of their flowers were fertilised by Mr. Munro with their own pollen; but they were found to be as self-impotent as the mother-plant had always proved, except when fertilised by the grafted Taymouth plant, and except, as we shall see, when fertilised by her own seedlings. For Mr. Munro fertilised eighteen flowers on the self-impotent mother-plant with pollen from these her own self-impotent seedlings, and obtained, remarkable as the fact is, eighteen fine capsules full of excellent seed! I have met with no case in regard to plants which shows so well as this of *P. alata,* on what small and mysterious causes complete fertility or complete sterility depends.

The facts hitherto given relate to the much-lessened or completely destroyed fertility of pure species when impregnated with their own pollen, in comparison with their fertility when impregnated by distinct individuals or distinct species; but closely analogous facts have been observed with hybrids.

Herbert states[82] that having in flower at the same time nine hybrid Hippeastrums, of complicated origin, descended from several species, he found that "almost every flower touched with pollen from another cross produced seed abundantly, and those which were touched with their own pollen either failed entirely, or formed slowly a pod of inferior size, with fewer seeds." In the 'Horticultural Journal' he adds that "the admission of the pollen of another cross-bred Hippeastrum (however complicated the cross) to any one flower of the number, is almost sure to check the fructification of the others." In a letter written to me in 1839, Dr. Herbert says that he had already tried these experiments during five consecutive years, and he subsequently repeated them, with the same invariable result. He was thus led to make an analogous trial on a pure species, namely, on the *Hippeastrum aulicum,* which he had lately imported from Brazil: this bulb produced four flowers, three of which were fertilised by their own pollen, and the fourth by the pollen of a triple cross between *H. bulbulosum, reginæ,* and *vittatum*; the result was, that "the ovaries of the three first flowers soon ceased to grow, and after a few days perished entirely: whereas the pod impregnated by the hybrid made vigorous and rapid progress to maturity, and bore good seed, which vegetated freely." This is, indeed, as Herbert remarks, "a strange truth," but not so strange as it then appeared.

As a confirmation of these statements, I may add that Mr. M. Mayes[83] after much experience in crossing the species of Amaryllis (Hippeastrum), says, "neither the species nor the hybrids will, we are well aware, produce seed so abundantly from their own pollen as from that of others." So, again, Mr. Bidwell, in New South Wales[84] asserts that *Amaryllis belladonna* bears many more seeds when fertilised by the pollen of *Brunswigia* (*Amaryllis* of some authors) *josephinæ* or of *B. multiflora,* than when fertilised by its own pollen. Mr. Beaton dusted four flowers of a Cyrtanthus with their own pollen, and four with the pollen of *Vallota (Amaryllis) purpurea*; on the seventh day "those which received their own pollen slackened their growth, and ultimately perished; those which were crossed with the Vallota held on."[85] These latter cases, however, relate to uncrossed species, like those before given with respect to Passiflora, Orchids, etc., and are here referred to only because the plants belong to the same group of Amaryllidaceæ.

In the experiments on the hybrid Hippeastrums, if Herbert had found that the pollen of two or three kinds alone had been more efficient on certain kinds than their own pollen, it might have been argued that these, from their mixed parentage, had a closer mutual affinity than the others; but this explanation is inadmissible, for the trials were made reciprocally backwards and forwards on nine different hybrids; and a cross, whichever way taken, always proved highly beneficial. I can add a striking and analogous case from experiments made by the Rev. A. Rawson, of Bromley Common, with some complex hybrids of Gladiolus. This skilful horticulturist possessed a number of French varieties, differing from each other only in the colour and size of the flowers, all descended from Gandavensis, a well-known old hybrid, said to be descended from *G. natalensis* by the pollen of *G. oppositiflorus*.[86] Mr. Rawson, after repeated trials, found that none of the varieties would set seed with their own pollen, although taken from distinct plants of the same variety (which had, of course, been propagated by bulbs), but that they all seeded freely with pollen from any other variety. To give two examples: Ophir did not produce a capsule with its own pollen, but when fertilised with that of Janire, Brenchleyensis, Vulcain and Linné, it produced ten fine capsules; but the pollen of Ophir was good, for when Linné was fertilised by it seven capsules were produced. This latter variety, on the other hand, was utterly barren with its own pollen, which we have seen was perfectly efficient on Ophir. Altogether, Mr. Rawson, in the year 1861 fertilised twenty-six flowers borne by four varieties with pollen taken from other varieties, and every single flower produced a fine seed-capsule; whereas fifty-two flowers on the same plants, fertilised at the same time with their own pollen, did not yield a single seed-capsule. Mr. Rawson fertilised, in some cases, the alternate flowers, and in other cases all those down one side of the spike, with pollen of other varieties, and the remaining flowers with their own pollen. I saw these plants when the capsules were nearly mature, and their curious arrangement at once brought full conviction to the mind that an immense advantage had been derived from crossing these hybrids.

Lastly, I have heard from Dr. E. Bornet, of Antibes, who has made numerous experiments in crossing the species of Cistus, but has not yet published the results, that, when any of these hybrids are fertile, they may be said to be, in regard to function, dioecious; "for the flowers are always sterile when the pistil is fertilised by pollen taken from the same flower or from flowers on the same plant. But they are often fertile if pollen be employed from a distinct individual of the same hybrid nature, or from a hybrid made by a reciprocal cross."

Conclusion.—That plants should be self-sterile, although both sexual elements are in a fit state for reproduction, appears at first sight opposed to all analogy. With respect to the species, all the individuals of which are in this state, although living under their natural conditions, we may conclude that their self-sterility has been acquired for the sake of effectually preventing self-fertilisation. The case is closely analogous with that of dimorphic and trimorphic or heterostyled plants, which can be fully fertilised only by plants belonging to a different form, and not, as in the foregoing cases, indifferently by any other individual of the species. Some of these hetero-styled plants are completely sterile with pollen taken from the same plant or from the same form. With respect to species living under their natural conditions, of which only certain individuals are self-sterile (as with *Reseda lutea*), it is probable that these have been rendered self-sterile to ensure occasional cross-fertilisation, whilst other individuals have remained self-fertile to ensure the propagation of the species. The case seems to be parallel with that of plants which produce, as Hermann Müller has discovered, two forms—one bearing more conspicuous flowers with their structure adapted for cross-fertilisation by insects, and the other form with less conspicuous flowers adapted for self-fertilisation. The self-sterility, however, of some of the foregoing plants is incidental on the conditions to which they have been subjected, as with the Eschscholtzia, the *Verbascum phœniceum* (the sterility of which varied according to the season), and with the *Passiflora alata,* which recovered its self-fertility when grafted on a different stock.

It is interesting to observe in the above several cases the graduated series from plants which, when fertilised by their own pollen, yield the full number of seeds, but with the seedlings a little dwarfed in stature—to plants which when self-fertilised yield few seeds—to those which yield none, but have their ovaria somewhat developed—and, lastly, to those in which the plant's own pollen and stigma mutually act on one another like poison. It is also interesting to observe on how slight a difference in the nature of the pollen or of the ovules complete self-sterility or complete self-fertility must depend in some of the above cases. Every individual of the self-sterile species appears to be capable of producing the full complement of seed when fertilised by the pollen of any other individual (though judging from the facts given with respect to Abutilon the nearest kin must be excepted); but not one individual can be fertilised by its own pollen. As every organism differs in some slight degree from every other individual of the same species, so no doubt it is with their pollen and ovules; and in the above cases we must believe that complete self-sterility and complete self-fertility depend on such slight differences in the ovules and pollen, and not their having been differentiated in some special manner in relation to one another; for it is impossible that the sexual elements of many thousand individuals should have been specialised in relation to every other individual. In some, however, of the above cases, as with certain Passifloras, an amount of differentiation between the pollen and ovules sufficient for fertilisation is gained only by employing pollen from a distinct species; but this is probably the result of such plants having been rendered somewhat sterile from the unnatural conditions to which they have been exposed.

Exotic animals confined in menageries are sometimes in nearly the same state as the above-described self-impotent plants; for, as we shall see in the following chapter, certain monkeys, the larger carnivora, several finches, geese, and pheasants, cross together, quite as freely as, or even more freely than the individuals of the same species breed together. Cases will, also, be given of sexual incompatibility between certain, male and female domesticated animals, which, nevertheless, are fertile when matched with any other individual of the same kind.

In the early part of this chapter it was shown that the crossing of individuals belonging to distinct families of the same race, or to different races or species, gives increased size and constitutional vigour to the offspring, and, except in the case of crossed species, increased fertility. The evidence rests on the universal testimony of breeders (for it should be observed that I am not here speaking of the evil results of close interbreeding), and is practically exemplified in the higher value of cross-bred animals for immediate consumption. The good results of crossing have also been demonstrated with some animals and with numerous plants, by actual weight and measurement. Although animals of pure blood will obviously be deteriorated by crossing, as far as their characteristic qualities are concerned, there seems to be no exception to the rule that advantages of the kind just mentioned are thus gained, even when there has not been any previous close interbreeding; and the rule applies to such animals as cattle and sheep, which can long resist breeding in-and-in between the nearest blood-relations.

In the case of crossed species, although size, vigour, precocity, and hardiness are, with rare exceptions, gained, fertility, in a greater or less degree, is lost; but the gain in the above respects can hardly be attributed to the principle of compensation; for there is no close parallelism between the increased size and vigour of hybrid offspring and their sterility. Moreover, it has been clearly proved that mongrels which are perfectly fertile gain these same advantages as well as sterile hybrids.

With the higher animals no special adaptations for ensuring occasional crosses between distinct families seem to exist. The eagerness of the males, leading to severe competition between them, is sufficient; for even with gregarious animals, the old and dominant males will be dispossessed after a time and it would be a mere chance if a closely related member of the same family were to be the victorious successor. The structure of many of the lower animals, when they are hermaphrodites, is such as to prevent the ovules being fertilised by the male element of the same individual; so that the concourse of two individuals is necessary. In other cases the access of the male element of a distinct individual is at least possible. With plants, which are affixed to the ground and cannot wander from place to place like animals, the numerous adaptations for cross-fertilisation are wonderfully perfect, as has been admitted by every one who has studied the subject.

The evil consequences of long-continued close interbreeding are not so easily recognised as the good effects from crossing, for the deterioration is gradual. Nevertheless, it is the general opinion of those who have had most experience, especially with animals which propagate quickly, that evil does inevitably follow sooner or later, but at different rates with different animals. No doubt a false belief may, like a superstition, prevail widely; yet it is difficult to suppose that so many acute observers have all been deceived at the expense of much cost and trouble. A male animal may sometimes be paired with his daughter, granddaughter, and so on, even for seven generations, without any manifest bad result: but the experiment has never been tried of matching brothers and sisters, which is considered the closest form of interbreeding, for an equal number of generations. There is good reason to believe that by keeping the members of the same family in distinct bodies, especially if exposed to somewhat different conditions of life, and by occasionally crossing these families, the evil results of interbreeding may be much diminished or quite eliminated. These results are loss of constitutional vigour, size, and fertility; but there is no necessary deterioration in the general form of the body, or in other good qualities. We have seen that with pigs first-rate animals have been produced after long-continued close interbreeding, though they had become extremely infertile when paired with their near relations. The loss of fertility, when it occurs, seems never to be absolute, but only relative to animals of the same blood; so that this sterility is to a certain extent analogous with that of self-impotent plants which cannot be fertilised by their own pollen, but are perfectly fertile with pollen of any other individual of the same species. The fact of infertility of this peculiar nature being one of the results of long-continued interbreeding, shows that interbreeding does not act merely by combining and augmenting various morbid tendencies common to both parents; for animals with such tendencies, if not at the time actually ill, can generally propagate their kind. Although offspring descended from the nearest blood-relations are not necessarily deteriorated in structure, yet some authors believe that they are eminently liable to malformations; and this is not improbable, as everything which lessens the vital powers acts in this manner. Instances of this kind have been recorded in the case of pigs, bloodhounds, and some other animals.

Finally, when we consider the various facts now given which plainly show that good follows from crossing, and less plainly that evil follows from close interbreeding, and when we bear in mind that with very many organisms elaborate provisions have been made for the occasional union of distinct individuals, the existence of a great law of nature is almost proved; namely, that the crossing of animals and plants which are not closely related to each other is highly beneficial or even necessary, and that interbreeding prolonged during many generations is injurious.

REFERENCES

[1] ‘The Art of Improving the Breed, etc.,’ 1809, p. 16.

[2] ‘The History of the Rise and Progress of the Killerby, etc. Herds,’ p. 41.

[3] For Andrew Knight, *see* A. Walker, on ‘Intermarriage,’ 1838, p. 227. Sir J. Sebright’s Treatise has just been quoted.

[4] ‘Cattle,’ p. 199.

[5] I give this on the authority of Nathusius, ‘Ueber Shorthorn Rindvieh,’ 1857, s. 71, (*see also* ‘Gardener’s Chronicle,’ 1860, p. 270). But Mr. J. Storer, a large breeder of cattle, informs me that the parentage of Clarissa is not well authenticated. In the first vol. of the ‘Herd Book,’ she was entered as having six descents from Favourite, “which was a palpable mistake,” and in all subsequent editions she was spoken of as having only four descents. Mr. Storer doubts even about the four, as no names of the dams are given. Moreover, Clarissa bore “only two bulls and one heifer, and in the next generation her progeny became extinct.” Analogous cases of close interbreeding are given in a pamphlet published by Mr. C. Macknight and Dr. H. Madden, ‘On the True Principles of Breeding;’ Melbourne, Australia, 1865.

[6] Mr. Willoughby Wood, in ‘Gardener’s Chronicle,’ 1855, p. 411; and 1860, p. 270. *See* the very clear tables and pedigrees given in Nathusius’ ‘Rindvieh,’ s. 72-77.

[7] Mr. Wright, ‘Journal of Royal Agricult. Soc.,’ vol. vii., 1846, p. 204. Mr. J. Downing (a successful breeder of Shorthorns in Ireland) informs me that the raisers of the great families of Shorthorns carefully conceal their sterility and want of constitution. He adds that Mr. Bates, after he had bred his herd in-and-in for some years, “lost in one season twenty-eight calves solely from want of constitution.”

[8] Youatt on Cattle, p. 202.

[9] ‘Report British Assoc., Zoolog. Sect.,’ 1838.

[10] Azara, ‘Quadrupèdes du Paraguay,’ tom. ii. pp. 354, 368.

[11] For the case of the Messrs. Brown, *see* ‘Gardener’s Chronicle,’ 1855, p. 26. For the Foscote flock, ‘Gardener’s Chronicle,’ 1860, p. 416. For the Naz flock, ‘Bull. de la Soc. d’Acclimat.,’ 1860, p. 477.

[12] Nathusius, ‘Rindvieh,’ s. 65; Youatt on Sheep, p. 495.

[13] ‘Gardener’s Chronicle,’ 1861, p. 631.

[14] ‘Journal R. Agricult. Soc.,’ vol. xiv., 1853, p. 212.

[15] Lord Somerville, ‘Facts on Sheep and Husbandry,’ p. 6. Mr. Spooner in ‘Journal of Royal Agricult. Soc. of England,’ vol. xx. part ii. *See also* an excellent paper on the same subject in ‘Gardener’s Chronicle,’ 1860, p. 321, by Mr. Charles Howard.

[16] ‘Some Account of English Deer Parks,’ by Evelyn P. Shirley, 1867.

[17] Stonehenge, ‘The Dog,’ 1867, pp. 175-178.

[18] ‘The Art of Improving the Breed,’ etc., p. 13. With respect to Scotch deerhounds, *see* Scrope’s ‘Art of Deer Stalking,’ pp. 350-353.

[19] ‘Cottage Gardener,’ 1861, p. 327.

[20] Mr. Huth gives (‘The Marriage of Near Kin,’ 1875, p. 302) from the ‘Bulletin de l’Acad. R. de Méd. de Belgique’ (vol. ix., 1866, pp. 287, 305), several statements made by a M. Legrain with respect to crossing brother and sister rabbits for five or six successive generations with no consequent evil results. I was so much surprised at this account, and at M. Legrain’s invariable success in his experiments, that I wrote to a distinguished naturalist in Belgium to inquire whether M. Legrain was a trustworthy observer. In answer, I have heard that, as doubts were expressed about the authenticity of these experiments, a commission of inquiry was appointed, and that at a succeeding meeting of the Society (‘Bull. de l’Acad. R. de Méd. de Belgique,’ 1867, 3rd series, Tome 1, No. 1 to 5), Dr. Crocq reported “qu’il était matériellement impossible que M. Legrain ait fait les expériences qu’il annonce.” To this public accusation no satisfactory answer was made.

[21] Sidney’s edit. of ‘Youatt on the Pig,’ 1860, p. 30; p. 33 quotation from Mr. Druce; p. 29 on Lord Western’s case.

[22] ‘Journal of Royal Agricult. Soc. of England,’ 1846, vol. vii. p. 205.

[23] ‘Ueber Rindvieh,’ etc., s. 78. Col. Le Couteur, who has done so much for the agriculture of Jersey, writes to me that from possessing a fine breed of pigs he bred them very closely, twice pairing brothers and sisters, but nearly all the young had fits and died suddenly.

[24] Sidney on the Pig, p. 36. *See also* note p. 34. Also Richardson on the Pig, 1847, p. 26.

[25] Dr. Dally has published an excellent article (translated in the ‘Anthropolog. Review,’ May, 1864, p. 65), criticising all writers who have maintained that evil follows from consanguineous marriages. No doubt on this side of the question many advocates have injured their cause by inaccuracies: thus it has been stated (Devay, ‘Du Danger des Mariages,’ etc., 1862, p. 141) that the marriages of cousins have been prohibited by the legislature of Ohio; but I have been assured, in answer to inquiries made in the United States, that this statement is a mere fable.

[26] *See* his interesting work on the ‘Early History of Man,’ 1865, chap. x.

[27] ‘The Marriage of Near Kin,’ 1875. The evidence given by Mr. Huth would, I think, have been even more valuable than it is on this and some other points, if he had referred solely to the works of men who had long resided in each country referred to, and who showed that they possessed

judgment and caution. *See also* Mr. W. Adam, 'On Consanguinity in Marriage' in the 'Fortnightly Review,' 1865, p. 710. Also Hofacker, 'Ueber die Eigenschaften,' etc., 1828.

[28] Sir G. Grey's 'Journal of Expeditions into Australia,' vol. ii. p. 243; and Dobrizhoffer, 'On the Abipones of South America.'

[29] 'Descent of Man,' 2nd. edit. p. 524.

[30] 'Journal of Statistical Soc.' June, 1875, p. 153; and 'Fortnightly Review,' June, 1875.

[31] 'The Art of Improving the Breed,' p. 13.

[32] 'The Poultry Book,' by W. B. Tegetmeier, 1866, p. 245.

[33] 'Journal Royal Agricult. Soc.,' 1846, vol. vii. p. 205; *see also* Ferguson on the Fowl, pp. 83, 317; *see also* 'The Poultry Book,' by Tegetmeier, 1866, p. 135, with respect to the extent to which cock-fighters found that they could venture to breed in-and-in, viz., occasionally a hen with her own son; "but they were cautious not to repeat the in-and-in breeding."

[34] 'The Poultry Book,' by W. B. Tegetmeier, 1866, p. 79.

[35] 'The Poultry Chronicle,' 1854, vol. i. p. 43.

[36] 'The Poultry Book,' by W. B. Tegetmeier, 1866, p. 79.

[37] 'The Poultry Chronicle,' vol. i. p. 89.

[38] 'The Poultry Book,' 1866, p. 210.

[39] Ibid. 1866, p. 167; and 'Poultry Chronicle,' vol. iii., 1855, p. 15.

[40] 'A Treatise on Fancy Pigeons,' by J. M. Eaton, p. 56.

[41] 'The Pigeon Book,' p. 46.

[42] 'Das Ganze der Taubenzucht,' 1837, s. 18.

[43] 'Les Pigeons,' 1824, p. 35.

[44] 'Proc. Entomolog. Soc.,' Aug. 6th, 1860, p. 126.

[45] 'Journal of Horticulture,' 1861, pp. 39, 77, 158; and 1864, p. 206.

[46] 'Beiträge zur Kenntniss der Befruchtung,' 1844, s. 366.

[47] 'Amaryllidaceæ,' p. 371.

[48] 'De la Fécondation,' 2nd edit., 1862, p. 79.

[49] ‘Mémoire sur les Cucurbitacées,’ pp. 36, 28, 30.

[50] Loudon’s ‘Gard. Mag.,’ vol. viii., 1832, p. 52.

[51] ‘Transact. Hort. Soc.,’ vol. i. p. 25.

[52] ‘Annal. des Sc. Nat.,’ 3rd series, Bot., tom. vi. p. 189.

[53] ‘Philosophical Transactions,’ 1799, p. 200.

[54] ‘Ueber die Bastarderzeugung,’ 1828, s. 32, 33. For Mr. Chaundy’s case, *see* Loudon’s ‘Gard. Mag.’ vol. vii. 1831, p. 696.

[55] ‘Gardener’s Chron.,’ 1846, p. 601.

[56] ‘Philosoph. Transact.,’ 1799, p. 201.

[57] Quoted in ‘Bull. Bot. Soc. France,’ vol. ii., 1855, p. 327.

[58] Gärtner, ‘Bastarderzeugung,’ s. 259, 518, 526 *et seq.*

[59] ‘Fortsetzung,’ 1763, s. 29; ‘Dritte Fortsetzung,’ s. 44, 96; ‘Act. Acad. St. Petersburg,’ 1782, part ii., p. 251; ‘Nova Acta,’ 1793, pp. 391, 394; ‘Nova Acta,’ 1795, pp. 316, 323.

[60] ‘Die Bastardbefruchtung,’ etc., 1865, s. 31, 41, 42.

[61] Max Wichura fully accepts this view (‘Bastardbefruchtung,’ s. 43), as does the Rev. M. J. Berkeley, in ‘Journal of Hort. Soc.,’ Jan. 1866, p. 70.

[62] ‘Bastarderzeugung,’ s. 394, 526, 528.

[63] Kölreuter, ‘Nova Acta,’ 1795, p. 316.

[64] Gärtner, ‘Bastarderzeugung,’ s. 430.

[65] Quoted by Dr. Murie, in ‘Proc. Zoolog. Soc.,’ 1870, p. 40.

[66] ‘Botanische Zeitung,’ Jan. 1864, s. 3.

[67] ‘Monatsbericht Akad. Wissen.’ Berlin, 1866, s. 372.

[68] International Hort. Congress, London, 1866.

[69] ‘Proc. Bot. Soc. of Edinburgh,’ May, 1863: these observations are given in abstract, and others are added, in the ‘Journal of Proc. of Linn. Soc.,’ vol. viii. Bot., 1864, p. 162.

[70] Prof. Lecoq, ‘De la Fécondation,’ 2nd edit., 1862, p. 76.

[71] ‘Jenaische Zeitschrift fur Naturwiss.’ B. vii. p. 22, 1872, and p. 441, 1873. A large part of this paper has been translated in the ‘American Naturalist,’ 1874, p. 223.

[72] ‘Bastarderzeugung,’ s. 64, 357.

[73] Ibid., s. 357.

[74] ‘Zweite Fortsetzung,’ s. 10; ‘Dritte Forts.,’ s. 40. Mr. Scott likewise fertilised fifty-four flowers of *Verbascum phœniceum,* including two varieties, with their own pollen, and not a single capsule was produced. Many of the pollen-grains emitted their tubes, but only a few of them penetrated the stigmas; some slight effect however was produced, as many of the ovaries became somewhat developed: ‘Journal Asiatic Soc. Bengal,’ 1867, p. 150.

[75] Duvernoy, quoted by Gärtner, ‘Bastarderzeugung,’ s. 334.

[76] ‘Gardener’s Chronicle,’ 1846, p. 183.

[77] ‘Transact. Hort. Soc.,’ vol. vii., 1830, p. 95.

[78] Prof. Lecoq ‘De la Fécondation,’ 1845, p. 70; Gärtner, ‘Bastarderzeugung,’ s. 64.

[79] ‘Gardener’s Chronicle,’ 1868, p. 1341.

[80] ‘Gardener’s Chronicle,’ 1866, p. 1068.

[81] ‘Journal of Proc. of Linn. Soc.,’ vol. viii., 1864, p. 1168. Mr. Robertson Munro, in ‘Trans. Bot. Soc.’ of Edinburgh, vol. ix. p. 399.

[82] ‘Amaryllidaceæ,’ 1837, p. 371; ‘Journal of Hort. Soc.,’ vol. ii., 1847, p. 19.

[83] Loudon’s ‘Gardener’s Magazine,’ vol. xi., 1835, p. 260.

[84] ‘Gardener’s Chronicle,’ 1850, p. 470.

[85] ‘Journal Hort. Soc.,’ vol. v. p. 135. The seedlings thus raised were given to the Hort. Soc.; but I find, on inquiry, that they unfortunately died the following winter.

[86] Mr. D. Beaton, in ‘Journal of Hort.,’ 1861, p. 453. Lecoq however (‘De la Fécond.,’ 1862, p. 369), states that this hybrid is descended from *G. psittacinus* and *cardinalis*; but this is opposed to Herbert’s experience, who found that the former species could not be crossed.

CHAPTER XVIII.
ON THE ADVANTAGES AND DISADVANTAGES OF CHANGED CONDITIONS OF LIFE: STERILITY FROM VARIOUS CAUSES.

ON THE GOOD DERIVED FROM SLIGHT CHANGES IN THE CONDITIONS OF LIFE—STERILITY FROM CHANGED CONDITIONS, IN ANIMALS, IN THEIR NATIVE COUNTRY AND IN MENAGERIES—MAMMALS, BIRDS, AND INSECTS—LOSS OF SECONDARY SEXUAL CHARACTERS AND OF INSTINCTS—CAUSES OF STERILITY—STERILITY OF DOMESTICATED ANIMALS FROM CHANGED CONDITIONS—SEXUAL INCOMPATIBILITY OF INDIVIDUAL ANIMALS—STERILITY OF PLANTS FROM CHANGED CONDITIONS OF LIFE—CONTABESCENCE OF THE ANTHERS—MONSTROSITIES AS A CAUSE OF STERILITY—DOUBLE FLOWERS—SEEDLESS FRUIT—STERILITY FROM THE EXCESSIVE DEVELOPMENT OF THE ORGANS OF VEGETATION—FROM LONG-CONTINUED PROPAGATION BY BUDS—INCIPIENT STERILITY THE PRIMARY CAUSE OF DOUBLE FLOWERS AND SEEDLESS FRUIT.

On the Good derived from slight Changes in the Conditions of Life.—In considering whether any facts were known which might throw light on the conclusion arrived at in the last chapter, namely, that benefits ensue from crossing, and that it is a law of nature that all organic beings should occasionally cross, it appeared to me probable that the good derived from slight changes in the conditions of life, from being an analogous phenomenon, might serve this purpose. No two individuals, and still less no two varieties, are absolutely alike in constitution and structure; and when the germ of one is fertilised by the male element of another, we may believe that it is acted on in a somewhat similar manner as an individual when exposed to slightly changed conditions. Now, every one must have observed the remarkable influence on convalescents of a change of residence, and no medical man doubts the truth of this fact. Small farmers who hold but little land are convinced that their cattle derive great benefit from a change of pasture. In the case of plants, the evidence is strong that a great advantage is derived from exchanging seeds, tubers, bulbs, and cuttings from one soil or place to another as different as possible.

The belief that plants are thus benefited, whether or not well founded, has been firmly maintained from the time of Columella, who wrote shortly after the Christian era, to the present day; and it now prevails in England, France, and Germany.[1] A sagacious observer, Bradley, writing in 1724,[2] says, "When we once become Masters of a good Sort of Seed, we should at least put it into Two or Three Hands, where the Soils and Situations are as different as possible; and every Year the Parties should change with one another; by which Means, I find the Goodness of the Seed will be maintained for several Years. For Want of this Use many Farmers have failed in their Crops and been great Losers." He then gives his own practical experience on this head. A modern writer[3] asserts, "Nothing can be more clearly established in agriculture than that the continual growth of any one variety in the same district makes it liable to deterioration either in quality or quantity." Another writer states that he sowed close together in the same field two lots of wheat-seed, the product of the same original stock, one of which had been grown on the same land and the other at a distance, and the difference in favour of the crop from the latter seed was remarkable. A gentleman in Surrey who has long made it his business to raise wheat to sell for seed, and who has constantly realised in the market higher prices than others, assures me that he finds it indispensable continually to change his seed; and that for this purpose he keeps two farms differing much in soil and elevation.

With respect to the tubers of the potato, I find that at the present day the practice of exchanging sets is almost everywhere followed. The great growers of potatoes in Lancashire formerly used to get tubers from Scotland, but they found that "a change from the moss-lands, and *vice versa*, was generally sufficient." In former times in France the crop of potatoes in the Vosges had become reduced in the course of fifty or sixty years in the proportion from 120-150 to 30-40 bushels; and the famous Oberlin attributed the surprising good which he effected in large part to changing the sets.[4]

A well-known practical gardener, Mr. Robson[5] positively states that he has himself witnessed decided advantage from obtaining bulbs of the onion, tubers of the potato, and various seeds, all of the same kind, from different soils and distant parts of England. He further states that with plants propagated by cuttings, as with the Pelargonium, and especially the Dahlia, manifest advantage is derived from getting plants of the same variety, which have been cultivated in another place; or, "where the extent of the place allows, to take cuttings from one description of soil to plant on another, so as to afford the change that seems so necessary to the well-being of the plants." He maintains that after a time an exchange of this nature is "forced on the grower, whether he be prepared for it or not." Similar remarks have been made by another excellent gardener, Mr. Fish, namely, that cuttings of the same variety of Calceolaria, which he obtained from a neighbour, "showed much greater vigour than some of his own that were treated in exactly the same manner," and he attributed this solely to his own plants having become "to a certain extent worn out or tired of their quarters." Something of this kind apparently occurs in grafting and budding fruit-trees; for, according to Mr. Abbey, grafts or buds generally take with greater facility on a distinct variety or even species, or on a stock previously grafted, than on stocks raised from seeds of the variety which is to be grafted; and he believes this cannot be altogether explained by the stocks in question being better adapted to the soil and climate of the place. It should, however, be added, that varieties grafted or budded on very distinct kinds, though they may take more readily and grow at first more vigorously than when grafted on closely allied stocks, afterwards often become unhealthy.

I have studied M. Tessier's careful and elaborate experiments[6] made to disprove the common belief that good is derived from a change of seed; and he certainly shows that the same seed may with care be cultivated on the same farm (it is not stated whether on exactly the same soil) for ten consecutive years without loss. Another excellent observer, Colonel Le Couteur[7] has come to the same conclusion; but then he expressly adds, if the same seed be used, "that which is grown on land manured from the mixen one year becomes seed for land prepared with lime, and that again becomes seed for land dressed with ashes, then for land dressed with mixed manure, and so on." But this in effect is a systematic exchange of seed, within the limits of the same farm.

On the whole the belief, which has long been held by many cultivators, that good follows from exchanging seed, tubers, etc., seems to be fairly well founded. It seems hardly credible that the advantage thus derived can be due to the seeds, especially if very small ones, obtaining in one soil some chemical element deficient in the other and in sufficient quantity to influence the whole after-growth of the plant. As plants after once germinating are fixed to the same spot, it might have been anticipated that they would show the good effects of a change more plainly than do animals which continually wander about; and this apparently is the case. Life depending on, or consisting in, an incessant play of the most complex forces, it would appear that their action is in some way stimulated by slight changes in the circumstances to which each organism is exposed. All forces throughout nature, as Mr. Herbert Spencer[8] remarks, tend towards an equilibrium, and for the life of each organism it is necessary that this tendency should be checked. These views and the foregoing facts probably throw light, on the one hand, on the good effects of crossing the breed, for the germ will be thus slightly modified or acted on by new forces; and on the other hand, on the evil effects of close interbreeding prolonged during many generations, during which the germ will be acted on by a male having almost identically the same constitution.

Sterility from Changed Conditions of Life.

I will now attempt to show that animals and plants, when removed from their natural conditions, are often rendered in some degree infertile or completely barren; and this occurs even when the conditions have not been greatly changed. This conclusion is not necessarily opposed to that at which we have just arrived, namely, that lesser changes of other kinds are advantageous to organic beings. Our present subject is of some importance, from having an intimate connection with the causes of variability. Indirectly it perhaps bears on the sterility of species when crossed: for as, on the one hand, slight changes in the conditions of life are favourable to plants and animals, and the crossing of varieties adds to the size, vigour, and fertility of their offspring; so, on the other hand, certain other changes in the conditions of life cause sterility; and as this likewise ensues from crossing much-modified forms or species, we have a parallel and double series of facts, which apparently stand in close relation to each other.

It is notorious that many animals, though perfectly tamed, refuse to breed in captivity. Isidore Geoffroy St.-Hilaire[9] consequently has drawn a broad distinction between tamed animals which will not breed under captivity, and truly domesticated animals which breed freely—generally more freely, as shown in the sixteenth chapter, than in a state of nature. It is possible and generally easy to tame most animals; but experience has shown that it is difficult to get them to breed regularly, or even at all. I shall discuss this subject in detail; but will give only those cases which seem most illustrative. My materials are derived from notices scattered through various works, and especially from a Report, kindly drawn up for me by the officers of the Zoological Society of London, which has especial value, as it records all the cases, during nine years from 1838-46, in which the animals were seen to couple but produced no offspring, as well as the cases in which they never, as far as known, coupled. This MS. Report I have corrected by the annual Reports subsequently published up to the year 1865.[10] Many facts are given on the breeding of the animals in that magnificent work, ‘Gleanings from the Menageries of Knowsley Hall’ by Dr. Gray. I made, also, particular inquiries from the experienced keeper of the birds in the old Surrey Zoological Gardens. I should premise that a slight change in the treatment of animals sometimes makes a great difference in their fertility; and it is probable that the results observed in different menageries would differ. Indeed, some animals in our Zoological Gardens have become more productive since the year 1846. It is, also, manifest from F. Cuvier’s account of the Jardin des Plantes[11] that the animals formerly bred much less freely there than with us; for instance, in the Duck tribe, which is highly prolific, only one species had at that period produced young.

The most remarkable cases, however, are afforded by animals kept in their native country, which, though perfectly tamed, quite healthy, and allowed some freedom, are absolutely incapable of breeding. Rengger,[12] who in Paraguay particularly attended to this subject, specifies six quadrupeds in this condition; and he mentions two or three others which most rarely breed. Mr. Bates, in his admirable work on the Amazons, strongly insists on similar cases;[13] and he remarks, that the fact of thoroughly tamed native mammals and birds not breeding when kept by the Indians, cannot be wholly accounted for by their negligence or indifference, for the turkey and fowl are kept and bred by various remote tribes. In almost every part of the world—for instance, in the interior of Africa, and in several of the Polynesian islands—the natives are extremely fond of taming the indigenous quadrupeds and birds; but they rarely or never succeed in getting them to breed.

The most notorious case of an animal not breeding in captivity is that of the elephant. Elephants are kept in large numbers in their native Indian home, live to old age, and are vigorous enough for the severest labour; yet, with a very few exceptions, they have never been known even to couple, though both males and females have their proper periodical seasons. If, however, we proceed a little eastward to Ava, we hear from Mr. Crawfurd[14] that their "breeding in the domestic state, or at least in the half-domestic state in which the female elephants are generally kept, is of everyday occurrence;" and Mr. Crawfurd informs me that he believes that the difference must be attributed solely to the females being allowed to roam the forest with some degree of freedom. The captive rhinoceros, on the other hand, seems from Bishop Heber's account[15] to breed in India far more readily than the elephant. Four wild species of the horse genus have bred in Europe, though here exposed to a great change in their natural habits of life; but the species have generally been crossed one with another. Most of the members of the pig family breed readily in our menageries; even the Red River hog (*Potamochœrus penicillatus*), from the sweltering plains of West Africa, has bred twice in the Zoological Gardens. Here also the Peccary (*Dicotyles torquatus*) has bred several times; but another species, the *D. labiatus*, though rendered so tame as to be half-domesticated, is said to breed so rarely in its native country of Paraguay, that according to Rengger[16] the fact requires confirmation. Mr. Bates remarks that the tapir, though often kept tame in Amazonia by the Indians, never breeds.

Ruminants generally breed quite freely in England, though brought from widely different climates, as may be seen in the Annual Reports of the Zoological Gardens, and in the Gleanings from Lord Derby's menagerie.

The Carnivora, with the exception of the Plantigrade division, breed (though with capricious exceptions) about half as freely as ruminants. Many species of Felidae have bred in various menageries, although imported from diverse climates and closely confined. Mr. Bartlett, the present superintendent of the Zoological Gardens[17] remarks that the lion appears to breed more frequently and to bring forth more young at a birth than any other species of the family. He adds that the tiger has rarely bred; "but there are several well-authenticated instances of the female tiger breeding with the lion." Strange as the fact may appear, many animals under confinement unite with distinct species and produce hybrids quite as freely as, or even more freely than, with their own species. On inquiring from Dr. Falconer and others, it appears that the tiger when confined in India does not breed, though it has been known to couple. The chetah (*Felis jubata*) has never been known by Mr. Bartlett to breed in England, but it has bred at Frankfort; nor does it breed in India, where it is kept in large numbers for hunting; but no pains would be taken to make them breed, as only those animals which have hunted for themselves in a state of nature are serviceable and worth training.[18] According to Rengger, two species of wild cats in Paraguay, though thoroughly tamed, have never bred. Although so many of the Felidae breed readily in the Zoological Gardens, yet conception by no means always follows union: in the nine-year Report, various species are specified which were observed to couple seventy-three times, and no doubt this must have passed many times unnoticed; yet from the seventy- three unions only fifteen births ensued. The Carnivora in the Zoological Gardens were formerly less freely exposed to the air and cold than at present, and this change of treatment, as I was assured by the former superintendent, Mr. Miller, greatly increased their fertility. Mr. Bartlett, and there cannot be a more capable judge, says, "it is remarkable that lions breed more freely in travelling collections than in the Zoological Gardens; probably the constant excitement and irritation produced by moving from place to place, or change of air, may have considerable influence in the matter."

Many members of the Dog family breed readily when confined. The Dhole is one of the most untamable animals in India, yet a pair kept there by Dr. Falconer produced young. Foxes, on the other hand, rarely breed, and I have never heard of such an occurrence with the European fox: the silver fox of North America (*Canis argentatus*), however, has bred several times in the Zoological Gardens. Even the otter has bred there. Every one knows how readily the semi-domesticated ferret breeds, though shut up in miserably small cages; but other species of Viverra and Paradoxurus absolutely refuse to breed in the Zoological Gardens. The Genetta has bred both here and in the Jardin des Plantes, and produced hybrids. The *Herpestes fasciatus* has likewise bred; but I was formerly assured that the *H. griseus*, though many were kept in the Gardens, never bred.

The Plantigrade Carnivora breed under confinement much less freely than other Carnivora, although no reason can be assigned for this fact. In the nine-year Report it is stated that the bears had been seen in the Zoological Gardens to couple freely, but previously to 1848 had most rarely conceived. In the Reports published since this date three species have produced young (hybrids in one case), and, wonderful to relate, the white Polar bear has produced young. The badger (*Meles taxus*) has bred several times in the Gardens; but I have not heard of this occurring elsewhere in England, and the event must be very rare, for an instance in Germany has been thought worth recording.[19] In Paraguay the native Nasua, though kept in pairs during many years and perfectly tamed, has never been known, according to Rengger, to breed or show any sexual passion; nor, as I hear from Mr. Bates, does this animal, or the Cercoleptes, breed in Amazonia. Two other plantigrade genera, Procyon and Gulo, though often kept tame in Paraguay, never breed there. In the Zoological Gardens species of Nasua and Procyon have been seen to couple; but they did not produce young.

As domesticated rabbits, guinea-pigs, and white mice breed so abundantly when closely confined under various climates, it might have been thought that most other members of the Rodent order would have bred in captivity, but this is not the case. It deserves notice, as showing how the capacity to breed sometimes goes by affinity, that the one native rodent of Paraguay, which there breeds *freely* and has yielded successive generations, is the *Cavia aperea*; and this animal is so closely allied to the guinea-pig, that it has been erroneously thought to be the parent form.[20] In the Zoological Gardens, some rodents have coupled, but have never produced young; some have neither coupled nor bred; but a few have bred, as the porcupine more than once, the Barbary mouse, lemming, chinchilla, and agouti (*Dasyprocta aguti*) several times. This latter animal has also produced young in Paraguay, though they were born dead and ill-formed; but in Amazonia, according to Mr. Bates, it never breeds, though often kept tame about the houses. Nor does the paca (*Cælogenys paca*) breed there. The common hare when confined has, I believe, never bred in Europe; though, according to a recent statement, it has crossed with the rabbit.[21] I have never heard of the dormouse breeding in confinement. But squirrels offer a more curious case: with one exception, no species has bred in the Zoological Gardens, yet as many as fourteen individuals of *S. palmarum* were kept together during several years. The *S. cinera* has been seen to couple, but it did not produce young; nor has this species, when rendered extremely tame in its native country, North America, been ever known to breed.[22] At Lord Derby's menagerie squirrels of many kinds were kept in numbers, but Mr. Thompson, the superintendent, told me that none had ever bred there, or elsewhere as far as he knew. I have never heard of the English squirrel breeding in confinement. But the species which has bred more than once in the Zoological Gardens is the one which perhaps might have been least expected, namely, the flying squirrel (*Sciuropterus volucella*): it has, also, bred several times near Birmingham; but the female never produced more than two young at a birth, whereas in its native American home she bears from three to six young.[23]

Monkeys, in the nine-year Report from the Zoological Gardens, are stated to unite most freely, but during this period, though many individuals were kept, there were only seven births. I have heard of only one American monkey, the Ouistiti, breeding in Europe.[24] A Macacus, according to Flourens, bred in Paris; and more than one species of this genus has produced young in London, especially the *Macacus rhesus*, which everywhere shows a special capacity to breed under confinement. Hybrids have been produced both in Paris and London from this same genus. The Arabian baboon, or *Cynocephalus hamadryas*,[25] and a Cercopithecus have bred in the Zoological Gardens, and the latter species at the Duke of Northumberland's. Several members of the family of Lemurs have produced hybrids in the Zoological Gardens. It is much more remarkable that monkeys very rarely breed when confined in their native country; thus the Cay (*Cebus azaræ*) is frequently and completely tamed in Paraguay, but Rengger[26] says that it breeds so rarely, that he never saw more than two females which had produced young. A similar observation has been made with respect to the monkeys which are frequently tamed by the aborigines in Brazil.[27] In Amazonia, these animals are so often kept in a tame state, that Mr. Bates in walking through the streets of Para counted thirteen species; but, as he asserts, they have never been known to breed in captivity.[28]

Birds.

Birds offer in some respects better evidence than quadrupeds, from their breeding more rapidly and being kept in greater numbers.[29] We have seen that carnivorous animals are more fertile under confinement than most other mammals. The reverse holds good with carnivorous birds. It is said[30] that as many as eighteen species have been used in Europe for hawking, and several others in Persia and India;[31] they have been kept in their native country in the finest condition, and have been flown during six, eight, or nine years;[32] yet there is no record of their having ever produced young. As these birds were formerly caught whilst young, at great expense, being imported from Iceland, Norway, and Sweden, there can be little doubt that, if possible, they would have been propagated. In the Jardin des Plantes, no bird of prey has been known to couple.[33] No hawk, vulture, or owl has ever produced fertile eggs in the Zoological Gardens, or in the old Surrey Gardens, with the exception, in the former place on one occasion, of a condor and a kite (*Milvus niger*). Yet several species, namely, the *Aquila fusca, Haliaetus leucocephalus, Falco tinnunculus, F. subbuteo,* and *Buteo vulgaris,* have been seen to couple in the Zoological Gardens. Mr. Morris[34] mentions as a unique fact that a kestrel (*Falco tinnunculus*) bred in an aviary. The one kind of owl which has been known to couple in the Zoological Gardens was the Eagle Owl (*Bubo maximus*); and this species shows a special inclination to breed in captivity; for a pair at Arundel Castle, kept more nearly in a state of nature "than ever fell to the lot of an animal deprived of its liberty,"[35] actually reared their young. Mr. Gurney has given another instance of this same owl breeding in confinement; and he records the case of a second species of owl, the *Strix passerina,* breeding in captivity.[36]

Of the smaller graminivorous birds, many kinds have been kept tame in their native countries, and have lived long; yet, as the highest authority on cage-birds[37] remarks, their propagation is "uncommonly difficult." The canary-bird shows that there is no inherent difficulty in these birds breeding freely in confinement; and Audubon says[38] that the *Fringilla (Spiza) ciris* of North America breeds as perfectly as the canary. The difficulty with the many finches which have been kept in confinement is all the more remarkable as more than a dozen species could be named which have yielded hybrids with the canary; but hardly any of these, with the exception of the siskin (*Fringilla spinus*), have reproduced their own kind. Even the bullfinch (*Loxia pyrrhula*) has bred as frequently with the canary, though belonging to a distinct genus, as with its own species.[39] With respect to the skylark (*Alauda arvensis*), I have heard of birds living for seven years in an aviary, which never produced young; and a great London bird-fancier assured me that he had never known an instance of their breeding; nevertheless one case has been recorded.[40] In the nine-year Report from the Zoological Society, twenty-four insessorial species are enumerated which had not bred, and of these only four were known to have coupled.

Parrots are singularly long-lived birds; and Humboldt mentions the curious fact of a parrot in South America, which spoke the language of an extinct Indian tribe, so that this bird preserved the sole relic of a lost language. Even in this country there is reason to believe[41] that parrots have lived to the age of nearly one hundred years; yet they breed so rarely, though many have been kept in Europe, that the event has been thought worth recording in the gravest publications.[42] Nevertheless, when Mr. Buxton turned out a large number of parrots in Norfolk, three pairs bred and reared ten young birds in the course of two seasons; and this success may be attributed to their free life.[43] According to Bechstein[44] the African *Psittacus erithacus* breeds oftener than any other species in Germany: the *P. macoa* occasionally lays fertile eggs, but rarely succeeds in hatching them; this bird, however, has the instinct of incubation sometimes so strongly developed, that it will hatch the eggs of fowls or pigeons. In the Zoological Gardens and in the old Surrey Gardens some few species have coupled, but, with the exception of three species of parakeets, none have bred. It is a much more remarkable fact that in Guiana parrots of two kinds, as I am informed by Sir R. Schomburgk, are often taken from the nests by the Indians and reared in large numbers; they are so tame that they fly freely about the houses, and come when called to be fed, like pigeons; yet he has never heard of a single instance of their breeding.[45] In Jamaica, a resident naturalist, Mr. R. Hill,[46] says, "no birds more readily submit to human dependence than the parrot-tribe, but no instance of a parrot breeding in this tame life has been known yet." Mr. Hill specifies a number of other native birds kept tame in the West Indies, which never breed in this state.

The great pigeon family offers a striking contrast with the parrots: in the nine-year Report thirteen species are recorded as having bred, and, what is more noticeable, only two were seen to couple without any result. Since the above date every annual Report gives many cases of various pigeons breeding. The two magnificent crowned pigeons (*Goura coronata* and *victoriæ*) produced hybrids; nevertheless, of the former species more than a dozen birds were kept, as I am informed by Mr. Crawfurd, in a park at Penang, under a perfectly well-adapted climate, but never once bred. The *Columba migratoria* in its native country, North America, invariably lays two eggs, but in Lord Derby's menagerie never more than one. The same fact has been observed with the *C. leucocephala*.[47]

Gallinaceous birds of many genera likewise show an eminent capacity for breeding under captivity. This is particularly the case with pheasants, yet our English species seldom lays more than ten eggs in confinement; whilst from eighteen to twenty is the usual number in the wild state.[48] With the Gallinaceæ, as with all other orders, there are marked and inexplicable exceptions in regard to the fertility of certain species and genera under confinement. Although many trials have been made with the common partridge, it has rarely bred, even when reared in large aviaries; and the hen will never hatch her own eggs.[49] The American tribe of Guans or Cracidæ are tamed with remarkable ease, but are very shy breeders in this country;[50] but with care various species were formerly made to breed rather freely in Holland.[51] Birds of this tribe are often kept in a perfectly tamed condition in their native country by the Indians, but they never breed.[52] It might have been expected that grouse from their habits of life would not have bred in captivity, more especially as they are said soon to languish and die.[53] But many cases are recorded of their breeding: the capercailzie (*Tetrao urogallus*) has bred in the Zoological Gardens; it breeds without much difficulty when confined in Norway, and in Russia five successive generations have been reared: *Tetrao tetrix* has likewise bred in Norway; *T. scoticus* in Ireland; *T. umbellus* at Lord Derby's; and *T. cupido* in North America.

It is scarcely possible to imagine a greater change in habits than that which the members of the ostrich family must suffer, when cooped up in small enclosures under a temperate climate, after freely roaming over desert and tropical plains or entangled forests; yet almost all the kinds have frequently produced young in the various European menageries, even the mooruk (*Casuarius bennetii*) from New Ireland. The African ostrich, though perfectly healthy and living long in the South of France, never lays more than from twelve to fifteen eggs, though in its native country it lays from twenty-five to thirty.[54] Here we have another instance of fertility impaired, but not lost, under confinement, as with the flying squirrel, the hen-pheasant, and two species of American pigeons.

Most Waders can be tamed, as the Rev. E. S. Dixon informs me, with remarkable facility; but several of them are short-lived under confinement, so that their sterility in this state is not surprising. The cranes breed more readily than other genera: *Grus montigresia* has bred several times in Paris and in the Zoological Gardens, as has *G. cinerea* at the latter place, and *G. antigone* at Calcutta. Of other members of this great order, *Tetrapteryx paradisea* has bred at Knowsley, a Porphyrio in Sicily, and the *Gallinula chloropus* in the Zoological Gardens. On the other hand, several birds belonging to this order will not breed in their native country, Jamaica; and the Psophia, though often kept by the Indians of Guiana about their houses, "is seldom or never known to breed."[55]

The members of the great Duck family breed as readily in confinement as do the Columbæ and Gallinæ and this, considering their aquatic and wandering habits, and the nature of their food, could not have been anticipated. Even some time ago above two dozen species had bred in the Zoological Gardens; and M. Selys-Longchamps has recorded the production of hybrids from forty-four different members of the family; and to these Professor Newton has added a few more cases.[56] "There is not," says Mr. Dixon,[57] "in the wide world, a goose which is not in the strict sense of the word domesticable;" that is, capable of breeding under confinement; but this statement is probably too bold. The capacity to breed sometimes varies in individuals of the same species; thus Audubon[58] kept for more than eight years some wild geese (*Anser canadensis*), but they would not mate; whilst other individuals of the same species produced young during the second year. I know of but one instance in the whole family of a species which absolutely refuses to breed in captivity, namely, the *Dendrocygna viduata,* although, according to Sir R. Schomburgk,[59] it is easily tamed, and is frequently kept by the Indians of Guiana. Lastly, with respect to Gulls, though many have been kept in the Zoological Gardens and in the old Surrey Gardens, no instance was known before the year 1848 of their coupling or breeding; but since that period the herring gull (*Larus argentatus*) has bred many times in the Zoological Gardens and at Knowsley.

There is reason to believe that insects are affected by confinement like the higher animals. It is well known that the Sphingidae rarely breed when thus treated. An entomologist[60] in Paris kept twenty-five specimens of *Saturnia pyri,* but did not succeed in getting a single fertile egg. A number of females of *Orthosia munda* and of *Mamestra suasa* reared in confinement were unattractive to the males.[61] Mr. Newport kept nearly a hundred individuals of two species of Vanessa, but not one paired; this, however, might have been due to their habit of coupling on the wing.[62] Mr. Atkinson could never succeed in India in making the Tarroo silk-moth breed in confinement.[63] It appears that a number of moths, especially the Sphingidae, when hatched in the autumn out of their proper season, are completely barren; but this latter case is still involved in some obscurity.[64]

Independently of the fact of many animals under confinement not coupling, or, if they couple, not producing young, there is evidence of another kind that their sexual functions are disturbed. For many cases have been recorded of the loss by male birds when confined of their characteristic plumage. Thus the common linnet (*Linota cannabina*) when caged does not acquire the fine crimson colour on its breast, and one of the buntings (*Emberiza passerina*) loses the black on its head. A Pyrrhula and an Oriolus have been observed to assume the quiet plumage of the hen-bird; and the *Falco albidus* returned to the dress of an earlier age.[65] Mr. Thompson, the superintendent of the Knowsley menagerie, informed me that he had often observed analogous facts. The horns of a male deer (*Cervus canadensis*) during the voyage from America were badly developed; but subsequently in Paris perfect horns were produced.

When conception takes place under confinement, the young are often born dead, or die soon, or are ill-formed. This frequently occurs in the Zoological Gardens, and, according to Rengger, with native animals confined in Paraguay. The mother’s milk often fails. We may also attribute to the disturbance of the sexual functions the frequent occurrence of that monstrous instinct which leads the mother to devour her own offspring,—a mysterious case of perversion, as it at first appears.

Sufficient evidence has now been advanced to prove that animals when first confined are eminently liable to suffer in their reproductive systems. We feel at first naturally inclined to attribute the result to loss of health, or at least to loss of vigour; but this view can hardly be admitted when we reflect how healthy, long-lived, and vigorous many animals are under captivity, such as parrots, and hawks when used for hawking, cheetahs when used for hunting, and elephants. The reproductive organs themselves are not diseased; and the diseases, from which animals in menageries usually perish, are not those which in any way affect their fertility. No domestic animal is more subject to disease than the sheep, yet it is remarkably prolific. The failure of animals to breed under confinement has been sometimes attributed exclusively to a failure in their sexual instincts: this may occasionally come into play, but there is no obvious reason why this instinct should be especially liable to be affected with perfectly tamed animals, except, indeed, indirectly through the reproductive system itself being disturbed. Moreover, numerous cases have been given of various animals which couple freely under confinement, but never conceive; or, if they conceive and produce young, these are fewer in number than is natural to the species. In the vegetable kingdom instinct of course can play no part; and we shall presently see that plants when removed from their natural conditions are affected in nearly the same manner as animals. Change of climate cannot be the cause of the loss of fertility, for, whilst many animals imported into Europe from extremely different climates breed freely, many others when confined in their native land are completely sterile. Change of food cannot be the chief cause; for ostriches, ducks, and many other animals, which must have undergone a great change in this respect, breed freely. Carnivorous birds when confined are extremely sterile, whilst most carnivorous mammals, except plantigrades, are moderately fertile. Nor can the amount of food be the cause; for a sufficient supply will certainly be given to valuable animals; and there is no reason to suppose that much more food would be given to them than to our choice domestic productions which retain their full fertility. Lastly, we may infer from the case of the elephant, cheetah, various hawks, and of many animals which are allowed to lead an almost free life in their native land, that want of exercise is not the sole cause.

It would appear that any change in the habits of life, whatever these habits may be, if great enough, tends to affect in an inexplicable manner the powers of reproduction. The result depends more on the constitution of the species than on the nature of the change; for certain whole groups are affected more than others; but exceptions always occur, for some species in the most fertile groups refuse to breed, and some in the most sterile groups breed freely. Those animals which usually breed freely under confinement, rarely breed, as I was assured, in the Zoological Gardens, within a year or two after their first importation. When an animal which is generally sterile under confinement happens to breed, the young apparently do not inherit this power: for had this been the case, various quadrupeds and birds, which are valuable for exhibition, would have become common. Dr. Broca even affirms[66] that many animals in the Jardin des Plantes, after having produced young for three or four successive generations, become sterile; but this may be the result of too close interbreeding. It is a remarkable circumstance that many mammals and birds have produced hybrids under confinement quite as readily as, or even more readily than, they have procreated their own kind. Of this fact many instances have been given;[67] and we are thus reminded of those plants which when cultivated refuse to be fertilised by their own pollen, but can easily be fertilised by that of a distinct species. Finally, we must conclude, limited as the conclusion is, that changed conditions of life have an especial power of acting injuriously on the reproductive system. The whole case is quite peculiar, for these organs, though not diseased, are thus rendered incapable of performing their proper functions, or perform them imperfectly.

Sterility of Domesticated Animals from changed conditions.—With respect to domesticated animals, as their domestication mainly depends on the accident of their breeding freely under captivity, we ought not to expect that their reproductive system would be affected by any moderate degree of change. Those orders of quadrupeds and birds, of which the wild species breed most readily in our menageries, have afforded us the greatest number of domesticated productions. Savages in most parts of the world are fond of taming animals;[68] and if any of these regularly produced young, and were at the same time useful, they would be at once domesticated. If, when their masters migrated into other countries, they were in addition found capable of withstanding various climates, they would be still more valuable; and it appears that the animals which breed readily in captivity can generally withstand different climates. Some few domesticated animals, such as the reindeer and camel, offer an exception to this rule. Many of our domesticated animals can bear with undiminished fertility the most unnatural conditions; for instance, rabbits, guinea-pigs, and ferrets breed in miserably confined hutches. Few European dogs of any kind withstand the climate of India without degenerating, but as long as they survive, they retain, as I hear from Dr. Falconer, their fertility; so it is, according to Dr. Daniell, with English dogs taken to Sierra Leone. The fowl, a native of the hot jungles of India, becomes more fertile than its parent-stock in every quarter of the world, until we advance as far north as Greenland and Northern Siberia, where this bird will not breed. Both fowls and pigeons, which I received during the autumn direct from Sierra Leone, were at once ready to couple.[69] I have, also, seen pigeons breeding as freely as the common kinds within a year after their importation from the upper Nile. The guinea- fowl, an aboriginal of the hot and dry deserts of Africa, whilst living under our damp and cool climate, produces a large supply of eggs.

Nevertheless, our domesticated animals under new conditions occasionally show signs of lessened fertility. Roulin asserts that in the hot valleys of the equatorial Cordillera sheep are not fully fecund;[70] and according to Lord Somerville[71] the merino-sheep which he imported from Spain were not at first perfectly fertile, it is said[72] that mares brought up on dry food in the stable, and turned out to grass, do not at first breed. The peahen, as we have seen, is said not to lay so many eggs in England as in India. It was long before the canary-bird was fully fertile, and even now first-rate breeding birds are not common.[73] In the hot and dry province of Delhi, as I hear from Dr. Falconer, the eggs of the turkey, though placed under a hen, are extremely liable to fail. According to Roulin, geese taken to the lofty plateau of Bogota, at first laid seldom, and then only a few eggs; of these scarcely a fourth were hatched, and half the young birds died; in the second generation they were more fertile; and when Roulin wrote they were becoming as fertile as our geese in Europe. With respect to the valley of Quito, Mr.

Orton says[74] "the only geese in the valley are a few imported from Europe, and these refuse to propagate." In the Philippine Archipelago the goose, it is asserted, will not breed or even lay eggs.[75] A more curious case is that of the fowl, which, according to Roulin, when first introduced would not breed at Cusco in Bolivia, but subsequently became quite fertile; and the English Game fowl, lately introduced, had not as yet arrived at its full fertility, for to raise two or three chickens from a nest of eggs was thought fortunate. In Europe close confinement has a marked effect on the fertility of the fowl: it has been found in France that with fowls allowed considerable freedom only twenty per cent of the eggs failed; when allowed less freedom forty per cent failed; and in close confinement sixty out of the hundred were not hatched.[76] So we see that unnatural and changed conditions of life produce some effect on the fertility of our most thoroughly domesticated animals, in the same manner, though in a far less degree, as with captive wild animals.

It is by no means rare to find certain males and females which will not breed together, though both are known to be perfectly fertile with other males and females. We have no reason to suppose that this is caused by these animals having been subjected to any change in their habits of life; therefore such cases are hardly related to our present subject. The cause apparently lies in an innate sexual incompatibility of the pair which are matched. Several instances have been communicated to me by Mr. W. C. Spooner (well known for his essay on Cross-breeding), by Mr. Eyton of Eyton, by Mr. Wicksted and other breeders, and especially by Mr. Waring of Chelsfield, in relation to horses, cattle, pigs, foxhounds, other dogs, and pigeons.[77] In these cases, females, which either previously or subsequently were proved to be fertile, failed to breed with certain males, with whom it was particularly desired to match them. A change in the constitution of the female may sometimes have occurred before she was put to the second male; but in other cases this explanation is hardly tenable, for a female, known not to be barren, has been unsuccessfully paired seven or eight times with the same male likewise known to be perfectly fertile. With cart-mares, which sometimes will not breed with stallions of pure blood, but subsequently have bred with cart-stallions, Mr. Spooner is inclined to attribute the failure to the lesser sexual power of the racehorse. But I have heard from the greatest breeder of racehorses at the present day, through Mr. Waring, that "it frequently occurs with a mare to be put several times during one or two seasons to a particular stallion of acknowledged power, and yet prove barren; the mare afterwards breeding at once with some other horse." These facts are worth recording, as they show, like so many previous facts, on what slight constitutional differences the fertility of an animal often depends.

Sterility of Plants from changed Conditions of Life, and from other causes.

In the vegetable kingdom cases of sterility frequently occur, analogous with those previously given in the animal kingdom. But the subject is obscured by several circumstances, presently to be discussed, namely, the contabescence of the anthers, as

Gärtner has named a certain affection—monstrosities—doubleness of the flower—much-enlarged fruit—and long-continued or excessive propagation by buds.

It is notorious that many plants in our gardens and hot-houses, though preserved in the most perfect health, rarely or never produce seed. I do not allude to plants which run to leaves, from being kept too damp, or too warm, or too much manured; for these do not flower, and the case may be wholly different. Nor do I allude to fruit not ripening from want of heat or rotting from too much moisture. But many exotic plants, with their ovules and pollen appearing perfectly sound, will not set any seed. The sterility in many cases, as I know from my own observation, is simply due to the absence of the proper insects for carrying the pollen to the stigma. But after excluding the several cases just specified, there are many plants in which the reproductive system has been seriously affected by the altered conditions of life to which they have been subjected.

It would be tedious to enter on many details. Linnæus long ago observed[78] that Alpine plants, although naturally loaded with seed, produce either few or none when cultivated in gardens. But exceptions often occur: the *Draba sylvestris,* one of our most thoroughly Alpine plants, multiplies itself by seed in Mr. H. C. Watson's garden, near London; and Kerner, who has particularly attended to the cultivation of Alpine plants, found that various kinds, when cultivated, spontaneously sowed themselves.[79] Many plants which naturally grow in peat-earth are entirely sterile in our gardens. I have noticed the same fact with several liliaceous plants, which nevertheless grew vigorously.

Too much manure renders some kinds utterly sterile, as I have myself observed. The tendency to sterility from this cause runs in families; thus, according to Gärtner,[80] it is hardly possible to give too much manure to most Gramineæ, Cruciferæ, and Leguminosæ, whilst succulent and bulbous-rooted plants are easily affected. Extreme poverty of soil is less apt to induce sterility; but dwarfed plants of *Trifolium minus* and *repens,* growing on a lawn often mown and never manured, were found by me not to produce any seed. The temperature of the soil, and the season at which plants are watered, often have a marked effect on their fertility, as was observed by Kölreuter in the case of Mirabilis.[81] Mr. Scott, in the Botanic Gardens of Edinburgh, observed that *Oncidium divaricatum* would not set seed when grown in a basket in which it throve, but was capable of fertilisation in a pot where it was a little damper. *Pelargonium fulgidum,* for many years after its introduction, seeded freely; it then became sterile; now it is fertile[82] if kept in a dry stove during the winter. Other varieties of pelargonium are sterile and others fertile without our being able to assign any cause. Very slight changes in the position of a plant, whether planted on a bank or at its base, sometimes make all the difference in its producing seed. Temperature apparently has a much more powerful influence on the fertility of plants than on that of animals. Nevertheless it is wonderful what changes some few plants will withstand with undiminished fertility: thus the *Zephyranthes candida,* a native of the moderately warm banks of the Plata, sows itself in the hot dry country near Lima, and in Yorkshire resists the severest frosts, and I have seen seeds gathered from pods which had been covered with snow during three weeks.[83] *Berberis wallichii*, from the hot Khasia range in India, is uninjured by our sharpest frosts, and ripens its fruit under our cool summers. Nevertheless, I presume we must attribute to change of climate the sterility of many foreign plants; thus, the Persian and Chinese lilacs (*Syringa persica* and *chinensis*), though perfectly hardy here, never produce a seed; the common lilac (*S. vulgaris*) seeds with us moderately well, but in parts of Germany the capsules never contain seed.[84] Some few of the cases, given in the last chapter, of self-impotent plants, might have been here introduced, as their state seems due to the conditions to which they have been subjected.

The liability of plants to be affected in their fertility by slightly changed conditions is the more remarkable, as the pollen when once in process of formation is not easily injured; a plant may be transplanted, or a branch with flower-buds be cut off and placed in water, and the pollen will be matured. Pollen, also, when once mature, may be kept for weeks or even months.[85] The female organs are more sensitive, for Gärtner[86] found that dicotyledonous plants, when carefully removed so that they did not in the least flag, could seldom be fertilised; this occurred even with potted plants if the roots had grown out of the hole at the bottom. In some few cases, however, as with Digitalis, transplantation did not prevent fertilisation; and according to the testimony of Mawz, *Brassica rapa*, when pulled up by its roots and placed in water, ripened its seed. Flower-stems of several monocotyledonous plants when cut off and placed in water likewise produce seed. But in these cases I presume that the flowers had been already fertilised, for Herbert[87] found with the Crocus that the plants might be removed or mutilated after the act of fertilisation, and would still perfect their seeds; but that, if transplanted before being fertilised, the application of pollen was powerless.

Plants which have been long cultivated can generally endure with undiminished fertility various and great changes; but not in most cases so great a change of climate as domesticated animals. It is remarkable that many plants under these circumstances are so much affected that the proportion and the nature of their chemical ingredients are modified, yet their fertility is unimpaired. Thus, as Dr. Falconer informs me, there is a great difference in the character of the fibre in hemp, in the quantity of oil in the seed of the Linum, in the proportion of narcotin to morphine in the poppy, in gluten to starch in wheat, when these plants are cultivated on the plains and on the mountains of India; nevertheless, they all remain fully fertile.

Contabescence.—Gärtner has designated by this term a peculiar condition of the anthers in certain plants, in which they are shrivelled, or become brown and tough, and contain no good pollen. When in this state they exactly resemble the anthers of the most sterile hybrids. Gärtner,[88] in his discussion on this subject, has shown that plants of many orders are occasionally thus affected; but the Caryophyllaceæ and Liliaceæ suffer most, and to these orders, I think, the Ericaceæ may be added. Contabescence varies in degree, but on the same plant all the flowers are generally affected to nearly the same extent. The anthers are affected at a very early period in the flower-bud, and remain in the same state (with one recorded exception) during the life of the plant. The affection cannot be cured by any change of treatment, and is propagated by layers, cuttings, etc., and perhaps even by seed. In contabescent plants the female organs are seldom affected, or merely become precocious in their development. The cause of this affection is doubtful, and is different in different cases. Until I read Gärtner's discussion I attributed it, as apparently did Herbert, to the unnatural treatment of the plants; but its permanence under changed conditions, and the female organs not being affected, seem incompatible with this view. The fact of several endemic plants becoming contabescent in our gardens seems, at first sight, equally incompatible with this view; but Kölreuter believes that this is the result of their transplantation. The contabescent plants of Dianthus and Verbascum, found wild by Wiegmann, grew on a dry and sterile bank. The fact that exotic plants are eminently liable to this affection also seems to show that it is in some manner caused by their unnatural treatment. In some instances, as with Silene, Gärtner's view seems the most probable, namely, that it is caused by an inherent tendency in the species to become dioecious. I can add another cause, namely, the illegitimate unions of heterostyled plants, for I have observed seedlings of three species of Primula and of *Lythrum salicaria*, which had been raised from plants illegitimately fertilised by their own-form pollen, with some or all their anthers in a contabescent state. There is perhaps an additional cause, namely, self-fertilisation; for many plants of Dianthus and Lobelia, which had been raised from self-fertilised seeds, had their anthers in this state; but these instances are not conclusive, as both genera are liable from other causes to this affection.

Cases of an opposite nature likewise occur, namely, plants with the female organs struck with sterility, whilst the male organs remain perfect. *Dianthus japonicus*, a Passiflora, and Nicotiana, have been described by Gärtner[89] as being in this unusual condition.

Monstrosities as a cause of sterility.—Great deviations of structure, even when the reproductive organs themselves are not seriously affected, sometimes cause plants to become sterile. But in other cases plants may become monstrous to an extreme degree and yet retain their full fertility. Gallesio, who certainly had great experience,[90] often attributes sterility to this cause; but it may be suspected that in some of his cases sterility was the cause, and not the result, of the monstrous growths. The curious St. Valery apple, although it bears fruit, rarely produces seed. The wonderfully anomalous flowers of *Begonia frigida*, formerly described, though they appear fit for fructification, are sterile.[91] Species of Primula in which the calyx is brightly coloured are said[92] to be often sterile, though I have known them to be fertile. On the other hand, Verlot gives several cases of proliferous flowers which can be propagated by seed. This was the case with a poppy, which had become monopetalous by the union of its petals.[93] Another extraordinary poppy, with the stamens replaced by numerous small supplementary capsules, likewise reproduces itself by seed. This has also occurred with a plant of *Saxifraga geum,* in which a series of adventitious carpels, bearing ovules on their margins, had been developed between the stamens and the normal carpels[94] Lastly, with respect to peloric flowers, which depart wonderfully from the natural structure,—those of *Linaria vulgaris* seem generally to be more or less sterile, whilst those before described of *Antirrhinum majus,* when artificially fertilised with their own pollen, are perfectly fertile, though sterile when left to themselves, for bees are unable to crawl into the narrow tubular flower. The peloric flowers of *Corydalis solida,* according to Godron,[95] are sometimes barren and sometimes fertile; whilst those of Gloxinia are well known to yield plenty of seed. In our greenhouse Pelargoniums, the central flower of the truss is often peloric, and Mr. Masters informs me that he tried in vain during several years to get seed from these flowers. I likewise made many vain attempts, but sometimes succeeded in fertilising them with pollen from a normal flower of another variety; and conversely I several times fertilised ordinary flowers with peloric pollen. Only once I succeeded in raising a plant from a peloric flower fertilised by pollen from a peloric flower borne by another variety; but the plant, it may be added, presented nothing particular in its structure. Hence we may conclude that no general rule can be laid down; but any great deviation from the normal structure, even when the reproductive organs themselves are not seriously affected, certainly often leads to sexual impotence.

Double Flowers.—When the stamens are converted into petals, the plant becomes on the male side sterile; when both stamens and pistils are thus changed, the plant becomes completely barren. Symmetrical flowers having numerous stamens and petals are the most liable to become double, as perhaps follows from all multiple organs being the most subject to variability. But flowers furnished with only a few stamens, and others which are asymmetrical in structure, sometimes become double, as we see with the double gorse or Ulex, and Antirrhinum. The Compositæ bear what are called double flowers by the abnormal development of the corolla of their central florets. Doubleness is sometimes connected with prolification,[96] or the continued growth of the axis of the flower. Doubleness is strongly inherited. No one has produced, as Lindley remarks,[97] double flowers by promoting the perfect health of the plant. On the contrary, unnatural conditions of life favour their production. There is some reason to believe that seeds kept during many years, and seeds believed to be imperfectly fertilised, yield double flowers more freely than fresh and perfectly fertilised seed.[98] Long-continued cultivation in rich soil seems to be the commonest exciting cause. A double narcissus and a double *Anthemis nobilis,* transplanted into very poor soil, has been observed to become single;[99] and I have seen a completely double white primrose rendered permanently single by being divided and transplanted whilst in full flower. It has been observed by Professor E. Morren that doubleness of the flowers and variegation of the leaves are antagonistic states; but so many exceptions to the rule have lately been recorded,[100] that, though general, it cannot be looked at as invariable. Variegation seems generally to result from a feeble or atrophied condition of the plant, and a large proportion of the seedlings raised from parents, if both are variegated, usually perish at an early age; hence we may perhaps infer that doubleness, which is the antagonistic state, commonly arises from a plethoric condition. On the other hand, extremely poor soil sometimes, though rarely, appears to cause doubleness: I formerly described[101] some completely double, bud-like, flowers produced in large numbers by stunted wild plants of *Gentiana amarella* growing on a poor chalky bank. I have also noticed a distinct tendency to doubleness in the flowers of a Ranunculus, Horse-chestnut, and Bladder-nut (*Ranunculus repens*, *Aesculus pavia*, and *Staphylea*), growing under very unfavourable conditions. Professor Lehmann[102] found several wild plants growing near a hot spring with double flowers. With respect to the cause of doubleness, which arises, as we see, under widely different circumstances, I shall presently attempt to show that the most probable view is that unnatural conditions first give a tendency to sterility, and that then, on the principle of compensation, as the reproductive organs do not perform their proper functions, they either become developed into petals, or additional petals are formed. This view has lately been supported by Mr. Laxton[103] who advances the case of some common peas, which, after long-continued heavy rain, flowered a second time, and produced double flowers.

Seedless Fruit.—Many of our most valuable fruits, although consisting in a homological sense of widely different organs, are either quite sterile, or produce extremely few seeds. This is notoriously the case with our best pears, grapes, and figs, with the pine-apple, banana, bread-fruit, pomegranate, azarole, date-palms, and some members of the orange-tribe. Poorer varieties of these same fruits either habitually or occasionally yield seed.[104] Most horticulturists look at the great size and anomalous development of the fruit as the cause, and sterility as the result; but the opposite view, as we shall presently see, is more probable.

Sterility from the excessive development of the organs of Growth or Vegetation.—Plants which from any cause grow too luxuriantly, and produce leaves, stems, runners, suckers, tubers, bulbs, etc., in excess, sometimes do not flower, or if they flower do not yield seed. To make European vegetables under the hot climate of India yield seed, it is necessary to check their growth; and, when one-third grown, they are taken up, and their stems and tap-roots are cut or mutilated.[105] So it is with hybrids; for instance, Prof. Lecoq[106] had three plants of Mirabilis, which, though they grew luxuriantly and flowered, were quite sterile; but after beating one with a stick until a few branches alone were left, these at once yielded good seed. The sugar-cane, which grows vigorously and produces a large supply of succulent stems, never, according to various observers, bears seed in the West Indies, Malaga, India, Cochin China, Mauritius, or the Malay Archipelago.[107] Plants which produce a large number of tubers are apt to be sterile, as occurs, to a certain extent, with the common potato; and Mr. Fortune informs me that the sweet potato (*Convolvulus batatas*) in China never, as far as he has seen, yields seed. Dr. Royle remarks[108] that in India the *Agave vivipara*, when grown in rich soil, invariably produces bulbs, but no seeds; whilst a poor soil and dry climate lead to an opposite result. In China, according to Mr. Fortune, an extraordinary number of little bulbs are developed in the axils of the leaves of the yam, and this plant does not bear seed. Whether in these cases, as in those of double flowers and seedless fruit, sexual sterility from changed conditions of life is the primary cause which leads to the excessive development of the organs of vegetation, is doubtful; though some evidence might be advanced in favour of this view. It is perhaps a more probable view that plants which propagate themselves largely by one method, namely by buds, have not sufficient vital power or organised matter for the other method of sexual generation.

Several distinguished botanists and good practical judges believe that long- continued propagation by cuttings, runners, tubers, bulbs, etc., independently of any excessive development of these parts, is the cause of many plants failing to produce flowers, or producing only barren flowers,—it is as if they had lost the habit of sexual generation.[109] That many plants when thus propagated are sterile there can be no doubt, but as to whether the long continuance of this form of propagation is the actual cause of their sterility, I will not venture, from the want of sufficient evidence, to express an opinion.

That plants may be propagated for long periods by buds, without the aid of sexual generation, we may safely infer from this being the case with many plants which must have long survived in a state of nature. As I have had occasion before to allude to this subject, I will here give such cases as I have collected. Many alpine plants ascend mountains beyond the height at which they can produce seed.[110] Certain species of Poa and Festuca, when growing on mountain-pastures, propagate themselves, as I hear from Mr. Bentham, almost exclusively by bulblets. Kalm gives a more curious instance[111] of several American trees, which grow so plentifully in marshes or in thick woods, that they are certainly well adapted for these stations, yet scarcely ever produce seeds; but when accidentally growing on the outside of the marsh or wood, are loaded with seed. The common ivy is found in Northern Sweden and Russia, but flowers and fruits only in the southern provinces. The *Acorus calamus* extends over a large portion of the globe, but so rarely perfects fruit that this has been seen only by a few botanists; according to Caspary, all its pollen-grains are in a worthless condition.[112] The *Hypericum calycinum*, which propagates itself so freely in our shrubberies by rhizomes, and is naturalised in Ireland, blossoms profusely, but rarely sets any seed, and this only during certain years; nor did it set any when fertilised in my garden by pollen from plants growing at a distance. The *Lysimachia nummularia*, which is furnished with long runners, so seldom produces seed-capsules, that Prof. Decaisne,[113] who has especially attended to this plant, has never seen it in fruit. The *Carex rigida* often fails to perfect its seed in Scotland, Lapland, Greenland, Germany, and New Hampshire in the United States.[114] The periwinkle (*Vinca minor*), which spreads largely by runners, is said scarcely ever to produce fruit in England;[115] but this plant requires insect-aid for its fertilisation, and the proper insects may be absent or rare. The Jussiaea grandiflora has become naturalised in Southern France, and has spread by its rhizomes so extensively as to impede the navigation of the waters, but never produces fertile seed.[116] The horse-radish (*Cochleria armoracia*) spreads pertinaciously and is naturalised in various parts of Europe; though it bears flowers, these rarely produce capsules: Professor Caspary informs me that he has watched this plant since 1851, but has never seen its fruit; 65 per cent of its pollen-grains are bad. The common *Ranunculus ficaria* rarely bears seed in England, France, or Switzerland; but in 1863 I observed seeds on several plants growing near my house.[117] Other cases analogous with the foregoing could be given; for instance, some kinds of mosses and lichens have never been seen to fructify in France.

Some of these endemic and naturalised plants are probably rendered sterile from excessive multiplication by buds, and their consequent incapacity to produce and nourish seed. But the sterility of others more probably depends on the peculiar conditions under which they live, as in the case of the ivy in the northern part of Europe, and of the trees in the swamps of the United States; yet these plants must be in some respects eminently well adapted for the stations which they occupy, for they hold their places against a host of competitors.

Finally, the high degree of sterility which often accompanies the doubling of flowers, or an excessive development of fruit, seldom supervenes at once. An incipient tendency is observed, and continued selection completes the result. The view which seems the most probable, and which connects together all the foregoing facts and brings them within our present subject, is, that changed and unnatural conditions of life first give a tendency to sterility; and in consequence of this, the organs of reproduction being no longer able fully to perform their proper functions, a supply of organised matter, not required for the development of the seed, flows either into these organs and renders them foliaceous, or into the fruit, stems, tubers, etc., increasing their size and succulency. But it is probable that there exists, independently of any incipient sterility, an antagonism between the two forms of reproduction, namely, by seed and buds, when either is carried to an extreme degree. That incipient sterility plays an important part in the doubling of flowers, and in the other cases just specified, I infer chiefly from the following facts. When fertility is lost from a wholly different cause, namely, from hybridism, there is a strong tendency, as Gärtner[118] affirms, for flowers to become double, and this tendency is inherited. Moreover, it is notorious that with hybrids the male organs become sterile before the female organs, and with double flowers the stamens first become foliaceous. This latter fact is well shown by the male flowers of dioecious plants, which, according to Gallesio[119] first become double. Again, Gärtner[120] often insists that the flowers of even utterly sterile hybrids, which do not produce any seed, generally yield perfect capsules or fruit,—a fact which has likewise been repeatedly observed by Naudin with the Cucurbitaceæ; so that the production of fruit by plants rendered sterile through any cause is intelligible. Kölreuter has also expressed his unbounded astonishment at the size and development of the tubers in certain hybrids; and all experimentalists[121] have remarked on the strong tendency in hybrids to increase by roots, runners, and suckers. Seeing that hybrid plants, which from their nature are more or less sterile, thus tend to produce double flowers; that they have the parts including the seed, that is the fruit, perfectly developed, even when containing no seed; that they sometimes yield gigantic roots; that they almost invariably tend to increase largely by suckers and other such means;—seeing this, and knowing, from the many facts given in the earlier parts of this chapter, that almost all organic beings when exposed to unnatural conditions tend to become more or less sterile, it seems much the most probable view that with cultivated plants sterility is the exciting cause, and double flowers, rich seedless fruit, and in some cases largely-developed organs of vegetation, etc., are the indirect results—these results having been in most cases largely increased through continued selection by man.

REFERENCES

[1] For England, *see* below. For Germany, *see* Metzger, 'Getreidearten,' 1841, s. 63. For France, Loiseleur-Deslongchamps ('Consid. sur les Céréales,' 1843, p. 200) gives numerous references on this subject. For Southern France, *see* Godron, 'Florula Juvenalis,' 1854, p. 28.

[2] 'A General Treatise of Husbandry,' vol. 3 p. 58.

[3] 'Gardener's Chronicle and Agricult. Gazette,' 1858, p. 247; and for the second statement, Ibid., 1850, p. 702. On this same subject *see also* Rev. D. Walker's 'Prize Essay of Highland Agricult. Soc.' vol. ii. p. 200. Also Marshall 'Minutes of Agriculture,' November, 1775.

[4] Oberlin's 'Memoirs,' Eng. translat., p. 73. For Lancashire *see* Marshall's 'Review of Reports,' 1808, p. 295.

[5] 'Cottage Gardener,' 1856, p. 186. For Mr. Robson's subsequent statements, *see* 'Journal of Horticulture,' Feb. 18, 1866, p. 121. For Mr. Abbey's remarks on grafting, etc., Ibid., July 18, 1865, p. 44.

[6] 'Mém. de l'Acad. des Sciences,' 1790, p. 209.

[7] 'On the Varieties of Wheat,' p. 52.

[8] Mr. Spencer has fully and ably discussed this whole subject in his 'Principles of Biology,' 1864, vol. ii. ch. x. In the first edition of my 'Origin of Species,' 1859, p. 267, I spoke of the good effects from slight changes in the conditions of life and from cross-breeding, and of the evil effects from great changes in the conditions and from crossing widely distinct forms, as a series of facts "connected together by some common but unknown bond, which is essentially related to the principle of life."

[9] 'Essais de Zoologie Générale,' 1841, p. 256.

[10] Since the appearance of the first edition of this work, Mr. Sclater has published ('Proc. Zoolog. Soc.,' 1868, p. 623) a list of the species of

mammals which have bred in the gardens from 1848 to 1867 inclusive. Of the Artiodactyla 85 species have been kept, and of these 1 species in 1·9 have bred at least once during the 20 years; of 28 Marsupialia, 1 in 2·5 have bred; of 74 Carnivora, 1 in 3·0 have bred; of 52 Rodentia, 1 in 4·7 have bred; and of Quadrumana 75 species have been kept, and 1 in 6·2 have bred.

[11] Du Rut, 'Annales du Muséum,' 1807, tom. ix. p. 120.

[12] 'Saugethiere von Paraguay,' 1830, s. 49, 106, 118, 124, 201, 208, 249, 265, 327.

[13] 'The Naturalist on the Amazons,' 1863, vol. i. pp. 99, 193; vol. ii. p. 113.

[14] 'Embassy to the Court of Ava,' vol. i. p. 534.

[15] 'Journal,' vol. i. p. 213.

[16] 'Säugethiere,' s. 327.

[17] On the Breeding of the Larger Felidæ, 'Proc. Zoolog. Soc.,' 1861, p. 140.

[18] Sleeman's 'Rambles in India,' vol. ii. p. 10.

[19] Wiegmann's 'Archiv. fur Naturgesch.,' 1837, s. 162.

[20] Rengger 'Säugethiere,' etc., s. 276. On the parentage of the guinea-pig, *see also* Isid. Geoffroy St.-Hilaire, 'Hist. Nat. Gen.' I sent to Mr. H. Denny of Leeds the lice which I collected from the wild aperea in La Plata, and he informs me that they belong to a genus distinct from those found on the guinea-pig. This is important evidence that the aperea is not the parent of the guinea-pig; and is worth giving, as some authors erroneously suppose that the guinea-pig since being domesticated has become sterile when crossed with the aperea.

[21] Although the existence of the *Leporides*, as described by Dr. Broca ('Journal de Phys.,' tom. ii. p. 370), has been positively denied, yet Dr. Pigeaux ('Annals and Mag. of Nat. Hist.,' vol. xx., 1867, p. 75) affirms that the hare and rabbit have produced hybrids.

[22] 'Quadrupeds of North America,' by Audubon and Bachman, 1846, p. 268.

[23] Loudon's 'Mag. of Nat. Hist.,' vol. ix., 1836, p. 571; Audubon and Bachman's 'Quadrupeds of North America,' p. 221.

[24] Flourens, 'De l'Instinct,' etc., 1845, p. 88.

[25] *See* 'Annual Reports Zoolog. Soc.,' 1855, 1858, 1863, 1864; 'Times' newspaper, Aug. 10th, 1847; Flourens, 'De l'Instinct,' p. 85.

[26] ‘Säugethiere,’ etc., s. 34, 49.

[27] Art. Brazil, ‘Penny Cyclop.,’ p. 363.

[28] ‘The Naturalist on the Amazons,’ vol. i. p. 99.

[29] A list of the species of birds which have bred in the Zoological Gardens from 1848 to 1867 inclusive has been published by Mr. Sclater in ‘Proc. Zoolog. Soc.,’ 1869, p. 626, since the first edition of this work appeared. Of Columbæ 51 species have been kept, and of Anseres 80 species, and in both these families 1 species in 2·6 have bred at least once in the 20 years. Of Gallinæ 83 species have been kept and 1 in 27 have bred; of 57 Grallæ 1 in 9 have bred; of 110 Prehensores 1 in 22 have bred; of 178 Passeres 1 in 25·4 have bred; of 94 Accipitres 1 in 47 have bred; of 25 Picariæ and of 35 Herodiones not one species in either group has bred.

[30] ‘Encyclop. of Rural Sports,’ p. 691.

[31] According to Sir A. Burnes (‘Cabool,’ etc., p. 51), eight species are used for hawking in Sinde.

[32] Loudon’s ‘Mag. of Nat. Hist.,’ vol. vi., 1833, p. 110.

[33] F. Cuvier, ‘Annal. du Muséum,’ tom. ix. p. 128.

[34] ‘The Zoologist,’ vol. vii.-viii., 1849-50, p. 2648.

[35] Knox, ‘Ornithological Rambles in Sussex,’ p. 91.

[36] ‘The Zoologist,’ vol. vii.-viii., 1849-50, p. 2566; vol. ix.-x., 1851-2, p. 3207.

[37] Bechstein, ‘Naturgesch. der Stubenvögel,’ 1840, s. 20.

[38] ‘Ornithological Biography,’ vol. v. p. 517.

[39] A case is recorded in ‘The Zoologist,’ vol. i.-ii., 1843-45, p. 453. For the siskin breeding, vol. iii.-iv., 1845-46, p. 1075. Bechstein ‘Stubenvögel,’ s. 139, speaks of bullfinches making nests, but rarely producing young.

[40] Yarrell’s ‘Hist. British Birds,’ 1839, vol. i. p. 412.

[41] Loudon’s ‘Mag. of Nat. History,’ vol. xix., 1836, p. 347.

[42] ‘Mémoires du Muséum d’Hist. Nat.,’ tom. x. p. 314: five cases of parrots breeding in France are here recorded. *See also* ‘Report Brit. Assoc. Zoolog.,’ 1843.

[43] ‘Annals and Mag. of Nat. Hist.,’ Nov. 1868, p. 311.

[44] ‘Stubenvögel,’ s. 105, 83.

[45] Dr. Hancock remarks ('Charlesworth's Mag. of Nat. Hist.' vol. ii., 1838, p. 492), "it is singular that, amongst the numerous useful birds that are indigenous to Guiana, none are found to propagate among the Indians; yet the common fowl is reared in abundance throughout the country."

[46] 'A Week at Pert Royal,' 1855, p. 7.

[47] Audubon, 'American Ornithology,' vol. v. pp. 552, 557.

[48] Mowbray on Poultry, 7th edit., p. 133.

[49] Temminck, 'Hist. Nat. Gén. des Pigeons,' etc., 1813, tom. iii. pp. 288, 382; 'Annals and Mag. of Nat. Hist.,' vol. xii., 1843, p. 453. Other species of partridge have occasionally bred; as the red-legged (*P. rubra*), when kept in a large court in France (*see* 'Journal de Physique,' tom. xxv. p. 294), and in the Zoological Gardens in 1856.

[50] Rev. E. S. Dixon, 'The Dovecote,' 1851, pp. 243-252.

[51] Temminck, 'Hist. Nat. Gén. des Pigeons,' etc., tom. ii. pp. 456, 458; tom. iii. pp. 2, 13, 47.

[52] Bates, 'The Naturalist on the Amazons,' vol. i. p. 193; vol. ii. p. 112.

[53] Temminck, 'Hist. Nat. Gén.,' etc., tom. ii. p. 125. For *Tetrao urogallus, see* L. Lloyd, 'Field Sports of North of Europe,' vol. i. pp. 287, 314; and 'Bull. de la Soc. d'Acclimat.,' tom. vii., 1860, p. 600. For *T. scoticus,* Thompson, 'Nat. Hist. of Ireland,' vol. ii. 1850, p. 49. For *T. cupido,* 'Boston Journal of Nat. Hist.,' vol. iii. p. 199.

[54] Marcel de Serres, 'Annales des Sc. Nat.,' 2nd series, Zoolog., tom. xiii. p. 175.

[55] Dr. Hancock, in 'Charlesworth's Mag. of Nat. Hist.,' vol. ii., 1838, p. 491; R. Hill, 'A Week at Port Royal,' p. 8; 'Guide to the Zoological Gardens,' by P. L. Sclater, 1859, pp. 11, 12; 'The Knowsley Menagerie,' by D. Gray, 1846, pl. xiv.; E. Blyth, 'Report Asiatic Soc. of Bengal,' May 1855.

[56] Prof. Newton, in 'Proc. Zoolog. Soc.,' 1860, p. 336.

[57] 'The Dovecote and Aviary,' p. 428.

[58] 'Ornithological Biography,' vol. iii. p. 9.

[59] 'Geograph. Journal,' vol. xiii., 1844, p. 32.

[60] Loudon's 'Mag. of Nat. Hist.,' vol. v., 1832, p. 153.

[61] 'Zoologist,' vols. v.-vi., 1847-48, p. 1660.

[62] 'Transact. Entomolog. Soc.,' vol. iv., 1845, p. 60.

[63] ‘Transact. Linn. Soc.,’ vol. vii. p. 40.

[64] *See* an interesting paper by Mr. Newman in the ‘Zoologist,’ 1857, p. 5764; and Dr. Wallace, in ‘Proc. Entomolog. Soc.,’ June 4th, 1860, p. 119.

[65] Yarrell’s ‘British Birds,’ vol. i. p. 506; Bechstein ‘Stubenvögel,’ s. 185; ‘Philosoph. Transact.,’ 1772, p. 271. Bronn (‘Geschichte der Natur,’ Band ii. s. 96) has collected a number of cases. For the case of the deer, *see* ‘Penny Cyclop.,’ vol. viii. p. 350.

[66] ‘Journal de Physiologie,’ tom. ii. p. 347.

[67] For additional evidence on this subject, *see* F. Cuvier in ‘Annales du Muséum,’ tom. xii. p. 119.

[68] Numerous instances could be given. Thus Livingstone (‘Travels,’ p. 217) states that the King of the Barotse, an inland tribe which never had any communication with white men, was extremely fond of taming animals, and every young antelope was brought to him. Mr. Galton informs me that the Damaras are likewise fond of keeping pets. The Indians of South America follow the same habit. Capt. Wilkes states that the Polynesians of the Samoan Islands tamed pigeons; and the New Zealanders, as Mr. Mantell informs me, kept various kinds of birds.

[69] For analogous cases with the fowl, *see* Réaumur, ‘L’Art de faire Eclore,’ etc., 1749, p. 243; and Col. Sykes, in ‘Proc. Zoolog. Soc.,’ 1832, etc. With respect to the fowl not breeding in northern regions, *see* Latham’s ‘Hist. of Birds,’ vol. viii., 1823, p. 169.

[70] “Mém. par divers Savans,” ‘Acad. des Sciences,’ tom. vi., 1835, p. 347.

[71] Youatt on Sheep, p. 181.

[72] J. Mills, ‘Treatise on Cattle,’ 1776, p. 72.

[73] Bechstein, ‘Stubenvögel,’ s. 242.

[74] ‘The Andes and the Amazon,’ 1870, p. 107.

[75] Crawfurd’s ‘Descriptive Dict. of the Indian Islands,’ 1856, p. 145.

[76] ‘Bull. de la Soc. d’Acclimat.,’ tom. ix., 1862, pp. 380, 384.

[77] For pigeons, *see* Dr. Chapuis, ‘Le Pigeon Voyageur Belge,’ 1865, p. 66.

[78] ‘Swedish Acts,’ vol. i., 1739, p. 3. Pallas makes the same remark in his ‘Travels’ (Eng. translat.), vol. i. p. 292.

[79] A. Kerner, ‘Die Cultur der Alpenpflanzen,’ 1864, s. 139; Watson’s ‘Cybele Britannica,’ vol. i. p. 131; Mr. D. Cameron, also, has written on the

culture of Alpine plants in ‘Gard. Chronicle,’ 1848, pp. 253, 268, and mentions a few which seed.

[80] ‘Beiträge zur Kenntniss der Befruchtung,’ 1844 s. 333.

[81] ‘Nova Acta Petrop.,’ 1793, p. 391.

[82] ‘Cottage Gardener,’ 1856, pp. 44, 109.

[83] Dr. Herbert, ‘Amaryllidaceæ,’ p. 176.

[84] Gärtner, ‘Beiträge zur Kenntniss,’ etc., s. 560, 564.

[85] ‘Gardener’s Chronicle,’ 1844, p. 215; 1850, p. 470. Faivre gives a good résumé on this subject in his ‘La Variabilité des Espèces,’ 1868, p. 155.

[86] ‘Beiträge zur Kenntniss,’ etc., s. 252, 338.

[87] ‘Journal of Hort. Soc.,’ vol. ii., 1847, p. 83.

[88] ‘Beiträge zur Kenntniss,’ etc., s. 117 *et seq.*; Kölreuter, ‘Zweite Fortsetzung,’ s. 10, 121; ‘Dritte Fortsetzung,’ s. 57. Herbert, ‘Amaryllidaceæ,’ p. 355. Wiegmann ‘Ueber die Bastarderzeugung,’ s. 27.

[89] ‘Bastarderzengung,’ s. 356.

[90] ‘Teoria della Riproduzione,’ 1816, p. 84; ‘Traité du Citrus,’ 1811, p. 67.

[91] Mr. C. W. Crocker, in ‘Gardener’s Chronicle,’ 1861, p. 1092.

[92] Verlot, ‘Des Variétés,’ 1865, p. 80.

[93] Verlot, ibid., p. 88.

[94] Prof. Allman, Brit. Assoc., quoted in the ‘Phytologist,’ vol. ii. p. 483. Prof. Harvey, on the authority of Mr. Andrews, who discovered the plant, informed me that this monstrosity could be propagated by seed. With respect to the poppy, *see* Prof. Goeppert, as quoted in ‘Journal of Horticulture,’ July 1st, 1863, p. 171.

[95] ‘Comptes Rendus,’ Dec. 19th, 1864, p. 1039.

[96] ‘Gardener’s Chronicle,’ 1866, p. 681.

[97] ‘Theory of Horticulture,’ p. 333.

[98] Mr. Fairweather, in ‘Transact. Hort. Soc.,’ vol. iii. p. 406: Bosse, quoted by Bronn, ‘Geschichte der Natur,’ B. ii. s. 77. On the effects of the removal of the anthers, *see* Mr. Leitner, in Silliman’s ‘North American Journ. of Science,’ vol. xxiii. p. 47; and Verlot, ‘Des Variétés,’ 1865, p. 84.

[99] Lindley's 'Theory of Horticulture,' p. 3?3.

[100] 'Gardener's Chronicle,' 1865, p. 626; 1866, pp. 290, 730; and Verlot, 'Des Variétés,' p. 75.

[101] 'Gardener's Chronicle,' 1843, p. 628. In this article I suggested the theory above given on the doubleness of flowers. This view is adopted by Carrière, 'Production et Fix. des Variétés,' 1865, p. 67.

[102] Quoted by Gärtner, 'Bastarderzeugung,' s. 567.

[103] 'Gardener's Chronicle,' 1866, p. 901.

[104] Lindley, 'Theory of Horticulture,' pp. 175-179; Godron, 'De l'Espèce,' tom. ii. p. 106; Pickering, 'Races of Man;' Gallesio, 'Teoria della Riproduzione,' l816, pp. 101-110. Meyen, ('Reise um Erde,' Th. ii. s. 214) states that at Manilla one variety of the banana is full of seeds: and Chamisso (Hooker's 'Bot. Misc.,' vol. i. p. 310) describes a variety of the bread-fruit in the Mariana Islands with small fruit, containing seeds which are frequently perfect. Burnes, in his 'Travels in Bokhara,' remarks on the pomegranate seeding in Mazenderan, as a remarkable peculiarity.

[105] Ingledew, in 'Transact. of Agricult. and Hort. Soc. of India,' vol. ii.

[106] 'De la Fécondation,' 1862, p. 308.

[107] Hooker's 'Bot. Misc.,' vol. i. p. 99; Gallesio, 'Teoria della Riproduzione,' p. 110. Dr. J. de Cordemoy, in 'Transact. of the R. Soc. of Mauritius' (new series), vol. vi. 1873, pp. 60-67, gives a large number of cases of plants which never seed, including several species indigenous in Mauritius.

[108] 'Transact. Linn. Soc.,' vol. xvii. p. 563.

[109] Godron, 'De l'Espèce,' tom. ii. p. 106; Herbert on Crocus, in 'Journal of Hort. Soc.,' vol. i., 1846, p. 254: Dr. Wight, from what he has seen in India, believes in this view; 'Madras Journal of Lit. and Science,' vol. iv., 1836, p. 61.

[110] Wahlenberg specifies eight species in this state on the Lapland Alps: *see* Appendix to Linnæus' 'Tour in Lapland,' translated by Sir J. E. Smith, vol. ii. pp. 274-280.

[111] 'Travels in North America,' Eng. translat., vol. iii. p. 175.

[112] With respect to the ivy and Acorus, *see* Dr. Broomfield in the 'Phytologist,' vol. iii. p. 376. Also Lindley and Vaucher on the Acorus, and *see* Caspary as below.

[113] 'Annal. des Sc. Nat.,' 3rd series, Zool., tom. iv. p. 280. Prof. Decaisne refers also to analogous cases with mosses and lichens near Paris.

[114] Mr. Tuckermann, in Silliman's 'American Journal of Science,' vol. xlv. p. 1.

[115] Sir J. E. Smith, 'English Flora,' vol. i. p. 339.

[116] G. Planchon, 'Flora de Montpellier,' 1864, p. 20.

[117] On the non-production of seeds in England, *see* Mr. Crocker, in 'Gardener's Weekly Magazine,' 1852, p. 70; Vaucher, 'Hist. Phys. Plantes d'Europe,' tom. i. p. 33; Lecoq, 'Géograph. Bot. d'Europe,' tom. iv. p. 466; Dr. D. Clos, in 'Annal. des Sc. Nat.,' 3rd series, Bot., tom. xvii. 1852, p. 129: this latter author refers to other analogous cases. *See* more especially on this plant and on other allied cases Prof. Caspary, "Die Nuphar," 'Abhand. Naturw. Gesellsch. zu Halle,' B. xi. 1870, p. 40, 78.

[118] 'Bastarderzeugung,' s. 565. Kölreuter (Dritte Fortsetzung, s. 73, 87, 119) also shows that when two species, one single and the other double, are crossed, the hybrids are apt to be extremely double.

[119] 'Teoria della Riproduzione Veg.,' 1816, p. 73.

[120] 'Bastarderzeugung,' s. 573.

[121] Ibid., s. 527.

CHAPTER XIX.
SUMMARY OF THE FOUR LAST CHAPTERS, WITH REMARKS ON HYBRIDISM.

ON THE GOOD DERIVED ON THE EFFECTS OF CROSSING—THE INFLUENCE OF DOMESTICATION ON FERTILITY—CLOSE INTERBREEDING—GOOD AND EVIL RESULTS FROM CHANGED CONDITIONS OF LIFE—VARIETIES WHEN CROSSED NOT INVARIABLY FERTILE—ON THE DIFFERENCE IN FERTILITY BETWEEN CROSSED SPECIES AND VARIETIES—CONCLUSIONS WITH RESPECT TO HYBRIDISM—LIGHT THROWN ON HYBRIDISM BY THE ILLEGITIMATE PROGENY OF HETEROSTYLED PLANTS—STERILITY OF CROSSED SPECIES DUE TO DIFFERENCES CONFINED TO THE REPRODUCTIVE SYSTEM—NOT ACCUMULATED THROUGH NATURAL SELECTION—REASONS WHY DOMESTIC VARIETIES ARE NOT MUTUALLY STERILE—TOO MUCH STRESS HAS BEEN LAID ON THE DIFFERENCE

IN FERTILITY BETWEEN CROSSED SPECIES AND CROSSED VARIETIES—CONCLUSION.

It was shown in the fifteenth chapter that when individuals of the same variety, or even of a distinct variety, are allowed freely to intercross, uniformity of character is ultimately acquired. Some few characters, however, are incapable of fusion, but these are unimportant, as they are often of a semi-monstrous nature, and have suddenly appeared. Hence, to preserve our domesticated breeds true, or to improve them by methodical selection, it is obviously necessary that they should be kept separate. Nevertheless, a whole body of individuals may be slowly modified, through unconscious selection, as we shall see in a future chapter, without separating them into distinct lots. Domestic races have often been intentionally modified by one or two crosses, made with some allied race, and occasionally even by repeated crosses with very distinct races; but in almost all such cases, long-continued and careful selection has been absolutely necessary, owing to the excessive variability of the crossed offspring, due to the principle of reversion. In a few instances, however, mongrels have retained a uniform character from their first production.

When two varieties are allowed to cross freely, and one is much more numerous than the other, the former will ultimately absorb the latter. Should both varieties exist in nearly equal numbers, it is probable that a considerable period would elapse before the acquirement of a uniform character; and the character ultimately acquired would largely depend on prepotency of transmission and on the conditions of life; for the nature of these conditions would generally favour one variety more than another, so that a kind of natural selection would come into play. Unless the crossed offspring were slaughtered by man without the least discrimination, some degree of unmethodical selection would likewise come into action. From these several considerations we may infer, that when two or more closely allied species first came into the possession of the same tribe, their crossing will not have influenced, in so great a degree as has often been supposed, the character of the offspring in future times; although in some cases it probably has had a considerable effect.

Domestication, as a general rule, increases the prolificness of animals and plants. It eliminates the tendency to sterility which is common to species when first taken from a state of nature and crossed. On this latter head we have no direct evidence; but as our races of dogs, cattle, pigs etc., are almost certainly descended from aboriginally distinct stocks, and as these races are now fully fertile together, or at least incomparably more fertile than most species when crossed, we may with entire confidence accept this conclusion.

Abundant evidence has been given that crossing adds to the size, vigour, and fertility of the offspring. This holds good when there has been no previous close interbreeding. It applies to the individuals of the same variety but belonging to different families, to distinct varieties, sub-species, and even to species. In the latter case, though size is gained, fertility is lost; but the increased size, vigour, and hardiness of many hybrids cannot be accounted for solely on the principle of compensation from the inaction of the reproductive system. Certain plants whilst growing under their natural conditions, others when cultivated, and others of hybrid origin, are completely self-impotent, though perfectly healthy; and such plants can be stimulated to fertility only by being crossed with other individuals of the same or of a distinct species.

On the other hand, long-continued close interbreeding between the nearest relations diminishes the constitutional vigour, size, and fertility of the offspring; and occasionally leads to malformations, but not necessarily to general deterioration of form or structure. This failure of fertility shows that the evil results of interbreeding are independent of the augmentation of morbid tendencies common to both parents, though this augmentation no doubt is often highly injurious. Our belief that evil follows from close interbreeding rests to a certain extent on the experience of practical breeders, especially of those who have reared many animals of quickly propagating kinds; but it likewise rests on several carefully recorded experiments. With some animals close interbreeding may be carried on for a long period with impunity by the selection of the most vigorous and healthy individuals; but sooner or later evil follows. The evil, however, comes on so slowly and gradually that it easily escapes observation, but can be recognised by the almost instantaneous manner in which size, constitutional vigour, and fertility are regained when animals that have long been interbred are crossed with a distinct family.

These two great classes of facts, namely, the good derived from crossing, and the evil from close interbreeding, with the consideration of the innumerable adaptations throughout nature for compelling, or favouring, or at least permitting, the occasional union of distinct individuals, taken together, lead to the conclusion that it is a law of nature that organic beings shall not fertilise themselves for perpetuity. This law was first plainly hinted at in 1799, with respect to plants, by Andrew Knight[1] and, not long afterwards, that sagacious observer Kölreuter, after showing how well the Malvaceæ are adapted for crossing, asks, "an id aliquid in recessu habeat, quod hujuscemodi flores nunquam proprio suo pulvere, sed semper eo aliarum su speciei impregnentur, merito quæritur? Certe natura nil facit frustra." Although we may demur to Kölreuter's saying that nature does nothing in vain, seeing how many rudimentary and useless organs there are, yet undoubtedly the argument from the innumerable contrivances, which favour crossing, is of the greatest weight. The most important result of this law is that it leads to uniformity of character in the individuals of the same species. In the case of certain hermaphrodites, which probably intercross only at long intervals of time, and with unisexual animals inhabiting somewhat separated localities, which can only occasionally come into contact and pair, the greater vigour and fertility of the crossed offspring will ultimately tend to give uniformity of character. But when we go beyond the limits of the same species, free intercrossing is barred by the law of sterility.

In searching for facts which might throw light on the cause of the good effects from crossing, and of the evil effects from close interbreeding, we have seen that, on the one hand, it is a widely prevalent and ancient belief, that animals and plants profit from slight changes in their condition of life; and it would appear that the germ, in a somewhat analogous manner, is more effectually stimulated by the male element, when taken from a distinct individual, and therefore slightly modified in nature, than when taken from a male having the same identical constitution. On the other hand, numerous facts have been given, showing that when animals are first subjected to captivity, even in their native land, and although allowed much liberty, their reproductive functions are often greatly impaired or quite annulled. Some groups of animals are more affected than others, but with apparently capricious exceptions in every group. Some animals never or rarely couple under confinement; some couple freely, but never or rarely conceive. The secondary male characters, the maternal functions and instincts, are occasionally affected. With plants, when first subjected to cultivation, analogous facts have been observed. We probably owe our double flowers, rich seedless fruits, and in some cases greatly developed tubers, etc., to incipient sterility of the above nature combined with a copious supply of nutriment. Animals which have long been domesticated, and plants which have long been cultivated, can generally withstand, with unimpaired fertility, great changes in their conditions of life; though both are sometimes slightly affected. With animals the somewhat rare capacity of breeding freely under confinement, together with their utility, mainly determine the kinds which have been domesticated.

We can in no case precisely say what is the cause of the diminished fertility of an animal when first captured, or of a plant when first cultivated; we can only infer that it is caused by a change of some kind in the natural conditions of life. The remarkable susceptibility of the reproductive system to such changes,—a susceptibility not common to any other organ,—apparently has an important bearing on Variability, as we shall see in a future chapter.

It is impossible not to be struck with the double parallelism between the two classes of facts just alluded to. On the one hand, slight changes in the conditions of life, and crosses between slightly modified forms or varieties, are beneficial as far as prolificness and constitutional vigour are concerned. On the other hand, changes in the conditions greater in degree, or of a different nature, and crosses between forms which have been slowly and greatly modified by natural means,—in other words, between species,—are highly injurious, as far as the reproductive system is concerned, and in some few instances as far as constitutional vigour is concerned. Can this parallelism be accidental? Does it not rather indicate some real bond of connection? As a fire goes out unless it be stirred up, so the vital forces are always tending, according to Mr. Herbert Spencer, to a state of equilibrium, unless disturbed and renovated through the action of other forces.

In some few cases varieties tend to keep distinct, by breeding at different seasons, by great difference in size, or by sexual preference. But the crossing of varieties, far from diminishing, generally adds to the fertility of the first union and of the mongrel offspring. Whether all the more widely distinct domestic varieties are invariably quite fertile when crossed, we do not positively know; much time and trouble would be requisite for the necessary experiments, and many difficulties occur, such as the descent of the various races from aboriginally distinct species, and the doubts whether certain forms ought to be ranked as species or varieties. Nevertheless, the wide experience of practical breeders proves that the great majority of varieties, even if some should hereafter prove not to be indefinitely fertile *inter se,* are far more fertile when crossed, than the vast majority of closely allied natural species. A few remarkable cases have, however, been given on the authority of excellent observers, showing that with plants certain forms, which undoubtedly must be ranked as varieties, yield fewer seeds when crossed than is natural to the parent-species. Other varieties have had their reproductive powers so far modified that they are either more or less fertile than their parents, when crossed with a distinct species.

Nevertheless, the fact remains indisputable that domesticated varieties, of animals and of plants, which differ greatly from one another in structure, but which are certainly descended from the same aboriginal species, such as the races of the fowl, pigeon, many vegetables, and a host of other productions, are extremely fertile when crossed; and this seems to make a broad and impassable barrier between domestic varieties and natural species. But, as I will now attempt to show, the distinction is not so great and overwhelmingly important as it at first appears.

On the Difference in Fertility between Varieties and Species when crossed.

This work is not the proper place for fully treating the subject of hybridism, and I have already given in my ‘Origin of Species’ a moderately full abstract. I will here merely enumerate the general conclusions which may be relied on, and which bear on our present point.

Firstly, the laws governing the production of hybrids are identical, or nearly identical, in the animal and vegetable kingdoms.

Secondly, the sterility of distinct species when first united, and that of their hybrid offspring, graduate, by an almost infinite number of steps, from zero, when the ovule is never impregnated and a seed-capsule is never formed, up to complete fertility. We can only escape the conclusion that some species are fully fertile when crossed, by determining to designate as varieties all the forms which are quite fertile. This high degree of fertility is, however, rare. Nevertheless, plants, which have been exposed to unnatural conditions, sometimes become modified in so peculiar a manner, that they are much more fertile when crossed with a distinct species than when fertilised by their own pollen. Success in effecting a first union between two species, and the fertility of their hybrids, depend in an eminent degree on the conditions of life being favourable. The innate sterility of hybrids of the same parentage and raised from the same seed-capsule often differs much in degree.

Thirdly, the degree of sterility of a first cross between two species does not always run strictly parallel with that of their hybrid offspring. Many cases are known of species which can be crossed with ease, but yield hybrids excessively sterile; and conversely some which can be crossed with great difficulty, but produce fairly fertile hybrids. This is an inexplicable fact, on the view that species have been specially endowed with mutual sterility in order to keep them distinct.

Fourthly, the degree of sterility often differs greatly in two species when reciprocally crossed; for the first will readily fertilise the second; but the latter is incapable, after hundreds of trials, of fertilising the former. Hybrids produced from reciprocal crosses between the same two species likewise sometimes differ in their degree of sterility. These cases also are utterly inexplicable on the view of sterility being a special endowment.

Fifthly, the degree of sterility of first crosses and of hybrids runs, to a certain extent, parallel with the general or systematic affinity of the forms which are united. For species belonging to distinct genera can rarely, and those belonging to distinct families can never, be crossed. The parallelism, however, is far from complete; for a multitude of closely allied species will not unite, or unite with extreme difficulty, whilst other species, widely different from one another, can be crossed with perfect facility. Nor does the difficulty depend on ordinary constitutional differences, for annual and perennial plants, deciduous and evergreen trees, plants flowering at different seasons, inhabiting different stations, and naturally living under the most opposite climates, can often be crossed with ease. The difficulty or facility apparently depends exclusively on the sexual constitution of the species which are crossed; or on their sexual elective affinity, *i.e. Wahlverwandtschaft* of Gärtner. As species rarely or never become modified in one character, without being at the same time modified in many characters, and as systematic affinity includes all visible similarities and dissimilarities, any difference in sexual constitution between two species would naturally stand in more or less close relation with their systematic position.

Sixthly, the sterility of species when first crossed, and that of hybrids, may possibly depend to a certain extent on distinct causes. With pure species the reproductive organs are in a perfect condition, whilst with hybrids they are often plainly deteriorated. A hybrid embryo which partakes of the constitution of its father and mother is exposed to unnatural conditions, as long as it is nourished within the womb, or egg, or seed of the mother-form; and as we know that unnatural conditions often induce sterility, the reproductive organs of the hybrid might at this early age be permanently affected. But this cause has no bearing on the infertility of first unions. The diminished number of the offspring from first unions may often result, as is certainly sometimes the case, from the premature death of most of the hybrid embryos. But we shall immediately see that a law of an unknown nature apparently exists, which leads to the offspring from unions, which are infertile, being themselves more or less infertile; and this at present is all that can be said.

Seventhly, hybrids and mongrels present, with the one great exception of fertility, the most striking accordance in all other respects; namely, in the laws of their resemblance to their two parents, in their tendency to reversion, in their variability, and in being absorbed through repeated crosses by either parent-form.

After arriving at these conclusions, I was led to investigate a subject which throws considerable light on hybridism, namely, the fertility of heterostyled or dimorphic and trimorphic plants, when illegitimately united. I have had occasion several times to allude to these plants, and I may here give a brief abstract of my observations. Several plants belonging to distinct orders present two forms, which exist in about equal numbers, and which differ in no respect except in their reproductive organs; one form having a long pistil with short stamens, the other a short pistil with long stamens; both with differently sized pollen-grains. With trimorphic plants there are three forms likewise differing in the lengths of their pistils and stamens, in the size and colour of the pollen-grains, and in some other respects; and as in each of the three forms there are two sets of stamens, there are altogether six sets of stamens and three kinds of pistils. These organs are so proportioned in length to one another that, in any two of the forms, half the stamens in each stand on a level with the stigma of the third form. Now I have shown, and the result has been confirmed by other observers, that, in order to obtain full fertility with these plants, it is necessary that the stigma of the one form should be fertilised by pollen taken from the stamens of corresponding height in the other form. So that with dimorphic species two unions, which may be called legitimate, are fully fertile, and two, which may be called illegitimate, are more or less infertile. With trimorphic species six unions are legitimate, or fully fertile, and twelve are illegitimate, or more or less infertile.[2]

The infertility which may be observed in various dimorphic and trimorphic plants, when illegitimately fertilised, that is, by pollen taken from stamens not corresponding in height with the pistil, differs much in degree, up to absolute and utter sterility; just in the same manner as occurs in crossing distinct species. As the degree of sterility in the latter case depends in an eminent degree on the conditions of life being more or less favourable, so I have found it with illegitimate unions. It is well known that if pollen of a distinct species be placed on the stigma of a flower, and its own pollen be afterwards, even after a considerable interval of time, placed on the same stigma, its action is so strongly prepotent that it generally annihilates the effect of the foreign pollen; so it is with the pollen of the several forms of the same species, for legitimate pollen is strongly prepotent over illegitimate pollen, when both are placed on the same stigma. I ascertained this by fertilising several flowers, first illegitimately, and twenty-four hours afterwards legitimately, with pollen taken from a peculiarly coloured variety, and all the seedlings were similarly coloured; this shows that the legitimate pollen, though applied twenty-four hours subsequently, had wholly destroyed or prevented the action of the previously applied illegitimate pollen. Again, as, in making reciprocal crosses between the same two species, there is occasionally a great difference in the result, so the same thing occurs with trimorphic plants; for instance, the mid-styled form of *Lythrum salicaria* could be illegitimately fertilised with the greatest ease by pollen from the longer stamens of the short-styled form, and yielded many seeds; but the short-styled form did not yield a single seed when fertilised by the longer stamens of the mid-styled form.

In all these respects the forms of the same undoubted species, when illegitimately united, behave in exactly the same manner as do two distinct species when crossed. This led me carefully to observe during four years many seedlings, raised from several illegitimate unions. The chief result is that these illegitimate plants, as they may be called, are not fully fertile. It is possible to raise from dimorphic species, both long-styled and short-styled illegitimate plants, and from trimorphic plants all three illegitimate forms. These can then be properly united in a legitimate manner. When this is done, there is no apparent reason why they should not yield as many seeds as did their parents when legitimately fertilised. But such is not the case; they are all infertile, but in various degrees; some being so utterly and incurably sterile that they did not yield during four seasons a single seed or even seed-capsule. These illegitimate plants, which are so sterile, although united with each other in a legitimate manner, may be strictly compared with hybrids when crossed *inter se*, and it is well known how sterile these latter generally are. When, on the other hand, a hybrid is crossed with either pure parent-species, the sterility is usually much lessened: and so it is when an illegitimate plant is fertilised by a legitimate plant. In the same manner as the sterility of hybrids does not always run parallel with the difficulty of making the first cross between the two parent-species, so the sterility of certain illegitimate plants was unusually great, whilst the sterility of the union from which they were derived was by no means great. With hybrids raised from the same seed-capsule the degree of sterility is innately variable, so it is in a marked manner with illegitimate plants. Lastly, many hybrids are profuse and persistent flowerers, whilst other and more sterile hybrids produce few flowers, and are weak, miserable dwarfs; exactly similar cases occur with the illegitimate offspring of various dimorphic and trimorphic plants.

Although there is the closest identity in character and behaviour between illegitimate plants and hybrids, it is hardly an exaggeration to maintain that the former are hybrids, but produced within the limits of the same species by the improper union of certain forms, whilst ordinary hybrids are produced from an improper union between so-called distinct species. We have already seen that there is the closest similarity in all respects between first illegitimate unions, and first crosses between distinct species. This will perhaps be made more fully apparent by an illustration:—we may suppose that a botanist found two well-marked varieties (and such occur) of the long-styled form of the trimorphic *Lithrum salicaria*, and that he determined to try by crossing whether they were specifically distinct. He would find that they yielded only about one-fifth of the proper number of seed, and that they behaved in all the other above-specified respects as if they had been two distinct species. But to make the case sure, he would raise plants from his supposed hybridised seed, and he would find that the seedlings were miserably dwarfed and utterly sterile, and that they behaved in all other respects like ordinary hybrids, he might then maintain that he had actually proved, in accordance with the common view, that his two varieties were as good and as distinct species as any in the world; but he would be completely mistaken.

The facts now given on dimorphic and trimorphic plants are important, because they show us, first, that the physiological test of lessened fertility, both in first crosses and in hybrids, is no criterion of specific distinction; secondly, because we may conclude that there is some unknown bond which connects the infertility of illegitimate unions with that of their illegitimate offspring, and we are led to extend the same view to first crosses and hybrids; thirdly, because we find, and this seems to me of especial importance, that two or three forms of the same species may exist and may differ in no respect whatever, either in structure or in constitution, relatively to external conditions, and yet be sterile when united in certain ways. For we must remember that it is the union of the sexual elements of individuals of the same form, for instance, of two long-styled forms, which results in sterility; whilst it is the union of the sexual element proper to two distinct forms which is fertile. Hence the case appears at first sight exactly the reverse of what occurs in the ordinary unions of the individuals of the same species, and with crosses between distinct species. It is, however, doubtful whether this is really so; but I will not enlarge on this obscure subject.

We may, however, infer as probable from the consideration of dimorphic and trimorphic plants, that the sterility of distinct species when crossed, and of their hybrid progeny, depends exclusively on the nature of their sexual elements, and not on any difference in their structure or general constitution. We are also led to this same conclusion by considering reciprocal crosses, in which the male of one species cannot be united, or only with great difficulty, with the female of a second species, whilst the converse cross can be effected with perfect facility. That excellent observer, Gärtner, likewise concluded that species when crossed are sterile owing to differences confined to their reproductive systems.

On the principle which makes it necessary for man, whilst he is selecting and improving his domestic varieties, to keep them separate, it would clearly be advantageous to varieties in a state of nature, that is to incipient species, if they could be kept from blending, either through sexual aversion, or by becoming mutually sterile. Hence it at one time appeared to me probable, as it has to others, that this sterility might have been acquired through natural selection. On this view we must suppose that a shade of lessened fertility first spontaneously appeared, like any other modification, in certain individuals of a species when crossed with other individuals of the same species; and that successive slight degrees of infertility, from being advantageous, were slowly accumulated. This appears all the more probable, if we admit that the structural differences between the forms of dimorphic and trimorphic plants, as the length and curvature of the pistil, etc., have been co-adapted through natural selection; for if this be admitted, we can hardly avoid extending the same conclusion to their mutual infertility. Sterility, moreover, has been acquired through natural selection for other and widely different purposes, as with neuter insects in reference to their social economy. In the case of plants, the flowers on the circumference of the truss in the guelder rose (*Viburnum opulus*) and those on the summit of the spike in the feather-hyacinth (*Muscari comosum*) have been rendered conspicuous, and apparently in consequence sterile, in order that insects might easily discover and visit the perfect flowers. But when we endeavour to apply the principle of natural selection to the acquirement by distinct species of mutual sterility, we meet with great difficulties. In the first place, it may be remarked that separate regions are often inhabited by groups of species or by single species, which when brought together and crossed are found to be more or less sterile; now it could clearly have been no advantage to such separated species to have been rendered mutually sterile, and consequently this could not have been effected through natural selection; but it may perhaps be argued, that, if a species were rendered sterile with some one compatriot, sterility with other species would follow as a necessary consequence. In the second place, it is as much opposed to the theory of natural selection, as to the theory of special creation, that in reciprocal crosses the male element of one form should have been rendered utterly impotent on a second form, whilst at the same time the male element of this second form is enabled freely to fertilise the first form; for this peculiar state of the reproductive system could not possibly have been advantageous to either species.

In considering the probability of natural selection having come into action in rendering species mutually sterile, one of the greatest difficulties will be found to lie in the existence of many graduated steps from slightly lessened fertility to absolute sterility. It may be admitted, on the principle above explained, that it would profit an incipient species if it were rendered in some slight degree sterile when crossed with its parent-form or with some other variety; for thus fewer bastardised and deteriorated offspring would be produced to commingle their blood with the new species in process of formation. But he who will take the trouble to reflect on the steps by which this first degree of sterility could be increased through natural selection to that higher degree which is common to so many species, and which is universal with species which have been differentiated to a generic or family rank, will find the subject extraordinarily complex. After mature reflection it seems to me that this could not have been effected through natural selection. Take the case of any two species which, when crossed, produce few and sterile offspring; now, what is there which could favour the survival of those individuals which happened to be endowed in a slightly higher degree with mutual infertility, and which thus approached by one small step towards absolute sterility? Yet an advance of this kind, if the theory of natural selection be brought to bear, must have incessantly occurred with many species, for a multitude are mutually quite barren. With sterile neuter insects we have reason to believe that modifications in their structure and fertility have been slowly accumulated by natural selection, from an advantage having been thus indirectly given to the community to which they belonged over other communities of the same species; but an individual animal not belonging to a social community, if rendered slightly sterile when crossed with some other variety, would not thus itself gain any advantage or indirectly give any advantage to the other individuals of the same variety, thus leading to their preservation.

But it would be superfluous to discuss this question in detail; for with plants we have conclusive evidence that the sterility of crossed species must be due to some principle, quite independent of natural selection. Both Gärtner and Kolreuter have proved that in general including numerous species, a series can be formed from species which when crossed yield fewer and fewer seeds, to species which never produce a single seed, but yet are affected by the pollen of certain other species, for the germen swells. It is here manifestly impossible to select the more sterile individuals, which have already ceased to yield seeds; so that this acme of sterility, when the germen alone is affected, cannot have been gained through selection; and from the laws governing the various grades of sterility being so uniform throughout the animal and vegetable kingdoms, we may infer that the cause, whatever it may be, is the same or nearly the same in all cases.

As species have not been rendered mutually infertile through the accumulative action of natural selection, and as we may safely conclude, from the previous as well as from other and more general considerations, that they have not been endowed through an act of creation with this quality, we must infer that it has arisen incidentally during their slow formation in connection with other and unknown changes in their organisation. By a quality arising incidentally, I refer to such cases as different species of animals and plants being differently affected by poisons to which they are not naturally exposed; and this difference in susceptibility is clearly incidental on other and unknown differences in their organisation. So again the capacity in different kinds of trees to be grafted on each other, or on a third species, differs much, and is of no advantage to these trees, but is incidental on structural or functional differences in their woody tissues. We need not feel surprise at sterility incidentally resulting from crosses between distinct species,—the modified descendants of a common progenitor,—when we bear in mind how easily the reproductive system is affected by various causes—often by extremely slight changes in the conditions of life, by too close interbreeding, and by other agencies. It is well to bear in mind such cases as that of the *Passiflora alata,* which recovered its self-fertility from being grafted on a distinct species—the cases of plants which normally or abnormally are self-impotent, but can readily be fertilised by the pollen of a distinct species—and lastly the cases of individual domesticated animals which evince towards each other sexual incompatibility.

We now at last come to the immediate point under discussion: how is it that, with some few exceptions in the case of plants, domesticated varieties, such as those of the dog, fowl, pigeon, several fruit-trees, and culinary vegetables, which differ from each other in external characters more than many species, are perfectly fertile when crossed, or even fertile in excess, whilst closely allied species are almost invariably in some degree sterile? We can, to a certain extent, give a satisfactory answer to this question. Passing over the fact that the amount of external difference between two species is no sure guide to their degree of mutual sterility, so that similar differences in the case of varieties would be no sure guide, we know that with species the cause lies exclusively in differences in their sexual constitution. Now the conditions to which domesticated animals and cultivated plants have been subjected have had so little tendency towards modifying the reproductive system in a manner leading to mutual sterility, that we have very good grounds for admitting the directly opposite doctrine of Pallas, namely, that such conditions generally eliminate this tendency; so that the domesticated descendants of species, which in their natural state would have been in some degree sterile when crossed, become perfectly fertile together. With plants, so far is cultivation from giving a tendency towards mutual sterility, that in several well-authenticated cases, already often alluded to, certain species have been affected in a very different manner, for they have become self-impotent, whilst still retaining the capacity of fertilising, and being fertilised by, distinct species. If the Pallasian doctrine of the elimination of sterility through long-continued domestication be admitted, and it can hardly be rejected, it becomes in the highest degree improbable that similar circumstances should commonly both induce and eliminate the same tendency; though in certain cases, with species having a peculiar constitution, sterility might occasionally be thus induced. Thus, as I believe, we can understand why with domesticated animals varieties have not been produced which are mutually sterile; and why with plants only a few such cases have been observed, namely, by Gärtner, with certain varieties of maize and verbascum, by other experimentalists with varieties of the gourd and melon, and by Kölreuter with one kind of tobacco.

With respect to varieties which have originated in a state of nature, it is almost hopeless to expect to prove by direct evidence that they have been rendered mutually sterile; for if even a trace of sterility could be detected, such varieties would at once be raised by almost every naturalist to the rank of distinct species. If, for instance, Gärtner’s statement were fully confirmed, that the blue and red flowered forms of the pimpernel (*Anagallis arvensis*) are sterile when crossed, I presume that all the botanists who now maintain on various grounds that these two forms are merely fleeting varieties, would at once admit that they were specifically distinct.

The real difficulty in our present subject is not, as it appears to me, why domestic varieties have not become mutually infertile when crossed, but why this has so generally occurred with natural varieties as soon as they have been modified in a sufficient and permanent degree to take rank as species. We are far from precisely knowing the cause; but we can see that the species, owing to their struggle for existence with numerous competitors, must have been exposed to more uniform conditions of life during long periods of time than domestic varieties have been, and this may well make a wide difference in the result. For we know how commonly wild animals and plants, when taken from their natural conditions and subjected to captivity, are rendered sterile; and the reproductive functions of organic beings which have always lived and been slowly modified under natural conditions would probably in like manner be eminently sensitive to the influence of an unnatural cross. Domesticated productions, on the other hand, which, as shown by the mere fact of their domestication, were not originally highly sensitive to changes in their conditions of life, and which can now generally resist with undiminished fertility repeated changes of conditions, might be expected to produce varieties, which would be little liable to have their reproductive powers injuriously affected by the act of crossing with other varieties which had originated in a like manner.

Certain naturalists have recently laid too great stress, as it appears to me, on the difference in fertility between varieties and species when crossed. Some allied species of trees cannot be grafted on one another, whilst all varieties can be so grafted. Some allied animals are affected in a very different manner by the same poison, but with varieties no such case until recently was known; whilst now it has been proved that immunity from certain poisons sometimes stands in correlation with the colour of the individuals of the same species. The period of gestation generally differs much in distinct species, but with varieties until lately no such difference had been observed. Here we have various physiological differences, and no doubt others could be added, between one species and another of the same genus, which do not occur, or occur with extreme rarity, in the case of varieties; and these differences are apparently wholly or in chief part incidental on other constitutional differences, just in the same manner as the sterility of crossed species is incidental on differences confined to the sexual system. Why, then, should these latter differences, however serviceable they may indirectly be in keeping the inhabitants of the same country distinct, be thought of such paramount importance, in comparison with other incidental and functional differences? No sufficient answer to this question can be given. Hence the fact that widely distinct domestic varieties are, with rare exceptions, perfectly fertile when crossed, and produce fertile offspring, whilst closely allied species are, with rare exceptions, more or less sterile, is not nearly so formidable an objection as it appears at first to the theory of the common descent of allied species.

REFERENCES

[1] ‘Transactions Phil. Soc.,’ 1799, p. 202. For Kölreuter *see* ‘Mém. de l’Acad. de St.-Pétersbourg,’ tom. iii. 1809 (published 1811) p. 197. In reading C. K. Sprengel’s remarkable work, ‘Das entdeckte Geheimniss,’ etc., 1793, it is curious to observe how often this wonderfully acute observer failed to understand the full meaning of the structure of the flowers which he has so well described, from not always having before his mind the key to the problem, namely, the good derived from the crossing of distinct individual plants.

[2] My observations ‘On the Character and hybrid-like nature of the offspring from the illegitimate union of Dimorphic and Trimorphic Plants’

were published in the 'Journal of the Linnean Soc.,' vol. x. p. 393. The abstract here given is nearly the same with that which appeared in the 6th edition of my 'Origin of Species.'

CHAPTER XX.
SELECTION BY MAN.

SELECTION A DIFFICULT ART—METHODICAL, UNCONSCIOUS, AND NATURAL SELECTION—RESULTS OF METHODICAL SELECTION—CARE TAKEN IN SELECTION—SELECTION WITH PLANTS—SELECTION CARRIED ON BY THE ANCIENTS AND BY SEMI-CIVILISED PEOPLE—UNIMPORTANT CHARACTERS OFTEN ATTENDED TO—UNCONSCIOUS SELECTION—AS CIRCUMSTANCES SLOWLY CHANGE, SO HAVE OUR DOMESTICATED ANIMALS CHANGED THROUGH THE ACTION OF UNCONSCIOUS SELECTION—INFLUENCE OF DIFFERENT BREEDERS ON THE SAME SUB-VARIETY—PLANTS AS AFFECTED BY UNCONSCIOUS SELECTION—EFFECTS OF SELECTION AS SHOWN BY THE GREAT AMOUNT OF DIFFERENCE IN THE PARTS MOST VALUED BY MAN.

The power of Selection, whether exercised by man, or brought into play under nature through the struggle for existence and the consequent survival of the fittest, absolutely depends on the variability of organic beings. Without variability nothing can be effected; slight individual differences, however, suffice for the work, and are probably the chief or sole means in the production of new species. Hence our discussion on the causes and laws of variability ought in strict order to have preceded the present subject, as well as inheritance, crossing, etc.; but practically the present arrangement has been found the most convenient. Man does not attempt to cause variability; though he unintentionally effects this by exposing organisms to new conditions of life, and by crossing breeds already formed. But variability being granted, he works wonders. Unless some degree of selection be exercised, the free commingling of the individuals of the same variety soon obliterates, as we have previously seen, the slight differences which arise, and gives uniformity of character to the whole body of individuals. In separated districts, long-continued exposure to different conditions of life may produce new races without the aid of selection; but to this subject of the direct action of the conditions of life I shall recur in a future chapter.

When animals or plants are born with some conspicuous and firmly inherited new character, selection is reduced to the preservation of such individuals, and to the subsequent prevention of crosses; so that nothing more need be said on the subject. But in the great majority of cases a new character, or some superiority in an old character, is at first faintly pronounced, and is not strongly inherited; and then the full difficulty of selection is experienced. Indomitable patience, the finest powers of discrimination, and sound judgment must be exercised during many years. A clearly predetermined object must be kept steadily in view. Few men are endowed with all these qualities, especially with that of discriminating very slight differences; judgment can be acquired only by long experience; but if any of these qualities be wanting, the labour of a life may be thrown away. I have been astonished when celebrated breeders, whose skill and judgment have been proved by their success at exhibitions, have shown me their animals, which appeared all alike, and have assigned their reasons for matching this and that individual. The importance of the great principle of Selection mainly lies in this power of selecting scarcely appreciable differences, which nevertheless are found to be transmissible, and which can be accumulated until the result is made manifest to the eyes of every beholder.

The principle of selection may be conveniently divided into three kinds. *Methodical selection* is that which guides a man who systematically endeavours to modify a breed according to some predetermined standard. *Unconscious selection* is that which follows from men naturally preserving the most valued and destroying the less valued individuals, without any thought of altering the breed; and undoubtedly this process slowly works great changes. Unconscious selection graduates into methodical, and only extreme cases can be distinctly separated; for he who preserves a useful or perfect animal will generally breed from it with the hope of getting offspring of the same character; but as long as he has not a predetermined purpose to improve the breed, he may be said to be selecting unconsciously.[1] Lastly, we have *Natural selection,* which implies that the individuals which are best fitted for the complex, and in the course of ages changing conditions to which they are exposed, generally survive and procreate their kind. With domestic productions, natural selection comes to a certain extent into action, independently of, and even in opposition to, the will of man.

Methodical Selection.—What man has effected within recent times in England by methodical selection is clearly shown by our exhibitions of improved quadrupeds and fancy birds. With respect to cattle, sheep, and pigs, we owe their great improvement to a long series of well-known names—Bakewell, Coiling, Ellman, Bates, Jonas Webb, Lords Leicester and Western, Fisher Hobbs, and others. Agricultural writers are unanimous on the power of selection: any number of statements to this effect could be quoted; a few will suffice. Youatt, a sagacious and experienced observer, writes[2] the principle of selection is “that which enables the agriculturist, not only to modify the character of his flock, but to change it altogether.” A great breeder of Shorthorns[3] says, “In the anatomy of the shoulder modern breeders have made great improvement on the

Ketton shorthorns by correcting the defect in the knuckle or shoulder-joint, and by laying the top of the shoulder more snugly in the crop, and thereby filling up the hollow behind it . . . The eye has its fashion at different periods: at one time the eye high and outstanding from the head, and at another time the sleepy eye sunk into the head; but these extremes have merged into the medium of a full, clear and prominent eye with a placid look."

Again, hear what an excellent judge of pigs[4] says: "The legs should be no longer than just to prevent the animal's belly from trailing on the ground. The leg is the least profitable portion of the hog, and we therefore require no more of it than is absolutely necessary for the support of the rest." Let any one compare the wild-boar with any improved breed, and he will see how effectually the legs have been shortened.

Few persons, except breeders, are aware of the systematic care taken in selecting animals, and of the necessity of having a clear and almost prophetic vision into futurity. Lord Spencer's skill and judgment were well known; and he writes,[5] "It is therefore very desirable, before any man commences to breed either cattle or sheep, that he should make up his mind to the shape and qualities he wishes to obtain, and steadily pursue this object." Lord Somerville, in speaking of the marvellous improvement of the New Leicester sheep, effected by Bakewell and his successors, says, "It would seem as if they had first drawn a perfect form, and then given it life." Youatt[6] urges the necessity of annually drafting each flock, as many animals will certainly degenerate "from the standard of excellence which the breeder has established in his own mind." Even with a bird of such little importance as the canary, long ago (1780-1790) rules were established, and a standard of perfection was fixed according to which the London fanciers tried to breed the several sub-varieties.[7] A great winner of prizes at the Pigeon-shows,[8] in describing the short-faced Almond Tumbler, says, "There are many first-rate fanciers who are particularly partial to what is called the goldfinch-beak, which is very beautiful; others say, take a full-size round cherry then take a barleycorn, and judiciously placing and thrusting it into the cherry, form as it were your beak; and that is not all, for it will form a good head and beak, provided, as I said before, it is judiciously done; others take an oat; but as I think the goldfinch-beak the handsomest, I would advise the inexperienced fancier to get the head of a goldfinch, and keep it by him for his observation." Wonderfully different as are the beaks of the rock pigeon and goldfinch, the end has undoubtedly been nearly gained, as far as external shape and proportions are concerned.

Not only should our animals be examined with the greatest care whilst alive, but, as Anderson remarks[9] their carcases should be scrutinised, "so as to breed from the descendants of such only as, in the language of the butcher, cut up well." The "grain of the meat" in cattle, and its being well marbled with fat,[10] and the greater or less accumulation of fat in the abdomen of our sheep, have been attended to with success. So with poultry, a writer,[11] speaking of Cochin-China fowls, which are said to differ much in the quality of their flesh, says, "the best mode is to purchase two young brother-cocks, kill, dress, and serve up one; if he be indifferent, similarly dispose of the other, and try again; if, however, he be fine and well-flavoured, his brother will not be amiss for breeding purposes for the table."

The great principle of the division of labour has been brought to bear on selection. In certain districts[12] "the breeding of bulls is confined to a very limited number of persons, who by devoting their whole attention to this department, are able from year to year to furnish a class of bulls which are steadily improving the general breed of the district." The rearing and letting of choice rams has long been, as is well known, a chief source of profit to several eminent breeders. In parts of Germany this principle is carried with merino sheep to an extreme point.[13] So "important is the proper selection of breeding animals considered, that the best flock-masters do not trust to their own judgment or to that of their shepherds, but employ persons called 'sheep-classifiers' who make it their special business to attend to this part of the management of several flocks, and thus to preserve, or if possible to improve, the best qualities of both parents in the lambs." In Saxony, "when the lambs are weaned, each in his turn is placed upon a table that his wool and form may be minutely observed. The finest are selected for breeding and receive a first mark. When they are one year old, and prior to shearing them, another close examination of those previously marked takes place: those in which no defect can be found receive a second mark, and the rest are condemned. A few months afterwards a third and last scrutiny is made; the prime rams and ewes receive a third and final mark, but the slightest blemish is sufficient to cause the rejection of the animal." These sheep are bred and valued almost exclusively for the fineness of their wool; and the result corresponds with the labour bestowed on their selection. Instruments have been invented to measure accurately the thickness of the fibres; and "an Austrian fleece has been produced of which twelve hairs equalled in thickness one from a Leicester sheep."

Throughout the world, wherever silk is produced, the greatest care is bestowed on selecting the cocoons from which the moths for breeding are to be reared. A careful cultivator[14] likewise examines the moths themselves, and destroys those that are not perfect. But what more immediately concerns us is that certain families in France devote themselves to raising eggs for sale.[15] In China, near Shanghai, the inhabitants of two small districts have the privilege of raising eggs for the whole surrounding country, and that they may give up their whole time to this business, they are interdicted by law from producing silk.[16]

The care which successful breeders take in matching their birds is surprising. Sir John Sebright, whose fame is perpetuated by the "Sebright Bantam," used to spend "two and three days in examining, consulting, and disputing with a friend which were the best of five or six birds."[17] Mr. Bult, whose pouter-pigeons won so many prizes, and were exported to North America under the charge of a man sent on purpose, told me that he always deliberated for several days before he matched each pair. Hence we can understand the advice of an eminent fancier, who writes[18] "I would here particularly guard you against having too great a variety of pigeons, otherwise you will know a little of all, but nothing about one as it ought to be known." Apparently it transcends the power of the human intellect to breed all kinds: "it is possible that there may be a few fanciers that have a good general knowledge of fancy pigeons; but there are many more who labour under the delusion of supposing they know what they do not." The excellence of one sub-variety, the Almond Tumbler, lies in the plumage, carriage, head, beak, and eye; but it is too presumptuous in the beginner to try for all these points. The great judge above quoted says, "There are some young fanciers who are over-covetous, who go for all the above five properties at once; they have their reward by getting nothing." We thus see that breeding even fancy pigeons is no simple art: we may smile at the solemnity of these precepts, but he who laughs will win no prizes.

What methodical selection has effected for our animals is sufficiently proved, as already remarked, by our Exhibitions. So greatly were the sheep belonging to some of the earlier breeders, such as Bakewell and Lord Western, changed, that many persons could not be persuaded that they had not been crossed. Our pigs, as Mr. Corringham remarks[19] during the last twenty years have undergone, through rigorous selection together with crossing, a complete metamorphosis. The first exhibition for poultry was held in the Zoological Gardens in 1845; and the improvement effected since that time has been great. As Mr. Bailey, the great judge, remarked to me, it was formerly ordered that the comb of the Spanish cock should be upright, and in four or five years all good birds had upright combs; it was ordered that the Polish cock should have no comb or wattles, and now a bird thus furnished would be at once disqualified; beards were ordered, and out of fifty-seven pens lately (1860) exhibited at the Crystal Palace, all had beards. So it has been in many other cases. But in all cases the judges order only what is occasionally produced and what can be improved and rendered constant by selection. The steady increase in weight during the last few years in our fowls, turkeys, ducks, and geese is notorious; "six-pound ducks are now common, whereas four pounds was formerly the average." As the time required to make a change has not often been recorded, it may be worth mentioning that it took Mr. Wicking thirteen years to put a clean white head on an almond tumbler's body, "a triumph," says another fancier, "of which he may be justly proud."[20]

Mr. Tollet, of Betley Hall, selected cows, and especially bulls, descended from good milkers, for the sole purpose of improving his cattle for the production of cheese; he steadily tested the milk with the lactometer, and in eight years he increased, as I was informed by him, the product in proportion of four to three. Here is a curious case[21] of steady but slow progress, with the end not as yet fully attained: in 1784 a race of silkworms was introduced into France, in which one hundred in the thousand failed to produce white cocoons; but now after careful selection during sixty-five generations, the proportion of yellow cocoons has been reduced to thirty-five in the thousand.

With plants selection has been followed with the same good result as with animals. But the process is simpler, for plants in the great majority of cases bear both sexes. Nevertheless, with most kinds it is necessary to take as much care to prevent crosses as with animals or unisexual plants; but with some plants, such as peas, this care is not necessary. With all improved plants, excepting of course those which are propagated by buds, cuttings, etc., it is almost indispensable to examine the seedlings and destroy those which depart from the proper type. This is called "roguing," and is, in fact, a form of selection, like the rejection of inferior animals. Experienced horticulturists and agriculturists incessantly urge every one to preserve the finest plants for the production of seed.

Although plants often present much more conspicuous variations than animals, yet the closest attention is generally requisite to detect each slight and favourable change. Mr. Masters relates[22] how "many a patient hour was devoted," whilst he was young, to the detection of differences in peas intended for seed. Mr. Barnet[23] remarks that the old scarlet American strawberry was cultivated for more than a century without producing a single variety; and another writer observes how singular it was that when gardeners first began to attend to this fruit it began to vary; the truth no doubt being that it had always varied, but that, until slight variations were selected and propagated by seed, no conspicuous result was obtained. The finest shades of difference in wheat have been discriminated and selected with almost as much care as, in the case of the higher animals, for instance by Col. Le Couteur and more especially by Major Hallett.

It may be worth while to give a few examples of methodical selection with plants; but in fact the great improvement of all our anciently cultivated plants may be attributed to selection long carried on, in part methodically, and in part unconsciously. I have shown in a former chapter how the weight of the gooseberry has been increased by systematic selection and culture. The flowers of the Heartsease have been similarly increased in size and regularity of outline. With the Cineraria, Mr. Glenny[24] "was bold enough when the flowers were ragged and starry and ill defined in colour, to fix a standard which was then considered outrageously high and impossible, and which, even if reached, it was said, we should be no gainers by, as it would spoil the beauty of the flowers. He maintained that he was right; and the event has proved it to be so." The doubling of flowers has several times been effected by careful selection: the Rev. W. Williamson,[25] after sowing during several years seed of *Anemone coronaria*, found a plant with one additional petal; he sowed the seed of this, and by perseverance in the same course obtained several varieties with six or seven rows of petals. The single Scotch rose was doubled, and yielded eight good varieties in nine or ten years.[26] The Canterbury bell (*Campanula medium*) was doubled by careful selection in four generations.[27] In four years Mr. Buckman,[28] by culture and careful selection, converted parsnips, raised from wild seed, into a new and good variety. By selection during a long course of years, the early maturity of peas has been hastened by between ten and twenty-one days.[29] A more curious case is offered by the beet plant, which since its cultivation in France, has almost exactly doubled its yield of sugar. This has been effected by the most careful selection; the specific gravity of the roots being regularly tested, and the best roots saved for the production of seed.[30]

Selection by Ancient and Semi-civilised People.

In attributing so much importance to the selection of animals and plants, it may be objected, that methodical selection would not have been carried on during ancient times. A distinguished naturalist considers it as absurd to suppose that semi-civilised people should have practised selection of any kind. Undoubtedly the principle has been systematically acknowledged and followed to a far greater extent within the last hundred years than at any former period, and a corresponding result has been gained; but it would be a greater error to suppose, as we shall immediately see, that its importance was not recognised and acted on during the most ancient times, and by semi-civilised people. I should premise that many facts now to be given only show that care was taken in breeding; but when this is the case, selection is almost sure to be practised to a certain extent. We shall hereafter be enabled better to judge how far selection, when only occasionally carried on, by a few of the inhabitants of a country, will slowly produce a great effect.

In a well-known passage in the thirtieth chapter of Genesis, rules are given for influencing, as was then thought possible, the colour of sheep; and speckled and dark breeds are spoken of as being kept separate. By the time of David the fleece was likened to snow. Youatt,[31] who has discussed all the passages in relation to breeding in the Old Testament, concludes that at this early period "some of the best principles of breeding must have been steadily and long pursued." It was ordered, according to Moses, that "Thou shalt not let thy cattle gender with a diverse kind;" but mules were purchased[32] so that at this early period other nations must have crossed the horse and ass. It is said[33] that Erichthonius, some generations before the Trojan war, had many brood-mares, "which by his care and judgment in the choice of stallions produced a breed of horses superior to any in the surrounding countries." Homer (Book 5) speaks of Aeneas' horses as bred from mares which were put to the steeds of Laomedon. Plato, in his 'Republic' says to Glaucus, "I see that you raise at your house a great many dogs for the chase. Do you take care about breeding and pairing them? Among animals of good blood, are there not always some which are superior to the rest?" To which Glaucus answers in the affirmative.[34] Alexander the Great selected the finest Indian cattle to send to Macedonia to improve the breed.[35] According to Pliny,[36] King Pyrrhus had an especially valuable breed of oxen: and he did not suffer the bulls and cows to come together till four years old, that the breed might not degenerate. Virgil, in his Georgics (lib. 3), gives as strong advice as any modern agriculturist could do, carefully to select the breeding stock; "to note the tribe, the lineage, and the sire; whom to reserve for husband of the herd;"—to brand the progeny;—to select sheep of the purest white, and to examine if their tongues are swarthy. We have seen that the Romans kept pedigrees of their pigeons, and this would have been a senseless proceeding had not great care been taken in breeding them. Columella gives detailed instructions about breeding fowls: "Let the breeding hens therefore be of a choice colour, a robust body, square-built, full-breasted, with large heads, with upright and bright-red combs. Those are believed to be the best bred which have five toes."[37] According to Tacitus, the Celts attended to the races of their domestic animals; and Caesar states that they paid high prices to merchants for fine imported horses.[38] In regard to plants, Virgil speaks of yearly culling the largest seeds; and Celsus says, "where the corn and crop is but small, we must pick out the best ears of corn, and of them lay up our seed separately by itself."[39]

Coming down the stream of time, we may be brief. At about the beginning of the ninth century Charlemagne expressly ordered his officers to take great care of his stallions; and if any proved bad or old, to forewarn him in good time before they were put to the mares.[40] Even in a country so little civilised as Ireland during the ninth century, it would appear from some ancient verses,[41] describing a ransom demanded by Cormac, that animals from particular places, or having a particular character, were valued. Thus it is said,—

Two pigs of the pigs of Mac Lir,
A ram and ewe both round and red,
I brought with me from Aengus.
I brought with me a stallion and a mare
From the beautiful stud of Manannan,
A bull and a white cow from Druim Cain.

Athelstan, in 930, received running-horses as a present from Germany; and he prohibited the exportation of English horses. King John imported "one hundred chosen stallions from Flanders."[42] On June 16th, 1305, the Prince of Wales wrote to the Archbishop of Canterbury, begging for the loan of any choice stallion, and promising its return at the end of the season.[43] There are numerous records at ancient periods in English history of the importation of choice animals of various kinds, and of foolish laws against their exportation. In the reigns of Henry VII. and VIII. it was ordered that the magistrates, at Michaelmas, should scour the heaths and commons, and destroy all mares beneath a certain size.[44] Some of our earlier kings passed laws against the slaughtering rams of any good breed before they were seven years old, so that they might have time to breed. In Spain Cardinal Ximenes issued, in 1509, regulations on the *selection* of good rams for breeding.[45]

The Emperor Akbar Khan before the year 1600 is said to have "wonderfully improved" his pigeons by crossing the breeds; and this necessarily implies careful selection. About the same period the Dutch attended with the greatest care to the breeding of these birds. Belon in 1555 says that good managers in France examined the colour of their goslings in order to get geese of a white colour and better kinds. Markham in 1631 tells the breeder "to elect the largest and goodliest conies," and enters into minute details. Even with respect to seeds of plants for the flower-garden, Sir J. Hanmer writing about the year 1660[46] says, in "choosing seed, the best seed is the most weighty, and is had from the lustiest and most vigorous stems;" and he then gives rules about leaving only a few flowers on plants for seed; so that even such details were attended to in our flower-gardens two hundred years ago. In order to show that selection has been silently carried on in places where it would not have been expected, I may add that in the middle of the last century, in a remote part of North America, Mr. Cooper improved by careful selection all his vegetables, "so that they were greatly superior to those of any other person. When his radishes, for instance, are fit for use, he takes ten or twelve that he most approves, and plants them at least 100 yards from others that blossom at the same time. In the same manner he treats all his other plants, varying the circumstances according to their nature."[47]

In the great work on China published in the last century by the Jesuits, and which is chiefly compiled from ancient Chinese encyclopaedias, it is said that with sheep "improving the breed consists in choosing with particular care the lambs which are destined for propagation, in nourishing them well, and in keeping the flocks separate." The same principles were applied by the Chinese to various plants and fruit-trees.[48] An imperial edict recommends the choice of seed of remarkable size; and selection was practised even by imperial hands, for it is said that the Ya-mi, or imperial rice, was noticed at an ancient period in a field by the Emperor Khang-hi, was saved and cultivated in his garden, and has since become valuable from being the only kind which will grow north of the Great Wall.[49] Even with flowers, the tree paeony (*P. moutan*) has been cultivated, according to Chinese traditions, for 1400 years; between 200 and 300 varieties have been raised, which are cherished like tulips formerly were by the Dutch.[50]

Turning now to semi-civilised people and to savages: it occurred to me, from what I had seen of several parts of South America, where fences do not exist, and where the animals are of little value, that there would be absolutely no care in breeding or selecting them; and this to a large extent is true. Roulin,[51] however, describes in Columbia a naked race of cattle, which are not allowed to increase, on account of their delicate constitution. According to Azara[52] horses are often born in Paraguay with curly hair; but, as the natives do not like them, they are destroyed. On the other hand, Azara states that a hornless bull, born in 1770, was preserved and propagated its race. I was informed of the existence in Banda Oriental of a breed with reversed hair; and the extraordinary niata cattle first appeared and have since been kept distinct in La Plata. Hence certain conspicuous variations have been preserved, and others have been habitually destroyed, in these countries, which are so little favourable for careful selection. We have also seen that the inhabitants sometimes introduce fresh cattle on their estates to prevent the evil effects of close interbreeding. On the other hand, I have heard on reliable authority that the Gauchos of the Pampas never take any pains in selecting the best bulls or stallions for breeding; and this probably accounts for the cattle and horses being remarkably uniform in character throughout the immense range of the Argentine republic.

Looking to the Old World, in the Sahara Desert "The Touareg is as careful in the selection of his breeding Mahari (a fine race of the dromedary) as the Arab is in that of his horse. The pedigrees are handed down, and many a dromedary can boast a genealogy far longer than the descendants of the Darley Arabian."[53] According to Pallas the Mongolians endeavour to breed the Yaks or horse-tailed buffaloes with white tails, for these are sold to the Chinese mandarins as fly-flappers; and Moorcroft, about seventy years after Pallas, found that white-tailed animals were still selected for breeding.[54]

We have seen in the chapter on the Dog that savages in different parts of North America and in Guiana cross their dogs with wild Canidæ, as did the ancient Gauls, according to Pliny. This was done to give their dogs strength and vigour, in the same way as the keepers in large warrens now sometimes cross their ferrets (as I have been informed by Mr. Yarrell) with the wild polecat, "to give them more devil." According to Varro, the wild ass was formerly caught and crossed with the tame animal to improve the breed, in the same manner as at the present day the natives of Java sometimes drive their cattle into the forests to cross with the wild Banteng (*Bos sondaicus*).[55] In Northern Siberia, among the Ostyaks, the dogs vary in markings in different districts, but in each place they are spotted black and white in a remarkably uniform manner;[56] and from this fact alone we may infer careful breeding, more especially as the dogs of one locality are famed throughout the country for their superiority. I have heard of certain tribes of Esquimaux who take pride in their teams of dogs being uniformly coloured. In Guiana, as Sir H. Schomburgk informs me,[57] the dogs of the Turuma Indians are highly valued and extensively bartered: the price of a good one is the same as that given for a wife: they are kept in a sort of cage, and the Indians "take great care when the female is in season to prevent her uniting with a dog of an inferior description." The Indians told Sir Robert that, if a dog proved bad or useless, he was not killed, but was left to die from sheer neglect. Hardly any nation is more barbarous than the Fuegians, but I hear from Mr. Bridges, the Catechist to the Mission, that, "when these savages have a large, strong, and active bitch, they take care to put her to a fine dog, and even take care to feed her well, that her young may be strong and well favoured."

In the interior of Africa, negroes, who have not associated with white men, show great anxiety to improve their animals; they "always choose the larger and stronger males for stock;" the Malakolo were much pleased at Livingstone's promise to send them a bull, and some Bakalolo carried a live cock all the way from Loanda into the interior.[58] At Falaba Mr. Winwood Reade noticed an unusually fine horse, and the negro King informed him that "the owner was noted for his skill in breeding horses." Further south on the same continent, Andersson states that he has known a Damara give two fine oxen for a dog which struck his fancy. The Damaras take great delight in having whole droves of cattle of the same colour, and they prize their oxen in proportion to the size of their horns. "The Namaquas have a perfect mania for a uniform team; and almost all the people of Southern Africa value their cattle next to their women, and take a pride in possessing animals that look high-bred. They rarely or never make use of a handsome animal as a beast of burden."[59] The power of discrimination which these savages possess is wonderful, and they can recognise to which tribe any cattle belong. Mr.

Andersson further informs me that the natives frequently match a particular bull with a particular cow.

The most curious case of selection by semi-civilised people, or indeed by any people, which I have found recorded, is that given by Garcilazo de la Vega, a descendant of the Incas, as having been practised in Peru before the country was subjugated by the Spaniards.[60] The Incas annually held great hunts, when all the wild animals were driven from an immense circuit to a central point. The beasts of prey were first destroyed as injurious. The wild Guanacos and Vicunas were sheared; the old males and females killed, and the others set at liberty. The various kinds of deer were examined; the old males and females were likewise killed, "but the young females, with a certain number of males, selected from the most beautiful and strong," were given their freedom. Here, then, we have selection by man aiding natural selection. So that the Incas followed exactly the reverse system of that which our Scottish sportsman are accused of following, namely, of steadily killing the finest stags, thus causing the whole race to degenerate.[61] In regard to the domesticated llamas and alpacas, they were separated in the time of the Incas according to colour: and if by chance one in a flock was born of the wrong colour, it was eventually put into another flock.

In the genus Auchenia there are four forms,—the Guanaco and Vicuna, found wild and undoubtedly distinct species; the Llama and Alpaca, known only in a domesticated condition. These four animals appear so different, that most naturalists, especially those who have studied these animals in their native country, maintain that they are specifically distinct, notwithstanding that no one pretends to have seen a wild llama or alpaca. Mr. Ledger, however, who has closely studied these animals both in Peru and during their exportation to Australia, and who has made many experiments on their propagation, adduces arguments[62] which seem to me conclusive, that the llama is the domesticated descendant of the guanaco, and the alpaca of the vicuna. And now that we know that these animals were systematically bred and selected many centuries ago, there is nothing surprising in the great amount of change which they have undergone.

It appeared to me at one time probable that, though ancient and semi-civilised people might have attended to the improvement of their more useful animals in essential points, yet that they would have disregarded unimportant characters. But human nature is the same throughout the world: fashion everywhere reigns supreme, and man is apt to value whatever he may chance to possess. We have seen that in South America the niata cattle, which certainly are not made useful by their shortened faces and upturned nostrils, have been preserved. The Damaras of South Africa value their cattle for uniformity of colour and enormously long horns. And I will now show that there is hardly any peculiarity in our most useful animals which, from fashion, superstition, or some other motive, has not been valued, and consequently preserved. With respect to cattle, "an early record," according to Youatt[63] "speaks of a hundred white cows with red ears being demanded as a compensation by the princes of North and South Wales. If the cattle were of a dark or black colour, 150 were to be presented." So that colour was attended to in Wales before its subjugation by England. In Central Africa, an ox that beats the ground with its tail is killed; and in South Africa some of the Damaras will not eat the flesh of a spotted ox. The Kaffirs value an animal with a musical voice; and "at a sale in British Kaffraria the low of a heifer excited so much admiration that a sharp competition sprung up for her possession, and she realised a considerable price."[64] With respect to sheep, the Chinese prefer rams without horns; the Tartars prefer them with spirally wound horns, because the hornless are thought to lose courage.[65] Some of the Damaras will not eat the flesh of hornless sheep. In regard to horses, at the end of the fifteenth century animals of the colour described as liart pomme were most valued in France. The Arabs have a proverb, "Never buy a horse with four white feet, for he carries his shroud with him";[66] the Arabs also, as we have seen, despise dun-coloured horses. So with dogs, Xenophon and others at an ancient period were prejudiced in favour of certain colours; and "white or slate-coloured hunting dogs were not esteemed."[67]

Turning to poultry, the old Roman gourmands thought that the liver of a white goose was the most savoury. In Paraguay black-skinned fowls are kept because they are thought to be more productive, and their flesh the most proper for invalids.[68] In Guiana, as I am informed by Sir R. Schomburgk, the aborigines will not eat the flesh or eggs of the fowl, but two races are kept distinct merely for ornament. In the Philippines, no less than nine sub-varieties of the game-cock are kept and named, so that they must be separately bred.

At the present time in Europe, the smallest peculiarities are carefully attended to in our most useful animals, either from fashion, or as a mark of purity of blood. Many examples could be given; two will suffice. "In the Western counties of England the prejudice against a white pig is nearly as strong as against a black one in Yorkshire." In one of the Berkshire sub-breeds, it is said, "the white should be confined to four white feet, a white spot between the eyes, and a few white hairs behind each shoulder." Mr. Saddler possessed "three hundred pigs, every one of which was marked in this manner."[69] Marshall, towards the close of the last century, in speaking of a change in one of the Yorkshire breeds of cattle, says the horns have been considerably modified, as "a clean, small, sharp horn has been *fashionable* for the last twenty years."[70] In a part of Germany the cattle of the Race de Gfoehl are valued for many good qualities, but they must have horns of a particular curvature and tint, so much so that mechanical means are applied if they take a wrong direction; but the inhabitants "consider it of the highest importance that the nostrils of the bull should be flesh-coloured, and the eyelashes light; this is an indispensable condition. A calf with blue nostrils would not be purchased, or purchased at a very low price."[71] Therefore let no man say that any point or character is too trifling to be methodically attended to and selected by breeders.

Unconscious Selection.—By this term I mean, as already more than once explained, the preservation by man of the most valued, and the destruction of the least valued individuals, without any conscious intention on his part of altering the breed. It is difficult to offer direct proofs of the results which follow from this kind of selection;

but the indirect evidence is abundant. In fact, except that in the one case man acts intentionally, and in the other unintentionally, there is little difference between methodical and unconscious selection. In both cases man preserves the animals which are most useful or pleasing to him, and destroys or neglects the others. But no doubt a far more rapid result follows from methodical than from unconscious selection. The "roguing" of plants by gardeners, and the destruction by law in Henry VIII.'s reign of all under-sized mares, are instances of a process the reverse of selection in the ordinary sense of the word, but leading to the same general result. The influence of the destruction of individuals having a particular character is well shown by the necessity of killing every lamb with a trace of black about it, in order to keep the flock white; or again, by the effects on the average height of the men of France of the destructive wars of Napoleon, by which many tall men were killed, the short ones being left to be the fathers of families. This at least is the conclusion of some of those who have closely studied the effects of the conscription; and it is certain that since Napoleon's time the standard for the army has been lowered two or three times.

Unconscious selection blends with methodical, so that it is scarcely possible to separate them. When a fancier long ago first happened to notice a pigeon with an unusually short beak, or one with the tail-feathers unusually developed, although he bred from these birds with the distinct intention of propagating the variety, yet he could not have intended to make a short-faced tumbler or a fantail, and was far from knowing that he had made the first step towards this end. If he could have seen the final result, he would have been struck with astonishment, but, from what we know of the habits of fanciers, probably not with admiration. Our English carriers, barbs, and short-faced tumblers have been greatly modified in the same manner, as we may infer both from the historical evidence given in the chapters on the Pigeon, and from the comparison of birds brought from distant countries.

So it has been with dogs; our present fox-hounds differ from the old English hound; our greyhounds have become lighter: the Scotch deer-hound has been modified, and is now rare. Our bulldogs differ from those which were formerly used for baiting bulls. Our pointers and Newfoundlands do not closely resemble any native dog now found in the countries whence they were brought. These changes have been effected partly by crosses; but in every case the result has been governed by the strictest selection. Nevertheless, there is no reason to suppose that man intentionally and methodically made the breeds exactly what they now are. As our horses became fleeter, and the country more cultivated and smoother, fleeter fox-hounds were desired and produced, but probably without any one distinctly foreseeing what they would become. Our pointers and setters, the latter almost certainly descended from large spaniels, have been greatly modified in accordance with fashion and the desire for increased speed. Wolves have become extinct, and so has the wolf-dog; deer have become rarer, bulls are no longer baited, and the corresponding breeds of the dog have answered to the change. But we may feel almost sure that when, for instance, bulls were no longer baited, no man said to himself, I will now breed my dogs of smaller size, and thus create the present race. As circumstances changed, men unconsciously and slowly modified their course of selection.

With racehorses selection for swiftness has been followed methodically, and our horses now easily surpass their progenitors. The increased size and different appearance of the English racehorse led a good observer in India to ask, “Could any one in this year of 1856, looking at our racehorses, conceive that they were the result of the union of the Arab horse and the African mare?”[72] This change has, it is probable, been largely effected through unconscious selection, that is, by the general wish to breed as fine horses as possible in each generation, combined with training and high feeding, but without any intention to give to them their present appearance. According to Youatt,[73] the introduction in Oliver Cromwell’s time of three celebrated Eastern stallions speedily affected the English breed; “so that Lord Harleigh, one of the old school, complained that the great horse was fast disappearing.” This is an excellent proof how carefully selection must have been attended to; for without such care, all traces of so small an infusion of Eastern blood would soon have been absorbed and lost. Notwithstanding that the climate of England has never been esteemed particularly favourable to the horse, yet long-continued selection, both methodical and unconscious, together with that practised by the Arabs during a still longer and earlier period, has ended in giving us the best breed of horses in the world. Macaulay[74] remarks, “Two men whose authority on such subjects was held in great esteem, the Duke of Newcastle and Sir John Fenwick, pronounced that the meanest hack ever imported from Tangier would produce a finer progeny than could be expected from the best sire of our native breed. They would not readily have believed that a time would come when the princes and nobles of neighbouring lands would be as eager to obtain horses from England as ever the English had been to obtain horses from Barbary.”

The London dray-horse, which differs so much in appearance from any natural species, and which from its size has so astonished many Eastern princes, was probably formed by the heaviest and most powerful animals having been selected during many generations in Flanders and England, but without the least intention or expectation of creating a horse such as we now see. If we go back to an early period of history, we behold in the antique Greek statues, as Schaaffhausen has remarked,[75] a horse equally unlike a race or dray horse, and differing from any existing breed.

The results of unconscious selection, in an early stage, are well shown in the difference between the flocks descended from the same stock, but separately reared by careful breeders. Youatt gives an excellent instance of this fact in the sheep belonging to Messrs. Buckley and Burgess, which “have been purely bred from the original stock of Mr. Bakewell for upwards of fifty years. There is not a suspicion existing in the mind of any one at all acquainted with the subject that the owner of either flock has deviated in any one instance from the pure blood of Mr. Bakewell’s flock; yet the difference between the sheep possessed by these two gentlemen is so great, that they have the appearance of being quite different varieties."[76] I have seen several analogous and well marked cases with pigeons: for instance, I had a family of barbs descended from those long bred by Sir J. Sebright, and another family long bred by another fancier, and the two families plainly differed from each other. Nathusius—and a more competent witness could not be cited—observes that, though the Shorthorns are remarkably uniform in appearance (except in colour), yet the individual character and wishes of each breeder become impressed on his cattle, so that different herds differ slightly from one another.[77] The Hereford cattle assumed their present well-marked character soon after the year 1769, through careful selection by Mr. Tomkins[78] and the breed has lately split into two strains—one strain having a white face, and differing slightly, it is said,[79] in some other points: but there is no reason to believe that this split, the origin of which is unknown, was intentionally made; it may with much more probability be attributed to different breeders having attended to different points. So again, the Berkshire breed of swine in the year 1810 had greatly changed from what it was in 1780; and since 1810 at least two distinct sub-breeds have arisen bearing the same name.[80] Keeping in mind how rapidly all animals increase, and that some must be annually slaughtered and some saved for breeding, then, if the same breeder during a long course of years deliberately settles which shall be saved and which shall be killed, it is almost inevitable that his individual turn of mind will influence the character of his stock, without his having had any intention to modify the breed.

Unconscious selection in the strictest sense of the word, that is, the saving of the more useful animals and the neglect or slaughter of the less useful, without any thought of the future, must have gone on occasionally from the remotest period and amongst the most barbarous nations. Savages often suffer from famines, and are sometimes expelled by war from their own homes. In such cases it can hardly be doubted that they would save their most useful animals. When the Fuegians are hard pressed by want, they kill their old women for food rather than their dogs; for, as we were assured, "old women no use—dogs catch otters." The same sound sense would surely lead them to preserve their more useful dogs when still harder pressed by famine. Mr. Oldfield, who has seen so much of the aborigines of Australia, informs me that "they are all very glad to get a European kangaroo dog, and several instances have been known of the father killing his own infant that the mother might suckle the much-prized puppy." Different kinds of dogs would be useful to the Australian for hunting opossums and kangaroos, and to the Fuegian for catching fish and otters; and the occasional preservation in the two countries of the most useful animals would ultimately lead to the formation of two widely distinct breeds.

With plants, from the earliest dawn of civilisation, the best variety which was known would generally have been cultivated at each period and its seeds occasionally sown; so that there will have been some selection from an extremely remote period, but without any prefixed standard of excellence or thought of the future. We at the present day profit by a course of selection occasionally and unconsciously carried on during thousands of years. This is proved in an interesting manner by Oswald Heer's researches on the lake-inhabitants of Switzerland, as given in a former chapter; for he shows that the grain and seed of our present varieties of wheat, barley, oats, peas, beans, lentils, and poppy, exceed in size those which were cultivated in Switzerland during the Neolithic and Bronze periods. These ancient people, during the Neolithic period, possessed also a crab considerably larger than that now growing wild on the Jura.[81] The pears described by Pliny were evidently extremely inferior in quality to our present pears. We can realise the effects of long-continued selection and cultivation in another way, for would any one in his senses expect to raise a first-rate apple from the seed of a truly wild crab, or a luscious melting pear from the wild pear? Alphonse de Candolle informs me that he has lately seen on an ancient mosaic at Rome a representation of the melon; and as the Rotnans, who were such gourmands, are silent on this fruit, he infers that the melon has been greatly ameliorated since the classical period.

Coming to later times, Buffon[82] on comparing the flowers, fruit, and vegetables which were then cultivated with some excellent drawings made a hundred and fifty years previously, was struck with surprise at the great improvement which had been effected; and remarks that these ancient flowers and vegetables would now be rejected, not only by a florist but by a village gardener. Since the time of Buffon the work of improvement has steadily and rapidly gone on. Every florist who compares our present flowers with those figured in books published not long since, is astonished at the change. A well-known amateur,[83] in speaking of the varieties of Pelargonium raised by Mr. Garth only twenty-two years before, remarks, "What a rage they excited: surely we had attained perfection, it was said; and now not one of the flowers of those days will be looked at. But none the less is the debt of gratitude which we owe to those who saw what was to be done, and did it." Mr. Paul, the well-known horticulturist, in writing of the same flower,[84] says he remembers when young being delighted with the portraits in Sweet's work; "but what are they in point of beauty compared with the Pelargoniums of this day? Here again nature did not advance by leaps; the improvement was gradual, and if we had neglected those very gradual advances, we must have foregone the present grand results." How well this practical horticulturist appreciates and illustrates the gradual and accumulative force of selection! The Dahlia has advanced in beauty in a like manner; the line of improvement being guided by fashion, and by the successive modifications which the flower slowly underwent.[85] A steady and gradual change has been noticed in many other flowers: thus an old florist,[86] after describing the leading varieties of the Pink which were grown in 1813 adds, "the pinks of those days would now be scarcely grown as border-flowers." The improvement of so many flowers and the number of the varieties which have been raised is all the more striking when we hear that the earliest known flower-garden in Europe, namely at Padua, dates only from the year 1545.[87]

Effects of Selection, as shown by the parts most valued by man presenting the greatest amount of difference.—The power of long-continued selection, whether methodical or unconscious, or both combined, is well shown in a general way, namely, by the comparison of the differences between the varieties of distinct species, which are valued for different parts, such as for the leaves, or stems, or tubers, the seed, or fruit, or flowers. Whatever part man values most, that part will be found to present the greatest amount of difference. With trees cultivated for their fruit, Sageret remarks that the fruit is larger than in the parent-species, whilst with those cultivated for the seed, as with nuts, walnuts, almonds, chestnuts, etc., it is the seed itself which is larger; and he accounts for this fact by the fruit in the one case, and by the seed in the other, having been carefully attended to and selected during many ages. Gallesio has made the same observation. Godron insists on the diversity of the tuber in the potato, of the bulb in the onion, and of the fruit in the melon; and on the close similarity of the other parts in these same plants.[88]

In order to judge how far my own impression on this subject was correct, I cultivated numerous varieties of the same species close to one another. The comparison of the amount of difference between widely different organs is necessarily vague; I will therefore give the results in only a few cases. We have previously seen in the ninth chapter how greatly the varieties of the cabbage differ in their foliage and stems, which are the selected parts, and how closely they resemble one another in their flowers, capsules, and seeds. In seven varieties of the radish, the roots differed greatly in colour and shape, but no difference whatever could be detected in their foliage, flowers, or seeds. Now what a contrast is presented, if we compare the flowers of the varieties of these two plants with those of any species cultivated in our flower-gardens for ornament; or if we compare their seeds with those of the varieties of maize, peas, beans, etc., which are valued and cultivated for their seeds. In the ninth chapter it was shown that the varieties of the pea differ but little except in the tallness of the plant, moderately in the shape of the pod, and greatly in the pea itself, and these are all selected points. The varieties, however, of the *Pois sans parchemin* differ much more in their pods, and these are eaten and valued. I cultivated twelve varieties of the common bean; one alone, the Dwarf Fan, differed considerably in general appearance; two differed in the colour of their flowers, one being an albino, and the other being wholly instead of partially purple; several differed considerably in the shape and size of the pod, but far more in the bean itself, and this is the valued and selected part. Toker's bean, for instance, is twice-and-a-half as long and broad as the horse-bean, and is much thinner and of a different shape.

The varieties of the gooseberry, as formerly described, differ much in their fruit, but hardly perceptibly in their flowers or organs of vegetation. With the plum, the differences likewise appear to be greater in the fruit than in the flowers or leaves. On the other hand, the seed of the strawberry, which corresponds with the fruit of the plum, differs hardly at all; whilst every one knows how greatly the fruit—that is, the enlarged receptacle—differs in several varieties. In apples, pears, and peaches the flowers and leaves differ considerably, but not, as far as I can judge, in proportion with the fruit.

The Chinese double-flowering peaches, on the other hand, show that varieties of this tree have been formed, which differ more in flower than in fruit. If, as is highly probable, the peach is the modified descent of the almond, a surprising amount of change has been effected in the same species, in the fleshy covering of the former and in the kernels of the latter.

When parts stand in close relationship to each other, such as the seed and the fleshy covering of the fruit (whatever its homological nature may be), changes in the one are usually accompanied by modifications in the other, though not necessarily to the same degree. With the plum-tree, for instance, some varieties produce plums which are nearly alike, but include stones extremely dissimilar in shape; whilst conversely other varieties produce dissimilar fruit with barely distinguishable stones; and generally the stones, though they have never been subjected to selection, differ greatly in the several varieties of the plum. In other cases organs which are not manifestly related, through some unknown bond vary together, and are consequently liable, without any intention on man’s part, to be simultaneously acted on by selection. Thus the varieties of the stock (Matthiola) have been selected solely for the beauty of their flowers, but the seeds differ greatly in colour and somewhat in size. Varieties of the lettuce have been selected solely on account of their leaves, yet produce seeds which likewise differ in colour. Generally, through the law of correlation, when a variety differs greatly from its fellow-varieties in any one character, it differs to a certain extent in several other characters. I observed this fact when I cultivated together many varieties of the same species, for I used first to make a list of the varieties which differed most from each other in their foliage and manner of growth, afterwards of those that differed most in their flowers, then in their seed-capsules, and lastly in their mature seed; and I found that the same names generally occurred in two, three, or four of the successive lists. Nevertheless the greatest amount of difference between the varieties was always exhibited, as far as I could judge, by that part or organ for which the plant was cultivated.

When we bear in mind that each plant was at first cultivated because useful to man, and that its variation was a subsequent, often a long subsequent, event, we cannot explain the greater amount of diversity in the valuable parts by supposing that species endowed with an especial tendency to vary in any particular manner were originally chosen. We must attribute the result to the variations in these parts having been successively preserved, and thus continually augmented; whilst other variations, excepting such as inevitably appeared through correlation, were neglected and lost. We may therefore infer that most plants might be made, through long-continued selection, to yield races as different from one another in any character as they now are in those parts for which they are valued and cultivated.

With animals we see nothing of the same kind; but a sufficient number of species have not been domesticated for a fair comparison. Sheep are valued for their wool, and the wool differs much more in the several races than the hair in cattle. Neither sheep, goats, European cattle, nor pigs are valued for their fleetness or strength; and we do not possess breeds differing in these respects like the racehorse and dray-horse. But fleetness and strength are valued in camels and dogs; and we have with the former the swift dromedary and heavy camel; with the latter the greyhound and mastiff. But dogs are valued even in a higher degree for their mental qualities and senses; and every one knows how greatly the races differ in these respects. On the other hand, where the dog is kept solely to serve for food, as in the Polynesian islands and China, it is described as an extremely stupid animal.[89] Blumenbach remarks that "many dogs, such as the badger-dog, have a build so marked and so appropriate for particular purposes, that I should find it very difficult to persuade myself that this astonishing figure was an accidental consequence of degeneration."[90] Had Blumenbach reflected on the great principle of selection, he would not have used the term degeneration, and he would not have been astonished that dogs and other animals should become excellently adapted for the service of man.

On the whole we may conclude that whatever part or character is most valued—whether the leaves, stems, tubers, bulbs, flowers, fruit, or seed of plants, or the size, strength, fleetness, hairy covering, or intellect of animals—that character will almost invariably be found to present the greatest amount of difference both in kind and degree. And this result may be safely attributed to man having preserved during a long course of generations the variations which were useful to him, and neglected the others.

I will conclude this chapter by some remarks on an important subject. With animals such as the giraffe, of which the whole structure is admirably co-ordinated for certain purposes, it has been supposed that all the parts must have been simultaneously modified; and it has been argued that, on the principle of natural selection, this is scarcely possible. But in thus arguing, it has been tacitly assumed that the variations must have been abrupt and great. No doubt, if the neck of a ruminant were suddenly to become greatly elongated, the fore limbs and back would have to be simultaneously strengthened and modified; but it cannot be denied that an animal might have its neck, or head, or tongue, or fore-limbs elongated a very little without any corresponding modification in other parts of the body; and animals thus slightly modified would, during a dearth, have a slight advantage, and be enabled to browse on higher twigs, and thus survive. A few mouthfuls more or less every day would make all the difference between life and death. By the repetition of the same process, and by the occasional intercrossing of the survivors, there would be some progress, slow and fluctuating though it would be, towards the admirably coordinated structure of the giraffe. If the short-faced tumbler-pigeon, with its small conical beak, globular head, rounded body, short wings, and small feet—characters which appear all in harmony—had been a natural species, its whole structure would have been viewed as well fitted for its life; but in this case we know that inexperienced breeders are urged to attend to point after point, and not to attempt improving the whole structure at the same time. Look at the greyhound, that perfect image of grace, symmetry, and vigour; no natural species can boast of a more admirably co-ordinated structure, with its tapering head, slim body, deep chest, tucked-up abdomen, rat-like tail, and long muscular limbs, all adapted for extreme fleetness, and for running down weak prey. Now, from what we see of the variability of animals, and from what we know of the method which different men follow in improving their stock—some chiefly attending to one point, others to another point, others again correcting defects by crosses, and so forth—we may feel assured that if we could see the long line of ancestors of a first-rate greyhound up to its wild wolf-like progenitor, we should behold an infinite number of the finest gradations, sometimes in one character and sometimes in another, but all leading towards our present perfect type. By small and doubtful steps such as these, nature, as we may confidently believe, has progressed, on her grand march of improvement and development.

A similar line of reasoning is as applicable to separate organs as to the whole organisation. A writer[91] has recently maintained that "it is probably no exaggeration to suppose that in order to improve such an organ as the eye at all, it must be improved in ten different ways at once. And the improbability of any complex organ being produced and brought to perfection in any such way is an improbability of the same kind and degree as that of producing a poem or a mathematical demonstration by throwing letters at random on a table." If the eye were abruptly and greatly modified, no doubt many parts would have to be simultaneously altered, in order that the organ should remain serviceable.

But is this the case with smaller changes? There are persons who can see distinctly only in a dull light, and this condition depends, I believe, on the abnormal sensitiveness of the retina, and is known to be inherited. Now if a bird, for instance, receive some great advantage from seeing well in the twilight, all the individuals with the most sensitive retina would succeed best and be the most likely to survive; and why should not all those which happened to have the eye itself a little larger, or the pupil capable of greater dilatation, be likewise preserved, whether or not these modifications were strictly simultaneous? These individuals would subsequently intercross and blend their respective advantages. By such slight successive changes, the eye of a diurnal bird would be brought into the condition of that of an owl, which has often been advanced as an excellent instance of adaptation. Short-sight, which is often inherited, permits a person to see distinctly a minute object at so near a distance that it would be indistinct to ordinary eyes; and here we have a capacity which might be serviceable under certain conditions, abruptly gained. The Fuegians on board the Beagle could certainly see distant objects more distinctly than our sailors with all their long practice; I do not know whether this depends upon sensitiveness or on the power of adjustment in the focus; but this capacity for distant vision might, it is probable, be slightly augmented by successive modifications of either kind. Amphibious animals which are enabled to see both in the water and in the air, require and possess, as M. Plateau has shown,[92] eyes constructed on the following plan: "the cornea is always flat, or at least much flattened in the front of the crystalline and over a space equal to the diameter of that lens, whilst the lateral portions may be much curved." The crystalline is very nearly a sphere, and the humours have nearly the same density as water. Now as a terrestrial animal became more and more aquatic in its habits, very slight changes, first in the curvature of the cornea or crystalline, and then in the density of the humours, or conversely, might successively occur, and would be advantageous to the animal whilst under water, without serious detriment to its power of vision in the air. It is of course impossible to conjecture by what steps the fundamental structure of the eye in the Vertebrata was originally acquired, for we know nothing about this organ in the first progenitors of the class. With respect to the lowest animals in the scale, the transitional states through which the eye at first probably passed, can by the aid of analogy be indicated, as I have attempted to show in my 'Origin of Species.'[93]

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[2] 'On Sheep,' 1838, p. 60.

[3] Mr. J. Wright on Shorthorn Cattle, in 'Journal of Royal Agricult. Soc.,' vol. vii. pp. 208, 209.

[4] H. D. Richardson 'On Pigs,' 1847, p. 44.

[5] 'Journal of Royal Agricult. Soc.,' vol. i. p. 24.

[6] 'On Sheep,' pp. 520, 319.

[7] Loudon's 'Mag. of Nat. Hist.,' vol. viii., 1835, p. 618.

[8] 'A treatise on the Art of Breeding the Almond Tumbler.' 1851. p. 9.

[9] 'Recreations in Agriculture,' vol. ii. p. 409.

[10] Youatt on Cattle, pp. 191, 227.

[11] Ferguson, 'Prize Poultry,' 1854, p. 208.

[12] Wilson, in 'Transact. Highland Agricult. Soc.,' quoted in 'Gardener's Chronicle,' 1844, p. 29.

[13] Simmonds, quoted in 'Gardener's Chronicle,' 1855, p. 637. And for the second quotation, *see* Youatt on Sheep, p. 171.

[14] Robinet, 'Vers à Soie,' 1848, p. 271.

[15] Quatrefages, ‘Les Maladies du Ver à Soie,’ 1859, p. 101.

[16] M. Simon, in ‘Bull. de la Soc. d’Acclimat.,’ tom. ix., 1862, p. 221.

[17] ‘The Poultry Chronicle,’ vol. i., 1854, p. 607.

[18] J. M. Eaton, ‘A Treatise on Fancy Pigeons,’ 1852, p. xiv., and ‘A Treatise on the Almond Tumbler,’ 1851, p. 11.

[19] ‘Journal Royal Agricultural Soc.,’ vol. vi., p. 22.

[20] ‘Poultry Chronicle,’ vol. ii., 1855, p. 596.

[21] Isid. Geoffroy St.-Hilaire, ‘Hist. Nat. Gén.,’ tom. iii. p. 254.

[22] ‘Gardener’s Chronicle,’ 1850, p. 198.

[23] ‘Transact. Hort. Soc.,’ vol. vi. p. 152.

[24] ‘Journal of Horticulture,’ 1862, p. 369.

[25] ‘Transact. Hort. Soc.,’ vol. iv. p. 381.

[26] ‘Transact. Hort. Soc.,’ vol. iv. p. 285.

[27] Rev. W. Bromehead, in ‘Gardener’s Chronicle,’ 1857, p. 550.

[28] ‘Gardener’s Chronicle,’ 1862, p. 721.

29[] Dr. Anderson, in ‘The Bee,’ vol. vi. p. 96; Mr. Barnes in ‘Gardener’s Chronicle,’ 1844, p. 476.

[30] Godron, ‘De l’Espèce,’ 1859, tom. ii. p. 69; ‘Gardener’s Chronicle,’ 1854, p. 258.

[31] On Sheep, p. 18.

[32] Volz, ‘Beiträge zur Kulturgeschichte,’ 1852, s. 47.

[33] Mitford’s ‘History of Greece,’ vol. i. p. 73.

[34] Dr. Dally, translated in ‘Anthropological Review,’ May 1864, p. 101.

[35] Volz, ‘Beiträge,’ etc., 1852, s. 80.

[36] ‘History of the World,’ ch. 45.

[37] ‘Gardener’s Chronicle,’ 1848, p. 323.

[38] Reynier, ‘De l’Économie des Celtes,’ 1818, pp. 487, 503.

[39] Le Couteur on Wheat, p. 15.

[40] Michel, ‘Des Haras,’ 1861, p. 84.

[41] Sir W. Wilde, an ‘Essay on Unmanufactured Animal Remains,’ etc., 1860, p. 11.

[42] Col. Hamilton Smith, ‘Nat. Library,’ vol. xii., Horses, pp. 135, 140.

[43] Michel, ‘Des Haras,’ p. 90.

[44] Mr. Baker, ‘History of the Horse,’ ‘Veterinary,’ vol. xiii. p. 423.

[45] M. l’Abbé Carlier, in ‘Journal de Physique,’ vol. xxiv., 1784, p. 181; this memoir contains much information on the ancient selection of sheep; and is my authority for rams not being killed young in England.

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[50] Anderson, in ‘Linn. Transact.,’ vol. xii. p. 253.

[51] ‘Mém. de l’Acad.’ (divers savants), tom. vi., 1835, p. 333.

[52] ‘Des Quadrupèdes du Paraguay,’ 1801, tom. ii. pp. 333, 371.

[53] ‘The Great Sahara,’ by the Rev. H. B. Tristram, 1860, p. 238.

[54] Pallas, ‘Act. Acad. St. Petersburg,’ 1777, p. 249; Moorcroft and Trebeck, ‘Travels in the Himalayan Provinces,’ 1841.

[55] Quoted from Raffles, in the ‘Indian Field,’ 1859, p. 196: for Varro, *see* Pallas *ut supra.*

[56] Erman’s ‘Travels in Siberia,’ Eng. translat., vol. i. p. 453.

[57] *See also* ‘Journal of R. Geograph. Soc.,’ vol. xiii. part i. p. 65.

[58] Livingstone’s ‘First Travels,’ pp. 191, 439, 565; *see also* ‘Expedition to the Zambesi,’ 1865, p. 495, for an analogous case respecting a good breed of goats.

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[60] Dr. Vavasseur, in ‘Bull. de La Soc. d’Acclimat.,’ tom. viii. 1861, p. 136.

[61] ‘The Natural History of Dee Side,’ 1855, p. 476.

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[63] ‘Cattle,’ p. 48.

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[83] ‘Journal of Horticulture,’ 1862, p. 394.

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[85] *See* Mr. Wildman’s address to the Floricult. Soc. in ‘Gardener’s Chronicle,’ 1843, p. 86.

[86] ‘Journal of Horticulture,’ Oct. 24th, 1865, p. 239.

[87] Prescott’s ‘Hist. of Mexico,’ vol. ii. p. 61.

[88] Sagaret, ‘Pomologie Physiologique,’ 1830, p. 47; Gallesio, ‘Teoria della Riproduzione,’ 1816, p. 88; Godron, ‘De l’Espèce,’ 1859, tom. 2 pp. 63, 67, 70. In my tenth and eleventh chapters I have given details on the potato; and I can confirm similar remarks with respect to the onion. I have also shown how far Naudin concurs in regard to the varieties of the melon.

[89] Godron, ‘De l’Espèce,’ tom. ii. p. 27.

[90] ‘The Anthropological Treatises of Blumenbach,’ 1856, p. 292.

[91] Mr. J. J. Murphy, in his opening address to the Belfast Nat. Hist. Soc., as given in the ‘Belfast Northern Whig,’ Nov. 19th, 1866. Mr. Murphy here follows the line of argument against my views previously and more cautiously given by the Rev. C. Pritchard, Pres. Royal Astronomical Soc., in his sermon (Appendix, p. 33) preached before the British Association at Nottingham, 1866.

[92] On the Vision of Fishes and Amphibia, translated in ‘Annals and Mag. of Nat. Hist.,’ vol. xviii., 1866, p. 469.

[93] Sixth edition, 1872, p. 144.

CHAPTER XXI.
SELECTION, *continued.*

NATURAL SELECTION AS AFFECTING DOMESTIC PRODUCTIONS—CHARACTERS WHICH APPEAR OF TRIFLING VALUE OFTEN OF REAL IMPORTANCE—CIRCUMSTANCES FAVOURABLE TO SELECTION BY MAN—FACILITY IN PREVENTING CROSSES, AND THE NATURE OF THE CONDITIONS—CLOSE ATTENTION AND PERSEVERANCE INDISPENSABLE—THE PRODUCTION OF A LARGE NUMBER OF INDIVIDUALS ESPECIALLY FAVOURABLE—WHEN NO SELECTION IS APPLIED, DISTINCT RACES ARE NOT FORMED—HIGHLY-BRED ANIMALS LIABLE TO DEGENERATION—TENDENCY IN MAN TO CARRY THE SELECTION OF

EACH CHARACTER TO AN EXTREME POINT, LEADING TO DIVERGENCE OF CHARACTER, RARELY TO CONVERGENCE—CHARACTERS CONTINUING TO VARY IN THE SAME DIRECTION IN WHICH THEY HAVE ALREADY VARIED—DIVERGENCE OF CHARACTER, WITH THE EXTINCTION OF INTERMEDIATE VARIETIES, LEADS TO DISTINCTNESS IN OUR DOMESTIC RACES—LIMIT TO THE POWER OF SELECTION—LAPSE OF TIME IMPORTANT—MANNER IN WHICH DOMESTIC RACES HAVE ORIGINATED—SUMMARY.

Natural Selection, or the Survival of the Fittest, as affecting domestic productions.—We know little on this head. But as animals kept by savages have to provide throughout the year their own food either entirely or to a large extent, it can hardly be doubted that in different countries, varieties differing in constitution and in various characters would succeed best, and so be naturally selected. Hence perhaps it is that the few domesticated animals kept by savages partake, as has been remarked by more than one writer, of the wild appearance of their masters, and likewise resemble natural species. Even in long-civilised countries, at least in the wilder parts, natural selection must act on our domestic races. It is obvious that varieties having very different habits, constitution, and structure, would succeed best on mountains and on rich lowland pastures. For example, the improved Leicester sheep were formerly taken to the Lammermuir Hills; but an intelligent sheep-master reported that "our coarse lean pastures were unequal to the task of supporting such heavy-bodied sheep; and they gradually dwindled away into less and less bulk: each generation was inferior to the preceding one; and when the spring was severe, seldom more than two-thirds of the lambs survived the ravages of the storms."[1] So with the mountain cattle of North Wales and the Hebrides, it has been found that they could not withstand being crossed with the larger and more delicate lowland breeds. Two French naturalists, in describing the horses of Circassia, remark that, subjected as they are to extreme vicissitudes of climate, having to search for scanty pasture, and exposed to constant danger from wolves, the strongest and most vigorous alone survive.[2]

Every one must have been struck with the surpassing grace, strength, and vigour of the Game-cock, with its bold and confident air, its long, yet firm neck, compact body, powerful and closely pressed wings, muscular thighs, strong beak massive at the base, dense and sharp spurs set low on the legs for delivering the fatal blow, and its compact, glossy, and mail-like plumage serving as a defence. Now the English game-cock has not only been improved during many years by man's careful selection, but in addition, as Mr. Tegetmeier has remarked,[3] by a kind of natural selection, for the strongest, most active and courageous birds have stricken down their antagonists in the cockpit, generation after generation, and have subsequently served as the progenitors of their race. The same kind of double selection has come into play with the carrier pigeon, for during their training the inferior birds fail to return home and are lost, so that even without selection by man only the superior birds propagate their race.

In Great Britain, in former times, almost every district had its own breed of cattle and sheep; "they were indigenous to the soil, climate, and pasturage of the locality on which they grazed: they seemed to have been formed for it and by it."[4] But in this case we are quite unable to disentangle the effects of the direct action of the conditions of life,—of use or habit—of natural selection—and of that kind of selection which we have seen is occasionally and unconsciously followed by man even during the rudest periods of history.

Let us now look to the action of natural selection on special characters. Although nature is difficult to resist, yet man often strives against her power, and sometimes with success. From the facts to be given, it will also be seen that natural selection would powerfully affect many of our domestic productions if left unprotected. This is a point of much interest, for we thus learn that differences apparently of very slight importance would certainly determine the survival of a form when forced to struggle for its own existence. It may have occurred to some naturalists, as it formerly did to me, that, though selection acting under natural conditions would determine the structure of all important organs, yet that it could not affect characters which are esteemed by us of little importance; but this is an error to which we are eminently liable, from our ignorance of what characters are of real value to each living creature.

When man attempts to make a breed with some serious defect in structure, or in the mutual relation of the several parts, he will partly or completely fail, or encounter much difficulty; he is in fact resisted by a form of natural selection. We have seen that an attempt was once made in Yorkshire to breed cattle with enormous buttocks, but the cows perished so often in bringing forth their calves, that the attempt had to be given up. In rearing short-faced tumblers, Mr. Eaton says,[5] "I am convinced that better head and beak birds have perished in the shell than ever were hatched; the reason being that the amazingly short-faced bird cannot reach and break the shell with its beak, and so perishes." Here is a more curious case, in which natural selection comes into play only at long intervals of time: during ordinary seasons the Niata cattle can graze as well as others, but occasionally, as from 1827 to 1830 the plains of La Plata suffer from long-continued droughts and the pasture is burnt up; at such times common cattle and horses perish by the thousand, but many survive by browsing on twigs, reeds, etc.; this the Niata cattle cannot so well effect from their upturned jaws and the shape of their lips; consequently, if not attended to, they perish before the other cattle. In Columbia, according to Roulin, there is a breed of nearly hairless cattle, called Pelones; these succeed in their native hot district, but are found too tender for the Cordillera; in this case, however, natural selection determines only the range of the variety. It is obvious that a host of artificial races could never survive in a state of nature;—such as Italian greyhounds,—hairless and almost toothless Turkish dogs,—fantail pigeons, which cannot fly well against a strong wind,—barbs and Polish fowls, with their vision impeded by their eye wattles and great topknots,—hornless bulls and rams, which consequently cannot cope with other males, and thus have a poor chance of leaving offspring,—seedless plants, and many other such cases.

Colour is generally esteemed by the systematic naturalist as unimportant: let us, therefore, see how far it indirectly affects our domestic productions, and how far it would affect them if they were left exposed to the full force of natural selection. In a future chapter I shall have to show that constitutional peculiarities of the strangest kind, entailing liability to the action of certain poisons, are correlated with the colour of the skin. I will here give a single case, on the high authority of Professor Wyman; he informs me that, being surprised at all the pigs in a part of Virginia being black, he made inquiries, and ascertained that these animals feed on the roots of the *Lachnanthes tinctoria*, which colours their bones pink, and, excepting in the case of the black varieties, causes the hoofs to drop off. Hence, as one of the squatters remarked, "we select the black members of the litter for raising, as they alone have a good chance of living." So that here we have artificial and natural selection working hand in hand. I may add that in the Tarentino the inhabitants keep black sheep alone, because the *Hypericum crispum* abounds there; and this plant does not injure black sheep, but kills the white ones in about a fortnight's time.[6]

Complexion, and liability to certain diseases, are believed to run together in man and the lower animals. Thus white terriers suffer more than those of any other colour from the fatal distemper.[7] In North America plum-trees are liable to a disease which Downing[8] believes is not caused by insects; the kinds bearing purple fruit are most affected, "and we have never known the green or yellow fruited varieties infected until the other sorts had first become filled with the knots." On the other hand, peaches in North America suffer much from a disease called the *yellows*, which seems to be peculiar to that continent, and more than nine-tenths of the victims, "when the disease first appeared, were the yellow-fleshed peaches. The white-fleshed kinds are much more rarely attacked; in some parts of the country never." In Mauritius, the white sugar-canes have of late years been so severely attacked by a disease, that many planters have been compelled to give up growing this variety (although fresh plants were imported from China for trial), and cultivate only red canes.[9] Now, if these plants had been forced to struggle with other competing plants and enemies, there cannot be a doubt that the colour of the flesh or skin of the fruit, unimportant as these characters are considered, would have rigorously determined their existence.

Liability to the attacks of parasites is also connected with colour. White chickens are certainly more subject than dark-coloured chickens to the "gapes," which is caused by a parasitic worm in the trachea.[10] On the other hand, experience has shown that in France the caterpillars which produce white cocoons resist the deadly fungus better than those producing yellow cocoons.[11] Analogous facts have been observed with plants: a new and beautiful white onion, imported from France, though planted close to other kinds, was alone attacked by a parasitic fungus.[12] White verbenas are especially liable to mildew.[13] Near Malaga, during an early period of the vine-disease, the green sorts suffered most; "and red and black grapes, even when interwoven with the sick plants, suffered not at all." In France whole groups of varieties were comparatively free, and others, such as the Chasselas, did not afford a single fortunate exception; but I do not know whether any correlation between colour and liability to disease was here observed.[14] In a former chapter it was shown how curiously liable one variety of the strawberry is to mildew.

It is certain that insects regulate in many cases the range and even the existence of the higher animals, whilst living under their natural conditions. Under domestication light-coloured animals suffer most: in Thuringia[15] the inhabitants do not like grey, white, or pale cattle, because they are much more troubled by various kinds of flies than the brown, red, or black cattle. An Albino negro, it has been remarked,[16] was peculiarly sensitive to the bites of insects. In the West Indies[17] it is said that "the only horned cattle fit for work are those which have a good deal of black in them. The white are terribly tormented by the insects; and they are weak and sluggish in proportion to the white."

In Devonshire there is a prejudice against white pigs, because it is believed that the sun blisters them when turned out;[18] and I knew a man who would not keep white pigs in Kent, for the same reason. The scorching of flowers by the sun seems likewise to depend much on colour; thus, dark pelargoniums suffer most; and from various accounts it is clear that the cloth-of-gold variety will not withstand a degree of exposure to sunshine which other varieties enjoy. Another amateur asserts that not only all dark-coloured verbenas, but likewise scarlets, suffer from the sun: "the paler kinds stand better, and pale blue is perhaps the best of all." So again with the heartsease (*Viola tricolor*); hot weather suits the blotched sorts, whilst it destroys the beautiful markings of some other kinds.[19] During one extremely cold season in Holland all red-flowered hyacinths were observed to be very inferior in quality. It is believed by many agriculturists that red wheat is hardier in northern climates than white wheat.[20]

With animals, white varieties from being conspicuous are the most liable to be attacked by beasts and birds of prey. In parts of France and Germany where hawks abound, persons are advised not to keep white pigeons; for, as Parmentier says, "it is certain that in a flock the white always first fall victims to the kite." In Belgium, where so many societies have been established for the flight of carrier-pigeons, white is the one colour which for the same reason is disliked.[21] Prof. G. Jaeger[22] whilst fishing found four pigeons which had been killed by hawks, and all were white; on another occasion he examined the eyrie of a hawk, and the feathers of the pigeons which had been caught were all of a white or yellow colour. On the other hand, it is said that the sea-eagle (*Falco ossifragus*, Linn.) on the west coast of Ireland picks out the black fowls, so that "the villagers avoid as much as possible rearing birds of that colour." M. Daudin,[23] speaking of white rabbits kept in warrens in Russia, remarks that their colour is a great disadvantage, as they are thus more exposed to attack, and can be seen during bright nights from a distance. A gentleman in Kent, who failed to stock his woods with a nearly white and hardy kind of rabbit, accounted in the same manner for their early disappearance. Any one who will watch a white cat prowling after her prey will soon perceive under what a disadvantage she lies.

The white Tartarian cherry, "owing either to its colour being so much like that of the leaves, or to the fruit always appearing from a distance unripe," is not so readily attacked by birds as other sorts. The yellow-fruited raspberry, which generally comes nearly true by seed, "is very little molested by birds, who evidently are not fond of it; so that nets may be dispensed with in places where nothing else will protect the red fruit."[24] This immunity, though a benefit to the gardener, would be a disadvantage in a state of nature both to the cherry and raspberry, as dissemination depends on birds. I noticed during several winters that some trees of the yellow-berried holly, which were raised from seed from a tree found wild by my father remained covered with fruit, whilst not a scarlet berry could be seen on the adjoining trees of the common kind. A friend informs me that a mountain-ash (*Pyrus aucuparia*) growing in his garden bears berries which, though not differently coloured, are always devoured by birds before those on the other trees. This variety of the mountain-ash would thus be more freely disseminated, and the yellow-berried variety of the holly less freely, than the common varieties of these two trees.

Independently of colour, trifling differences are sometimes found to be of importance to plants under cultivation, and would be of paramount importance if they had to fight their own battle and to struggle with many competitors. The thin-shelled peas, called *pois sans parchemin*, are attacked by birds[25] much more commonly than ordinary peas. On the other hand, the purple-podded pea, which has a hard shell, escaped the attacks of tomtits (*Parus major*) in my garden far better than any other kind. The thin-shelled walnut likewise suffers greatly from the tomtit.[26] These same birds have been observed to pass over and thus favour the filbert, destroying only the other kinds of nuts which grew in the same orchard.[27]

Certain varieties of the pear have soft bark, and these suffer severely from wood-boring beetles; whilst other varieties are known to resist their attacks much better.[28] In North America the smoothness, or absence of down on the fruit, makes a great difference in the attacks of the weevil, "which is the uncompromising foe of all smooth stone-fruits;" and the cultivator "has the frequent mortification of seeing nearly all, or indeed often the whole crop, fall from the trees when half or two-thirds grown." Hence the nectarine suffers more than the peach. A particular variety of the Morello cherry, raised in North America, is, without any assignable cause, more liable to be injured by this same insect than other cherry-trees.[29] From some unknown cause, certain varieties of the apple enjoy, as we have seen, the great advantage in various parts of the world of not being infested by the coccus. On the other hand, a particular case has been recorded in which aphides confined themselves to the Winter Nelis pear and touched no other kind in an extensive orchard.[30] The existence of minute glands on the leaves of peaches, nectarines, and apricots, would not be esteemed by botanists as a character of the least importance for they are present or absent in closely-related sub-varieties, descended from the same parent-tree; yet there is good evidence[31] that the absence of glands leads to mildew, which is highly injurious to these trees.

A difference either in flavour or in the amount of nutriment in certain varieties causes them to be more eagerly attacked by various enemies than other varieties of the same species. Bullfinches (*Pyrrhula vulgaris*) injure our fruit-trees by devouring the flower-buds, and a pair of these birds have been seen “to denude a large plum-tree in a couple of days of almost every bud;” but certain varieties[32] of the apple and thorn (*Cratægus oxyacantha*) are more especially liable to be attacked. A striking instance of this was observed in Mr. Rivers’s garden, in which two rows of a particular variety of plum[33] had to be carefully protected, as they were usually stripped of all their buds during the winter, whilst other sorts growing near them escaped. The root (or enlarged stem) of Laing’s Swedish turnip is preferred by hares, and therefore suffers more than other varieties. Hares and rabbits eat down common rye before St. John’s-day-rye, when both grow together.[34] In the south of France, when an orchard of almond-trees is formed, the nuts of the bitter variety are sown, “in order that they may not be devoured by field-mice”;[35] so we see the use of the bitter principle in almonds.

Other slight differences, which would be thought quite unimportant, are no doubt sometimes of great service both to plants and animals. The Whitesmith’s gooseberry, as formerly stated, produces its leaves later than other varieties, and, as the flowers are thus left unprotected, the fruit often fails. In one variety of the cherry, according to Mr. Rivers,[36] the petals are much curled backwards, and in consequence of this the stigmas were observed to be killed by a severe frost; whilst at the same time, in another variety with incurved petals, the stigmas were not in the least injured. The straw of the Fenton wheat is remarkably unequal in height; and a competent observer believes that this variety is highly productive, partly because the ears from being distributed at various heights above the ground are less crowded together. The same observer maintains that in the upright varieties the divergent awns are serviceable by breaking the shocks when the ears are dashed together by the wind.[37] If several varieties of a plant are grown together, and the seed is indiscriminately harvested, it is clear that the hardier and more productive kinds will, by a sort of natural selection, gradually prevail over the others; this takes place, as Colonel Le Couteur believes,[38] in our wheat-fields, for, as formerly shown, no variety is quite uniform in character. The same thing, as I am assured by nurserymen, would take place in our flower-gardens, if the seed of the different varieties were not separately saved. When the eggs of the wild and tame duck are hatched together, the young wild ducks almost invariably perish, from being of smaller size and not getting their fair share of food.[39]

Facts in sufficient number have now been given showing that natural selection often checks, but occasionally favours, man’s power of selection. These facts teach us, in addition, a valuable lesson, namely, that we ought to be extremely cautious in judging what characters are of importance in a state of nature to animals and plants, which have to struggle for existence from the hour of their birth to that of their death,—their existence depending on conditions, about which we are profoundly ignorant.

Circumstances favourable to Selection by Man.

The possibility of selection rests on variability, and this, as we shall see in the following chapters, mainly depends on changed conditions of life, but is governed by infinitely complex and unknown laws. Domestication, even when long continued, occasionally causes but a small amount of variability, as in the case of the goose and turkey. The slight differences, however, which characterise each individual animal and plant would in most, probably in all, cases suffice for the production of distinct races through careful and prolonged selection. We see what selection, though acting on mere individual differences, can effect when families of cattle, sheep, pigeons, etc., of the same race, have been separately bred during a number of years by different men without any wish on their part to modify the breed. We see the same fact in the difference between hounds bred for hunting in different districts,[40] and in many other such cases.

In order that selection should produce any result, it is manifest that the crossing of distinct races must be prevented; hence facility in pairing, as with the pigeon, is highly favourable for the work; and difficulty in pairing, as with cats, prevents the formation of distinct breeds. On nearly the same principle the cattle of the small island of Jersey have been improved in their milking qualities "with a rapidity that could not have been obtained in a widely extended country like France."[41] Although free crossing is a danger on the one side which every one can see, too close interbreeding is a hidden danger on the other side. Unfavourable conditions of life overrule the power of selection. Our improved heavy breeds of cattle and sheep could not have been formed on mountainous pastures; nor could dray-horses have been raised on a barren and inhospitable land, such as the Falkland Islands, where even the light horses of La Plata rapidly decrease in size. It seems impossible to preserve several English breeds of sheep in France; for as soon as the lambs are weaned their vigour decays as the heat of the summer increases:[42] it would be impossible to give great length of wool to sheep within the tropics; yet selection has kept the Merino breed nearly true under diversified and unfavourable conditions. The power of selection is so great, that breeds of the dog, sheep, and poultry, of the largest and smallest size, long and short beaked pigeons, and other breeds with opposite characters, have had their characteristic qualities augmented, though treated in every way alike, being exposed to the same climate and fed on the same food. Selection, however, is either checked or favoured by the effects of use or habit. Our wonderfully-improved pigs could never have been formed if they had been forced to search for their own food; the English racehorse and greyhound could not have been improved up to their present high standard of excellence without constant training.

As conspicuous deviations of structure occur rarely, the improvement of each breed is generally the result of the selection of slight individual differences. Hence the closest attention, the sharpest powers of observation, and indomitable perseverance, are indispensable. It is, also, highly important that many individuals of the breed which is to be improved should be raised; for thus there will be a better chance of the appearance of variations in the right direction, and individuals varying in an unfavourable manner may be freely rejected or destroyed. But that a large number of individuals should be raised, it is necessary that the conditions of life should favour the propagation of the species. Had the peacock been reared as easily as the fowl, we should probably ere this have had many distinct races. We see the importance of a large number of plants, from the fact of nursery gardeners almost always beating amateurs in the exhibition of new varieties. In 1845 it was estimated[43] that between 4000 and 5000 pelargoniums were annually raised from seed in England, yet a decidedly improved variety is rarely obtained. At Messrs. Carter's grounds, in Essex, where such flowers as the Lobelia, Nemophila, Mignonette, etc., are grown by the acre for seed, "scarcely a season passes without some new kinds being raised, or some improvement effected on old kinds."[44] At Kew, as Mr. Beaton remarks, where many seedlings of common plants are raised, "you see new forms of Laburnums, Spiraeas, and other shrubs."[45] So with animals: Marshall,[46] in speaking of the sheep in one part of Yorkshire, remarks, "as they belong to poor people, and are mostly in small lots, they never can be improved." Lord Rivers, when asked how he succeeded in always having first-rate greyhounds, answered, "I breed many, and hang many." This, as another man remarks, "was the secret of his success; and the same will be found in exhibiting fowls,— successful competitors breed largely, and keep the best."[47]

It follows from this that the capacity of breeding at an early age and at short intervals, as with pigeons, rabbits, etc., facilitates selection; for the result is thus soon made visible, and perseverance in the work encouraged. It can hardly be an accident that the great majority of the culinary and agricultural plants which have yielded numerous races are annuals or biennials, which therefore are capable of rapid propagation, and thus of improvement. Sea-kale, asparagus, common and Jerusalem artichokes, potatoes, and onions, must be excepted, as they are perennials: but onions are propagated like annuals, and of the other plants just specified, none, with the exception of the potato, have yielded in this country more than one or two varieties. In the Mediterranean region, where artichokes are often raised from seed, there are several kinds, as I hear from Mr. Bentham. No doubt fruit-trees, which cannot be propagated quickly by seed, have yielded a host of varieties, though not permanent races; but these, judging from prehistoric remains, have been produced at a comparatively late period.

A species may be highly variable, but distinct races will not be formed, if from any cause selection be not applied. It would be difficult to select slight variations in fishes from their place of habitation; and though the carp is extremely variable and is much attended to in Germany, only one well-marked race has been formed, as I hear from

Lord A. Russell, namely the *spiegel-carpe*; and this is carefully secluded from the common scaly kind. On the other hand, a closely allied species, the gold-fish, from being reared in small vessels, and from having been carefully attended to by the Chinese, has yielded many races. Neither the bee, which has been semi-domesticated from an extremely remote period, nor the cochineal insect, which was cultivated by the aboriginal Mexicans,[48] has yielded races; and it would be impossible to match the queen-bee with any particular drone, and most difficult to match cochineal insects. Silk-moths, on the other hand, have been subjected to rigorous selection, and have produced a host of races. Cats, which from their nocturnal habits cannot be selected for breeding, do not, as formerly remarked, yield distinct races within the same country. Dogs are held in abomination in the East, and their breeding is neglected; consequently, as Prof. Moritz Wagner[49] remarks, one kind alone exists there. The ass in England varies much in colour and size; but as it is an animal of little value and bred by poor people, there has been no selection, and distinct races have not been formed. We must not attribute the inferiority of our asses to climate, for in India they are of even smaller size than in Europe. But when selection is brought to bear on the ass, all is changed. Near Cordova, as I am informed (Feb. 1860) by Mr. W. E. Webb, C.E., they are carefully bred, as much as 200*l*. having been paid for a stallion ass, and they have been immensely improved. In Kentucky, asses have been imported (for breeding mules) from Spain, Malta, and France; these "seldom averaged more than fourteen hands high: but the Kentuckians, by great care, have raised them up to fifteen hands, and sometimes even to sixteen. The prices paid for these splendid animals, for such they really are, will prove how much they are in request. One male, of great celebrity, was sold for upwards of one thousand pounds sterling." These choice asses are sent to cattle-shows, a day being given for their exhibition.[50]

Analogous facts have been observed with plants: the nutmeg-tree in the Malay archipelago is highly variable, but there has been no selection, and there are no distinct races.[51] The common mignonette (*Reseda odorata*), from bearing inconspicuous flowers, valued solely for their fragrance, "remains in the same unimproved condition as when first introduced."[52] Our common forest-trees are very variable, as may be seen in every extensive nursery-ground; but as they are not valued like fruit-trees, and as they seed late in life, no selection has been applied to them; consequently, as Mr. Patrick Matthews remarks,[53] they have not yielded distinct races, leafing at different periods, growing to different sizes, and producing timber fit for different purposes. We have gained only some fanciful and semi-monstrous varieties, which no doubt appeared suddenly as we now see them.

Some botanists have argued that plants cannot have so strong a tendency to vary as is generally supposed, because many species long grown in botanic gardens, or unintentionally cultivated year after year mingled with our corn crops, have not produced distinct races; but this is accounted for by slight variations not having been selected and propagated. Let a plant which is now grown in a botanic garden, or any common weed, be cultivated on a large scale, and let a sharp-sighted gardener look out for each slight variety and sow the seed, and then, if distinct races are not produced, the argument will be valid.

The importance of selection is likewise shown by considering special characters. For instance, with most breeds of fowls the form of the comb and the colour of the plumage have been attended to, and are eminently characteristic of each race; but in Dorkings fashion has never demanded uniformity of comb or colour; and the utmost diversity in these respects prevails. Rose-combs, double-combs, cup-combs, etc., and colours of all kinds, may be seen in purely bred and closely related Dorking fowls, whilst other points, such as the general form of body, and the presence of an additional toe, have been attended to, and are invariably present. It has also been ascertained that colour can be fixed in this breed, as well as in any other.[54]

During the formation or improvement of a breed, its members will always be found to vary much in those characters to which especial attention is directed, and of which each slight improvement is eagerly sought and selected. Thus, with short-faced tumbler-pigeons, the shortness of the beak, shape of head and plumage,—with carriers, the length of the beak and wattle,—with fantails, the tail and carriage,—with Spanish fowls, the white face and comb,—with long-eared rabbits, the length of ear, are all points which are eminently variable. So it is in every case; and the large price paid for first-rate animals proves the difficulty of breeding them up to the highest standard of excellence. This subject has been discussed by fanciers,[55] and the greater prizes given for highly improved breeds, in comparison with those given for old breeds which are not now undergoing rapid improvement, have been fully justified. Nathusius makes[56] a similar remark when discussing the less uniform character of improved Shorthorn cattle and of the English horse, in comparison, for example, with the unennobled cattle of Hungary, or with the horses of the Asiatic steppes. This want of uniformity in the parts which at the time are undergoing selection chiefly depends on the strength of the principle of reversion; but it likewise depends to a certain extent on the continued variability of the parts which have recently varied. That the same parts do continue varying in the same manner we must admit, for if it were not so, there could be no improvement beyond an early standard of excellence, and we know that such improvement is not only possible, but is of general occurrence.

As a consequence of continued variability, and more especially of reversion, all highly improved races, if neglected or not subjected to incessant selection, soon degenerate. Youatt gives a curious instance of this in some cattle formerly kept in Glamorganshire; but in this case the cattle were not fed with sufficient care. Mr. Baker, in his memoir on the Horse, sums up: “It must have been observed in the preceding pages that, whenever there has been neglect, the breed has proportionally deteriorated.”[57] If a considerable number of improved cattle, sheep, or other animals of the same race, were allowed to breed freely together, with no selection, but with no change in their condition of life, there can be no doubt that after a score or hundred generations they would be very far from excellent of their kind; but, from what we see of the many common races of dogs, cattle, fowls, pigeons, etc., which without any particular care have long retained nearly the same character, we have no grounds for believing that they would altogether depart from their type.

It is a general belief amongst breeders that characters of all kinds become fixed by long-continued inheritance. But I have attempted to show in the fourteenth chapter that this belief apparently resolves itself into the following proposition, namely, that all characters whatever, whether recently acquired or ancient, tend to be transmitted, but that those which have already long withstood all counteracting influences, will, as a general rule, continue to withstand them, and consequently be faithfully transmitted.

Tendency in Man to carry the practice of Selection to an extreme point.

It is an important principle that in the process of selection man almost invariably wishes to go to an extreme point. Thus, there is no limit to his desire to breed certain kinds of horses and dogs as fleet as possible, and others as strong as possible; certain kinds of sheep for extreme fineness, and others for extreme length of wool; and he wishes to produce fruit, grain, tubers, and other useful parts of plants, as large and excellent as possible. With animals bred for amusement, the same principle is even more powerful; for fashion, as we see in our dress, always runs to extremes. This view has been expressly admitted by fanciers. Instances were given in the chapters on the pigeon, but here is another: Mr. Eaton, after describing a comparatively new variety, namely, the Archangel, remarks, “What fanciers intend doing with this bird I am at a loss to know, whether they intend to breed it down to the tumbler’s head and beak, or carry it out to the carrier’s head and beak; leaving it as they found it, is not progressing.” Ferguson, speaking of fowls, says, “their peculiarities, whatever they may be, must necessarily be fully developed: a little peculiarity forms nought but ugliness, seeing it violates the existing laws of symmetry.” So Mr. Brent, in discussing the merits of the sub-varieties of the Belgian canary-bird, remarks, “Fanciers always go to extremes; they do not admire indefinite properties.”[58]

This principle, which necessarily leads to divergence of character, explains the present state of various domestic races. We can thus see how it is that racehorses and dray-horses, greyhounds and mastiffs, which are opposed to each other in every character,—how varieties so distinct as Cochin-china fowls and bantams, or carrier-pigeons with very long beaks, and tumblers with excessively short beaks, have been derived from the same stock. As each breed is slowly improved, the inferior varieties are first neglected and finally lost. In a few cases, by the aid of old records, or from intermediate varieties still existing in countries where other fashions have prevailed, we are enabled partially to trace the graduated changes through which certain breeds have passed. Selection, whether methodical or unconscious, always tending towards an extreme point, together with the neglect and slow extinction of the intermediate and less-valued forms, is the key which unlocks the mystery of how man has produced such wonderful results.

In a few instances selection, guided by utility for a single purpose, has led to convergence of character. All the improved and different races of the pig, as Nathusius has well shown,[59] closely approach each other in character, in their shortened legs and muzzles, their almost hairless, large, rounded bodies, and small tusks. We see some degree of convergence in the similar outline of the body in well-bred cattle belonging to distinct races.[60] I know of no other such cases.

Continued divergence of character depends on, and is indeed a clear proof, as previously remarked, of the same parts continuing to vary in the same direction. The tendency to mere general variability or plasticity of organisation can certainly be inherited, even from one parent, as has been shown by Gärtner and Kölreuter, in the production of varying hybrids from two species, of which one alone was variable. It is in itself probable that, when an organ has varied in any manner, it will again vary in the same manner, if the conditions which first caused the being to vary remain, as far as can be judged, the same. This is either tacitly or expressly admitted by all horticulturists: if a gardener observes one or two additional petals in a flower, he feels confident that in a few generations he will be able to raise a double flower, crowded with petals. Some of the seedlings from the weeping Moccas oak were so prostrate that they only crawled along the ground. A seedling from the fastigiate or upright Irish yew is described as differing greatly from the parent-form "by the exaggeration of the fastigiate habit of its branches."[61] Mr. Shirreff, who has been highly successful in raising new kinds of wheat, remarks, "A good variety may safely be regarded as the forerunner of a better one."[62] A great rose-grower, Mr. Rivers, has made the same remark with respect to roses. Sageret,[63] who had large experience, in speaking of the future progress of fruit-trees, observes that the most important principle is "that the more plants have departed from their original type, the more they tend to depart from it." There is apparently much truth in this remark; for we can in no other way understand the surprising amount of difference between varieties in the parts or qualities which are valued, whilst other parts retain nearly their original character.

The foregoing discussion naturally leads to the question, what is the limit to the possible amount of variation in any part or quality, and, consequently, is there any limit to what selection can effect? Will a racehorse ever be reared fleeter than Eclipse? Can our prize-cattle and sheep be still further improved? Will a gooseberry ever weigh more than that produced by "London" in 1852? Will the beet-root in France yield a greater percentage of sugar? Will future varieties of wheat and other grain produce heavier crops than our present varieties? These questions cannot be positively answered; but it is certain that we ought to be cautious in answering them by a negative. In some lines of variation the limit has probably been reached. Youatt believes that the reduction of bone in some of our sheep has already been carried so far that it entails great delicacy of constitution.[64] But seeing the great improvement within recent times in our cattle and sheep, and especially in our pigs; seeing the wonderful increase in weight in our poultry of all kinds during the last few years; he would be a bold man who would assert that perfection has been reached. It has often been said that Eclipse never was, and never will be, beaten in speed by any other horse; but on making inquiries I find that the best judges believe that our present racehorses are fleeter.[65] The attempt to raise a new variety of wheat more productive than the many old kinds, might have been thought until lately quite hopeless; but this has been effected by Major Hallett, by careful selection. With respect to almost all our animals and plants, those who are best qualified to judge do not believe that the extreme point of perfection has yet been reached even in the characters which have already been carried to a high standard. For instance, the short-faced tumbler-pigeon has been greatly modified; nevertheless, according to Mr. Eaton[66] "the field is still as open for fresh competitors as it was one hundred years ago." Over and over again it has been said that perfection had been attained with our flowers, but a higher standard has soon been reached. Hardly any fruit has been more improved than the strawberry, yet a great authority remarks,[67] "it must not be concealed that we are far from the extreme limits at which we may arrive."

No doubt there is a limit beyond which the organisation cannot be modified compatibly with health or life. The extreme degree of fleetness, for instance, of which a terrestrial animal is capable, may have been acquired by our present racehorses; but as Mr. Wallace has well remarked,[68] the question that interests us, "is not whether indefinite and unlimited change in any or all directions is possible, but whether such differences as do occur in nature could have been produced by the accumulation of varieties by selection." And in the case of our domestic productions, there can be no doubt that many parts of the organisation, to which man has attended, have been thus modified to a greater degree than the corresponding parts in the natural species of the same genera or even families. We see this in the form and size of our light and heavy dogs or horses,—in the beak and many other characters of our pigeons,—in the size and quality of many fruits,—in comparison with the species belonging to the same natural groups.

Time is an important element in the formation of our domestic races, as it permits innumerable individuals to be born, and these when exposed to diversified conditions are rendered variable. Methodical selection has been occasionally practised from an ancient period to the present day, even by semi-civilised people, and during former times will have produced some effect. Unconscious selection will have been still more effective; for during a lengthened period the more valuable individual animals will occasionally have been saved, and the less valuable neglected. In the course of time, different varieties, especially in the less civilised countries, will also have been more or less modified through natural selection. It is generally believed, though on this head we have little or no evidence, that new characters in time become fixed; and after having long remained fixed it seems possible that under new conditions they might again be rendered variable.

How great the lapse of time has been since man first domesticated animals and cultivated plants, we begin dimly to see. When the lake-dwellings of Switzerland were inhabited during the Neolithic period, several animals were already domesticated and various plants cultivated. The science of language tells us that the art of ploughing and sowing the land was followed, and the chief animals had been already domesticated, at an epoch so immensely remote, that the Sanskrit, Greek, Latin, Gothic, Celtic, and Sclavonic languages had not as yet diverged from their common parent-tongue.[69]

It is scarcely possible to overrate the effects of selection occasionally carried on in various ways and places during thousands of generations. All that we know, and, in a still stronger degree, all that we do not know,[70] of the history of the great majority of our breeds, even of our more modern breeds, agrees with the view that their production, through the action of unconscious and methodical selection, has been almost insensibly slow. When a man attends rather more closely than is usual to the breeding of his animals, he is almost sure to improve them to a slight extent. They are in consequence valued in his immediate neighbourhood, and are bred by others; and their characteristic features, whatever these may be, will then slowly but steadily be increased, sometimes by methodical and almost always by unconscious selection. At last a strain, deserving to be called a sub-variety, becomes a little more widely known, receives a local name, and spreads. The spreading will have been extremely slow during ancient and less civilised times, but now is rapid. By the time that the new breed had assumed a somewhat distinct character, its history, hardly noticed at the time, will have been completely forgotten; for, as Low remarks,[71] "we know how quickly the memory of such events is effaced."

As soon as a new breed is thus formed, it is liable through the same process to break up into new strains and sub-varieties. For different varieties are suited for, and are valued under, different circumstances. Fashion changes, but, should a fashion last for even a moderate length of time, so strong is the principle of inheritance, that some effect will probably be impressed on the breed. Thus varieties go on increasing in number, and history shows us how wonderfully they have increased since the earliest records.[72] As each new variety is produced, the earlier, intermediate, and less valuable forms will be neglected, and perish. When a breed, from not being valued, is kept in small numbers, its extinction almost inevitably follows sooner or later, either from accidental causes of destruction or from close interbreeding; and this is an event which, in the case of well-marked breeds, excites attention. The birth or production of a new domestic race is so slow a process that it escapes notice; its death or destruction is comparatively sudden, is often recorded, and when too late sometimes regretted.

Several authors have drawn a wide distinction between artificial and natural races. The latter are more uniform in character, possessing in a high degree the appearance of natural species, and are of ancient origin. They are generally found in less civilised countries, and have probably been largely modified by natural selection, and only to a small extent by man's unconscious and methodical selection. They have, also, during a long period, been directly acted on by the physical conditions of the countries which they inhabit. The so-called artificial races, on the other hand, are not so uniform in character; some have a semi-monstrous character, such as “the wry-legged terriers so useful in rabbit-shooting,”[73] turnspit dogs, ancon sheep, niata oxen, Polish fowls, fantail-pigeons, etc.; their characteristic features have generally been acquired suddenly, though subsequently increased by careful selections in many cases. Other races, which certainly must be called artificial, for they have been largely modified by methodical selection and by crossing, as the English racehorse, terrier-dogs, the English game-cock, Antwerp carrier-pigeons, etc., nevertheless cannot be said to have an unnatural appearance; and no distinct line, as it seems to me, can be drawn between natural and artificial races.

It is not surprising that domestic races should generally present a different aspect from natural species. Man selects and propagates modifications solely for his own use or fancy, and not for the creature’s own good. His attention is struck by strongly marked modifications, which have appeared suddenly, due to some great disturbing cause in the organisation. He attends almost exclusively to external characters; and when he succeeds in modifying internal organs,—when for instance he reduces the bones and offal, or loads the viscera with fat, or gives early maturity, etc.-the chances are strong that he will at the same time weaken the constitution. On the other hand, when an animal has to struggle throughout its life with many competitors and enemies, under circumstances inconceivably complex and liable to change, modifications of the most varied nature in the internal organs as well as in external characters, in the functions and mutual relations of parts, will be rigorously tested, preserved, or rejected. Natural selection often checks man’s comparatively feeble and capricious attempts at improvement; and if it were not so, the result of his work, and of nature’s work, would be even still more different. Nevertheless, we must not overrate the amount of difference between natural species and domestic races; the most experienced naturalists have often disputed whether the latter are descended from one or from several aboriginal stocks, and this clearly shows that there is no palpable difference between species and races.

Domestic races propagate their kind far more truly, and endure for munch longer periods, than most naturalists are willing to admit. Breeders feel no doubt on this head: ask a man who has long reared Shorthorn or Hereford cattle, Leicester or Southdown sheep, Spanish or Game poultry, tumbler or carrier-pigeons, whether these races may not have been derived from common progenitors, and he will probably laugh you to scorn. The breeder admits that he may hope to produce sheep with finer or longer wool and with better carcases, or handsomer fowls, or carrier-pigeons with beaks just perceptibly longer to the practised eye, and thus be successful at an exhibition. Thus far he will go, but no farther. He does not reflect on what follows from adding up during a long course of time many slight, successive modifications; nor does he reflect on the former existence of numerous varieties, connecting the links in each divergent line of descent. He concludes, as was shown in the earlier chapters, that all the chief breeds to which he has long attended are aboriginal productions. The systematic naturalist, on the other hand, who generally knows nothing of the art of breeding, who does not pretend to know how and when the several domestic races were formed, who cannot have seen the intermediate gradations, for they do not now exist, nevertheless feels no doubt that these races are sprung from a single source. But ask him whether the closely allied natural species which he has studied may not have descended from a common progenitor, and he in his turn will perhaps reject the notion with scorn. Thus the naturalist and breeder may mutually learn a useful lesson from each other.

Summary on Selection by Man.—There can be no doubt that methodical selection has effected and will effect wonderful results. It was occasionally practised in ancient times, and is still practised by semi-civilised people. Characters of the highest importance, and others of trifling value, have been attended to, and modified. I need not here repeat what has been so often said on the part which unconscious selection has played: we see its power in the difference between flocks which have been separately bred, and in the slow changes, as circumstances have slowly changed, which many animals have undergone in the same country, or when transported into a foreign land. We see the combined effects of methodical and unconscious selection, in the great amount of difference in those parts or qualities which are valued by man in comparison with the parts which are not valued, and consequently have not been attended to. Natural selection often determines man's power of selection. We sometimes err in imagining that characters, which are considered as unimportant by the systematic naturalist, could not be affected by the struggle for existence, and could not be acted on by natural selection; but striking cases have been given, showing how great an error this is.

The possibility of selection coming into action rests on variability; and this is mainly caused, as we shall hereafter see, by changes in the conditions of life. Selection is sometimes rendered difficult, or even impossible, by the conditions being opposed to the desired character or quality. It is sometimes checked by the lessened fertility and weakened constitution which follow from long-continued close interbreeding. That methodical selection may be successful, the closest attention and discernment, combined with unwearied patience, are absolutely necessary; and these same qualities, though not indispensable, are highly serviceable in the case of unconscious selection. It is almost necessary that a large number of individuals should be reared; for thus there will be a fair chance of variations of the desired nature arising, and of every individual with the slightest blemish or in any degree inferior being freely rejected. Hence length of time is an important element of success. Thus, also, reproduction at an early age and at short intervals favours the work. Facility in pairing animals, or their inhabiting a confined area, is advantageous as a check to free crossing. Whenever and wherever selection is not practised, distinct races are not formed within the same country. When any one part of the body or one quality is not attended to, it remains either unchanged or varies in a fluctuating manner, whilst at the same time other parts and other qualities may become permanently and greatly modified. But from the tendency to reversion and to continued variability, those parts or organs which are now undergoing rapid improvement through selection, are likewise found to vary much. Consequently highly-bred animals when neglected soon degenerate; but we have no reason to believe that the effects of long-continued selection would, if the conditions of life remained the same, be soon and completely lost.

Man always tends to go to an extreme point in the selection, whether methodical or unconscious, of all useful and pleasing qualities. This is an important principle, as it leads to continued divergence, and in some rare cases to convergence of character. The possibility of continued divergence rests on the tendency in each part or organ to go on varying in the same manner in which it has already varied; and that this occurs, is proved by the steady and gradual improvement of many animals and plants during lengthened periods. The principle of divergence of character, combined with the neglect and final extinction of all previous, less-valued, and intermediate varieties, explains the amount of difference and the distinctness of our several races. Although we may have reached the utmost limit to which certain characters can be modified, yet we are far from having reached, as we have good reason to believe, the limit in the majority of cases. Finally, from the difference between selection as carried on by man and by nature, we can understand how it is that domestic races often, though by no means always, differ in general aspect from closely allied natural species.

Throughout this chapter and elsewhere I have spoken of selection as the paramount power, yet its action absolutely depends on what we in our ignorance call spontaneous or accidental variability. Let an architect be compelled to build an edifice with uncut stones, fallen from a precipice. The shape of each fragment may be called accidental; yet the shape of each has been determined by the force of gravity, the nature of the rock, and the slope of the precipice,—events and circumstances, all of which depend on natural laws; but there is no relation between these laws and the purpose for which each fragment is used by the builder. In the same manner the variations of each creature are determined by fixed and immutable laws; but these bear no relation to the living structure which is slowly built up through the power of selection, whether this be natural or artificial selection.

If our architect succeeded in rearing a noble edifice, using the rough wedge-shaped fragments for the arches, the longer stones for the lintels, and so forth, we should admire his skill even in a higher degree than if he had used stones shaped for the purpose. So it is with selection, whether applied by man or by nature; for although variability is indispensably necessary, yet, when we look at some highly complex and excellently adapted organism, variability sinks to a quite subordinate position in importance in comparison with selection, in the same manner as the shape of each fragment used by our supposed architect is unimportant in comparison with his skill.

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CHAPTER XXII.
CAUSES OF VARIABILITY.

VARIABILITY DOES NOT NECESSARILY ACCOMPANY REPRODUCTION—CAUSES ASSIGNED BY VARIOUS AUTHORS—INDIVIDUAL DIFFERENCES—VARIABILITY OF EVERY KIND DUE TO CHANGED CONDITIONS OF LIFE—ON THE NATURE OF SUCH CHANGES—CLIMATE, FOOD, EXCESS OF NUTRIMENT—SLIGHT CHANGES SUFFICIENT—EFFECTS OF GRAFTING ON THE VARIABILITY OF SEEDLING-TREES—DOMESTIC PRODUCTIONS BECOME HABITUATED TO CHANGED CONDITIONS—ON THE ACCUMULATIVE ACTION OF CHANGED CONDITIONS—CLOSE INTERBREEDING AND THE IMAGINATION OF THE MOTHER SUPPOSED TO CAUSE VARIABILITY—CROSSING AS A CAUSE OF THE APPEARANCE OF NEW CHARACTERS—VARIABILITY FROM THE COMMINGLING OF CHARACTERS AND FROM REVERSION—ON THE MANNER AND PERIOD OF ACTION OF THE CAUSES WHICH EITHER DIRECTLY, OR INDIRECTLY THROUGH THE REPRODUCTIVE SYSTEM, INDUCE VARIABILITY.

We will now consider, as far as we can, the causes of the almost universal variability of our domesticated productions. The subject is an obscure one; but it may be useful to probe our ignorance. Some authors, for instance Dr. Prosper Lucas, look at variability as a necessary contingent on reproduction, and as much an aboriginal law as growth or inheritance. Others have of late encouraged, perhaps unintentionally, this view by speaking of inheritance and variability as equal and antagonistic principles. Pallas maintained, and he has had some followers, that variability depends exclusively on the crossing of primordially distinct forms. Other authors attribute variability to an excess of food, and with animals to an excess relatively to the amount of exercise taken, or again to the effects of a more genial climate. That these causes are all effective is highly probable. But we must, I think, take a broader view, and conclude that organic beings, when subjected during several generations to any change whatever in their conditions, tend to vary; the kind of variation which ensues depending in most cases in a far higher degree on the nature or constitution of the being, than on the nature of the changed conditions.

Those authors who believe that it is a law of nature that each individual should differ in some slight degree from every other, may maintain, apparently with truth, that this is the fact, not only with all domesticated animals and cultivated plants, but likewise with all organic beings in a state of nature. The Laplander by long practice knows and gives a name to each reindeer, though, as Linnæus remarks, "to distinguish one from another among such multitudes was beyond my comprehension, for they were like ants on an anthill." In Germany shepherds have won wagers by recognising each sheep in a flock of a hundred, which they had never seen until the previous fortnight. This power of discrimination, however, is as nothing compared to that which some florists have acquired. Verlot mentions a gardener who could distinguish 150 kinds of camellia, when not in flower; and it has been positively asserted that the famous old Dutch florist Voorhelm, who kept above 1200 varieties of the hyacinth, was hardly ever deceived in knowing each variety by the bulb alone. Hence we must conclude that the bulbs of the hyacinth and the branches and leaves of the camellia, though appearing to an unpractised eye absolutely undistinguishable, yet really differ.[1]

As Linnæus has compared the reindeer in number to ants, I may add that each ant knows its fellow of the same community. Several times I carried ants of the same species (*Formica rufa*) from one ant-hill to another, inhabited apparently by tens of thousands of ants; but the strangers were instantly detected and killed. I then put some ants taken from a very large nest into a bottle strongly perfumed with assafœtida, and after an interval of twenty-four hours returned them to their home; they were at first threatened by their fellows, but were soon recognised and allowed to pass. Hence each ant certainly recognised, independently of odour, its fellow; and if all the ants of the same community have not some countersign or watchword, they must present to each other's senses some distinguishable character.

The dissimilarity of brothers or sisters of the same family, and of seedlings from the same capsule, may be in part accounted for by the unequal blending of the characters of the two parents, and by the more or less complete recovery through reversion of ancestral characters on either side; but we thus only push the difficulty further back in time, for what made the parents or their progenitors different? Hence the belief[2] that an innate tendency to vary exists, independently of external differences, seems at first sight probable. But even the seeds nurtured in the same capsule are not subjected to absolutely uniform conditions, as they draw their nourishment from different points; and we shall see in a future chapter that this difference sometimes suffices to affect the character of the future plant. The greater dissimilarity of the successive children of the same family in comparison with twins, which often resemble each other in external appearance, mental disposition, and constitution, in so extraordinary a manner, apparently proves that the state of the parents at the exact period of conception, or the nature of the subsequent embryonic development, has a direct and powerful influence on the character of the offspring. Nevertheless, when we reflect on the individual differences between organic beings in a state of nature, as shown by every wild animal knowing its mate; and when we reflect on the infinite diversity of the many varieties of our domesticated productions, we may well be inclined to exclaim, though falsely as I believe, that Variability must be looked at as an ultimate fact, necessarily contingent on reproduction.

Those authors who adopt this latter view would probably deny that each separate variation has its own proper exciting cause. Although we can seldom trace the precise relation between cause and effect, yet the considerations presently to be given lead to the conclusion that each modification must have its own distinct cause, and is not the result of what we blindly call accident. The following striking case has been communicated to me by Dr. William Ogle. Two girls, born as twins, and in all respects extremely alike, had their little fingers on both hands crooked; and in both children the second bicuspid tooth of the second dentition on the right side in the upper jaw was misplaced; for, instead of standing in a line with the others, it grew from the roof of the mouth behind the first bicuspid. Neither the parents nor any other members of the family were known to have exhibited any similar peculiarity; but a son of one of these girls had the same tooth similarly misplaced. Now, as both the girls were affected in exactly the same manner, the idea of accident is at once excluded: and we are compelled to admit that there must have existed some precise and sufficient cause which, if it had occurred a hundred times, would have given crooked fingers and misplaced bicuspid teeth to a hundred children. It is of course possible that this case may have been due to reversion to some long-forgotten progenitor, and this would much weaken the value of the argument. I have been led to think of the probability of reversion, from having been told by Mr. Galton of another case of twin girls born with their little fingers slightly crooked, which they inherited from their maternal grandmother.

We will now consider the general arguments, which appear to me to have great weight, in favour of the view that variations of all kinds and degrees are directly or indirectly caused by the conditions of life to which each being, and more especially its ancestors, have been exposed.

No one doubts that domesticated productions are more variable than organic beings which have never been removed from their natural conditions. Monstrosities graduate so insensibly into mere variations that it is impossible to separate them; and all those who have studied monstrosities believe that they are far commoner with domesticated than with wild animals and plants;[3] and in the case of plants, monstrosities would be equally noticeable in the natural as in the cultivated state. Under nature, the individuals of the same species are exposed to nearly uniform conditions, for they are rigorously kept to their proper places by a host of competing animals and plants; they have, also, long been habituated to their conditions of life; but it cannot be said that they are subject to quite uniform conditions, and they are liable to a certain amount of variation. The circumstances under which our domestic productions are reared are widely different: they are protected from competition; they have not only been removed from their natural conditions and often from their native land, but they are frequently carried from district to district, where they are treated differently, so that they rarely remain during any considerable length of time exposed to closely similar conditions. In conformity with this, all our domesticated productions, with the rarest exceptions, vary far more than natural species. The hive-bee, which feeds itself and follows in most respects its natural habits of life, is the least variable of all domesticated animals, and probably the goose is the next least variable; but even the goose varies more than almost any wild bird, so that it cannot be affiliated with perfect certainty to any natural species. Hardly a single plant can be named, which has long been cultivated and propagated by seed, that is not highly variable; common rye (*Secale cereale*) has afforded fewer and less marked varieties than almost any other cultivated plant;[4] but it may be doubted whether the variations of this, the least valuable of all our cereals, have been closely observed.

Bud-variation, which was fully discussed in a former chapter, shows us that variability may be quite independent of seminal reproduction, and likewise of reversion to long-lost ancestral characters. No one will maintain that the sudden appearance of a moss-rose on a Provence-rose is a return to a former state, for mossiness of the calyx has been observed in no natural species; the same argument is applicable to variegated and laciniated leaves; nor can the appearance of nectarines on peach-trees be accounted for on the principle of reversion. But bud-variations more immediately concern us, as they occur far more frequently on plants which have been highly cultivated during a length of time, than on other and less highly cultivated plants; and very few well-marked instances have been observed with plants growing under strictly natural conditions. I have given one instance of an ash-tree growing in a gentleman’s pleasure-grounds; and occasionally there may be seen, on beech and other trees, twigs leafing at a different period from the other branches. But our forest trees in England can hardly be considered as living under strictly natural conditions; the seedlings are raised and protected in nursery-grounds, and must often be transplanted into places where wild trees of the kind would not naturally grow. It would be esteemed a prodigy if a dog-rose growing in a hedge produced by bud-variation a moss-rose, or a wild bullace or wild cherry-tree yielded a branch bearing fruit of a different shape and colour from the ordinary fruit. The prodigy would be enhanced if these varying branches were found capable of propagation, not only by grafts, but sometimes by seed; yet analogous cases have occurred with many of our highly cultivated trees and herbs.

These several considerations alone render it probable that variability of every kind is directly or indirectly caused by changed conditions of life. Or, to put the case under another point of view, if it were possible to expose all the individuals of a species during many generations to absolutely uniform conditions of life, there would be no variability.

On the Nature of the Changes in the Conditions of Life which induce Variability.

From a remote period to the present day, under climates and circumstances as different as it is possible to conceive, organic beings of all kinds, when domesticated or cultivated, have varied. We see this with the many domestic races of quadrupeds and birds belonging to different orders, with goldfish and silkworms, with plants of many kinds, raised in various quarters of the world. In the deserts of northern Africa the date-palm has yielded thirty-eight varieties; in the fertile plains of India it is notorious how many varieties of rice and of a host of other plants exist; in a single Polynesian island, twenty-four varieties of the bread-fruit, the same number of the banana, and twenty-two varieties of the arum, are cultivated by the natives; the mulberry-tree in India and Europe has yielded many varieties serving as food for the silkworm; and in China sixty-three varieties of the bamboo are used for various domestic purposes.[5] These facts, and innumerable others which could be added, indicate that a change of almost any kind in the conditions of life suffices to cause variability—different changes acting on different organisms.

Andrew Knight[6] attributed the variation of both animals and plants to a more abundant supply of nourishment, or to a more favourable climate, than that natural to the species. A more genial climate, however, is far from necessary; the kidney-bean, which is often injured by our spring frosts, and peaches, which require the protection of a wall, have varied much in England, as has the orange-tree in northern Italy, where it is barely able to exist.[7] Nor can we overlook the fact, though not immediately connected with our present subject, that the plants and shells of the Arctic regions are eminently variable.[8] Moreover, it does not appear that a change of climate, whether more or less genial, is one of the most potent causes of variability; for in regard to plants Alph. De Candolle, in his ‘Géographie Botanique’ repeatedly shows that the native country of a plant, where in most cases it has been longest cultivated, is that where it has yielded the greatest number of varieties.

It is doubtful whether a change in the nature of the food is a potent cause of variability. Scarcely any domesticated animal has varied more than the pigeon or the fowl, but their food, especially that of highly-bred pigeons, is generally the same. Nor can our cattle and sheep have been subjected to any great change in this respect. But in all these cases the food probably is much less varied in kind than that which was consumed by the species in its natural state.[9]

Of all the causes which induce variability, excess of food, whether or not changed in nature, is probably the most powerful. This view was held with regard to plants by Andrew Knight, and is now held by Schleiden, more especially in reference to the inorganic elements of the food.[10] In order to give a plant more food it suffices in most cases to grow it separately, and thus prevent other plants robbing its roots. It is surprising, as I have often seen, how vigorously our common wild species flourish when planted by themselves, though not in highly manured land; separate growth is, in fact, the first step in cultivation. We see the converse of the belief that excess of food induces variability in the following statement by a great raiser of seeds of all kinds:[11] "It is a rule invariably with us, when we desire to keep a true stock of any one kind of seed, to grow it on poor land without dung; but when we grow for quantity, we act contrary, and sometimes have dearly to repent of it." According also to Carrière, who has had great experience with flower-garden seeds, "On remarque en général les plantes de vigeur moyenne sont celles qui conservent le mieux leurs caractères."

In the case of animals the want of a proper amount of exercise, as Bechstein remarked, has perhaps played, independently of the direct effects of the disuse of any particular organ, an important part in causing variability. We can see in a vague manner that, when the organised and nutrient fluids of the body are not used during growth, or by the wear and tear of the tissues, they will be in excess; and as growth, nutrition, and reproduction are intimately allied processes, this superfluity might disturb the due and proper action of the reproductive organs, and consequently affect the character of the future offspring. But it may be argued that neither an excess of food nor a superfluity in the organised fluids of the body necessarily induces variability. The goose and the turkey have been well fed for many generations, yet have varied very little. Our fruit-trees and culinary plants, which are so variable, have been cultivated from an ancient period, and, though they probably still receive more nutriment than in their natural state, yet they must have received during many generations nearly the same amount; and it might be thought that they would have become habituated to the excess. Nevertheless, on the whole, Knight's view, that excess of food is one of the most potent causes of variability, appears, as far as I can judge, probable.

Whether or not our various cultivated plants have received nutriment in excess, all have been exposed to changes of various kinds. Fruit-trees are grafted on different stocks, and grown in various soils. The seeds of culinary and agricultural plants are carried from place to place; and during the last century the rotation of our crops and the manures used have been greatly changed.

Slight changes of treatment often suffice to induce variability. The simple fact of almost all our cultivated plants and domesticated animals having varied in all places and at all times, leads to this conclusion. Seeds taken from common English forest-trees, grown under their native climate, not highly manured or otherwise artificially treated, yield seedlings which vary much, as may be seen in every extensive seed-bed. I have shown in a former chapter what a number of well-marked and singular varieties the thorn (*Cratægus oxycantha*) has produced: yet this tree has been subjected to hardly any cultivation. In Staffordshire I carefully examined a large number of two British plants, namely *Geranium phæum* and *pyrenaicum*, which have never been highly cultivated. These plants had spread spontaneously by seed from a common garden into an open plantation; and the seedlings varied in almost every single character, both in their flower and foliage, to a degree which I have never seen exceeded; yet they could not have been exposed to any great change in their conditions.

With respect to animals, Azara has remarked with much surprise[12] that, whilst the feral horses on the Pampas are always of one of three colours, and the cattle always of a uniform colour, yet these animals, when bred on the unenclosed estancias, though kept in a state which can hardly be called domesticated, and apparently exposed to almost identically the same conditions as when they are feral, nevertheless display a great diversity of colour. So again in India several species of fresh-water fish are only so far treated artificially, that they are reared in great tanks; but this small change is sufficient to induce much variability.[13]

Some facts on the effects of grafting, in regard to the variability of trees, deserve attention. Cabanis asserts that when certain pears are grafted on the quince, their seeds yield a greater number of varieties than do the seeds of the same variety of pear when grafted on the wild pear.[14] But as the pear and quince are distinct species, though so closely related that the one can be readily grafted and succeeds admirably on the other, the fact of variability being thus caused is not surprising; as we are here enabled to see the cause, namely, the very different nature of the stock and graft. Several North American varieties of the plum and peach are well known to reproduce themselves truly by seed; but Downing asserts,[15] "that when a graft is taken from one of these trees and placed upon another stock, this grafted tree is found to lose its singular property of producing the same variety by seed, and becomes like all other worked trees;"—that is, its seedlings become highly variable. Another case is worth giving: the Lalande variety of the walnut-tree leafs between April 20th and May 15th, and its seedlings invariably inherit the same habit; whilst several other varieties of the walnut leaf in June. Now, if seedlings are raised from the May-leafing Lalande variety, grafted on another May-leafing variety, though both stock and graft have the same early habit of leafing, yet the seedlings leaf at various times, even as late as the 5th of June.[16] Such facts as these are well fitted to show on what obscure and slight causes variability depends.

I may here just allude to the appearance of new and valuable varieties of fruit-trees and of wheat in woods and waste places, which at first sight seems a most anomalous circumstance. In France a considerable number of the best pears have been discovered in woods; and this has occurred so frequently, that Poiteau asserts that "improved varieties of our cultivated fruits rarely originate with nurserymen."[17] In England, on the other hand, no instance of a good pear having been found wild has been recorded; and Mr. Rivers informs me that he knows of only one instance with apples, namely, the Bess Poole, which was discovered in a wood in Nottinghamshire. This difference between the two countries may be in part accounted for by the more favourable climate of France, but chiefly from the great number of seedlings which spring up there in the woods. I infer that this is the case from a remark made by a French gardener,[18] who regards it as a national calamity that such a number of pear-trees are periodically cut down for firewood, before they have borne fruit. The new varieties which thus spring up in the woods, though they cannot have received any excess of nutriment, will have been exposed to abruptly changed conditions, but whether this is the cause of their production is very doubtful. These varieties, however, are probably all descended[19] from old cultivated kinds growing in adjoining orchards— a circumstance which will account for their variability; and out of a vast number of varying trees there will always be a good chance of the appearance of a valuable kind. In North America, where fruit-trees frequently spring up in waste places, the Washington pear was found in a hedge, and the Emperor peach in a wood.[20]

With respect to wheat, some writers have spoken[21] as if it were an ordinary event for new varieties to be found in waste places; the Fenton wheat was certainly discovered growing on a pile of basaltic detritus in a quarry, but in such a situation the plant would probably receive a sufficient amount of nutriment. The Chidham wheat was raised from an ear found *on* a hedge; and Hunter's wheat was discovered *by* the roadside in Scotland, but it is not said that this latter variety grew where it was found.[22]

Whether our domestic productions would ever become so completely habituated to the conditions under which they now live, as to cease varying, we have no sufficient means for judging. But, in fact, our domestic productions are never exposed for a great length of time to uniform conditions, and it is certain that our most anciently cultivated plants, as well as animals, still go on varying, for all have recently undergone marked improvement. In some few cases, however, plants have become habituated to new conditions. Thus, Metzger, who cultivated in Germany during many years numerous varieties of wheat, brought from different countries,[23] states that some kinds were at first extremely variable, but gradually, in one instance after an interval of twenty-five years, became constant; and it does not appear that this resulted from the selection of the more constant forms.

On the Accumulative Action of changed Conditions of Life.—We have good grounds for believing that the influence of changed conditions accumulates, so that no effect is produced on a species until it has been exposed during several generations to continued cultivation or domestication. Universal experience shows us that when new flowers are first introduced into our gardens they do not vary; but ultimately all, with the rarest exceptions, vary to a greater or less extent. In a few cases the requisite number of generations, as well as the successive steps in the progress of variation, have been recorded, as in the often quoted instance of the Dahlia.[24] After several years' culture the Zinnia has only lately (1860) begun to vary in any great degree. "In the first seven or eight years of high cultivation, the Swan River daisy (*Brachycome iberidifolia*) kept to its original colour; it then varied into lilac and purple and other minor shades."[25] Analogous facts have been recorded with the Scotch rose. In discussing the variability of plants several experienced horticulturists have spoken to the same general effect. Mr. Salter[26] remarks, "Every one knows that the chief difficulty is in breaking through the original form and colour of the species, and every one will be on the look-out for any natural sport, either from seed or branch; that being once obtained, however trifling the change may be, the result depends upon himself." M. de Jonghe, who has had so much success in raising new varieties of pears and strawberries,[27] remarks with respect to the former, "There is another principle, namely, that the more a type has entered into a state of variation, the greater is its tendency to continue doing so; and the more it has varied from the original type, the more it is disposed to vary still farther." We have, indeed, already discussed this latter point when treating of the power which man possesses, through selection, of continually augmenting in the same direction each modification; for this power depends on continued variability of the same general kind. The most celebrated horticulturist in France, namely, Vilmorin,[28] even maintains that, when any particular variation is desired, the first step is to get the plant to vary in any manner whatever, and to go on selecting the most variable individuals, even though they vary in the wrong direction; for the fixed character of the species being once broken, the desired variation will sooner or later appear.

As nearly all our animals were domesticated at an extremely remote epoch, we cannot, of course, say whether they varied quickly or slowly when first subjected to new conditions. But Dr. Bachman[29] states that he has seen turkeys raised from the eggs of the wild species lose their metallic tints and become spotted with white in the third generation. Mr. Yarrell many years ago informed me that the wild ducks bred on the ponds in St. James's Park, which had never been crossed, as it is believed, with domestic ducks, lost their true plumage after a few generations. An excellent observer,[30] who has often reared ducks from the eggs of the wild bird, and who took precautions that there should be no crossing with domestic breeds, has given, as previously stated, full details on the changes which they gradually undergo. He found that he could not breed these wild ducks true for more than five or six generations, "as they then proved so much less beautiful. The white collar round the neck of the mallard became much broader and more irregular, and white feathers appeared in the ducklings' wings." They increased also in size of body; their legs became less fine, and they lost their elegant carriage. Fresh eggs were then procured from wild birds; but again the same result followed. In these cases of the duck and turkey we see that animals, like plants, do not depart from their primitive type until they have been subjected during several generations to domestication. On the other hand, Mr. Yarrell informed me that the Australian dingos, bred in the Zoological Gardens, almost invariably produced in the first generation puppies marked with white and other colours; but, these introduced dingos had probably been procured from the natives, who keep them in a semi-domesticated state. It is certainly a remarkable fact that changed conditions should at first produce, as far as we can see, absolutely no effect; but that they should subsequently cause the character of the species to change. In the chapter on pangenesis I shall attempt to throw a little light on this fact.

Returning now to the causes which are supposed to induce variability. Some authors[31] believe that close interbreeding gives this tendency, and leads to the production of monstrosities. In the seventeenth chapter some few facts were advanced, showing that monstrosities are, as it appears, occasionally thus induced; and there can be no doubt that close interbreeding causes lessened fertility and a weakened constitution; hence it may lead to variability: but I have not sufficient evidence on this head. On the other hand, close interbreeding, if not carried to an injurious extreme, far from causing variability, tends to fix the character of each breed.

It was formerly a common belief, still held by some persons, that the imagination of the mother affects the child in the womb.[32] This view is evidently not applicable to the lower animals, which lay unimpregnated eggs, or to plants. Dr. William Hunter, in the last century, told my father that during many years every woman in a large London Lying-in Hospital was asked before her confinement whether anything had specially affected her mind, and the answer was written down; and it so happened that in no one instance could a coincidence be detected between the woman's answer and any abnormal structure; but when she knew the nature of the structure, she frequently suggested some fresh cause. The belief in the power of the mother's imagination may perhaps have arisen from the children of a second marriage resembling the previous father, as certainly sometimes occurs, in accordance with the facts given in the eleventh chapter.

Crossing as a Cause of Variability.—In an early part of this chapter it was stated that Pallas[33] and a few other naturalists maintain that variability is wholly due to crossing. If this means that new characters never spontaneously appear in our domestic races, but that they are all directly derived from certain aboriginal species, the doctrine is little less than absurd; for it implies that animals like Italian greyhounds, pug-dogs, bull-dogs, pouter and fantail pigeons, etc., were able to exist in a state of nature. But the doctrine may mean something widely different, namely, that the crossing of distinct species is the sole cause of the first appearance of new characters, and that without this aid man could not have formed his various breeds. As, however, new characters have appeared in certain cases by bud-variation, we may conclude with certainty that crossing is not necessary for variability. It is, moreover, certain that the breeds of various animals, such as of the rabbit, pigeon, duck, etc., and the varieties of several plants, are the modified descendants of a single wild species. Nevertheless, it is probable that the crossing of two forms, when one or both have long been domesticated or cultivated, adds to the variability of the offspring, independently of the commingling of the characters derived from the two parent-forms; and this implies that new characters actually arise. But we must not forget the facts advanced in the thirteenth chapter, which clearly prove that the act of crossing often leads to the reappearance or reversion of long-lost characters; and in most cases it would be impossible to distinguish between the reappearance of ancient characters and the first appearance of absolutely new characters. Practically, whether new or old, they would be new to the breed in which they reappeared.

Gärtner declares,[34] and his experience is of the highest value on such a point, that, when he crossed native plants which had not been cultivated, he never once saw in the offspring any new character; but that from the odd manner in which the characters derived from the parents were combined, they sometimes appeared as if new. When, on the other hand, he crossed cultivated plants, he admits that new characters occasionally appeared, but he is strongly inclined to attribute their appearance to ordinary variability, not in any way to the cross. An opposite conclusion, however, appears to me the more probable. According to Kölreuter, hybrids in the genus Mirabilis vary almost infinitely, and he describes new and singular characters in the form of the seeds, in the colour of the anthers, in the cotyledons being of immense size, in new and highly peculiar odours, in the flowers expanding early in the season, and in their closing at night. With respect to one lot of these hybrids, he remarks that they presented characters exactly the reverse of what might have been expected from their parentage.[35]

Prof. Lecoq[36] speaks strongly to the same effect in regard to this same genus, and asserts that many of the hybrids from *Mirabilis jalapa* and *multiflora* might easily be mistaken for distinct species, and adds that they differed in a greater degree than the other species of the genus, from *M. jalapa*. Herbert, also, has described[37] certain hybrid Rhododendrons as being "as *unlike all others* in foliage, as if they had been a separate species." The common experience of floriculturists proves that the crossing and recrossing of distinct but allied plants, such as the species of Petunia, Calceolaria, Fuchsia, Verbena, etc., induces excessive variability; hence the appearance of quite new characters is probable. M. Carrière[38] has lately discussed this subject: he states that *Erythrina cristagalli* had been multiplied by seed for many years, but had not yielded any varieties: it was then crossed with the allied *E. herbacea,* and "the resistance was now overcome, and varieties were produced with flowers of extremely different size, form, and colour."

From the general and apparently well-founded belief that the crossing of distinct species, besides commingling their characters, adds greatly to their variability, it has probably arisen that some botanists have gone so far as to maintain[39] that, when a genus includes only a single species, this when cultivated never varies. The proposition made so broadly cannot be admitted; but it is probably true that the variability of monotypic genera when cultivated is generally less than that of genera including numerous species, and this quite independently of the effects of crossing. I have shown in my 'Origin of Species' that the species belonging to small genera generally yield a less number of varieties in a state of nature than those belonging to large genera. Hence the species of small genera would, it is probable, produce fewer varieties under cultivation than the already variable species of larger genera.

Although we have not at present sufficient evidence that the crossing of species, which have never been cultivated, leads to the appearance of new characters, this apparently does occur with species which have been already rendered in some degree variable through cultivation. Hence crossing, like any other change in the conditions of life, seems to be an element, probably a potent one, in causing variability. But we seldom have the means of distinguishing, as previously remarked, between the appearance of really new characters and the reappearance of long-lost characters, evoked through the act of crossing. I will give an instance of the difficulty in distinguishing such cases. The species of Datura may be divided into two sections, those having white flowers with green stems, and those having purple flowers with brown stems: now Naudin[40] crossed *Datura lævis* and *ferox*, both of which belong to the white section, and raised from them 205 hybrids. Of these hybrids, every one had brown stems and bore purple flowers; so that they resembled the species of the other section of the genus, and not their own two parents. Naudin was so much astonished at this fact, that he was led carefully to observe both parent-species, and he discovered that the pure seedlings of *D. ferox*, immediately after germination, had dark purple stems, extending from the young roots up to the cotyledons, and that this tint remained ever afterwards as a ring round the base of the stem of the plant when old. Now I have shown in the thirteenth chapter that the retention or exaggeration of an early character is so intimately related to reversion, that it evidently comes under the same principle. Hence probably we ought to look at the purple flowers and brown stems of these hybrids, not as new characters due to variability, but as a return to the former state of some ancient progenitor.

Independently of the appearance of new characters from crossing, a few words may be added to what has been said in former chapters on the unequal combination and transmission of the characters proper to the two parent-forms. When two species or races are crossed, the offspring of the first generation are generally uniform, but those subsequently produced display an almost infinite diversity of character. He who wishes, says Kölreuter,[41] to obtain an endless number of varieties from hybrids should cross and recross them. There is also much variability when hybrids or mongrels are reduced or absorbed by repeated crosses with either pure parent-form: and a still higher degree of variability when three distinct species, and most of all when four species, are blended together by successive crosses. Beyond this point Gärtner,[42] on whose authority the foregoing statements are made, never succeeded in effecting a union; but Max Wichura[43] united six distinct species of willows into a single hybrid. The sex of the parent species affects in an inexplicable manner the degree of variability of hybrids; for Gärtner[44] repeatedly found that when a hybrid was used as a father and either one of the pure parent-species, or a third species, was used as the mother, the offspring were more variable than when the same hybrid was used as the mother, and either pure parent or the same third species as the father: thus seedlings from *Dianthus barbatus* crossed by the hybrid *D. chinensi-barbatus* were more variable than those raised from this latter hybrid fertilised by the pure *D. barbatus.* Max Wichura[45] insists strongly on an analogous result with his hybrid willows. Again Gärtner[46] asserts that the degree of variability sometimes differs in hybrids raised from reciprocal crosses between the same two species; and here the sole difference is, that the one species is first used as the father and then as the mother. On the whole we see that, independently of the appearance of new characters, the variability of successive crossed generations is extremely complex, partly from the offspring partaking unequally of the characters of the two parent-forms, and more especially from their unequal tendency to revert to such characters or to those of more ancient progenitors.

On the Manner and on the Period of Action of the Causes which induce Variability.—This is an extremely obscure subject, and we need here only consider, whether inherited variations are due to certain parts being acted on after they have been formed, or through the reproductive system being affected before their formation; and in the former case at what period of growth or development the effect is produced. We shall see in the two following chapters that various agencies, such as an abundant supply of food, exposure to a different climate, increased use or disuse of parts, etc., prolonged during several generations, certainly modify either the whole organisation or certain organs; and it is clear at least in the case of bud-variation that the action cannot have been through the reproductive system.

With respect to the part which the reproductive system takes in causing variability, we have seen in the eighteenth chapter that even slight changes in the conditions of life have a remarkable power in causing a greater or less degree of sterility. Hence it seems not improbable that beings generated through a system so easily affected should themselves be affected, or should fail to inherit, or inherit in excess, characters proper to their parents. We know that certain groups of organic beings, but with exceptions in each group, have their reproductive systems much more easily affected by changed conditions than other groups; for instance, carnivorous birds, more readily than carnivorous mammals, and parrots more readily than pigeons; and this fact harmonises with the apparently capricious manner and degree in which various groups of animals and plants vary under domestication.

Kölreuter[47] was struck with the parallelism between the excessive variability of hybrids when crossed and recrossed in various ways,—these hybrids having their reproductive powers more or less affected,—and the variability of anciently cultivated plants. Max Wichura[48] has gone one step farther, and shows that with many of our highly cultivated plants, such as the hyacinth, tulip, auricula, snapdragon, potato, cabbage, etc., which there is no reason to believe have been hybridised, the anthers contain many irregular pollen-grains in the same state as in hybrids. He finds also in certain wild forms, the same coincidence between the state of the pollen and a high degree of variability, as in many species of Rubus; but in R. caesius and idaeus, which are not highly variable species, the pollen is sound. It is also notorious that many cultivated plants, such as the banana, pineapple, bread-fruit, and others previously mentioned, have their reproductive organs so seriously affected as to be generally quite sterile; and when they do yield seed, the seedlings, judging from the large number of cultivated races which exist, must be variable in an extreme degree. These facts indicate that there is some relation between the state of the reproductive organs and a tendency to variability; but we must not conclude that the relation is strict. Although many of our highly cultivated plants may have their pollen in a deteriorated condition, yet, as we have previously seen, they yield more seeds, and our anciently domesticated animals are more prolific, than the corresponding species in a state of nature. The peacock is almost the only bird which is believed to be less fertile under domestication than in its native state, and it has varied in a remarkably small degree. From these considerations it would seem that changes in the conditions of life lead either to sterility or to variability, or to both; and not that sterility induces variability. On the whole it is probable that any cause affecting the organs of reproduction would likewise affect their product,—that is, the offspring thus generated.

The period of life at which the causes that induce variability act, is likewise an obscure subject, which has been discussed by various authors.[49] In some of the cases, to be given in the following chapter, of modifications from the direct action of changed conditions, which are inherited, there can be no doubt that the causes have acted on the mature or nearly mature animal. On the other hand, monstrosities, which cannot be distinctly separated from lesser variations, are often caused by the embryo being injured whilst in the mother's womb or in the egg. Thus I. Geoffroy Saint-Hilaire[50] asserts that poor women who work hard during their pregnancy, and the mothers of illegitimate children troubled in their minds and forced to conceal their state, are far more liable to give birth to monsters than women in easy circumstances. The eggs of the fowl when placed upright or otherwise treated unnaturally frequently produce monstrous chickens. It would, however, appear that complex monstrosities are induced more frequently during a rather late than during a very early period of embryonic life; but this may partly result from some one part, which has been injured during an early period, affecting by its abnormal growth other parts subsequently developed; and this would be less likely to occur with parts injured at a later period.[51] When any part or organ becomes monstrous through abortion, a rudiment is generally left, and this likewise indicates that its development had already commenced.

Insects sometimes have their antennae or legs in a monstrous condition, the larvae of which do not possess either antennae or legs; and in these cases, as Quatrefages[52] believes, we are enabled to see the precise period at which the normal progress of development was troubled. But the nature of the food given to a caterpillar sometimes affects the colours of the moth, without the caterpillar itself being affected; therefore it seems possible that other characters in the mature insect might be indirectly modified through the larvae. There is no reason to suppose that organs which have been rendered monstrous have always been acted on during their development; the cause may have acted on the organisation at a much earlier stage. It is even probable that either the male or female sexual elements, or both, before their union, may be affected in such a manner as to lead to modifications in organs developed at a late period of life; in nearly the same manner as a child may inherit from his father a disease which does not appear until old age.

In accordance with the facts above given, which prove that in many cases a close relation exists between variability and the sterility following from changed conditions, we may conclude that the exciting cause often acts at the earliest possible period, namely, on the sexual elements, before impregnation has taken place. That an affection of the female sexual element may induce variability we may likewise infer as probable from the occurrence of bud-variations; for a bud seems to be the analogue of an ovule. But the male element is apparently much oftener affected by changed conditions, at least in a visible manner, than the female element or ovule and we know from Gärtner's and Wichura's statements that a hybrid used as the father and crossed with a pure species gives a greater degree of variability to the offspring, than does the same hybrid when used as the mother. Lastly, it is certain that variability may be transmitted through either sexual element, whether or not originally excited in them, for Kölreuter and Gärtner[53] found that when two species were crossed, if either one was variable, the offspring were rendered variable.

Summary.—From the facts given in this chapter, we may conclude that the variability of organic beings under domestication, although so general, is not an inevitable contingent on life, but results from the conditions to which the parents have been exposed. Changes of any kind in the conditions of life, even extremely slight changes, often suffice to cause variability. Excess of nutriment is perhaps the most efficient single exciting cause. Animals and plants continue to be variable for an immense period after their first domestication; but the conditions to which they are exposed never long remain quite constant. In the course of time they can be habituated to certain changes, so as to become less variable; and it is possible that when first domesticated they may have been even more variable than at present. There is good evidence that the power of changed conditions accumulates; so that two, three, or more generations must be exposed to new conditions before any effect is visible. The crossing of distinct forms, which have already become variable, increases in the offspring the tendency to further variability, by the unequal commingling of the characters of the two parents, by the reappearance of long-lost characters, and by the appearance of absolutely new characters. Some variations are induced by the direct action of the surrounding conditions on the whole organisation, or on certain parts alone; other variations appear to be induced indirectly through the reproductive system being affected, as we know is often the case with various beings, which when removed from their natural conditions become sterile. The causes which induce variability act on the mature organism, on the embryo, and, probably, on the sexual elements before impregnation has been effected.

REFERENCES

[1] ‘Des Jacinthes,’ etc., Amsterdam, 1768, p. 43; Verlot, ‘Des Variétés,’ etc., p. 86. On the reindeer *see* Linnæus, ‘Tour in Lapland,’ translated by Sir J. E. Smith, vol. i. p. 314. The statement in regard to German shepherds is given on the authority of Dr. Weinland.

[2] Müller’s ‘Physiology,’ Eng. translation, vol. ii. p. 1662. With respect to the similarity of twins in constitution, Dr. William Ogle has given me the following extract from Professor Trousseau’s Lectures (‘Clinique Médicale,’ tom. i.1 p. 523), in which a curious case is recorded:—“J’ai donné mes soins à deux frères jumeaux, tous deux si extraordinairement ressemblants qu’il m’était impossible de les reconnaitre, à moin de les voir l’un à côté de l’autre. Cette ressemblance physique s’étendait plus loin: ils avaient, permettez-moi l’expression, une similitude pathologique plus remarquable encore. Ainsi l’un d’eux que je voyais aux néothermes à Paris malade d’une ophthalmie rhumatismale me disait, ‘En ce moment mon frere doit avoir une ophthalmie comme la mienne;’ et comme je m’etais recrie, il me montrait quelques jours apres une lettre qu’il venait de recevoir de ce frère alors à Vienne, et qui lui écrivait en effet—‘J’ai mon ophthalmie, tu dois avoir la tienne.’ Quelque singulier que ceci puisse paraître, le fait n’en est pas moins exact: on ne me l’a pas raconté, je l’ai vu, et j’en ai vu d’autres analogues dans ma pratique. Ces deux jumeaux étaient aussi tous deux asthmatiques, et asthmatiques a un effroyable degré. Originaires de Marseille, ils n’ont jamais pu demeurer dans cette ville, ou leurs intérêts les appelaient souvent, sans etre pris de leurs acces; jamais ils n’en eprouvaient a Paris. Bien mieux, il leur suffisait de gagner Toulon pour être guéris de leurs attaques de Marseille. Voyageant sans cesse et dans tous pays pour leurs affaires, ils avaient remarque que certaines localités leur étaient funestes, que dans d’autres ils etaient exempts de tout phénomène d’oppression.”

[3] Isid. Geoffroy St.-Hilaire, ‘Hist. des Anomalies,’ tom. iii. p. 352; Moquin-Tandon, ‘Tératologie Végétale,’ 1841, p. 115.

[4] Metzger, ‘Die Getreidarten,’ 1841, s. 39.

[5] On the date-palm *see* Vogel, ‘Annals and Mag. of Nat. Hist.,’ 1854, p. 460. On Indian varieties, Dr. F. Hamilton, ‘Transact. Linn. Soc.,’ vol. xiv. p. 296. On the varieties cultivated in Tahiti, *see* Dr. Bennett, in Loudon’s ‘Mag. of N. Hist.,’ vol. v. 1832, p. 484. Also Ellis, ‘Polynesian Researches,’ vol. i. pp. 370, 375. On twenty varieties of the Pandanus and other trees in the Marianne Island, *see* ‘Hooker’s Miscellany,’ vol. i. p. 308. On the bamboo in China, *see* Huc’s ‘Chinese Empire,’ vol. ii. p. 307.

[6] ‘Treatise on the Culture of the Apple,’ etc., p. 3.

[7] Gallesio, ‘Teoria della Riproduzione Veg.,’ p. 125.

[8] *See* Dr. Hooker’s Memoir on Arctic Plants in ‘Linn. Transact.,’ vol. xxiii. part ii. Mr. Woodward, and a higher authority cannot be quoted, speaks of the Arctic mollusca (in his ‘Rudimentary Treatise,’ 1856, p. 355) as remarkably subject to variation.

[9] Bechstein, in his ‘Naturgeschichte der Stubenvögel,’ 1840, s. 238, has some good remarks on this subject. He states that his canary-birds varied in colour, though kept on uniform food.

[10] ‘The Plant,’ by Schleiden, translated by Henfrey, 1848, p. 169. *See also* Alex. Braun, in ‘Bot. Memoirs,’ Ray Soc., 1853, p. 313.

[11] Messrs. Hardy and Son, of Maldon, in ‘Gardener’s Chronicle,’ 1856, p. 458. Carrière, ‘Production et Fixation des Variétés,’ 1865, p. 31.

[12] ‘Quadrupedes du Paraguay,’ 1801, tom. ii. p. 319.

[13] M’Clelland on Indian Cyprinidæ, ‘Asiatic Researches,’ vol. xix. part ii., 1839, pp. 266, 268, 313.

[14] Quoted by Sageret, ‘Pom. Phys.,’ 1830, p. 43. This statement, however, is not believed by Decaisne.

[15] ‘The Fruits of America,’ 1845, p. 5.

[16] M. Cardan, in ‘Comptes Rendus,’ Dec. 1848, quoted in ‘Gardener’s Chronicle,’ 1849, p. 101.

[17] M. Alexis Jordan mentions four excellent pears found in woods in France, and alludes to others (‘Mém. Acad. de Lyon,’ tom. ii. 1852, p. 159). Poiteau’s remark is quoted in ‘Gardener’s Mag.,’ vol. iv., 1828, p. 385. *See* ‘Gardener’s Chronicle,’ 1862, p. 335, for another case of a new variety of the pear found in a hedge in France. Also for another case, *see* Loudon’s ‘Encyclop. of Gardening,’ p. 901. Mr. Rivers has given me similar information.

[18] Duval, ‘Hist. du Poirier,’ 1849, p. 2.

[19] I infer that this is the fact from Van Mons’ statement (‘Arbres Fruitiers,’ 1835, tom. i. p. 446) that he finds in the woods seedlings resembling all the chief cultivated races of both the pear and apple. Van Mons, however, looked at these wild varieties as aboriginal species.

[20] Downing, ‘Fruit-trees of North America,’ p. 422; Foley, in ‘Transact. Hort. Soc.,’ vol. vi. p. 412.

[21] ‘Gardener’s Chronicle,’ 1847, p. 244.

[22] ‘Gardener’s Chronicle,’ 1841, p. 383; 1850, p. 700; 1854, p. 650.

[23] ‘Die Getreidearten,’ 1843, s. 66, 116, 117.

[24] Sabine, in ‘Hort. Transact.,’ vol. iii. p. 225; Bronn, ‘Geschichte der Natur,’ b. ii. s. 119.

[25] ‘Journal of Horticulture,’ 1861, p. 112; on Zinnia, ‘Gardener’s Chronicle,’ 1860, p. 852.

[26] ‘The Chrysanthemum, its History, etc.,’ 1865, p. 3.

[27] ‘Gardener’s Chronicle,’ 1855, p. 54; ‘Journal of Horticulture,’ May 9, 1865, p. 363.

[28] Quoted by Verlot, ‘Des Variétés,’ etc., 1865, p. 28.

[29] ‘Examination of the Characteristics of Genera and Species,’ Charleston, 1855, p. 14.

[30] Mr. Hewitt, ‘Journal of Hort.,’ 1863, p. 39.

[31] Devay, ‘Mariages Consanguins,’ pp. 97, 125. In conversation I have found two or three naturalists of the same opinion.

[32] Müller has conclusively argued against this belief, ‘Elements of Phys.,’ Eng. translat., vol. ii. 1842, p. 1405.

[33] ‘Act. Acad. St. Petersburg,’ 1780, part ii. p. 84, etc.

[34] ‘Bastarderzeugung,’ s. 249, 255, 295.

[35] ‘Nova Acta, St. Petersburg,’ 1794, p. 378; 1795, pp. 307, 313, 316; 1787, p. 407.

[36] ‘De la Fécondation,’ 1862, p. 311.

[37] ‘Amaryllidaceæ,’ 1837, p. 362.

[38] Abstracted in ‘Gardener’s Chronicle,’ 1860, p. 1081.

[39] This was the opinion of the elder De Candolle, as quoted in ‘Dic. Class. d’Hist. Nat.,’ tom. viii. p. 405. Puvis, in his work, ‘De la Dégénération,’ 1837, p. 37, has discussed this same point.

[40] ‘Comptes Rendus,’ Novembre 21, 1864, p. 838.

[41] ‘Nova Acta, St. Petersburg,’ 1794, p. 391.

[42] ‘Bastarderzeugung,’ s. 507, 516, 572.

[43] ‘Die Bastardbefruchtung,’ etc., 1865, s. 24.

[44] ‘Bastarderzeugung,’ s. 452, 507.

[45] ‘Die Bastardbefruchtung,’ s. 56.

[46] ‘Bastarderzeugung,’ s. 423.

[47] ‘Dritte Fortsetzung,’ etc., 1766, s. 85.

[48] ‘Die Bastardbefruchtung,’ etc., 1865, s. 92: *see also* the Rev. M. J. Berkeley on the same subject, in ‘Journal of Royal Hort. Soc.,’ 1866, p. 80.

[49] Dr. P. Lucas has given a history of opinion on this subject: ‘Héréd. Nat.,’ 1847, tom. i. p. 175.

[50] ‘Hist. des Anomalies,’ tom. iii. p. 499.

[51] Ibid., tom. iii. pp. 392, 502. The several memoirs by M. Dareste hereafter referred to are of special value on this whole subject.

[52] *See* his interesting work, ‘Métamorphoses de l’Homme,’ etc., 1862, p. 129.

[53] ‘Dritte Fortsetzung,’ etc., s. 123; ‘Bastarderzeugung’ s. 249.

CHAPTER XXIII.
DIRECT AND DEFINITE ACTION OF THE EXTERNAL CONDITIONS OF LIFE.

SLIGHT MODIFICATIONS IN PLANTS FROM THE DEFINITE ACTION OF CHANGED CONDITIONS, IN SIZE, COLOUR, CHEMICAL PROPERTIES, AND IN THE STATE OF THE TISSUES—LOCAL DISEASES—CONSPICUOUS MODIFICATIONS FROM CHANGED CLIMATE OR FOOD, ETC—PLUMAGE OF BIRDS AFFECTED BY PECULIAR NUTRIMENT, AND BY THE INOCULATION OF POISON—LAND-SHELLS—MODIFICATIONS OF ORGANIC BEINGS IN A STATE OF NATURE THROUGH THE DEFINITE ACTION OF EXTERNAL CONDITIONS—COMPARISON OF AMERICAN AND EUROPEAN TREES—GALLS—EFFECTS OF PARASITIC FUNGI—CONSIDERATIONS OPPOSED TO THE BELIEF IN THE POTENT INFLUENCE OF CHANGED EXTERNAL CONDITIONS—PARALLEL SERIES OF VARIETIES—AMOUNT OF VARIATION DOES NOT CORRESPOND WITH THE DEGREE OF CHANGE IN THE CONDITIONS—BUD-VARIATION—MONSTROSITIES PRODUCED BY UNNATURAL TREATMENT—SUMMARY.

If we ask ourselves why this or that character has been modified under domestication, we are, in most cases, lost in utter darkness. Many naturalists, especially of the French school, attribute every modification to the "monde ambiant," that is, to changed climate, with all its diversities of heat and cold, dampness and dryness, light and electricity, to the nature of the soil, and to varied kinds and amount of food. By the term definite action, as used in this chapter, I mean an action of such a nature that, when many individuals of the same variety are exposed during several generations to any particular change in their conditions of life, all, or nearly all the individuals, are modified in the same manner. The effects of habit, or of the increased use and disuse of various organs, might have been included under this head; but it will be convenient to discuss this subject in a separate chapter. By the term indefinite action I mean an action which causes one individual to vary in one way and another individual in another way, as we often see with plants and animals after they have been subjected for some generations to changed conditions of life. But we know far too little of the causes and laws of variation to make a sound classification. The action of changed conditions, whether leading to definite or indefinite results, is a totally distinct consideration from the effects of selection; for selection depends on the preservation by man of certain individuals, or on their survival under various and complex natural circumstances, and has no relation whatever to the primary cause of each particular variation.

I will first give in detail all the facts which I have been able to collect, rendering it probable that climate, food, etc., have acted so definitely and powerfully on the organisation of our domesticated productions, that new sub-varieties or races have been thus formed without the aid of selection by man or nature. I will then give the facts and considerations opposed to this conclusion, and finally we will weigh, as fairly as we can, the evidence on both sides.

When we reflect that distinct races of almost all our domesticated animals exist in each kingdom of Europe, and formerly even in each district of England, we are at first strongly inclined to attribute their origin to the definite action of the physical conditions of each country; and this has been the conclusion of many authors. But we should bear in mind that man annually has to choose which animals shall be preserved for breeding, and which shall be slaughtered. We have also seen that both methodical and unconscious selection were formerly practised, and are now occasionally practised by the most barbarous races, to a much greater extent than might have been anticipated. Hence it is difficult to judge how far differences in the conditions between, for instance, the several districts in England, have sufficed to modify the breeds which have been reared in each. It may be argued that, as numerous wild animals and plants have ranged during many ages throughout Great Britain, and still retain the same character, the difference in conditions between the several districts could not have modified in a marked manner the various native races of cattle, sheep, pigs, and horses. The same difficulty of distinguishing between the effects of natural selection and the definite action of external conditions is encountered in a still higher degree when we compare closely allied species inhabiting two countries, such as North America and Europe, which do not differ greatly in climate, nature of soil, etc., for in this case natural selection will inevitably and rigorously have acted during a long succession of ages.

Prof. Weismann has suggested[1] that when a variable species enters a new and isolated country, although the variations may be of the same general nature as before, yet it is improbable that they should occur in the same proportional numbers. After a longer or shorter period, the species will tend to become nearly uniform in character from the incessant crossing of the varying individuals; but owing to the proportion of the individuals varying in different ways not being the same in the two cases, the final result will be the production of two forms somewhat different from one another. In cases of this kind it would falsely appear as if the conditions had induced certain definite modifications, whereas they had only excited indefinite variability, but with the variations in slightly different proportional numbers. This view may throw some light on the fact that the domestic animals which formerly inhabited the several districts in Great Britain, and the half wild cattle lately kept in several British parks, differed slightly from one another; for these animals were prevented from wandering over the whole country and intercrossing, but would have crossed freely within each district or park.

From the difficulty of judging how far changed conditions have caused definite modifications of structure, it will be advisable to give as large a body of facts as possible, showing that extremely slight differences within the same country, or during different seasons, certainly produce an appreciable effect, at least on varieties which are already in an unstable condition. Ornamental flowers are good for this purpose, as they are highly variable, and are carefully observed. All floriculturists are unanimous that certain varieties are affected by very slight differences in the nature of the artificial compost in which they are grown, and by the natural soil of the district, as well as by the season. Thus, a skilful judge, in writing on Carnations and Picotees[2] asks “where can Admiral Curzon be seen possessing the colour, size, and strength which it has in Derbyshire? Where can Flora’s Garland be found equal to those at Slough? Where do high-coloured flowers revel better than at Woolwich and Birmingham? Yet in no two of these districts do the same varieties attain an equal degree of excellence, although each may be receiving the attention of the most skilful cultivators.” The same writer then recommends every cultivator to keep five different kinds of soil and manure, “and to endeavour to suit the respective appetites of the plants you are dealing with, for without such attention all hope of general success will be vain.” So it is with the Dahlia:[3] the Lady Cooper rarely succeeds near London, but does admirably in other districts; the reverse holds good with other varieties; and again, there are others which succeed equally well in various situations. A skilful gardener[4] states that he procured cuttings of an old and well-known variety (pulchella) of Verbena, which from having been propagated in a different situation presented a slightly different shade of colour; the two varieties were afterwards multiplied by cuttings, being carefully kept distinct;

but in the second year they could hardly be distinguished, and in the third year no one could distinguish them.

The nature of the season has an especial influence on certain varieties of the Dahlia: in 1841 two varieties were pre-eminently good, and the next year these same two were pre-eminently bad. A famous amateur[5] asserts that in 1861 many varieties of the Rose came so untrue in character, "that it was hardly possible to recognise them, and the thought was not seldom entertained that the grower had lost his tally." The same amateur[6] states that in 1862 two-thirds of his Auriculas produced central trusses of flowers, and such trusses are liable not to keep true; and he adds that in some seasons certain varieties of this plant all prove good, and the next season all prove bad; whilst exactly the reverse happens with other varieties. In 1845 the editor of the 'Gardener's Chronicle'[7] remarked how singular it was that this year many Calceolarias tended to assume a tubular form. With Heartsease[8] the blotched sorts do not acquire their proper character until hot weather sets in; whilst other varieties lose their beautiful marks as soon as this occurs.

Analogous facts have been observed with leaves: Mr. Beaton asserts[9] that he raised at Shrubland, during six years, twenty thousand seedlings from the Punch Pelargonium, and not one had variegated leaves; but at Surbiton, in Surrey, one-third, or even a greater proportion, of the seedlings from this same variety were more or less variegated. The soil of another district in Surrey has a strong tendency to cause variegation, as appears from information given me by Sir F. Pollock. Verlot[10] states that the variegated strawberry retains its character as long as grown in a dryish soil, but soon loses it when planted in fresh and humid soil. Mr. Salter, who is well known for his success in cultivating variegated plants, informs me that rows of strawberries were planted in his garden in 1859, in the usual way; and at various distances in one row, several plants simultaneously became variegated; and what made the case more extraordinary, all were variegated in precisely the same manner. These plants were removed, but during the three succeeding years other plants in the same row became variegated, and in no instance were the plants in any adjoining row affected.

The chemical qualities, odours, and tissues of plants are often modified by a change which seems to us slight. The Hemlock is said not to yield conicine in Scotland. The root of the *Aconitum napellus* becomes innocuous in frigid climates. The medicinal properties of the Digitalis are easily affected by culture. As the *Pistacia lentiscus* grows abundantly in the South of France, the climate must suit it, but it yields no mastic. The Laurus sassafras in Europe loses the odour proper to it in North America.[11] Many similar facts could be given, and they are remarkable because it might have been thought that definite chemical compounds would have been little liable to change either in quality or quantity.

The wood of the American Locust-tree (*Robinia*) when grown in England is nearly worthless, as is that of the Oak-tree when grown at the Cape of Good Hope.[12] Hemp and flax, as I hear from Dr. Falconer, flourish and yield plenty of seed on the plains of India, but their fibres are brittle and useless. Hemp, on the other hand, fails to produce in England that resinous matter which is so largely used in India as an intoxicating drug.

The fruit of the Melon is greatly influenced by slight differences in culture and climate. Hence it is generally a better plan, according to Naudin, to improve an old kind than to introduce a new one into any locality. The seed of the Persian Melon produces near Paris fruit inferior to the poorest market kinds, but at Bordeaux yields delicious fruit.[13] Seed is annually brought from Thibet to Kashmir[14] and produces fruit weighing from four to ten pounds, but plants raised next year from seed saved in Kashmir give fruit weighing only from two to three pounds. It is well known that American varieties of the Apple produce in their native land magnificent and brightly-coloured fruit, but these in England are of poor quality and a dull colour. In Hungary there are many varieties of the kidney-bean, remarkable for the beauty of their seeds, but the Rev. M.J. Berkeley[15] found that their beauty could hardly ever be preserved in England, and in some cases the colour was greatly changed. We have seen in the ninth chapter, with respect to wheat, what a remarkable effect transportal from the north to the south of France, and conversely, produced on the weight of the grain.

When man can perceive no change in plants or animals which have been exposed to a new climate or to different treatment, insects can sometimes perceive a marked change. A cactus has been imported into India from Canton, Manilla Mauritius, and from the hot-houses of Kew, and there is likewise a so-called native kind which was formerly introduced from South America; all these plants belong to the same species and are alike in appearance, but the cochineal insect flourishes only on the native kind, on which it thrives prodigiously.[16] Humboldt remarks[17] that white men "born in the torrid zone walk barefoot with impunity in the same apartment where a European, recently landed, is exposed to the attacks of the *Pulex penetrans*." This insect, the too well-known chigoe, must therefore be able to perceive what the most delicate chemical analysis fails to discover, namely, a difference between the blood or tissues of a European and those of a white man born in the tropics. But the discernment of the chigoe is not so surprising as it at first appears; for according to Liebig[18] the blood of men with different complexions, though inhabiting the same country, emits a different odour.

Diseases peculiar to certain localities, heights, or climates, may be here briefly noticed, as showing the influence of external circumstances on the human body. Diseases confined to certain races of man do not concern us, for the constitution of the race may play the more important part, and this may have been determined by unknown causes. The Plica Polonica stands, in this respect, in a nearly intermediate position; for it rarely affects Germans, who inhabit the neighbourhood of the Vistula, where so many Poles are grievously affected; neither does it affect Russians, who are said to belong to the same original stock as the Poles.[19] The elevation of a district often governs the appearance of diseases; in Mexico the yellow fever does not extend above 924 metres;

and in Peru, people are affected with the *verugas* only between 600 and 1600 metres above the sea; many other such cases could be given. A peculiar cutaneous complaint, called the *Bouton d'Alep,* affects in Aleppo and some neighbouring districts almost every native infant, and some few strangers; and it seems fairly well established that this singular complaint depends on drinking certain waters. In the healthy little island of St. Helena the scarlet-fever is dreaded like the Plague; analogous facts have been observed in Chili and Mexico.[20] Even in the different departments of France it is found that the various infirmities which render the conscript unfit for serving in the army, prevail with remarkable inequality, revealing, as Boudin observes, that many of them are endemic, which otherwise would never have been suspected.[21] Any one who will study the distribution of disease will be struck with surprise at what slight differences in the surrounding circumstances govern the nature and severity of the complaints by which man is at least temporarily affected.

The modifications as yet referred to are extremely slight, and in most cases have been caused, as far as we can judge, by equally slight differences in the conditions. But such conditions acting during a series of generations would perhaps produce a marked effect.

With plants, a considerable change of climate sometimes produces a conspicuous result. I have given in the ninth chapter the most remarkable case known to me, namely, that of varieties of maize, which were greatly modified in the course of only two or three generations when taken from a tropical country to a cooler one, or conversely. Dr. Falconer informs me that he has seen the English Ribston-pippin apple, a Himalayan oak, Prunus and Pyrus, all assume in the hotter parts of India a fastigiate or pyramidal habit; and this fact is the more interesting, as a Chinese tropical species of Pyrus naturally grows thus. Although in these cases the changed manner of growth seems to have been directly caused by the great heat, we know that many fastigiate trees have originated in their temperate homes. In the Botanic Gardens of Ceylon the apple-tree[22] "sends out numerous runners under ground, which continually rise into small stems, and form a growth around the parent-tree." The varieties of the cabbage which produce heads in Europe fail to do so in certain tropical countries.[23] The *Rhododendron ciliatum* produced at Kew flowers so much larger and paler-coloured than those which it bears on its native Himalayan mountain, that Dr. Hooker[24] would hardly have recognised the species by the flowers alone. Many similar facts with respect to the colour and size of flowers could be given.

The experiments of Vilmorin and Buckman on carrots and parsnips prove that abundant nutriment produces a definite and inheritable effect on the roots, with scarcely any change in other parts of the plant. Alum directly influences the colour of the flowers of the Hydrangea.[25] Dryness seems generally to favour the hairiness or villosity of plants. Gärtner found that hybrid Verbascums became extremely woolly when grown in pots. Mr. Masters, on the other hand, states that the *Opuntia leucotricha* "is well clothed with beautiful white hairs when grown in a damp heat, but in a dry heat exhibits none of this peculiarity."[26] Slight variations of many kinds, not worth specifying in detail, are retained only as long as plants are grown in certain soils, of which Sageret[27] gives some instances from his own experience. Odart, who insists strongly on the permanence of the varieties of the grape, admits[28] that some varieties, when grown under a different climate or treated differently, vary in a slight degree, as in the tint of the fruit and in the period of ripening. Some authors have denied that grafting causes even the slightest difference in the scion; but there is sufficient evidence that the fruit is sometimes slightly affected in size and flavour, the leaves in duration, and the flowers in appearance.[29]

There can be no doubt, from the facts given in the first chapter, that European dogs deteriorate in India, not only in their instincts but in structure; but the changes which they undergo are of such a nature, that they may be partly due to reversion to a primitive form, as in the case of feral animals. In parts of India the turkey becomes reduced in size, "with the pendulous appendage over the beak enormously developed."[30] We have seen how soon the wild duck, when domesticated, loses its true character, from the effects of abundant or changed food, or from taking little exercise. From the direct action of a humid climate and poor pasture the horse rapidly decreases in size in the Falkland Islands. From information which I have received, this seems likewise to be the case to a certain extent with sheep in Australia.

Climate definitely influences the hairy covering of animals; in the West Indies a great change is produced in the fleece of sheep, in about three generations. Dr. Falconer states[31] that the Thibet mastiff and goat, when brought down from the Himalaya to Kashmir, lose their fine wool. At Angora not only goats, but shepherd-dogs and cats, have fine fleecy hair, and Mr. Ainsworth[32] attributes the thickness of the fleece to the severe winters, and its silky lustre to the hot summers. Burnes states positively[33] that the Karakool sheep lose their peculiar black curled fleeces when removed into any other country. Even within the limits of England, I have been assured that the wool of two breeds of sheep was slightly changed by the flocks being pastured in different localities.[34] It has been asserted on good authority[35] that horses kept during several years in the deep coal-mines of Belgium become covered with velvety hair, almost like that on the mole. These cases probably stand in close relation to the natural change of coat in winter and summer. Naked varieties of several domestic animals have occasionally appeared; but there is no reason to believe that this is in any way related to the nature of the climate to which they have been exposed.[36]

It appears at first sight probable that the increased size, the tendency to fatten, the early maturity and altered forms of our improved cattle, sheep, and pigs, have directly resulted from their abundant supply of food. This is the opinion of many competent judges, and probably is to a great extent true. But as far as form is concerned, we must not overlook the more potent influence of lessened use on the limbs and lungs. We see, moreover, as far as size is concerned, that selection is apparently a more powerful agent than a large supply of food, for we can thus only account for the existence, as remarked to me by Mr. Blyth, of the largest and smallest breeds of sheep in the same country, of

Cochin-China fowls and Bantams, of small Tumbler and large Runt pigeons, all kept together and supplied with abundant nourishment. Nevertheless there can be little doubt that our domesticated animals have been modified, independently of the increased or lessened use of parts, by the conditions to which they have been subjected, without the aid of selection. For instance, Prof. Rütimeyer[37] shows that the bones of domesticated quadrupeds can be distinguished from those of wild animals by the state of their surface and general appearance. It is scarcely possible to read Nathusius's excellent 'Vorstudien'[38] and doubt that, with the highly improved races of the pig, abundant food has produced a conspicuous effect on the general form of the body, on the breadth of the head and face, and even on the teeth. Nathusius rests much on the case of a purely bred Berkshire pig, which when two months old became diseased in its digestive organs, and was preserved for observation until nineteen months old; at this age it had lost several characteristic features of the breed, and had acquired a long, narrow head, of large size relatively to its small body, and elongated legs. But in this case and in some others we ought not to assume that, because certain characters are lost, perhaps through reversion, under one course of treatment, therefore that they were at first directly produced by an opposite treatment.

In the case of the rabbit, which has become feral on the island of Porto Santo, we are at first strongly tempted to attribute the whole change—the greatly reduced size, the altered tints of the fur, and the loss of certain characteristic marks—to the definite action of the new conditions to which it has been exposed. But in all such cases we have to consider in addition the tendency to reversion to progenitors more or less remote, and the natural selection of the finest shades of difference.

The nature of the food sometimes either definitely induces certain peculiarities, or stands in some close relation with them. Pallas long ago asserted that the fat-tailed sheep of Siberia degenerate and lose their enormous tails when removed from certain saline pastures; and recently Erman[39] states that this occurs with the Kirgisian sheep when brought to Orenburgh.

It is well known that hemp-seed causes bullfinches and certain other birds to become black. Mr. Wallace has communicated to me some much more remarkable facts of the same nature. The natives of the Amazonian region feed the common green parrot (*Chrysotis festiva*, Linn.) with the fat of large Siluroid fishes, and the birds thus treated become beautifully variegated with red and yellow feathers. In the Malayan archipelago, the natives of Gilolo alter in an analogous manner the colours of another parrot, namely, the *Lorius garrulus*, Linn., and thus produce the *Lori rajah* or King-Lory. These parrots in the Malay Islands and South America, when fed by the natives on natural vegetable food, such as rice and plaintains, retain their proper colours. Mr. Wallace has, also, recorded[40] a still more singular fact. "The Indians (of S. America) have a curious art by which they change the colours of the feathers of many birds. They pluck out those from the part they wish to paint, and inoculate the fresh wound with the milky secretion from the skin of a small toad. The feathers grow of a brilliant yellow colour, and on being plucked out, it is said, grow again of the same colour without any fresh operation."

Bechstein[41] does not entertain any doubt that seclusion from light affects, at least temporarily, the colours of cage-birds.

It is well known that the shells of land-mollusca are affected by the abundance of lime in different districts. Isidore Geoffroy Saint-Hilaire[42] gives the case of *Helix lactea*, which has recently been carried from Spain to the South of France and to the Rio Plata, and in both countries now presents a distinct appearance, but whether this has resulted from food or climate is not known. With respect to the common oyster, Mr. F. Buckland informs me that he can generally distinguish the shells from different districts; young oysters brought from Wales and laid down in beds where "*natives*" are indigenous, in the short space of two months begin to assume the "native" character. M. Costa[43] has recorded a much more remarkable case of the same nature, namely, that young shells taken from the shores of England and placed in the Mediterranean, at once altered their manner of growth and formed prominent diverging rays, like those on the shells of the proper Mediterranean oyster. The same individual shell, showing both forms of growth, was exhibited before a society in Paris. Lastly, it is well known that caterpillars fed on different food sometimes either themselves acquire a different colour or produce moths differing in colour.[44]

It would be travelling beyond my proper limits here to discuss how far organic beings in a state of nature are definitely modified by changed conditions. In my 'Origin of Species' I have given a brief abstract of the facts bearing on this point, and have shown the influence of light on the colours of birds, and of residence near the sea on the lurid tints of insects, and on the succulency of plants. Mr. Herbert Spencer[45] has recently discussed with much ability this whole subject on general grounds. He argues, for instance, that with all animals the external and internal tissues are differently acted on by the surrounding conditions, and they invariably differ in intimate structure. So again the upper and lower surfaces of true leaves, as well as of stems and petioles, when these assume the function and occupy the position of leaves, are differently circumstanced with respect to light, etc., and apparently in consequence differ in structure. But, as Mr. Herbert Spencer admits, it is most difficult in all such cases to distinguish between the effects of the definite action of physical conditions and the accumulation through natural selection of inherited variations which are serviceable to the organism, and which have arisen independently of the definite action of these conditions.

Although we are not here concerned with the definite action of the conditions of life on organisms in a state of nature, I may state that much evidence has been gained during the last few years on this subject. In the United States, for instance, it has been clearly proved, more especially by Mr. J. A. Allen, that, with birds, many species differ in tint, size of body and of beak, and in length of tail, in proceeding from the North to the South; and it appears that these differences must be attributed to the direct action of temperature.[46] With respect to plants I will give a somewhat analogous case: Mr. Meehan,[47] has compared twenty-nine kinds of American trees with their nearest European allies, all grown in close proximity and under as nearly as possible the same conditions. In the American species he finds, with the rarest exceptions, that the leaves fall earlier in the season, and assume before their fall a brighter tint; that they are less deeply toothed or serrated; that the buds are smaller; that the trees are more diffuse in growth and have fewer branchlets; and, lastly, that the seeds are smaller—all in comparison with the corresponding European species. Now considering that these corresponding trees belong to several distinct orders, and that they are adapted to widely different stations, it can hardly be supposed that their differences are of any special service to them in the New and Old worlds; and if so such differences cannot have been gained through natural selection, and must be attributed to the long continued action of a different climate.

Galls.—Another class of facts, not relating to cultivated plants, deserves attention. I allude to the production of galls. Every one knows the curious, bright-red, hairy productions on the wild rose-tree, and the various different galls produced by the oak. Some of the latter resemble fruit, with one face as rosy as the rosiest apple. These bright colours can be of no service either to the gall-forming insect or to the tree, and probably are the direct result of the action of the light, in the same manner as the apples of Nova Scotia or Canada are brighter coloured than English apples. According to Osten Sacken's latest revision, no less than fifty-eight kinds of galls are produced on the several species of oak, by Cynips with its sub-genera; and Mr. B. D. Walsh[48] states that he can add many others to the list. One American species of willow, the *Salix humilis,* bears ten distinct kinds of galls. The leaves which spring from the galls of various English willows differ completely in shape from the natural leaves. The young shoots of junipers and firs, when punctured by certain insects, yield monstrous growths resembling flowers and fir-cones; and the flowers of some plants become from the same cause wholly changed in appearance. Galls are produced in every quarter of the world; of several sent to me by Mr. Thwaites from Ceylon, some were as symmetrical as a composite flower when in bud, others smooth and spherical like a berry; some protected by long spines, others clothed with yellow wool formed of long cellular hairs, others with regularly tufted hairs. In some galls the internal structure is simple, but in others it is highly complex; thus M. Lacaze-Duthiers[49] has figured in the common ink-gall no less than seven concentric layers, composed of distinct tissue, namely, the epidermic, sub-epidermic, spongy, intermediate, and the hard protective layer formed of curiously thickened woody cells, and, lastly, the central mass, abounding with starch-granules on which the larvæ feed.

Galls are produced by insects of various orders, but the greater number by species of Cynips. It is impossible to read M. Lacaze-Duthiers' discussion and doubt that the poisonous secretion of the insect causes the growth of the gall; and every one knows how virulent is the poison secreted by wasps and bees, which belong to the same group with Cynips. Galls grow with extraordinary rapidity, and it is said that they attain their full size in a few days;[50] it is certain that they are almost completely developed before the larvae are hatched. Considering that many gall-insects are extremely small, the drop of secreted poison must be excessively minute; it probably acts on one or two cells alone, which, being abnormally stimulated, rapidly increase by a process of self-division. Galls, as Mr. Walsh[51] remarks, afford good, constant, and definite characters, each kind keeping as true to form as does any independent organic being. This fact becomes still more remarkable when we hear that, for instance, seven out of the ten different kinds of galls produced on *Salix humilis* are formed by gall-gnats (*Cecidomyidæ*) which "though essentially distinct species, yet resemble one another so closely that in almost all cases it is difficult, and in most cases impossible, to distinguish the full-grown insects one from the other."[52] For in accordance with a wide-spread analogy we may safely infer that the poison secreted by insects so closely allied would not differ much in nature; yet this slight difference is sufficient to induce widely different results. In some few cases the same species of gall-gnat produces on distinct species of willows galls which cannot be distinguished; the *Cynips fecundatrix*, also, has been known to produce on the Turkish oak, to which it is not properly attached, exactly the same kind of gall as on the European oak.[53] These latter facts apparently prove that the nature of the poison is a more powerful agent in determining the form of the gall than the specific character of the tree which is acted on.

As the poisonous secretion of insects belonging to various orders has the special power of affecting the growth of various plants; as a slight difference in the nature of the poison suffices to produce widely different results; and lastly, as we know that the chemical compounds secreted by plants are eminently liable to be modified by changed conditions of life, we may believe it possible that various parts of a plant might be modified through the agency of its own altered secretions. Compare, for instance, the mossy and viscid calyx of a moss-rose, which suddenly appears through bud-variation on a Provence-rose, with the gall of red moss growing from the inoculated leaf of a wild rose, with each filament symmetrically branched like a microscopical spruce-fir, bearing a glandular tip and secreting odoriferous gummy matter.[54] Or compare, on the one hand, the fruit of the peach, with its hairy skin, fleshy covering, hard shell and kernel, and on the other hand one of the more complex galls with its epidermic, spongy, and woody layers, surrounding tissue loaded with starch granules. These normal and abnormal structures manifestly present a certain degree of resemblance. Or, again, reflect on the cases above given of parrots which have had their plumage brightly decorated through some change in their blood, caused by having been fed on certain fishes, or locally inoculated with the poison of a toad. I am far from wishing to maintain that the moss-rose or the hard shell of the peach-stone or the bright colours of birds are actually due to any chemical change in the sap or blood; but these cases of galls and of parrots are excellently adapted to show us how powerfully and singularly external agencies may affect structure. With such facts before us, we need feel no surprise at the appearance of any modification in any organic being.

I may, also, here allude to the remarkable effects which parasitic fungi sometimes produce on plants. Reissek[55] has described a Thesium, affected by an Œcidium, which was greatly modified, and assumed some of the characteristic features of certain allied species, or even genera. Suppose, says Reissek, "the condition originally caused by the fungus to become constant in the course of time, the plant would, if found growing wild, be considered as a distinct species or even as belonging to a new genus." I quote this remark to show how profoundly, yet in how natural a manner, this plant must have been modified by the parasitic fungus. Mr. Meehan[56] also states that three species of Euphorbia and *Portulaca olereacea*, which naturally grow prostrate, become erect when they are attacked by the Œcidium. *Euphorbia maculata* in this case also becomes nodose, with the branchlets comparatively smooth and the leaves modified in shape, approaching in these respects to a distinct species, namely, the *E. hypericifolia*.

Facts and Considerations opposed to the belief that the Conditions of Life act in a potent manner in causing definite Modifications of Structure

I have alluded to the slight differences in species naturally living in distinct countries under different conditions; and such differences we feel at first inclined to attribute, probably often with justice, to the definite action of the surrounding conditions. But it must be borne in mind that there exist many animals and plants which range widely and have been exposed to great diversities of climate, yet remain uniform in character. Some authors, as previously remarked, account for the varieties of our culinary and agricultural plants by the definite action of the conditions to which they have been exposed in the different parts of Great Britain; but there are about 200 plants[57] which are found in every single English county; and these plants must have been exposed for an immense period to considerable differences of climate and soil, yet do not differ. So, again, some animals and plants range over a large portion of the world, yet retain the same character.

Notwithstanding the facts previously given on the occurrence of highly peculiar local diseases and on the strange modifications of structure in plants caused by the inoculated poison of insects, and other analogous cases; still there are a multitude of variations—such as the modified skull of the niata ox and bulldog, the long horns of Caffre cattle, the conjoined toes of the solid-hoofed swine, the immense crest and protuberant skull of Polish fowls, the crop of the pouter-pigeon, and a host of other such cases—which we can hardly attribute to the definite action, in the sense before specified, of the external conditions of life. No doubt in every case there must have been some exciting cause; but as we see innumerable individuals exposed to nearly the same conditions, and one alone is affected, we may conclude that the constitution of the individual is of far higher importance than the conditions to which it has been exposed. It seems, indeed, to be a general rule that conspicuous variations occur rarely, and in one individual alone out of millions, though all may have been exposed, as far as we can judge, to nearly the same conditions. As the most strongly marked variations graduate insensibly into the most trifling, we are led by the same train of thought to attribute each slight variation much more to innate differences of constitution, however caused, than to the definite action of the surrounding conditions.

We are led to the same conclusion by considering the cases, formerly alluded to, of fowls and pigeons, which have varied and will no doubt go on varying in directly opposite ways, though kept during many generations under nearly the same conditions. Some, for instance, are born with their beaks, wings, tails, legs, etc., a little longer, and others with these same parts a little shorter. By the long-continued selection of such slight individual differences which occur in birds kept in the same aviary, widely different races could certainly be formed; and long-continued selection, important as is the result, does nothing but preserve the variations which arise, as it appears to us, spontaneously.

In these cases we see that domesticated animals vary in an indefinite number of particulars, though treated as uniformly as is possible. On the other hand, there are instances of animals and plants, which, though they have been exposed to very different conditions, both under nature and domestication, have varied in nearly the same manner. Mr. Layard informs me that he has observed amongst the Caffres of South Africa a dog singularly like an arctic Esquimaux dog. Pigeons in India present nearly the same wide diversities of colour as in Europe; and I have seen chequered and simply barred pigeons, and pigeons with blue and white loins, from Sierra Leone, Madeira, England, and India. New varieties of flowers are continually raised in different parts of Great Britain, but many of these are found by the judges at our exhibitions to be almost identical with old varieties. A vast number of new fruit-trees and culinary vegetables have been produced in North America: these differ from European varieties in the same general manner as the several varieties raised in Europe differ from one another; and no one has ever pretended that the climate of America has given to the many American varieties any general character by which they can be recognised. Nevertheless, from the facts previously advanced on the authority of Mr. Meehan with respect to American and European forest-trees it would be rash to affirm that varieties raised in the two countries would not in the course of ages assume a distinctive character. Dr. M. Masters has recorded a striking fact[58] bearing on this subject: he raised numerous plants of *Hybiscus syriacus* from seed collected in South Carolina and the Holy Land, where the parent-plants must have been exposed to considerably different conditions; yet the seedlings from both localities broke into two similar strains, one with obtuse leaves and purple or crimson flowers, and the other with elongated leaves and more or less pink flowers.

We may, also, infer the prepotent influence of the constitution of the organism over the definite action of the conditions of life, from the several cases given in the earlier chapters of parallel series of varieties,—an important subject, hereafter to be more fully discussed. Sub-varieties of the several kinds of wheat, gourds, peaches, and other plants, and to a limited extent sub-varieties of the fowl, pigeon, and dog, have been shown either to resemble or to differ from one another in a closely corresponding or parallel manner. In other cases, a variety of one species resembles a distinct species; or the varieties of two distinct species resemble one another. Although these parallel resemblances no doubt often result from reversion to the former characters of a common progenitor; yet in other cases, when new characters first appear, the resemblance must be attributed to the inheritance of a similar constitution, and consequently to a tendency to vary in the same manner. We see something of a similar kind in the same monstrosity appearing and reappearing many times in the same species of animal, and, as Dr. Maxwell Masters has remarked to me, in the same species of plant.

We may at least conclude, that the amount of modification which animals and plants have undergone under domestication does not correspond with the degree to which they have been subjected to changed circumstances. As we know the parentage of domesticated birds far better than of most quadrupeds, we will glance through the list. The pigeon has varied in Europe more than almost any other bird; yet it is a native species, and has not been exposed to any extraordinary change of conditions. The fowl has varied equally, or almost equally, with the pigeon, and is a native of the hot jungles of India. Neither the peacock, a native of the same country, nor the guinea-fowl, an inhabitant of the dry deserts of Africa, has varied at all, or only in colour. The turkey, from Mexico, has varied but little. The duck, on the other hand, a native of Europe, has yielded some well-marked races; and as this is an aquatic bird, it must have been subjected to a far more serious change in its habits than the pigeon or even the fowl, which nevertheless have varied in a much higher degree. The goose, a native of Europe and aquatic like the duck, has varied less than any other domesticated bird, except the peacock.

Bud-variation is, also, important under our present point of view, in some few cases, as when all the eyes on the same tuber of the potato, or all the fruit on the same plum-tree, or all the flowers on the same plant, have suddenly varied in the same manner, it might be argued that the variation had been definitely caused by some change in the conditions to which the plants had been exposed; yet, in other cases, such an admission is extremely difficult. As new characters sometimes appear by bud-variation, which do not occur in the parent-species or in any allied species, we may reject, at least in these cases, the idea that they are due to reversion. Now it is well worth while to reflect maturely on some striking case of bud-variation, for instance that of the peach. This tree has been cultivated by the million in various parts of the world, has been treated differently, grown on its own roots and grafted on various stocks, planted as a standard, trained against a wall, or under glass; yet each bud of each sub-variety keeps true to its kind. But occasionally, at long intervals of time, a tree in England, or under the widely different climate of Virginia, produces a single bud, and this yields a branch which ever afterwards bears nectarines. Nectarines differ, as every one knows, from peaches in their smoothness, size, and flavour; and the difference is so great that some botanists have maintained that they are specifically distinct. So permanent are the characters thus suddenly acquired, that a nectarine produced by bud-variation has propagated itself by seed. To guard against the supposition that there is some fundamental distinction between bud and seminal variation, it is well to bear in mind that nectarines have likewise been produced from the stone of the peach; and, reversely, peaches from the stone of the nectarine. Now is it possible to conceive external conditions more closely alike than those to which the buds on the same tree are exposed? Yet one bud alone, out of the many thousands borne by the same tree, has suddenly, without any apparent cause, produced a nectarine. But the case is even stronger than this, for the same flower-bud has yielded a fruit, one-half or one-quarter a nectarine, and the other half or three-quarters a peach. Again, seven or eight varieties of the peach have yielded by bud-variation nectarines: the nectarines thus produced, no doubt, differ a little from one another; but still they are nectarines. Of course there must be some cause, internal or external, to excite the peach-bud to change its nature; but I cannot imagine a class of facts better adapted to force on our minds the conviction that what we call the external conditions of life are in many cases quite insignificant in relation to any particular variation, in comparison with the organisation or constitution of the being which varies.

It is known from the labours of Geoffroy Saint-Hilaire, and recently from those of Dareste and others, that eggs of the fowl, if shaken, placed upright, perforated, covered in part with varnish, etc., produce monstrous chickens. Now these monstrosities may be said to be directly caused by such unnatural conditions, but the modifications thus induced are not of a definite nature. An excellent observer, M. Camille Dareste,[59] remarks "that the various species of monstrosities are not determined by specific causes; the external agencies which modify the development of the embryo act solely in causing a perturbation—a perversion in the normal course of development." He compares the result to what we see in illness: a sudden chill, for instance, affects one individual alone out of many, causing either a cold, or sore-throat, rheumatism, or inflammation of the lungs or pleura. Contagious matter acts in an analogous manner.[60] We may take a still more specific instance: seven pigeons were struck by rattle-snakes:[61] some suffered from convulsions; some had their blood coagulated, in others it was perfectly fluid; some showed ecchymosed spots on the heart, others on the intestines, etc.; others again showed no visible lesion in any organ. It is well known that excess in drinking causes different diseases in different men; but in the tropics the effects of intemperance differ from those caused in a cold climate;[62] and in this case we see the definite influence of opposite conditions. The foregoing facts apparently give us as good an idea as we are likely for a long time to obtain, how in many cases external conditions act directly, though not definitely, in causing modifications of structure.

Summary.—There can be no doubt, from the facts given in this chapter, that extremely slight changes in the conditions of life sometimes, probably often, act in a definite manner on our domesticated productions; and, as the action of changed conditions in causing indefinite variability is accumulative, so it may be with their definite action. Hence considerable and definite modifications of structure probably follow from altered conditions acting during a long series of generations. In some few instances a marked effect has been produced quickly on all, or nearly all, the individuals which have been exposed to a marked change of climate, food, or other circumstance. This has occurred with European men in the United States, with European dogs in India, with horses in the Falkland Islands, apparently with various animals at Angora, with foreign oysters in the Mediterranean, and with maize transported from one climate to another. We have seen that the chemical compounds of some plants and the state of their tissues are readily affected by changed conditions. A relation apparently exists between certain characters and certain conditions, so that if the latter be changed the character is lost—as with the colours of flowers, the state of some culinary plants, the fruit of the melon, the tail of fat-tailed sheep, and the peculiar fleeces of other sheep.

The production of galls, and the change of plumage in parrots when fed on peculiar food or when inoculated by the poison of a toad, prove to us what great and mysterious changes in structure and colour, may be the definite result of chemical changes in the nutrient fluids or tissues.

We now almost certainly know that organic beings in a state of nature may be modified in various definite ways by the conditions to which they have been long exposed, as in the case of the birds and other animals in the northern and southern United States, and of American trees in comparison with their representatives in Europe. But in many cases it is most difficult to distinguish between the definite result of changed conditions, and the accumulation through natural selection of indefinite variations which have proved serviceable. If it profited a plant to inhabit a humid instead of an arid station, a fitting change in its constitution might possibly result from the direct action of the environment, though we have no grounds for believing that variations of the right kind would occur more frequently with plants inhabiting a station a little more humid than usual, than with other plants. Whether the station was unusually dry or humid, variations adapting the plant in a slight degree for directly opposite habits of life would occasionally arise, as we have good reason to believe from what we actually see in other cases.

The organisation or constitution of the being which is acted on, is generally a much more important element than the nature of the changed conditions, in determining the nature of the variation. We have evidence of this in the appearance of nearly similar modifications under different conditions, and of different modifications under apparently nearly the same conditions. We have still better evidence of this in closely parallel varieties being frequently produced from distinct races, or even distinct species; and in the frequent recurrence of the same monstrosity in the same species. We have also seen that the degree to which domesticated birds have varied, does not stand in any close relation with the amount of change to which they have been subjected.

To recur once again to bud-variations. When we reflect on the millions of buds which many trees have produced, before some one bud has varied, we are lost in wonder as to what the precise cause of each variation can be. Let us recall the case given by Andrew Knight of the forty-year-old tree of the yellow magnum bonum plum, an old variety which has been propagated by grafts on various stocks for a very long period throughout Europe and North America, and on which a single bud suddenly produced the red magnum bonum. We should also bear in mind that distinct varieties, and even distinct species,—as in the case of peaches, nectarines, and apricots,—of certain roses and camellias,—although separated by a vast number of generations from any progenitor in common, and although cultivated under diversified conditions, have yielded by bud-variation closely analogous varieties. When we reflect on these facts we become deeply impressed with the conviction that in such cases the nature of the variation depends but little on the conditions to which the plant has been exposed, and not in any especial manner on its individual character, but much more on the inherited nature or constitution of the whole group of allied beings to which the plant in question belongs. We are thus driven to conclude that in most cases the conditions of life play a subordinate part in causing any particular modification; like that which a spark plays, when a mass of combustibles bursts into flame—the nature of the flame depending on the combustible matter, and not on the spark.[63]

No doubt each slight variation must have its efficient cause; but it is as hopeless an attempt to discover the cause of each, as to say why a chill or a poison affects one man differently from another. Even with modifications resulting from the definite action of the conditions of life, when all or nearly all the individuals, which have been similarly exposed, are similarly affected, we can rarely see the precise relation between cause and effect. In the next chapter it will be shown that the increased use or disuse of various organs produces an inherited effect. It will further be seen that certain variations are bound together by correlation as well as by other laws. Beyond this we cannot at present explain either the causes or nature of the variability of organic beings.

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[24] ‘Journal of Horticultural Soc.,’ vol. vii., 1852, p. 117.

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[36] Azara has made some good remarks on this subject, ‘Quadrupedes du Paraguay,’ tom. ii. p. 337. *See* an account of a family of naked mice produced in England, ‘Proc. Zoolog. Soc.,’ 1856, p. 38.

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[44] *See* an account of Mr. Gregson’s experiments on the *Abraxus grossulariata*, ‘Proc. Entomolog. Soc.,’ Jan. 6th, 1862: these experiments have been confirmed by Mr. Greening, in ‘Proc. of the Northern Entomolog. Soc.,’ July 28th, 1862. For the effects of food on caterpillars, *see* a curious account by M. Michely in ‘Bull. De La Soc. Imp. d’Acclimat.,’ tom. viii. p. 563. For analogous facts from Dahlbom on Hymenoptera, *see* Westwood’s ‘Modern Class. of Insects,’ vol. ii. p. 98. *See also* Dr. L. Moller ‘Die Abhängigkeit der Insecten,’ 1867, s. 70.

[45] ‘The Principles of Biology,’ vol. ii., 1866. The present chapters were written before I had read Mr. Herbert Spencer’s work, so that I have not been able to make so much use of it as I should otherwise probably have done.)

[46] Professor Weismann comes to the same conclusion with respect to certain European butterflies in his valuable essay, 'Ueber den Saison-Dimorphismus,' 1875. I might also refer to the recent works of several other authors on the present subject; for instance to Kerner's 'Gute und schlechte Arten,' 1866.

[47] 'Proc. Acad. Nat. Soc. of Philadelphia,' Jan. 28th, 1862.

[48] *See* Mr. B. D. Walsh's excellent papers in 'Proc. Entomolog. Soc. Philadelphia,' Dec. 1866,, p. 284. With respect to the willow, *see* ibid., 1864. p. 546.

[49] See his admirable 'Histoire des Galles' in 'Annal. des Sc. Nat. Bot.' 3rd series tom. 19 1853 p. 273.)

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[51] 'Proc. Entomolog. Soc. Philadelphia,' 1864, p. 558.

[52] Mr. B. D. Walsh, ibid., p. 633, and Dec. 1866, p. 275.

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[54] Lacaze-Duthiers, ibid., pp. 325, 328.

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[56] 'Proc. Acad. Nat. Sc., Philadelphia,' June 16th, 1874, and July 23rd, 1875.

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[60] Paget, 'Lectures on Surgical Pathology,' 1853, vol. i. p. 483.

[61] 'Researches upon the Venom of the Rattle-snake,' Jan. 1861, by Dr. Mitchell, p. 67.

[62] Mr. Sedgwick, in 'British and Foreign Medico-Chirurg. Review,' July 1863, p. 175.

[63] Professor Weismann argues strongly in favour of this view in his 'Saison-Dimorphismus der Schmetterlinge,' 1875, pp. 40-43.

CHAPTER XXIV.
LAWS OF VARIATION—USE AND DISUSE, ETC.

NISUS FORMATIVUS, OR THE CO-ORDINATING POWER OF THE ORGANISATION—ON THE EFFECTS OF THE INCREASED USE AND DISUSE OF ORGANS—CHANGED HABITS OF LIFE—ACCLIMATISATION WITH ANIMALS AND PLANTS—VARIOUS METHODS BY WHICH THIS CAN BE EFFECTED—ARRESTS OF DEVELOPMENT—RUDIMENTARY ORGANS.

In this and the two following chapters I shall discuss, as well as the difficulty of the subject permits, the several laws which govern Variability. These may be grouped under the effects of use and disuse, including changed habits and acclimatisation—arrest of development—correlated variation—the cohesion of homologous parts-the variability of multiple parts—compensation of growth—the position of buds with respect to the axis of the plant—and lastly, analogous variation. These several subjects so graduate into one another that their distinction is often arbitrary.

It may be convenient first briefly to discuss that coordinating and reparative power which is common, in a higher or lower degree, to all organic beings, and which was formerly designated by physiologists as *nisus formativus*.

Blumenbach and others[1] have insisted that the principle which permits a Hydra, when cut into fragments, to develop itself into two or more perfect animals, is the same with that which causes a wound in the higher animals to heal by a cicatrice. Such cases as that of the Hydra are evidently analogous to the spontaneous division or fissiparous generation of the lowest animals, and likewise to the budding of plants. Between these extreme cases and that of a mere cicatrice we have every gradation. Spallanzani[2] by cutting off the legs and tail of a Salamander, got in the course of three months six crops of these members; so that 687 perfect bones were reproduced by one animal during one season. At whatever point the limb was cut off, the deficient part, and no more, was exactly reproduced. When a diseased bone has been removed, a new one sometimes "gradually assumes the regular form, and all the attachments of muscles, ligaments, etc., become as complete as before."[3]

This power of regrowth does not, however, always act perfectly; the reproduced tail of a lizard differs in the form of the scales from the normal tail: with certain Orthopterous insects the large hind legs are reproduced of smaller size:[4] the white cicatrice which in the higher animals unites the edges of a deep wound is not formed of perfect skin, for elastic tissue is not produced till long afterwards.[5] "The activity of the *nisus formativus*," says Blumenbach, "is in an inverse ratio to the age of the organised body." Its power is also greater with animals, the lower they stand in the scale of organisation; and animals low in the scale correspond with the embryos of higher animals belonging to the same class. Newport's observations[6] afford a good illustration of this fact, for he found that "myriapods, whose highest development scarcely carries them beyond the larva of perfect insects, can regenerate limbs and antennae up to the time of their last moult;" and so can the larvae of true insects, but, except in one order, not in the mature insect. Salamanders correspond in development with the tadpoles or larvae of the tailless Batrachians, and both possess to a large extent the power of regrowth; but not so the mature tailless Batrachians.

Absorption often plays an important part in the repair of injuries. When a bone is broken and does not unite, the ends are absorbed and rounded, so that a false joint is formed; or if the ends unite, but overlap, the projecting parts are removed.[7] A dislocated bone will form for itself a new socket. Displaced tendons and varicose veins excavate new channels in the bones against which they press. But absorption comes into action, as Virchow remarks, during the normal growth of bones; parts which are solid during youth become hollowed out for the medullary tissue as the bone increases in size. In trying to understand the many well-adapted cases of regrowth when aided by absorption, we should remember that almost all parts of the organisation, even whilst retaining the same form, undergo constant renewal; so that a part which is not renewed would be liable to absorption.

Some cases, usually classed under the so-called *nisus formativus*, at first appear to come under a distinct head; for not only are old structures reproduced, but new structures are formed. Thus, after inflammation "false membranes," furnished with blood-vessels, lymphatics, and nerves, are developed; or a fœtus escapes from the Fallopian tubes, and falls into the abdomen, "nature pours out a quantity of plastic lymph, which forms itself into organised membrane, richly supplied with blood-vessels," and the fœtus is nourished for a time. In certain cases of hydrocephalus the open and dangerous spaces in the skull are filled up with new bones, which interlock by perfect serrated sutures.[8] But most physiologists, especially on the Continent, have now given up the belief in plastic lymph or blastema, and Virchow[9] maintains that every structure, new or old, is formed by the proliferation of pre-existing cells. On this view false membranes, like cancerous or other tumours, are merely abnormal developments of normal growths; and we can thus understand how it is that they resemble adjoining structures; for instance, that a "false membrane in the serous cavities acquires a covering of epithelium exactly like that which covers the original serous membrane; adhesions of the iris may become black apparently from the production of pigment-cells like those of the uvea."[10]

No doubt the power of reparation, though not always perfect, is an admirable provision, ready for various emergencies, even for such as occur only at long intervals of time.[11] Yet this power is not more wonderful than the growth and development of every single creature, more especially of those which are propagated by fissiparous generation. This subject has been here noticed, because we may infer that, when any part or organ is either greatly increased in size or wholly suppressed through variation and continued selection, the co-ordinating power of the organisation will continually tend to bring again all the parts into harmony with one another.

On the Effects of the Increased Use and Disuse of Organs.

It is notorious, and we shall immediately adduce proofs, that increased use or action strengthens muscles, glands, sense-organs, etc.; and that disuse, on the other hand, weakens them. It has been experimentally proved by Ranke[12] that the flow of blood is greatly increased towards any part which is performing work, and sinks again when the part is at rest. Consequently, if the work is frequent, the vessels increase in size and the part is better nourished. Paget[13] also accounts for the long, thick, dark-coloured hairs which occasionally grow, even in young children, near old-standing inflamed surfaces or fractured bones by an increased flow of blood to the part. When Hunter inserted the spur of a cock into the comb, which is well supplied with blood-vessels, it grew in one case spirally to a length of six inches, and in another case forward, like a horn, so that the bird could not touch the ground with its beak. According to the interesting observations of M. Sedillot,[14] when a portion of one of the bones of the leg of an animal is removed, the associated bone enlarges till it attains a bulk equal to that of the two bones, of which it has to perform the functions. This is best exhibited in dogs in which the tibia has been removed; the companion bone, which is naturally almost filiform and not one-fifth the size of the other, soon acquires a size equal to or greater than that of the tibia. Now, it is at first difficult to believe that increased weight acting on a straight bone could, by alternately increasing and diminishing the pressure, cause the blood to flow more freely in the vessels which permeate the periosteum and thus supply more nutriment to the bone. Nevertheless the observations adduced by Mr. Spencer,[15] on the strengthening of the bowed bones of rickety children, along their concave sides, leads to the belief that this is possible.

The rocking of the stem of a tree increases in a marked manner the growth of the woody tissue in the parts which are strained. Prof. Sachs believes, from reasons which he assigns, that this is due to the pressure of the bark being relaxed in such parts, and not as Knight and H. Spencer maintain, to an increased flow of sap caused by the movement of the trunk.[16] But hard woody tissue may be developed without the aid of any movement, as we see with ivy closely attached to an old wall. In all such cases, it is very difficult to distinguish between the effects of long-continued selection and those which follow from the increased action of the part, or directly from some other cause. Mr. H. Spencer[17] acknowledges this difficulty, and gives as an instance the thorns on trees and the shells of nuts. Here we have extremely hard woody tissue without the possibility of any movement, and without, as far as we can see, any other directly exciting cause; and as the hardness of these parts is of manifest service to the plant, we may look at the result as probably due to the selection of so-called spontaneous variations. Every one knows that hard work thickens the epidermis on the hands; and when we hear that with infants, long before birth, the epidermis is thicker on the palms and soles of the feet than on any other part of the body, as was observed with admiration by Albinus,[18] we are naturally inclined to attribute this to the inherited effects of long-continued use or pressure. We are tempted to extend the same view even to the hoofs of quadrupeds; but who will pretend to determine how far natural selection may have aided in the formation of structures of such obvious importance to the animal?

That use strengthens the muscles may be seen in the limbs of artisans who follow different trades; and when a muscle is strengthened, the tendons, and the crests of bone to which they are attached, become enlarged; and this must likewise be the case with the blood-vessels and nerves. On the other hand, when a limb is not used, as by Eastern fanatics, or when the nerve supplying it with nervous power is effectually destroyed, the muscles wither. So again, when the eye is destroyed the optic nerve becomes atrophied, sometimes even in the course of a few months.[19] The Proteus is furnished with branchiae as well as with lungs: and Schreibers[20] found that when the animal was compelled to live in deep water, the branchiae were developed to thrice their ordinary size, and the lungs were partially atrophied. When, on the other hand, the animal was compelled to live in shallow water, the lungs became larger and more vascular, whilst the branchiae disappeared in a more or less complete degree. Such modifications as these are, however, of comparatively little value for us, as we do not actually know that they tend to be inherited.

In many cases there is reason to believe that the lessened use of various organs has affected the corresponding parts in the offspring. But there is no good evidence that this ever follows in the course of a single generation. It appears, as in the case of general or indefinite variability, that several generations must be subjected to changed habits for any appreciable result. Our domestic fowls, ducks, and geese have almost lost, not only in the individual but in the race, their power of flight; for we do not see a young fowl, when frightened, take flight like a young pheasant. Hence I was led carefully to compare the limb-bones of fowls, ducks, pigeons, and rabbits, with the same bones in the wild parent-species. As the measurements and weights were fully given in the earlier chapters I need here only recapitulate the results. With domestic pigeons, the length of the sternum, the prominence of its crest, the length of the scapulae and furculum, the length of the wings as measured from tip to tip of the radii, are all reduced relatively to the same parts in the wild pigeon. The wing and tail feathers, however, are increased in length, but this may have as little connection with the use of the wings or tail, as the lengthened hair on a dog with the amount of exercise which it has habitually taken. The feet of pigeons, except in the long-beaked races, are reduced in size. With fowls the crest of the sternum is less prominent, and is often distorted or monstrous; the wing-bones have become lighter relatively to the leg-bones, and are apparently a little shorter in comparison with those of the parent-form, the *Gallus bankiva*. With ducks, the crest of the sternum is affected in the same manner as in the foregoing cases: the furculum, coracoids, and scapulae are all reduced in weight relatively to the whole skeleton: the bones of the wings are shorter and lighter, and the bones of the legs longer and heavier, relatively to each other, and relatively to the whole skeleton, in comparison with the same bones in the wild-duck. The decreased weight and size of the bones, in the foregoing cases, is probably the indirect result of the reaction of the weakened muscles on the bones. I failed to compare the feathers of the wings of the tame and wild duck; but Gloger[21] asserts that in the wild duck the tips of the wing-feathers reach almost to the end of the tail, whilst in the domestic duck they often hardly reach to its base. He remarks also on the greater thickness of the legs, and says that the swimming membrane between the toes is reduced; but I was not able to detect this latter difference.

With the domesticated rabbit the body, together with the whole skeleton, is generally larger and heavier than in the wild animal, and the leg-bones are heavier in due proportion; but whatever standard of comparison be taken, neither the leg-bones nor the scapulae have increased in length proportionally with the increased dimensions of the rest of the skeleton. The skull has become in a marked manner narrower, and, from the measurements of its capacity formerly given, we may conclude, that this narrowness results from the decreased size of the brain, consequent on the mentally inactive life led by these closely-confined animals.

We have seen in the eighth chapter that silk-moths, which have been kept during many centuries closely confined, emerge from their cocoons with their wings distorted, incapable of flight, often greatly reduced in size, or even, according to Quatrefages, quite rudimentary. This condition of the wings may be largely owing to the same kind of monstrosity which often affects wild Lepidoptera when artificially reared from the cocoon; or it may be in part due to an inherent tendency, which is common to the females of many Bombycidae, to have their wings in a more or less rudimentary state; but part of the effect may be attributed to long-continued disuse.

From the foregoing facts there can be no doubt that with our anciently domesticated animals, certain bones have increased or decreased in size and weight owing to increased or decreased use; but they have not been modified, as shown in the earlier chapters, in shape or structure. With animals living a free life and occasionally exposed to severe competition the reduction would tend to be greater, as it would be an advantage to them to have the development of every superfluous part saved. With highly-fed domesticated animals, on the other hand, there seems to be no economy of growth, nor any tendency to the elimination of superfluous details. But to this subject I shall recur.

Turning now to more general observations, Nathusius has shown that with the improved races of the pig, the shortened legs and snout, the form of the articular condyles of the occiput, and the position of the jaws with the upper canine teeth projecting in a most anomalous manner in front of the lower canines, may be attributed to these parts not having been fully exercised. For the highly-cultivated races do not travel in search of food, nor root up the ground with their ringed muzzles.[22] These modifications of structure, which are all strictly inherited, characterise several improved breeds, so that they cannot have been derived from any single domestic stock. With respect to cattle, Professor Tanner has remarked that the lungs and liver in the improved breeds "are found to be considerably reduced in size when compared with those possessed by animals having perfect liberty";[23] and the reduction of these organs affects the general shape of the body. The cause of the reduced lungs in highly-bred animals which take little exercise is obvious; and perhaps the liver may be affected by the nutritious and artificial food on which they largely subsist. Again, Dr. Wilckens asserts[24] that various parts of the body certainly differ in Alpine and lowland breeds of several domesticated animals, owing to their different habits of life; for instance, the neck and fore-legs in length, and the hoofs in shape.

It is well known that, when an artery is tied, the anastomosing branches, from being forced to transmit more blood, increase in diameter; and this increase cannot be accounted for by mere extension, as their coats gain in strength. With respect to glands, Sir J. Paget observes that "when one kidney is destroyed the other often becomes much larger, and does double work."[25] If we compare the size of the udders and their power of secretion in cows which have been long domesticated, and in certain breeds of the goat in which the udders nearly touch the ground, with these organs in wild or half-domesticated animals, the difference is great. A good cow with us daily yields more than five gallons, or forty pints of milk, whilst a first-rate animal, kept, for instance, by the Damaras of South Africa,[26] "rarely gives more than two or three pints of milk daily, and, should her calf be taken from her, she absolutely refuses to give any." We may attribute the excellence of our cows and of certain goats, partly to the continued selection of the best milking animals, and partly to the inherited effects of the increased action, through man's art, of the secreting glands.

It is notorious that short-sight is inherited; and we have seen in the twelfth chapter from the statistical researches of M. Giraud-Teulon, that the habit of viewing near objects gives a tendency to short-sight. Veterinarians are unanimous that horses are affected with spavins, splints, ringbones, etc., from being shod and from travelling on hard roads, and they are almost equally unanimous that a tendency to these malformations is transmitted. Formerly horses were not shod in North Carolina, and it has been asserted that they did not then suffer from these diseases of the legs and feet.[27]

Our domesticated quadrupeds are all descended, as far as is known, from species having erect ears; yet few kinds can be named, of which at least one race has not drooping ears. Cats in China, horses in parts of Russia, sheep in Italy and elsewhere, the guinea-pig formerly in Germany, goats and cattle in India, rabbits, pigs, and dogs in all long-civilised countries have dependent ears. With wild animals, which constantly use their ears like funnels to catch every passing sound, and especially to ascertain the direction whence it comes, there is not, as Mr. Blyth has remarked, any species with drooping ears except the elephant. Hence the incapacity to erect the ears is certainly in some manner the result of domestication; and this incapacity has been attributed by various authors[28] to disuse, for animals protected by man are not compelled habitually to use their ears. Col. Hamilton Smith[29] states that in ancient effigies of the dog, “with the exception of one Egyptian instance, no sculpture of the earlier Grecian era produces representations of hounds with completely drooping ears; those with them half pendulous are missing in the most ancient; and this character increases, by degrees, in the works of the Roman period.” Godron also has remarked “that the pigs of the ancient Egyptians had not their ears enlarged and pendent.”[30] But it is remarkable that the drooping of the ear is not accompanied by any decrease in size; on the contrary, animals so different as fancy rabbits, certain Indian breeds of the goat, our petted spaniels, blood-hounds, and other dogs, have enormously elongated ears, so that it would appear as if their weight had caused them to droop, aided perhaps by disuse. With rabbits, the drooping of the much elongated ears has affected even the structure of the skull.

The tail of no wild animal, as remarked to me by Mr. Blyth, is curled; whereas pigs and some races of dogs have their tails much curled. This deformity, therefore, appears to be the result of domestication, but whether in any way connected with the lessened use of the tail is doubtful.

The epidermis on our hands is easily thickened, as every one knows, by hard work. In a district of Ceylon the sheep have “horny callosities that defend their knees, and which arise from their habit of kneeling down to crop the short herbage, and this distinguishes the Jaffna flocks from those of other portions of the island;” but it is not stated whether this peculiarity is inherited.[31]

The mucous membrane which lines the stomach is continuous with the external skin of the body; therefore it is not surprising that its texture should be affected by the nature of the food consumed, but other and more interesting changes likewise follow. Hunter long ago observed that the muscular coat of the stomach of a gull (*Larus tridactylus*) which had been fed for a year chiefly on grain was thickened; and, according to Dr. Edmondston, a similar change periodically occurs in the Shetland Islands in the stomach of the *Larus argentatus*, which in the spring frequents the cornfields and feeds on the seed. The same careful observer has noticed a great change in the stomach of a raven which had been long fed on vegetable food. In the case of an owl (*Strix grallaria*), similarly treated, Menetries states that the form of the stomach was changed, the inner coat became leathery, and the liver increased in size. Whether these modifications in the digestive organs would in the course of generations become inherited is not known.[32]

The increased or diminished length of the intestines, which apparently results from changed diet, is a more remarkable case, because it is characteristic of certain animals in their domesticated condition, and therefore must be inherited. The complex absorbent system, the blood-vessels, nerves, and muscles, are necessarily all modified together with the intestines. According to Daubenton, the intestines of the domestic cat are one-third longer than those of the wild cat of Europe; and although this species is not the parent-stock of the domestic animal, yet, as Isidore Geoffroy has remarked, the several species of cats are so closely allied that the comparison is probably a fair one. The increased length appears to be due to the domestic cat being less strictly carnivorous in its diet than any wild feline species; for instance, I have seen a French kitten eating vegetables as readily as meat. According to Cuvier, the intestines of the domesticated pig exceed greatly in proportionate length those of the wild boar. In the tame and wild rabbit the change is of an opposite nature, and probably results from the nutritious food given to the tame rabbit.[33]

Changed and inherited Habits of Life.—This subject, as far as the mental powers of animals are concerned, so blends into instinct, that I will here only remind the reader of such cases as the tameness of our domesticated animals—the pointing or retrieving of dogs— their not attacking the smaller animals kept by man—and so forth. How much of these changes ought to be attributed to mere habit, and how much to the selection of individuals which have varied in the desired manner, irrespectively of the special circumstances under which they have been kept, can seldom be told.

We have already seen that animals may be habituated to a changed diet; but some additional instances may be given. In the Polynesian Islands and in China the dog is fed exclusively on vegetable matter, and the taste for this kind of food is to a certain extent inherited.[34] Our sporting dogs will not touch the bones of game birds, whilst most other dogs devour them with greediness. In some parts of the world sheep have been largely fed on fish. The domestic hog is fond of barley, the wild boar is said to disdain it; and the disdain is partially inherited, for some young wild pigs bred in captivity showed an aversion for this grain, whilst others of the same brood relished it.[35] One of my relations bred some young pigs from a Chinese sow by a wild Alpine boar; they lived free in the park, and were so tame that they came to the house to be fed; but they would not touch swill, which was devoured by the other pigs. An animal when once accustomed to an unnatural diet, which can generally be effected only during youth, dislikes its proper food, as Spallanzani found to be the case with a pigeon which had been long fed on meat. Individuals of the same species take to new food with different degrees of readiness; one horse, it is stated, soon learned to eat meat, whilst another would have perished from hunger rather than have partaken of it.[36] The caterpillars of the *Bombyx hesperus* feed in a state of nature on the leaves of the *Café diable*, but, after having been reared on the Ailanthus, they would not touch the *Café diable*, and actually died of hunger.[37]

It has been found possible to accustom marine fish to live in fresh water; but as such changes in fish and other marine animals have been chiefly observed in a state of nature, they do not properly belong to our present subject. The period of gestation and of maturity, as shown in the earlier chapters,—the season and the frequency of the act of breeding,—have all been greatly modified under domestication. With the Egyptian goose the rate of change with respect to the season has been recorded.[38] The wild drake pairs with one female, the domestic drake is polygamous. Certain breeds of fowls have lost the habit of incubation. The paces of the horse, and the manner of flight of certain breeds of the pigeon, have been modified and are inherited. Cattle, horses, and pigs have learnt to browse under water in the St. John's River, East Florida, where the Vallisneria has been largely naturalised. The cows were observed by Prof. Wyman to keep their heads immersed for "a period varying from fifteen to thirty-five seconds."[39] The voice differs much in certain kinds of fowls and pigeons. Some varieties are clamorous and others silent, as the Call and common duck, or the Spitz and pointer dog. Every one knows how the breeds of the dog differ from one another in their manner of hunting, and in their ardour after different kinds of game or vermin.

With plants the period of vegetation is easily changed and is inherited, as in the case of summer and winter wheat, barley, and vetches; but to this subject we shall immediately return under acclimatisation. Annual plants sometimes become perennial under a new climate, as I hear from Dr. Hooker is the case with the stock and mignonette in Tasmania. On the other hand, perennials sometimes become annuals, as with the Ricinus in England, and as, according to Captain Mangles, with many varieties of the heartsease. Von Berg[40] raised from seed of *Verbascum phœniceum,* which is usually a biennial, both annual and perennial varieties. Some deciduous bushes become evergreen in hot countries.[41] Rice requires much water, but there is one variety in India which can be grown without irrigation.[42] Certain varieties of the oat and of our other cereals are best fitted for certain soils.[43] Endless similar facts could be given in the animal and vegetable kingdoms. They are noticed here because they illustrate analogous differences in closely allied natural species, and because such changed habits of life, whether due to habit, or to the direct action of external conditions, or to so-called spontaneous variability, would be apt to lead to modifications of structure.

Acclimatisation.—From the previous remarks we are naturally led to the much disputed subject of acclimatisation. There are two distinct questions: Do varieties descended from the same species differ in their power of living under different climates? And secondly, if they so differ, how have they become thus adapted? We have seen that European dogs do not succeed well in India, and it is asserted,[44] that no one has there succeeded in keeping the Newfoundland long alive; but then it may be argued, and probably with truth, that these northern breeds are specifically distinct from the native dogs which flourish in India. The same remark may be made with respect to different breeds of sheep, of which, according to Youatt,[45] not one brought "from a torrid climate lasts out the second year," in the Zoological Gardens. But sheep are capable of some degree of acclimatisation, for Merino sheep bred at the Cape of Good Hope have been found far better adapted for India than those imported from England.[46] It is almost certain that all the breeds of the fowl are descended from one species; but the Spanish breed, which there is good reason to believe originated near the Mediterranean,[47] though so fine and vigorous in England, suffers more from frost than any other breed. The Arrindy silk moth introduced from Bengal, and the Ailanthus moth from the temperate province of Shan Tung, in China, belong to the same species, as we may infer from their identity in the caterpillar, cocoon, and mature states;[48] yet they differ much in constitution: the Indian form “will flourish only in warm latitudes,” the other is quite hardy and withstands cold and rain.

Plants are more strictly adapted to climate than are animals. The latter when domesticated withstand such great diversities of climate, that we find nearly the same species in tropical and temperate countries; whilst the cultivated plants are widely dissimilar. Hence a larger field is open for inquiry in regard to the acclimatisation of plants than of animals. It is no exaggeration to say that with almost every plant which has long been cultivated, varieties exist which are endowed with constitutions fitted for very different climates; I will select only a few of the more striking cases, as it would be tedious to give all. In North America numerous fruit-trees have been raised, and in horticultural publications,—for instance, in that by Downing,—lists are given of the varieties which are best able to withstand the severe climate of the northern States and Canada. Many American varieties of the pear, plum, and peach are excellent in their own country, but until recently, hardly one was known that succeeded in England; and with apples,[49] not one succeeds. Though the American varieties can withstand a severer winter than ours, the summer here is not hot enough. Fruit-trees have also originated in Europe with different constitutions, but they are not much noticed, because nurserymen here do not supply wide areas. The Forelle pear flowers early, and when the flowers have just set, and this is the critical period, they have been observed, both in France and England, to withstand with complete impunity a frost of 18 deg and even 14° Fahr., which killed the flowers, whether fully expanded or in bud, of all other kinds of pears.[50] This power in the flower of resisting cold and afterwards producing fruit does not invariably depend, as we know on good authority,[51] on general constitutional vigour. In proceeding northward, the number of varieties which are found capable of resisting the climate rapidly decreases, as may be seen in the list of the varieties of the cherry, apple, and pear, which can be cultivated in the neighbourhood of Stockholm.[52] Near Moscow, Prince Troubetzkoy planted for experiment in the open ground several varieties of the pear, but one alone, the *Poire sans Pepins*, withstood the cold of winter.[53] We thus see that our fruit-trees, like distinct species of the same genus, certainly differ from each other in their constitutional adaptation to different climates.

With the varieties of many plants, the adaptation to climate is often very close. Thus it has been proved by repeated trials “that few if any of the English varieties of wheat are adapted for cultivation in Scotland”;[54] but the failure in this case is at first only in the quantity, though ultimately in the quality, of the grain produced. The Rev. M. J. Berkeley sowed wheat-seed from India, and got “the most meagre ears,” on land which would certainly have yielded a good crop from English wheat.[55] In these cases varieties have been carried from a warmer to a cooler climate; in the reverse case, as “when wheat was imported directly from France into the West Indian Islands, it produced either wholly barren spikes or furnished with only two or three miserable seeds, while West Indian seed by its side yielded an enormous harvest.”[56] Here is another case of close adaptation to a slightly cooler climate; a kind of wheat which in England may be used indifferently either as a winter or summer variety, when sown under the warmer climate of Grignan, in France, behaved exactly as if it had been a true winter wheat.[57]

Botanists believe that all the varieties of maize belong to the same species; and we have seen that in North America, in proceeding northward, the varieties cultivated in each zone produce their flowers and ripen their seed within shorter and shorter periods. So that the tall, slowly maturing southern varieties do not succeed in New England, and the New English varieties do not succeed in Canada. I have not met with any statement that the southern varieties are actually injured or killed by a degree of cold which the northern varieties can withstand with impunity, though this is probable; but the production of early flowering and early seeding varieties deserves to be considered as one form of acclimatisation. Hence it has been found possible, according to Kalm, to cultivate maize further and further northwards in America. In Europe, also, as we learn from the evidence given by Alph. De Candolle, the culture of maize has extended since the end of the last century thirty leagues north of its former boundary.[58] On the authority of Linnæus,[59] I may quote an analogous case, namely, that in Sweden tobacco raised from home-grown seed ripens its seed a month sooner and is less liable to miscarry than plants raised from foreign seed.

With the Vine, differently from the maize, the line of practical culture has retreated a little southward since the middle ages;[60] but this seems due to commerce being now easier, so that it is better to import wine from the south than to make it in northern districts. Nevertheless the fact of the vine not having spread northward shows that acclimatisation has made no progress during several centuries. There is, however, a marked difference in the constitution of the several varieties,— some being hardy, whilst others, like the muscat of Alexandria, require a very high temperature to come to perfection. According to Labat,[61] vines taken from France to the West Indies succeed with extreme difficulty, whilst those imported from Madeira or the Canary Islands thrive admirably.

Gallesio gives a curious account of the naturalisation of the Orange in Italy. During many centuries the sweet orange was propagated exclusively by grafts, and so often suffered from frosts, that it required protection. After the severe frost of 1709, and more especially after that of 1763, so many trees were destroyed, that seedlings from the sweet orange were raised, and, to the surprise of the inhabitants, their fruit was found to be sweet. The trees thus raised were larger, more productive, and hardier than the old kinds; and seedlings are now continually raised. Hence Gallesio concludes that much more was effected for the naturalisation of the orange in Italy by the accidental production of new kinds during a period of about sixty years, than had been effected by grafting old varieties during many ages.[62] I may add that Risso[63] describes some Portuguese varieties of the orange as extremely sensitive to cold, and as much tenderer than certain other varieties.

The peach was known to Theophrastus, 322 B.C.[64] According to the authorities quoted by Dr. F. Rolle,[65] it was tender when first introduced into Greece, and even in the island of Rhodes only occasionally bore fruit. If this be correct, the peach, in spreading during the last two thousand years over the middle parts of Europe, must have become much hardier. At the present day different varieties differ much in hardiness: some French varieties will not succeed in England; and near Paris, the *Pavie de Bonneuil* does not ripen its fruit till very late in the season, even when grown on a wall; "it is, therefore, only fit for a very hot southern climate."[66]

I will briefly give a few other cases. A variety of *Magnolia grandiflora*, raised by M. Roy, withstands a temperature several degrees lower than that which any other variety can resist. With camellias there is much difference in hardiness. One particular variety of the Noisette rose withstood the severe frost of 1860 "untouched and hale amidst a universal destruction of other Noisettes." In New York the "Irish yew is quite hardy, but the common yew is liable to be cut down." I may add that there are varieties of the sweet potato (*Convolvulus batatas*) which are suited for warmer, as well as for colder, climates.[67]

The plants as yet mentioned have been found capable of resisting an unusual degree of cold or heat, when fully grown. The following cases refer to plants whilst young. In a large bed of young Araucarias of the same age, growing close together and equally exposed, it was observed,[68] after the unusually severe winter of 1860-61, that, "in the midst of the dying, numerous individuals remained on which the frost had absolutely made no kind of impression." Dr. Lindley, after alluding to this and other similar cases, remarks, "Among the lessons which the late formidable winter has taught us, is that, even in their power of resisting cold, individuals of the same species of plants are remarkably different." Near Salisbury, there was a sharp frost on the night of May 24, 1836, and all the French beans (*Phaseolus vulgaris*) in a bed were killed except about one in thirty, which completely escaped.[69] On the same day of the month, but in the year 1864, there was a severe frost in Kent, and two rows of scarlet-runners (*P. multiflorus*) in my garden, containing 390 plants of the same age and equally exposed, were all blackened and killed except about a dozen plants. In an adjoining row of "Fulmer's dwarf bean" (*P. vulgaris*), one single plant escaped. A still more severe frost occurred four days afterwards, and of the dozen plants which had previously escaped only three survived; these were not taller or more vigorous than the other young plants, but they escaped completely, with not even the tips of their leaves browned. It was impossible to behold these three plants, with their blackened, withered, and dead brethren all around, and not see at a glance that they differed widely in constitutional power of resisting frost.

This work is not the proper place to show that wild plants of the same species, naturally growing at different altitudes or under different latitudes, become to a certain extent acclimatised, as is proved by the different behaviour of their seedlings when raised in another country. In my 'Origin of Species' I have alluded to some cases, and

I could add many others. One instance must suffice: Mr. Grigor, of Forres,[70] states that seedlings of the Scotch fir (*Pinus sylvestris*), raised from seed from the Continent and from the forests of Scotland, differ much. “The difference is perceptible in one-year-old, and more so in two-year-old seedlings; but the effects of the winter on the second year’s growth almost uniformly make those from the Continent quite brown, and so damaged, that by the month of March they are quite unsaleable, while the plants from the native Scotch pine, under the same treatment, and standing alongside, although considerably shorter, are rather stouter and quite green, so that the beds of the one can be known from the other when seen from the distance of a mile.” Closely similar facts have been observed with seedling larches.

Hardy varieties would alone be valued or noticed in Europe; whilst tender varieties, requiring more warmth, would generally be neglected; but such occasionally arise. Thus Loudon[71] describes a Cornish variety of the elm which is almost an evergreen, and of which the shoots are often killed by the autumnal frosts, so that its timber is of little value. Horticulturists know that some varieties are much more tender than others: thus all the varieties of the broccoli are more tender than cabbages; but there is much difference in this respect in the sub-varieties of the broccoli; the pink and purple kinds are a little hardier than the white Cape broccoli, “but they are not to be depended on after the thermometer falls below 24° Fahr.;” the Walcheren broccoli is less tender than the Cape, and there are several varieties which will stand much severer cold than the Walcheren.[72] Cauliflowers seed more freely in India than cabbages.[73] To give one instance with flowers: eleven plants raised from a hollyhock, called the *Queen of the Whites,*[74] were found to be much more tender than various other seedlings. It may be presumed that all tender varieties would succeed better under a climate warmer than ours. With fruit-trees, it is well known that certain varieties, for instance of the peach, stand forcing in a hot-house better than others; and this shows either pliability of organisation or some constitutional difference. The same individual cherry-tree, when forced, has been observed during successive years gradually to change its period of vegetation.[75] Few pelargoniums can resist the heat of a stove, but *Alba Multiflora* will, as a most skilful gardener asserts, “stand pine-apple top and bottom heat the whole winter; without looking any more drawn than if it had stood in a common greenhouse; and *Blanche Fleur* seems as if it had been made on purpose for growing in winter, like many bulbs, and to rest all summer.”[76] There can hardly be a doubt that the *Alba Multiflora* pelargonium must have a widely different constitution from that of most other varieties of this plant; it would probably withstand even an equatorial climate.

We have seen that according to Labat the vine and wheat require acclimatisation in order to succeed in the West Indies. Similar facts have been observed at Madras: “two parcels of mignonette-seed, one direct from Europe, the other saved at Bangalore (of which the mean temperature is much below that of Madras), were sown at the same time: they both vegetated equally favourably, but the former all died off a few days after they appeared above ground; the latter still survive, and are vigorous, healthy plants.”

"So again, turnip and carrot seed saved at Hyderabad are found to answer better at Madras than seed from Europe or from the Cape of Good Hope."[77] Mr. J. Scott of the Calcutta Botanic Gardens, informs me that seeds of the sweet-pea (*Lathyrus odoratus*) imported from England produce plants, with thick, rigid stems and small leaves, which rarely blossom and never yield seed; plants raised from French seed blossom sparingly, but all the flowers are sterile; on the other hand, plants raised from sweet-peas grown near Darjeeling in Upper India, but originally derived from England, can be successfully cultivated on the plains of India; for they flower and seed profusely, and their stems are lax and scandent. In some of the foregoing cases, as Dr. Hooker has remarked to me, the greater success may perhaps be attributed to the seeds having been more fully ripened under a more favourable climate; but this view can hardly be extended to so many cases, including plants, which, from being cultivated under a climate hotter than their native one, become fitted for a still hotter climate. We may therefore safely conclude that plants can to a certain extent become accustomed to a climate either hotter or colder than their own; although the latter cases have been more frequently observed.

We will now consider the means by which acclimatisation may be effected, namely, through the appearance of varieties having a different constitution, and through the effects of habit. In regard to new varieties, there is no evidence that a change in the constitution of the offspring necessarily stands in any direct relation with the nature of the climate inhabited by the parents. On the contrary, it is certain that hardy and tender varieties of the same species appear in the same country. New varieties thus spontaneously arising become fitted to slightly different climates in two different ways; firstly, they may have the power, either as seedlings or when full-grown, of resisting intense cold, as with the Moscow pear, or of resisting intense heat, as with some kinds of Pelargonium, or the flowers may withstand severe frost, as with the Forelle pear. Secondly, plants may become adapted to climates widely different from their own, from flowering and fruiting either earlier or later in the season. In both these cases the power of acclimatisation by man consists simply in the selection and preservation of new varieties. But without any direct intention on his part of securing a hardier variety, acclimatisation may be unconsciously effected by merely raising tender plants from seed, and by occasionally attempting their cultivation further and further northwards, as in the case of maize, the orange and the peach.

How much influence ought to be attributed to inherited habit or custom in the acclimatisation of animals and plants is a much more difficult question. In many cases natural selection can hardly have failed to have come into play and complicated the result. It is notorious that mountain sheep resist severe weather and storms of snow which would destroy lowland breeds; but then mountain sheep have been thus exposed from time immemorial, and all delicate individuals will have been destroyed, and the hardiest preserved. So with the Arrindy silk-moths of China and India; who can tell how far natural selection may have taken a share in the formation of the two races, which are now fitted for such widely different climates? It seems at first probable that the many fruit-trees which are so well fitted for the hot summers and cold winters of North America, in contrast with their poor success under our climate, have become adapted through habit; but when we reflect on the multitude of seedlings annually raised in that country, and that none would succeed unless born with a fitting constitution, it is possible that mere habit may have done nothing towards their acclimatisation. On the other hand, when we hear that Merino sheep, bred during no great number of generations at the Cape of Good Hope—that some European plants raised during only a few generations in the cooler parts of India, withstand the hotter parts of that country much better than the sheep or seeds imported directly from England, we must attribute some influence to habit. We are led to the same conclusion when we hear from Naudin[78] that the races of melons, squashes, and gourds, which have long been cultivated in Northern Europe, are comparatively more precocious, and need much less heat for maturing their fruit, than the varieties of the same species recently brought from tropical regions. In the reciprocal conversion of summer and winter wheat, barley, and vetches into each other, habit produces a marked effect in the course of a very few generations. The same thing apparently occurs with the varieties of maize, which, when carried from the Southern States of America, or into Germany, soon became accustomed to their new homes. With vine-plants taken to the West Indies from Madeira, which are said to succeed better than plants brought directly from France, we have some degree of acclimatisation in the individual, independently of the production of new varieties by seed.

The common experience of agriculturists is of some value, and they often advise persons to be cautious in trying the productions of one country in another. The ancient agricultural writers of China recommend the preservation and cultivation of the varieties peculiar to each country. During the classical period, Columella wrote, "Vernaculum pecus peregrino longe præstantius est."[79]

I am aware that the attempt to acclimatise either animals or plants has been called a vain chimera. No doubt the attempt in most cases deserves to be thus called, if made independently of the production of new varieties endowed with a different constitution. With plants propagated by buds, habit rarely produces any effect; it apparently acts only through successive seminal generations. The laurel, bay, laurestinus, etc., and the Jerusalem artichoke, which are propagated by cuttings or tubers, are probably now as tender in England as when first introduced; and this appears to be the case with the potato, which until recently was seldom multiplied by seed. With plants propagated by seed, and with animals, there will be little or no acclimatisation unless the hardier individuals are either intentionally or unconsciously preserved. The kidney-bean has often been advanced as an instance of a plant which has not become hardier since its first introduction into Britain. We hear, however, on excellent authority[80] that some very fine seed, imported from abroad, produced plants "which blossomed most profusely, but were nearly all but abortive, whilst plants grown alongside from English seed podded abundantly;" and this apparently shows some degree of acclimatisation in our English plants. We have also seen that seedlings of the kidney-bean occasionally appear with a marked power of resisting frost; but no one, as far as I can hear, has ever separated such hardy seedlings, so as to prevent accidental crossing, and then gathered their seed, and repeated the process year after year. It may, however, be objected with truth that natural selection ought to have had a decided effect on the hardiness of our kidney-beans; for the tenderest individuals must have been killed during every severe spring, and the hardier preserved. But it should be borne in mind that the result of increased hardiness would simply be that gardeners, who are always anxious for as early a crop as possible, would sow their seed a few days earlier than formerly. Now, as the period of sowing depends much on the soil and elevation of each district, and varies with the season; and as new varieties have often been imported from abroad, can we feel sure that our kidney-beans are not somewhat hardier? I have not been able, by searching old horticultural works, to answer this question satisfactorily.

On the whole the facts now given show that, though habit does something towards acclimatisation, yet that the appearance of constitutionally different individuals is a far more effective agent. As no single instance has been recorded either with animals or plants of hardier individuals having been long and steadily selected, though such selection is admitted to be indispensable for the improvement of any other character, it is not surprising that man has done little in the acclimatisation of domesticated animals and cultivated plants. We need not, however, doubt that under nature new races and new species would become adapted to widely different climates, by variation, aided by habit, and regulated by natural selection.

Arrests of Development: Rudimentary and Aborted Organs.

Modifications of structure from arrested development, so great or so serious as to deserve to be called monstrosities, are not infrequent with domesticated animals, but, as they differ much from any normal structure, they require only a passing notice. Thus the whole head may be represented by a soft nipple-like projection, and the limbs by mere papillae. These rudiments of limbs are sometimes inherited, as has been observed in a dog.[81]

Many lesser anomalies appear to be due to arrested development. What the cause of the arrest may be, we seldom know, except in the case of direct injury to the embryo. That the cause does not generally act at an extremely early embryonic period we may infer from the affected organ seldom being wholly aborted,—a rudiment being generally preserved. The external ears are represented by mere vestiges in a Chinese breed of sheep; and in another breed, the tail is reduced "to a little button, suffocated in a manner, by fat."[82] In tailless dogs and cats a stump is left. In certain breeds of fowls the comb and wattles are reduced to rudiments; in the Cochin-China breed scarcely more than rudiments of spurs exist. With polled Suffolk cattle, "rudiments of horns can often be felt at an early age";[83] and with species in a state of nature, the relatively great development of rudimentary organs at an early period of life is highly characteristic of such organs. With hornless breeds of cattle and sheep, another and singular kind of rudiment has been observed, namely, minute dangling horns attached to the skin alone, and which are often shed and grow again. With hornless goats, according to Desmarest,[84] the bony protuberance which properly supports the horn exists as a mere rudiment.

With cultivated plants it is far from rare to find the petals, stamens, and pistils represented by rudiments, like those observed in natural species. So it is with the whole seed in many fruits; thus, near Astrakhan there is a grape with mere traces of seeds, "so small and lying so near the stalk that they are not perceived in eating the grape."[85] In certain varieties of the gourd, the tendrils, according to Naudin, are represented by rudiments or by various monstrous growths. In the broccoli and cauliflower the greater number of the flowers are incapable of expansion, and include rudimentary organs. In the Feather hyacinth (*Muscari comosum*) in its natural state the upper and central flowers are brightly coloured but rudimentary; under cultivation the tendency to abortion travels downwards and outwards, and all the flowers become rudimentary; but the abortive stamens and pistils are not so small in the lower as in the upper flowers. In the *Viburnum opulus*, on the other hand, the outer flowers naturally have their organs of fructification in a rudimentary state, and the corolla is of large size; under cultivation, the change spreads to the centre, and all the flowers become affected. In the compositae, the so-called doubling of the flowers consists in the greater development of the corolla of the central florets, generally accompanied with some degree of sterility; and it has been observed[86] that the progressive doubling invariably spreads from the circumference to the centre,—that is, from the ray florets, which so often include rudimentary organs, to those of the disc. I may add, as bearing on this subject, that with Asters, seeds taken from the florets of the circumference have been found to yield the greatest number of double flowers.[87] In the above cases we have a natural tendency in certain parts to be rudimentary, and this under culture spreads either to, or from, the axis of the plant. It deserves notice, as showing how the same laws govern the changes which natural species and artificial varieties undergo, that in the species of Carthamus, one of the Compositae, a tendency to the abortion of the pappus may be traced extending from the circumference to the centre of the disc as in the so-called doubling of the flowers in the members of the same family. Thus, according to A. de Jussieu,[88] the abortion is only partial in *Carthamus creticus*, but more extended in *C. lanatus*; for in this species only two or three of the central seeds are furnished with a pappus, the surrounding seeds being either quite naked or furnished with a few hairs; and lastly in *C. tinctorius*, even the central seeds are destitute of pappus, and the abortion is complete.

With animals and plants under domestication, when an organ disappears, leaving only a rudiment, the loss has generally been sudden, as with hornless and tailless breeds; and such cases may be ranked as inherited monstrosities. But in some few cases the loss has been gradual, and has been effected partly by selection, as with the rudimentary combs and wattles of certain fowls. We have also seen that the wings of some domesticated birds have been slightly reduced by disuse, and the great reduction of the wings in certain silk-moths, with mere rudiments left, has probably been aided by disuse.

With species in a state of nature, rudimentary organs are extremely common. Such organs are generally variable, as several naturalists have observed; for, being useless, they are not regulated by natural selection, and they are more or less liable to reversion. The same rule certainly holds good with parts which have become rudimentary under domestication. We do not know through what steps under nature rudimentary organs have passed in being reduced to their present condition; but we so incessantly see in species of the same group the finest gradations between an organ in a rudimentary and perfect state, that we are led to believe that the passage must have been extremely gradual. It may be doubted whether a change of structure so abrupt as the sudden loss of an organ would ever be of service to a species in a state of nature; for the conditions to which all organisms are closely adapted usually change very slowly. Even if an organ did suddenly disappear in some one individual by an arrest of development, intercrossing with the other individuals of the same species would tend to cause its partial reappearance; so that its final reduction could only be effected by some other means. The most probable view is, that a part which is now rudimentary, was formerly, owing to changed habits of life, used less and less, being at the same time reduced in size by disuse, until at last it became quite useless and superfluous. But as most parts or organs are not brought into action during an early period of life, disuse or decreased action will not lead to their reduction until the organism arrives at a somewhat advanced age; and from the principle of inheritance at corresponding ages the reduction will be transmitted to the offspring at the same advanced stage of growth. The part or organ will thus retain its full size in the embryo, as we know to be the case with most rudiments. As soon as a part becomes useless, another principle, that of economy of growth, will come into play, as it would be an advantage to an organism exposed to severe competition to save the development of any useless part; and individuals having the part less developed will have a slight advantage over others. But, as Mr. Mivart has justly remarked, as soon as a part is much reduced, the saving from its further reduction will be utterly insignificant; so that this cannot be effected by natural selection. This manifestly holds good if the part be formed of mere cellular tissue, entailing little expenditure of nutriment. How then can the further reduction of an already somewhat reduced part be effected? That this has occurred repeatedly under Nature is shown by the many gradations which exist between organs in a perfect state and the merest vestiges of them. Mr. Romanes[89] has, I think, thrown much light on this difficult problem. His view, as far as it can be given in a few words, is as follows: all parts are somewhat variable and fluctuate in size round an average point. Now, when a part has already begun from any cause to decrease, it is very improbable that the variations should be as great in the direction of increase as of diminution; for the previous reduction shows that circumstances have not been favourable for its development; whilst there is nothing to check variations in the opposite direction. If this be so, the long continued crossing of many individuals furnished with an organ which fluctuates in a greater degree towards decrease than towards increase, will slowly but steadily lead to its diminution. With respect to the complete and absolute abortion of a part, a distinct principle, which will be discussed in the chapter on pangenesis, probably comes into action.

With animals and plants reared by man there is no severe or recurrent struggle for existence, and the principle of economy will not come into action, so that the reduction of an organ will not thus be aided. So far, indeed, is this from being the case, that in some few instances organs, which are naturally rudimentary in the parent-species, become partially redeveloped in the domesticated descendants. Thus cows, like most other ruminants, properly have four active and two rudimentary mamma; but in our domesticated animals, the latter occasionally become considerably developed and yield milk. The atrophied mammae, which, in male domesticated animals, including man, have in some rare cases grown to full size and secreted milk, perhaps offer an analogous case. The hind feet of dogs naturally include rudiments of a fifth toe, and in certain large breeds these toes, though still rudimentary, become considerably developed and are furnished with claws. In the common Hen, the spurs and comb are rudimentary, but in certain breeds these become, independently of age or disease of the ovaria, well developed. The stallion has canine teeth, but the mare has only traces of the alveoli, which, as I am informed by the eminent veterinarian Mr. G. T. Brown, frequently contain minute irregular nodules of bone. These nodules, however, sometimes become developed into imperfect teeth, protruding through the gums and coated with enamel; and occasionally they grow to a fourth or even a third of the length of the canines in the stallion. With plants I do not know whether the redevelopment of rudimentary organs occurs more frequently under culture than under nature. Perhaps the pear-tree may be a case in point, for when wild it bears thorns, which consist of branches in a rudimentary condition and serve as a protection, but, when the tree is cultivated, they are reconverted into branches.

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[67] For the magnolia, *see* Loudon's 'Gardener's Mag.,' vol. xiii. 1837, p. 21. For camellias and roses, *see* 'Gardener's Chronicle,' 1860, p. 384. For

the yew, ‘Journal of Hort.,’ March 3rd, 1863, p. 174. For sweet potatoes, *see* Col. von Siebold, in ‘Gardener’s Chronicle,’ 1855, p. 822.

[68] The Editor, ‘Gardener’s Chronicle,’ 1861, p. 239.

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[70] ‘Gardener’s Chronicle,’ 1865, p. 699. Mr. G. Maw gives (‘Gardener’s Chronicle,’ 1870, p. 895) a number of striking cases; he brought home from southern Spain and northern Africa several plants, which he cultivated in England alongside specimens from northern districts; and he found a great difference not only in their hardiness during the winter, but in the behaviour of some of them during the summer.

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[79] For China, *see* ‘Mémoire sur les Chinois,’ tom. xi. 1786, p. 60. Columella is quoted by Carlier, in ‘Journal de Physique,’ tom. xxiv. 1784.

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[81] Isid. Geoffroy Saint-Hilaire, ‘Hist. Nat. des Anomalies,’ 1836, tom. ii. pp. 210, 223, 224, 395; ‘Philosoph. Transact.,’ 1775, p. 313.

[82] Pallas, quoted by Youatt on Sheep, p. 25.

[83] Youatt on Cattle, 1834, p. 174.

[84] ‘Encyclop. Méthod.,’ 1820, p. 483: *see* p. 500, on the Indian zebu casting its horns. Similar cases in European cattle were given in the third chapter.

[85] Pallas, ‘Travels,’ Eng. Translat., vol. i. p. 243.

[86] Mr. Beaton, in ‘Journal of Horticulture,’ May 21st, 1861, p. 133.

[87] Lecoq, ‘De la Fécondation,’ 1862, p. 233.

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[89] I suggested in ‘Nature’ (vol. 8 pp. 432, 505) that with organisms subjected to unfavourable conditions all the parts would tend towards reduction, and that under such circumstances any part which was not kept up to its standard size by natural selection would, owing to intercrossing, slowly but steadily decrease. In three subsequent communications to ‘Nature’ (March 12, April 9, and July 2, 1874), Mr. Romanes gives his improved view.

CHAPTER XXV.
LAWS OF VARIATION, *continued.*—CORRELATED VARIABILITY.

EXPLANATION OF TERM CORRELATION—CONNECTED WITH DEVELOPMENT—MODIFICATIONS CORRELATED WITH THE INCREASED OR DECREASED SIZE OF PARTS—CORRELATED VARIATION OF HOMOLOGOUS PARTS—FEATHERED FEET IN BIRDS ASSUMING THE STRUCTURE OF THE WINGS—CORRELATION BETWEEN THE HEAD AND THE EXTREMITIES—BETWEEN THE SKIN AND DERMAL APPENDAGES—BETWEEN THE ORGANS OF SIGHT AND HEARING—CORRELATED MODIFICATIONS IN THE ORGANS OF PLANTS—CORRELATED MONSTROSITIES—CORRELATION BETWEEN THE SKULL AND EARS—SKULL AND CREST OF FEATHERS—SKULL AND HORNS—CORRELATION OF GROWTH COMPLICATED BY THE ACCUMULATED EFFECTS OF NATURAL SELECTION—COLOUR AS CORRELATED WITH CONSTITUTIONAL PECULIARITIES.

All parts of the organisation are to a certain extent connected together; but the connection may be so slight that it hardly exists, as with compound animals or the buds on the same tree. Even in the higher animals various parts are not at all closely related; for one part may be wholly suppressed or rendered monstrous without any other part of the body being affected. But in some cases, when one part varies, certain other parts always, or nearly always, simultaneously vary; they are then subject to the law of correlated variation. The whole body is admirably co-ordinated for the peculiar habits of life of each organic being, and may be said, as the Duke of Argyll insists in his 'Reign of Law' to be correlated for this purpose. Again, in large groups of animals certain structures always co-exist: for instance, a peculiar form of stomach with teeth of peculiar form, and such structures may in one sense be said to be correlated. But these cases have no necessary connection with the law to be discussed in the present chapter; for we do not know that the initial or primary variations of the several parts were in any way related: slight modifications or individual differences may have been preserved, first in one and then in another part, until the final and perfectly co-adapted structure was acquired; but to this subject I shall presently recur. Again, in many groups of animals the males alone are furnished with weapons, or are ornamented with gay colours; and these characters manifestly stand in some sort of correlation with the male reproductive organs, for when the latter are destroyed these characters disappear. But it was shown in the twelfth chapter that the very same peculiarity may become attached at any age to either sex, and afterwards be exclusively transmitted to the same sex at a corresponding age. In these cases we have inheritance limited by both sex and age; but we have no reason for supposing that the original cause of the variation was necessarily connected with the reproductive organs, or with the age of the affected being.

In cases of true correlated variation, we are sometimes able to see the nature of the connection; but in most cases it is hidden from us, and certainly differs in different cases. We can seldom say which of two correlated parts first varies, and induces a change in the other; or whether the two are the effects of some common cause. Correlated variation is an important subject for us; for when one part is modified through continued selection, either by man or under nature, other parts of the organisation will be unavoidably modified. From this correlation it apparently follows that with our domesticated animals and plants, varieties rarely or never differ from one another by a single character alone.

One of the simplest cases of correlation is that a modification which arises during an early stage of growth tends to influence the subsequent development of the same part, as well as of other and intimately connected parts. Isidore Geoffroy Saint-Hilaire states[1] that this may constantly be observed with monstrosities in the animal kingdom; and Moquin-Tandon[2] remarks, that, as with plants the axis cannot become monstrous without in some way affecting the organs subsequently produced from it, so axial anomalies are almost always accompanied by deviations of structure in the appended parts. We shall presently see that with short-muzzled races of the dog certain histological changes in the basal elements of the bones arrest their development and shorten them, and this affects the position of the subsequently developed molar teeth. It is probable that certain modifications in the larvæ of insects would affect the structure of the mature insects. But we must be careful not to extend this view too far, for during the normal course of development, certain species pass through an extraordinary course of change, whilst other and closely allied species arrive at maturity with little change of structure.

Another simple case of correlation is that with the increased or decreased dimensions of the whole body, or of any particular part, certain organs are increased or diminished in number, or are otherwise modified. Thus pigeon fanciers have gone on selecting pouters for length of body, and we have seen that their vertebrae are generally increased not only in size but in number, and their ribs in breadth. Tumblers have been selected for their small bodies, and their ribs and primary wing-feathers are generally lessened in number. Fantails have been selected for their large widely-expanded tails, with numerous tail-feathers, and the caudal vertebrae are increased in size and number. Carriers have been selected for length of beak, and their tongues have become longer, but not in strict accordance with the length of beak. In this latter breed and in others having large feet, the number of the scutellae on the toes is greater than in the breeds with small feet. Many similar cases could be given. In Germany it has been observed that the period of gestation is longer in large than in small breeds of cattle. With our highly-improved breeds of all kinds, the periods of maturity and of reproduction have advanced with respect to the age of the animal; and, in correspondence with this, the teeth are now developed earlier than formerly, so that, to the surprise of agriculturists, the ancient rules for judging of the age of an animal by the state of its teeth are no longer trustworthy.[3]

Correlated Variation of Homologous Parts.—Parts which are homologous tend to vary in the same manner; and this is what might have been expected, for such parts are identical in form and structure during an early period of embryonic development, and are exposed in the egg or womb to similar conditions. The symmetry, in most kinds of animals, of the corresponding or homologous organs on the right and left sides of the body, is the simplest case in point; but this symmetry sometimes fails, as with rabbits having only one ear, or stags with one horn, or with many-horned sheep which sometimes carry an additional horn on one side of their heads. With flowers which have regular corollas, all the petals generally vary in the same manner, as we see in the complicated and symmetrical pattern, on the flowers, for instance, of the Chinese pink; but with irregular flowers, though the petals are of course homologous, this symmetry often fails, as with the varieties of the *Antirrhinum* or snapdragon, or that variety of the kidney-bean (*Phaseolus*) which has a white standard-petal.

In the Vertebrata the front and hind limbs are homologous, and they tend to vary in the same manner, as we see in long and short legged, or in thick and thin legged races of the horse and dog. Isidore Geoffroy[4] has remarked on the tendency of supernumerary digits in man to appear, not only on the right and left sides, but on the upper and lower extremities. Meckel has insisted[5] that, when the muscles of the arm depart in number or arrangement from their proper type, they almost always imitate those of the leg; and so conversely the varying muscles of the leg imitate the normal muscles of the arm.

In several distinct breeds of the pigeon and fowl, the legs and the two outer toes are heavily feathered, so that in the trumpeter pigeon they appear like little wings. In the feather-legged bantam the “boots” or feathers, which grow from the outside of the leg and generally from the two outer toes, have, according to the excellent authority of Mr. Hewitt,[6] been seen to exceed the wing-feathers in length, and in one case were actually nine and a half inches long! As Mr. Blyth has remarked to me, these leg-feathers resemble the primary wing-feathers, and are totally unlike the fine down which naturally grows on the legs of some birds, such as grouse and owls. Hence it may be suspected that excess of food has first given redundancy to the plumage, and then that the law of homologous variation has led to the development of feathers on the legs, in a position corresponding with those on the wing, namely, on the outside of the tarsi and toes. I am strengthened in this belief by the following curious case of correlation, which for a long time seemed to me utterly inexplicable, namely, that in pigeons of any breed, if the legs are feathered, the two outer toes are partially connected by skin. These two outer toes correspond with our third and fourth toes.[7] Now, in the wing of the pigeon or of any other bird, the first and fifth digits are aborted; the second is rudimentary and carries the so-called "bastard-wing;" whilst the third and fourth digits are completely united and enclosed by skin, together forming the extremity of the wing. So that in feather-footed pigeons, not only does the exterior surface support a row of long feathers, like wing-feathers, but the very same digits which in the wing are completely united by skin become partially united by skin in the feet; and thus by the law of the correlated variation of homologous parts we can understand the curious connection of feathered legs and membrane between the two outer toes.

Andrew Knight[8] has remarked that the face or head and the limbs usually vary together in general proportions. Compare, for instance, the limbs of a dray and race horse, or of a greyhound and mastiff. What a monster a greyhound would appear with the head of a mastiff! The modern bulldog, however, has fine limbs, but this is a recently-selected character. From the measurements given in the sixth chapter, we see that in several breeds of the pigeon the length of the beak and the size of the feet are correlated. The view which, as before explained, seems the most probable is, that disuse in all cases tends to diminish the feet, the beak becoming at the same time shorter through correlation; but that in some few breeds in which length of beak has been a selected point, the feet, notwithstanding disuse, have increased in size through correlation. In the following case some kind of correlation is seen to exist between the feet and beak: several specimens have been sent to Mr. Bartlett at different times, as hybrids between ducks and fowls, and I have seen one; these were, as might be expected, ordinary ducks in a semi-monstrous condition, and in all of them the swimming-web between the toes was quite deficient or much reduced, and in all the beak was narrow and ill-shaped.

With the increased length of the beak in pigeons, not only the tongue increases in length, but likewise the orifice of the nostrils. But the increased length of the orifice of the nostrils perhaps stands in closer correlation with the development of the corrugated skin or wattle at the base of the beak, for when there is much wattle round the eyes, the eyelids are greatly increased or even doubled in length.

There is apparently some correlation even in colour between the head and the extremities. Thus with horses a large white star or blaze on the forehead is generally accompanied by white feet.[9] With white rabbits and cattle, dark marks often co-exist on the tips of the ears and on the feet. In black and tan dogs of different breeds, tan-coloured spots over the eyes and tan-coloured feet almost invariably go together. These latter cases of connected colouring may be due either to reversion or to analogous variation,—subjects to which I shall hereafter return,—but this does not necessarily determine the question of their original correlation. Mr. H. W. Jackson informs me that he has observed many hundred white-footed cats, and he finds that all are more or less conspicuously marked with white on the front of the neck or chest.

The lopping forwards and downwards of the immense ears of fancy rabbits seems partly due to the disuse of the muscles, and partly to the weight and length of the ears, which have been increased by selection during many generations. Now, with the increased size and changed direction of the ears not only has the bony auditory meatus become changed in outline, direction, and greatly in size, but the whole skull has been slightly modified. This could be clearly seen in "half-lops"—that is, in rabbits with only one ear lopping forward— for the opposite sides of their skulls were not strictly symmetrical. This seems to me a curious instance of correlation, between hard bones and organs so soft and flexible, as well as so unimportant under a physiological point of view, as the external ears. The result no doubt is largely due to mere mechanical action, that is, to the weight of the ears, on the same principle that the skull of a human infant is easily modified by pressure.

The skin and the appendages of hair, feathers, hoofs, horns, and teeth, are homologous over the whole body. Every one knows that the colour of the skin and that of the hair usually vary together; so that Virgil advises the shepherd to look whether the mouth and tongue of the ram are black, lest the lambs should not be purely white. The colour of the skin and hair, and the odour emitted by the glands of the skin, are said[10] to be connected, even in the same race of men. Generally the hair varies in the same way all over the body in length, fineness, and curliness. The same rule holds good with feathers, as we see with the laced and frizzled breeds both of fowls and pigeons. In the common cock the feathers on the neck and loins are always of a particular shape, called hackles: now in the Polish breed, both sexes are characterised by a tuft of feathers on the head, and through correlation these feathers in the male always assume the form of hackles. The wing and tail-feathers, though arising from parts not homologous, vary in length together; so that long or short winged pigeons generally have long or short tails. The case of the Jacobin-pigeon is more curious, for the wing and tail feathers are remarkably long; and this apparently has arisen in correlation with the elongated and reversed feathers on the back of the neck, which form the hood.

The hoofs and hair are homologous appendages; and a careful observer, namely Azara,[11] states that in Paraguay horses of various colours are often born with their hair curled and twisted like that on the head of a negro. This peculiarity is strongly inherited.

But what is remarkable is that the hoofs of these horses "are absolutely like those of a mule." The hair also of their manes and tails is invariably much shorter than usual, being only from four to twelve inches in length; so that curliness and shortness of the hair are here, as with the negro, apparently correlated.

With respect to the horns of sheep, Youatt[12] remarks that "multiplicity of horns is not found in any breed of much value; it is generally accompanied by great length and coarseness of the fleece." Several tropical breeds of sheep which are clothed with hair instead of wool, have horns almost like those of a goat. Sturm[13] expressly declares that in different races the more the wool is curled the more the horns are spirally twisted. We have seen in the third chapter, where other analogous facts have been given, that the parent of the Mauchamp breed, so famous for its fleece, had peculiarly shaped horns. The inhabitants of Angora assert[14] that "only the white goats which have horns wear the fleece in the long curly locks that are so much admired; those which are not horned having a comparatively close coat." From these cases we may infer that the hair or wool and the horns tend to vary in a correlated manner.[15] Those who have tried hydropathy are aware that the frequent application of cold water stimulates the skin; and whatever stimulates the skin tends to increase the growth of the hair, as is well shown in the abnormal growth of hair near old inflamed surfaces. Now, Professor Low[16] is convinced that with the different races of British cattle thick skin and long hair depend on the humidity of the climate which they inhabit. We can thus see how a humid climate might act on the horns—in the first place directly on the skin and hair, and secondly by correlation on the horns. The presence or absence of horns, moreover, both in the case of sheep and cattle, acts, as will presently be shown, by some sort of correlation on the skull.

With respect to hair and teeth, Mr. Yarrell[17] found many of the teeth deficient in three hairless "Egyptian dogs," and in a hairless terrier. The incisors, canines, and the premolars suffered most, but in one case all the teeth, except the large tubercular molar on each side, were deficient. With man several striking cases have been recorded[18] of inherited baldness with inherited deficiency, either complete or partial, of the teeth. I may give an analogous case, communicated to me by Mr. W. Wedderburn, of a Hindoo family in Scinde, in which ten men, in the course of four generations, were furnished, in both jaws taken together, with only four small and weak incisor teeth and with eight posterior molars. The men thus affected have very little hair on the body, and become bald early in life. They also suffer much during hot weather from excessive dryness of the skin. It is remarkable that no instance has occurred of a daughter being thus affected; and this fact reminds us how much more liable men are in England to become bald than women. Though the daughters in the above family are never affected, they transmit the tendency to their sons; and no case has occurred of a son transmitting it to his sons. The affection thus appears only in alternate generations, or after longer intervals. There is a similar connection between hair and teeth, according to Mr. Sedgwick, in those rare cases in which the hair has been renewed in old age, for this has "usually been accompanied by a renewal of the teeth." I have remarked in a former part of this volume that the great reduction in the size of the tusks in domestic boars probably stands in close relation with their diminished bristles, due to a certain amount of protection; and that the reappearance of the tusks in boars, which have become feral and are fully exposed to the weather, probably depends on the reappearance of the bristles. I may add, though not strictly connected with our present point, that an agriculturist[19] asserts that "pigs with little hair on their bodies are most liable to lose their tails, showing a weakness of the tegumental structure. It may be prevented by crossing with a more hairy breed."

In the previous cases deficient hair, and teeth deficient in number or size, are apparently connected. In the following cases abnormally redundant hair, and teeth either deficient or redundant, are likewise connected. Mr. Crawfurd[20] saw at the Burmese Court a man, thirty years old, with his whole body, except the hands and feet, covered with straight silky hair, which on the shoulders and spine was five inches in length. At birth the ears alone were covered. He did not arrive at puberty, or shed his milk teeth, until twenty years old; and at this period he acquired five teeth in the upper jaw, namely, four incisors and one canine, and four incisor teeth in the lower jaw; all the teeth were small. This man had a daughter who was born with hair within her ears; and the hair soon extended over her body. When Captain Yule[21] visited the Court, he found this girl grown up; and she presented a strange appearance with even her nose densely covered with soft hair. Like her father, she was furnished with incisor teeth alone. The King had with difficulty bribed a man to marry her, and of her two children, one, a boy fourteen months old, had hair growing out of his ears, with a beard and moustache. This strange peculiarity has, therefore, been inherited for three generations, with the molar teeth deficient in the grandfather and mother; whether these teeth would likewise fail in the infant could not then be told.

A parallel case of a man fifty-five years old, and of his son, with their faces covered with hair, has recently occurred in Russia. Dr. Alex. Brandt has sent me an account of this case, together with specimens of the extremely fine hair from the cheeks. The man is deficient in teeth, possessing only four incisors in the lower and two in the upper jaw. His son, about three years old, has no teeth except four lower incisors. The case, as Dr. Brandt remarks in his letter, no doubt is due to an arrest of development in the hair and teeth. We here see how independent of the ordinary conditions of existence such arrests must be, for the lives of a Russian peasant and of a native of Burmah are as different as possible.[22]

Here is another and somewhat different case communicated to me by Mr. Wallace on the authority of Dr. Purland, a dentist: Julia Pastrana, a Spanish dancer, was a remarkably fine woman, but she had a thick masculine beard and a hairy forehead; she was photographed, and her stuffed skin was exhibited as a show; but what concerns us is, that she had in both the upper and lower jaw an irregular double set of teeth, one row being placed within the other, of which Dr. Purland took a cast. From the redundancy of teeth her mouth projected, and her face had a gorilla-like appearance. These cases and those of the hairless dogs forcibly call to mind the fact, that the two orders of mammals—namely, the Edentata and Cetacea—which are the most abnormal in their dermal covering, are likewise the most abnormal either by deficiency or redundancy of teeth.

The organs of sight and hearing are generally admitted to be homologous with one another and with various dermal appendages; hence these parts are liable to be abnormally affected in conjunction. Mr. White Cowper says "that in all cases of double microphthalmia brought under his notice he has at the same time met with defective development of the dental system." Certain forms of blindness seem to be associated with the colour of the hair; a man with black hair and a woman with light-coloured hair, both of sound constitution, married and had nine children, all of whom were born blind; of these children, five "with dark hair and brown iris were afflicted with amaurosis; the four others, with light-coloured hair and blue iris, had amaurosis and cataract conjoined." Several cases could be given, showing that some relation exists between various affections of the eyes and ears; thus Liebreich states that out of 241 deaf-mutes in Berlin, no less than fourteen suffered from the rare disease called pigmentary retinitis. Mr. White Cowper and Dr. Earle have remarked that inability to distinguish different colours, or colour-blindness, "is often associated with a corresponding inability to distinguish musical sounds."[23]

Here is a more curious case: white cats, if they have blue eyes, are almost always deaf. I formerly thought that the rule was invariable, but I have heard of a few authentic exceptions. The first two notices were published in 1829 and relate to English and Persian cats: of the latter, the Rev. W. T. Bree possessed a female, and he states, "that of the offspring produced at one and the same birth, such as, like the mother, were entirely white (with blue eyes) were, like her, invariably deaf; while those that had the least speck of colour on their fur, as invariably possessed the usual faculty of hearing."[24] The Rev. W. Darwin Fox informs me that he has seen more than a dozen instances of this correlation in English, Persian, and Danish cats; but he adds "that, if one eye, as I have several times observed, be not blue, the cat hears. On the other hand, I have never seen a white cat with eyes of the common colour that was deaf." In France Dr. Sichel[25] has observed during twenty years similar facts; he adds the remarkable case of the iris beginning, at the end of four months, to grow dark-coloured, and then the cat first began to hear.

This case of correlation in cats has struck many persons as marvellous. There is nothing unusual in the relation between blue eyes and white fur; and we have already seen that the organs of sight and hearing are often simultaneously affected. In the present instance the cause probably lies in a slight arrest of development in the nervous system in connection with the sense-organs. Kittens during the first nine days, whilst their eyes are closed, appear to be completely deaf; I have made a great clanging noise with a poker and shovel close to their heads, both when they were asleep and awake, without producing any effect. The trial must not be made by shouting close to their ears, for they are, even when asleep, extremely sensitive to a breath of air. Now, as long as the eyes continue closed, the iris is no doubt blue, for in all the kittens which I have seen this colour remains for some time after the eyelids open. Hence, if we suppose the development of the organs of sight and hearing to be arrested at the stage of the closed eyelids, the eyes would remain permanently blue and the ears would be incapable of perceiving sound; and we should thus understand this curious case. As, however, the colour of the fur is determined long before birth, and as the blueness of the eyes and the whiteness of the fur are obviously connected, we must believe that some primary cause acts at a much earlier period.

The instances of correlated variability hitherto given have been chiefly drawn from the animal kingdom, and we will now turn to plants. Leaves, sepals, petals, stamens, and pistils are all homologous. In double flowers we see that the stamens and pistils vary in the same manner, and assume the form and colour of the petals. In the double columbine (*Aquilegia vulgaris*), the successive whorls of stamens are converted into cornucopias, which are enclosed within one another and resemble the true petals. In hose-in-hose flowers the sepals mock the petals. In some cases the flowers and leaves vary together in tint: in all the varieties of the common pea, which have purple flowers, a purple mark may be seen on the stipules.

M. Faivre states that with the varieties of *Primula sinensis* the colour of the flower is evidently correlated with the colour of the under side of the leaves; and he adds that the varieties with fimbriated flowers almost always have voluminous, balloon-like calyces.[26] With other plants the leaves and fruit or seeds vary together in colour, as in a curious pale-leaved variety of the sycamore, which has recently been described in France,[27] and as in the purple-leaved hazel, in which the leaves, the husk of the nut, and the pellicle round the kernel are all coloured purple.[28] Pomologists can predict to a certain extent, from the size and appearance of the leaves of their seedlings, the probable nature of the fruit; for, as Van Mons remarks[29] variations in the leaves are generally accompanied by some modification in the flower, and consequently in the fruit. In the Serpent melon, which has a narrow tortuous fruit above a yard in length, the stem of the plant, the peduncle of the female flower, and the middle lobe of the leaf, are all elongated in a remarkable manner. On the other hand, several varieties of Cucurbita, which have dwarfed stems, all produce, as Naudin remarks, leaves of the same peculiar shape. Mr. G. Maw informs me that all the varieties of the scarlet Pelargoniums which have contracted or imperfect leaves have contracted flowers: the difference between “Brilliant” and its parent “Tom Thumb” is a good instance of this. It may be suspected that the curious case described by Risso,[30] of a variety of the Orange which produces on the young shoots rounded leaves with winged petioles, and afterwards elongated leaves on long but wingless petioles, is connected with the remarkable change in form and nature which the fruit undergoes during its development.

In the following instance we have the colour and the form of the petals apparently correlated, and both dependent on the nature of the season. An observer, skilled in the subject, writes,[31] “I noticed, during the year 1842, that every Dahlia of which the colour had any tendency to scarlet, was deeply notched—indeed, to so great an extent as to give the petals the appearance of a saw; the indentures were, in some instances, more than a quarter of an inch deep.” Again, Dahlias which have their petals tipped with a different colour from the rest of the flower are very inconstant, and during certain years some, or even all the flowers, become uniformly coloured; and it has been observed with several varieties[32] that when this happens the petals grow much elongated and lose their proper shape. This, however, may be due to reversion, both in colour and form, to the aboriginal species.

In this discussion on correlation, we have hitherto treated of cases in which we can partly understand the bond of connection; but I will now give cases in which we cannot even conjecture, or can only very obscurely see, the nature of the bond. Isidore Geoffroy Saint-Hilaire, in his work on Monstrosities, insists,[33] “que certaines anomalies coexistent rarement entr’elles, d’autres fréquemment, d’autres enfin presque constamment, malgré la différence très-grande de leur nature, et quoiqu’elles puissent paraître *complètement indépendantes* les unes des autres.” We see something analogous in certain diseases: thus in a rare affection of the renal capsules (of which the functions are unknown), the skin becomes bronzed; and in hereditary syphilis, as I hear from Sir J. Paget, both the milk and the second teeth assume a peculiar and characteristic form. Professor Rolleston, also, informs me that the incisor teeth are sometimes furnished with a vascular rim in correlation with intra-pulmonary deposition of tubercles. In other cases of phthisis and of cyanosis the nails and finger-ends become clubbed like acorns. I believe that no explanation has been offered of these and of many other cases of correlated disease.

What can be more curious and less intelligible than the fact previously given, on the authority of Mr. Tegetmeier, that young pigeons of all breeds, which when mature have white, yellow, silver-blue, or dun-coloured plumage, come out of the egg almost naked; whereas pigeons of other colours when first born are clothed with plenty of down? White Pea-fowls, as has been observed both in England and France,[34] and as I have myself seen, are inferior in size to the common coloured kind; and this cannot be accounted for by the belief that albinism is always accompanied by constitutional weakness; for white or albino moles are generally larger than the common kind.

To turn to more important characters: the niata cattle of the Pampas are remarkable from their short foreheads, upturned muzzles, and curved lower jaws. In the skull the nasal and premaxillary bones are much shortened, the maxillaries are excluded from any junction with the nasals, and all the bones are slightly modified, even to the plane of the occiput. From the analogous case of the dog, hereafter to be given, it is probable that the shortening of the nasal and adjoining bones is the proximate cause of the other modifications in the skull, including the upward curvature of the lower jaw, though we cannot follow out the steps by which these changes have been effected.

Polish fowls have a large tuft of feathers on their heads; and their skulls are perforated by numerous holes, so that a pin can be driven into the brain without touching any bone. That this deficiency of bone is in some way connected with the tuft of feathers is clear from tufted ducks and geese likewise having perforated skulls. The case would probably be considered by some authors as one of balancement or compensation. In the chapter on Fowls, I have shown that with Polish fowls the tuft of feathers was probably at first small; by continued selection it became larger, and then rested on a fibrous mass; and finally, as it became still larger, the skull itself became more and more protuberant until it acquired its present extraordinary structure. Through correlation with the protuberance of the skull, the shape and even the relative connection of the premaxillary and nasal bones, the shape of the orifice of the nostrils, the breadth of the frontal bone, the shape of the post-lateral processes of the frontal and squamosal bones, and the direction of the bony cavity of the ear, have all been modified. The internal configuration of the skull and the whole shape of the brain have likewise been altered in a truly marvellous manner.

After this case of the Polish fowl it would be superfluous to do more than refer to the details previously given on the manner in which the changed form of the comb has affected the skull, in various breeds of the fowl, causing by correlation crests, protuberances, and depressions on its surface.

With our cattle and sheep the horns stand in close connection with the size of the skull, and with the shape of the frontal bones; thus Cline[35] found that the skull of a horned ram weighed five times as much as that of a hornless ram of the same age. When cattle become hornless, the frontal bones are "materially diminished in breadth towards the poll;" and the cavities between the bony plates "are not so deep, nor do they extend beyond the frontals."[36] It may be well here to pause and observe how the effects of correlated variability, of the increased use of parts, and of the accumulation of so-called spontaneous variations through natural selection, are in many cases inextricably commingled. We may borrow an illustration from Mr. Herbert Spencer, who remarks that, when the Irish elk acquired its gigantic horns, weighing above one hundred pounds, numerous co-ordinated changes of structure would have been indispensable,—namely, a thickened skull to carry the horns; strengthened cervical vertebrae, with strengthened ligaments; enlarged dorsal vertebrae to support the neck, with powerful fore-legs and feet; all these parts being supplied with proper muscles, blood-vessels, and nerves. How then could these admirably co-ordinated modifications of structure have been acquired? According to the doctrine which I maintain, the horns of the male elk were slowly gained through sexual selection,—that is, by the best-armed males conquering the worse-armed, and leaving a greater number of descendants. But it is not at all necessary that the several parts of the body should have simultaneously varied. Each stag presents individual characteristics, and in the same district those which had slightly heavier horns, or stronger necks, or stronger bodies, or were the most courageous, would secure the greater number of does, and consequently have a greater number of offspring. The offspring would inherit, in a greater or less degree, these same qualities, would occasionally intercross with one another, or with other individuals varying in some favourable manner; and of their offspring, those which were the best endowed in any respect would continue multiplying; and so onwards, always progressing, sometimes in one direction, and sometimes in another, towards the excellently co-ordinated structure of the male elk. To make this clear, let us reflect on the probable steps, as shown in the twentieth chapter, by which our race and dray horses have arrived at their present state of excellence; if we could view the whole series of intermediate forms between one of these animals and an early unimproved progenitor, we should behold a vast number of animals, not equally improved in each generation throughout their entire structure, but sometimes a little more in one point, and sometimes in another, yet on the whole gradually approaching in character to our present race or dray horses, which are so admirably fitted in the one case for fleetness and in the other for draught.

Although natural selection would thus[37] tend to give to the male elk its present structure, yet it is probable that the inherited effects of use, and of the mutual action of part on part, have been equally or more important. As the horns gradually increased in weight the muscles of the neck, with the bones to which they are attached, would increase in size and strength; and these parts would react on the body and legs. Nor must we overlook the fact that certain parts of the skull and the extremities would, judging by analogy, tend from the first to vary in a correlated manner. The increased weight of the horns would also act directly on the skull, in the same manner as when one bone is removed in the leg of a dog, the other bone, which has to carry the whole weight of the body, increases in thickness. But from the fact given with respect to horned and hornless cattle, it is probable that the horns and skull would immediately act on each other through the principle of correlation. Lastly, the growth and subsequent wear and tear of the augmented muscles and bones would require an increased supply of blood, and consequently increased supply of food; and this again would require increased powers of mastication, digestion, respiration, and excretion.

Colour as Correlated with Constitutional Peculiarities.

It is an old belief that with man there is a connection between complexions and constitution; and I find that some of the best authorities believe in this to the present day.[38] Thus Dr. Beddoe by his tables shows[39] that a relation exists between liability to consumption and the colour of the hair, eyes, and skin. It has been affirmed[40] that, in the French army which invaded Russia, soldiers having a dark complexion from the southern parts of Europe, withstood the intense cold better than those with lighter complexions from the north; but no doubt such statements are liable to error.

In the second chapter on Selection I have given several cases proving that with animals and plants differences in colour are correlated with constitutional differences, as shown by greater or less immunity from certain diseases, from the attacks of parasitic plants and animals, from scorching by the sun, and from the action of certain poisons. When all the individuals of any one variety possess an immunity of this nature, we do not know that it stands in any sort of correlation with their colour; but when several similarly coloured varieties of the same species are thus characterised, whilst other coloured varieties are not thus favoured, we must believe in the existence of a correlation of this kind. Thus, in the United States purple-fruited plums of many kinds are far more affected by a certain disease than green or yellow-fruited varieties. On the other hand, yellow-fleshed peaches of various kinds suffer from another disease much more than the white-fleshed varieties. In the Mauritius red sugar-canes are much less affected by a particular disease than the white canes. White onions and verbenas are the most liable to mildew; and in Spain the green-fruited grapes suffered from the vine-disease more than other coloured varieties. Dark-coloured pelargoniums and verbenas are more scorched by the sun than varieties of other colours. Red wheats are believed to be hardier than white; and red-flowered hyacinths were more injured during one particular winter in Holland than other coloured varieties. With animals, white terriers suffer most from the distemper, white chickens from a parasitic worm in their tracheae, white pigs from scorching by the sun, and white cattle from flies; but the caterpillars of the silk-moth which yield white cocoons suffered in France less from the deadly parasitic fungus than those producing yellow silk.

The cases of immunity from the action of certain vegetable poisons, in connexion with colour, are more interesting, and are at present wholly inexplicable. I have already given a remarkable instance, on the authority of Professor Wyman, of all the hogs, excepting those of a black colour, suffering severely in Virginia from eating the root of the *Lachnanthes tinctoria*. According to Spinola and others,[41] buckwheat (*Po1ygonum fagopyrum*), when in flower, is highly injurious to white or white-spotted pigs, if they are exposed to the heat of the sun, but is quite innocuous to black pigs. According to two accounts, the *Hypericum crispum* in Sicily is poisonous to white sheep alone; their heads swell, their wool falls off, and they often die; but this plant, according to Lecce, is poisonous only when it grows in swamps; nor is this improbable, as we know how readily the poisonous principle in plants is influenced by the conditions under which they grow.

Three accounts have been published in Eastern Prussia, of white and white-spotted horses being greatly injured by eating mildewed and honeydewed vetches; every spot of skin bearing white hairs becoming inflamed and gangrenous. The Rev. J. Rodwell informs me that his father turned out about fifteen cart-horses into a field of tares which in parts swarmed with black aphides, and which no doubt were honeydewed, and probably mildewed; the horses, with two exceptions, were chestnuts and bays with white marks on their faces and pasterns, and the white parts alone swelled and became angry scabs. The two bay horses with no white marks entirely escaped all injury. In Guernsey, when horses eat fool's parsley (*Æthusa cynapium*) they are sometimes violently purged; and this plant "has a peculiar effect on the nose and lips, causing deep cracks and ulcers, particularly on horses with white muzzles."[42] With cattle, independently of the action of any poison, cases have been published by Youatt and Erdt of cutaneous diseases with much constitutional disturbance (in one instance after exposure to a hot sun) affecting every single point which bore a white hair, but completely passing over other parts of the body. Similar cases have been observed with horses.[43]

We thus see that not only do those parts of the skin which bear white hair differ in a remarkable manner from those bearing hair of any other colour, but that some great constitutional difference must be correlated with the colour of the hair; for in the above-mentioned cases, vegetable poisons caused fever, swelling of the head, as well as other symptoms, and even death, to all the white, or white-spotted animals.

REFERENCES

[1] 'Hist. des Anomalies,' tom. iii. p. 392. Prof. Huxley applies the same principle in accounting for the remarkable, though normal, differences in the arrangement of the nervous system in the Mollusca, in his paper on the Morphology of the Cephalous Mollusca in 'Phil. Transact.,' 1853, p. 56.

[2] 'Eléments de Tératologie Veg.,' 1841, p. 13.

[3] Prof. J. B. Simonds on the Age of the Ox, Sheep, etc., quoted in 'Gardener's Chronicle,' 1854, p. 588.

[4] 'Hist. des Anomalies,' tom. i. p. 674.

[5] Quoted by Isid. Geoffroy, ibid., tom. i. p. 635.

[6] 'The Poultry Book,' by W. B. Tegetmeier, 1866, p. 250.

[7] Naturalists differ with respect to the homologies of the digits of birds; but several uphold the view above advanced. *See* on this subject Dr. E. S. Morse in 'Annals of the Lyceum of Nat. Hist. of New York,' vol. x. 1872, p. 16.

[8] A. Walker on Intermarriage, 1838, p. 160.

[9] 'The Farrier and Naturalist,' vol. i. 1828, p. 456. A gentleman who has attended to this point, tells me that about three-fourths of white-faced horses have white legs.

[10] Godron, 'Sur l'Espèce,' tom. ii. p. 217.

[11] 'Quadrupèdes du Paraguay,' tom. ii. p. 333.

[12] On Sheep, p. 142.

[13] ‘Ueber Racen, Kreuzungen,’ etc., 1825, s. 24.

[14] Quoted from Conolly, in ‘The Indian Field,’ Feb. 1859, vol. ii. p. 266.

[15] In the third chapter I have said that “the hair and horns are so closely related to each other, that they are apt to vary together.” Dr. Wilckens (“Darwin’s Theorie,” ‘Jahrbuch der Deutschen Viehzucht,’ 1866, 1. Heft) translates my words into “lang-und grobhaarige Thiere sollen geneigter sein, lange und viele Hörner zu bekommen” and he then justly disputes this proposition; but what I have really said, in accordance with the authorities just quoted, may, I think, be trusted.

[16] ‘Domesticated Animals of the British Islands,’ pp. 307, 368. Dr. Wilckens argues (‘Landwirth. Wochenblatt,’ Nr. 10, 1869) to the same effect with respect to domestic animals in Germany.

[17] ‘Proceedings Zoolog. Soc.,’ 1833, p. 113.

[18] Sedgwick, ‘Brit. and Foreign Medico-Chirurg. Review,’ April 1863, p. 453.

[19] ‘Gardener’s Chronicle,’ 1849, p. 205.

[20] ‘Embassy to the Court of Ava,’ vol. i. p. 320.

[21] ‘Narrative of a Mission to the Court of Ava in 1855,’ p. 94.

[22] I owe to the kindness of M. Chauman, of St. Petersburg, excellent photographs of this man and his son, both of whom have since been exhibited in Paris and London.

[23] These statements are taken from Mr. Sedgwick in the ‘Medico-Chirurg. Review,’ July, 1861, p. 198; April, 1863, pp. 455 and 458. Liebreich is quoted by Professor Devay, in his ‘Mariages Consanguins,’ 1862, p. 116.

[24] Loudon’s ‘Mag. of Nat. Hist.,’ vol. i. 1829, pp. 66, 178. *See also* Dr. P. Lucas, ‘L’Héréd. Nat.,’ tom. i. p. 428, on the inheritance of deafness in cats. Mr. Lawson Tait states (‘Nature,’ 1873, p. 323) that only male cats are thus affected; but this must be a hasty generalisation. The first case recorded in England by Mr. Bree related to a female, and Mr. Fox informs me that he has bred kittens from a white female with blue eyes, which was completely deaf; he has also observed other females in the same condition.

[25] ‘Annales des Sc. Nat.’ Zoolog., 3rd series, 1847, tom. viii. p. 239.

[26] ‘Revue des Cours Scientifiques,’ June 5th, 1869, p. 430.

[27] ‘Gardener’s Chronicle,’ 1864, p. 1202.

[28] Verlot gives several other instances, ‘Des Variétés,’ 1865, p. 72.

[29] ‘Arbres Fruitiers,’ 1836, tom. ii. pp. 204, 226.

[30] ‘Annales du Muséum,’ tom. xx. p. 188.

[31] ‘Gardener’s Chronicle,’ 1843, p. 877.

[32] Ibid., 1845, p. 102.

[33] ‘Hist. des Anomalies,’ tom. iii. p. 402. *See also* M. Camille Dareste, ‘Recherches sur les Conditions,’ etc., 1863, pp. 16, 48.

[34] Rev. E. S. Dixon, ‘Ornamental Poultry,’ 1848, p. 111; Isidore Geoffroy, ‘Hist. Anomalies,’ tom. i. p. 211.

[35] ‘On the Breeding of Domestic Animals,’ 1829, p. 6.

[36] Youatt on Cattle, 1834, p. 283.

[37] Mr. Herbert Spencer (‘Principles of Biology,’ 1864, vol. i. pp. 452, 468) takes a different view; and in one place remarks: “We have seen reason to think that, as fast as essential faculties multiply, and as fast as the number of organs that co-operate in any given function increases, indirect equilibration through natural selection becomes less and less capable of producing specific adaptations; and remains fully capable only of maintaining the general fitness of constitution to conditions.” This view that natural selection can do little in modifying the higher animals surprises me, seeing that man’s selection has undoubtedly effected much with our domesticated quadrupeds and birds.

[38] Dr. Prosper Lucas apparently disbelieves in any such connection; ‘L’Héréd. Nat.,’ tom. ii. pp. 88-94.

[39] ‘British Medical Journal,’ 1862, p. 433.

[40] Boudin, ‘Géograph. Médicale,’ tom. i. p. 406.

[41] This fact and the following cases, when not stated to the contrary, are taken from a very curious paper by Prof. Heusinger, in ‘Wochenschrift fur Heilkunde,’ May, 1846, s. 277. Settegast (‘Die Thierzucht,’ 1868, p. 39) says that white or white-spotted sheep suffer like pigs, or even die from eating buckwheat; whilst black or dark-woolled individuals are not in the least affected.

[42] Mr. Mogford, in the ‘Veterinarian,’ quoted in ‘The Field,’ Jan. 22nd, 1861, p. 545.

[43] ‘Edinburgh Veterinary Journal,’ Oct. 1860, p. 347.

CHAPTER XXVI.
LAWS OF VARIATION, *continued.*—SUMMARY.

THE FUSION OF HOMOLOGOUS PARTS—THE VARIABILITY OF MULTIPLE AND HOMOLOGOUS PARTS—COMPENSATION OF GROWTH—MECHANICAL PRESSURE—RELATIVE POSITION OF FLOWERS WITH RESPECT TO THE AXIS, AND OF SEEDS IN THE OVARY, AS INDUCING VARIATION—ANALOGOUS OR PARALLEL VARIETIES—SUMMARY OF THE THREE LAST CHAPTERS.

The Fusion of Homologous Parts.—Geoffroy Saint-Hilaire formerly propounded what he called *la loi de l'affinité de soi pour soi,* which has been discussed and illustrated by his son, Isidore, with respect to monsters in the animal kingdom,[1] and by Moquin-Tandon, with respect to monstrous plants. This law seems to imply that homologous parts actually attract one another and then unite. No doubt there are many wonderful cases, in which such parts become intimately fused together. This is perhaps best seen in monsters with two heads, which are united, summit to summit, or face to face, or Janus-like, back to back, or obliquely side to side. In one instance of two heads united almost face to face, but a little obliquely, four ears were developed, and on one side a perfect face, which was manifestly formed by the fusion of two half-faces. Whenever two bodies or two heads are united, each bone, muscle, vessel, and nerve on the line of junction appears as if it had sought out its fellow, and had become completely fused with it. Lereboullet,[2] who carefully studied the development of double monsters in fishes, observed in fifteen instances the steps by which two heads gradually became united into one. In all such cases it is now thought by the greater number of capable judges that the homologous parts do not attract each other, but that in the words of Mr. Lowne:[3] "As union takes place before the differentiation of distinct organs occurs, these are formed in continuity with each other." He adds that organs already differentiated probably in no case become united to homologous ones. M. Dareste does not speak[4] quite decisively against the law of *soi pour soi,* but concludes by saying, "On se rend parfaitement compte de la formation des monstres, si l'on admet que les embryons qui se soudent appartiennent à un même œuf; qu'ils s'unissent en même temps qu'ils se forment, et que la soudure ne se produit que pendant la première période de la vie embryonnaire, celle ou les organes ne sont encore constitués que par des blastèmes homogènes."

By whatever means the abnormal fusion of homologous parts is effected, such cases throw light on the frequent presence of organs which are double during an embryonic period (and throughout life in other and lower members of the same class) but which afterwards unite by a normal process into a single medial organ. In the vegetable kingdom Moquin-Tandon[5] gives a long list of cases, showing how frequently homologous parts, such as leaves, petals, stamens, and pistils, flowers, and aggregates of homologous parts, such as buds, as well as fruit, become blended, both normally and abnormally, with perfect symmetry into one another.

The Variability of Multiple and Homologous parts.—Isidore Geoffroy[6] insists that, when any part or organ is repeated many times in the same animal, it is particularly liable to vary both in number and structure. With respect to number, the proposition may, I think, be considered as fully established; but the evidence is chiefly derived from organic beings living under their natural conditions, with which we are not here concerned. Whenever such parts as the vertebrae or teeth, the rays in the fins of fishes, or the feathers in the tails of birds, or petals, stamens, pistils, or seeds, are very numerous, the number is generally variable. With respect to the structure of multiple parts, the evidence of variability is not so decisive; but the fact, as far as it may be trusted, probably depends on multiple parts being of less physiological importance than single parts; consequently their structure has been less rigorously guarded by natural selection.

Compensation of Growth, or Balancement.—This law, as applied to natural species, was propounded by Goethe and Geoffroy Saint-Hilaire at nearly the same time. It implies that, when much organised matter is used in building up some one part, other parts are starved and become reduced. Several authors, especially botanists, believe in this law; others reject it. As far as I can judge, it occasionally holds good; but its importance has probably been exaggerated. It is scarcely possible to distinguish between the supposed effects of such compensation, and the effects of long-continued selection which may lead to the augmentation of one part, and simultaneously to the diminution of another. Anyhow, there can be no doubt that an organ may be greatly increased without any corresponding diminution of an adjoining part. To recur to our former illustration of the Irish elk, it may be asked what part has suffered in consequence of the immense development of the horns?

It has already been observed that the struggle for existence does not bear hard on our domesticated productions, and consequently the principle of economy of growth will seldom come into play, so that we ought not to expect to find with them frequent evidence of compensation. We have, however, some such cases. Moquin-Tandon describes a monstrous bean,[7] in which the stipules were enormously developed, and the leaflets apparently in consequence completely aborted; this case is interesting, as it represents the natural condition of *Lathyrus aphaca,* with its stipules of great size, and its leaves reduced to mere threads, which act as tendrils. De Candolle[8] has remarked that the varieties of *Raphanus sativus* which have small roots yield numerous seed containing much oil, whilst those with large roots are not productive in oil; and so it is with *Brassica asperifolia.* The varieties of *Cucurbita pepo* which bear large fruit yield a small crop, according to Naudin; whilst those producing small fruit yield a vast number. Lastly, I have endeavoured to show in the eighteenth chapter that with many cultivated plants unnatural treatment checks the full and proper action of the reproductive organs, and they are thus rendered more or less sterile; consequently, in the way of compensation, the fruit becomes greatly enlarged, and, in double flowers, the petals are greatly increased in number.

With animals, it has been found difficult to produce cows which yield much milk, and are afterwards capable of fattening well. With fowls which have large top-knots and beards the comb and wattles are generally much reduced in size; though there are exceptions to this rule. Perhaps the entire absence of the oil-gland in fantail pigeons may be connected with the great development of their tails.

Mechanical Pressure as a Cause of Modifications.—In some few cases there is reason to believe that mere mechanical pressure has affected certain structures. Vrolik and Weber[9] maintain that the shape of the human head is influenced by the shape of the mother's pelvis. The kidneys in different birds differ much in form, and St. Ange[10] believes that this is determined by the form of the pelvis, which again, no doubt, stands in close relation with their power of locomotion. In snakes, the viscera are curiously displaced, in comparison with their position in other vertebrates; and this has been attributed by some authors to the elongation of their bodies; but here, as in so many previous cases, it is impossible to disentangle a direct result of this kind from that consequent on natural selection. Godron has argued[11] that the abortion of the spur on the inner side of the flowers in Corydalis, is caused by the buds at a very early period of growth whilst underground being closely pressed against one another and against the stem. Some botanists believe that the singular difference in the shape both of the seed and corolla, in the interior and exterior florets in certain Compositous and Umbelliferous plants, is due to the pressure to which the inner florets are subjected; but this conclusion is doubtful.

The facts just given do not relate to domesticated productions, and therefore do not strictly concern us. But here is a more appropriate case: H. Müller[12] has shown that in shortfaced races of the dog some of the molar teeth are placed in a slightly different position to that which they occupy in other dogs, especially in those having elongated muzzles; and as he remarks, any inherited change in the arrangement of the teeth deserves notice, considering their classificatory importance. This difference in position is due to the shortening of certain facial bones and the consequent want of space; and the shortening results from a peculiar and abnormal state of the embryonal cartilages of the bones.

Relative Position of Flowers with respect to the Axis, and of Seeds in the Ovary, as inducing Variation.

In the thirteenth chapter various peloric flowers were described, and their production was shown to be due either to arrested development, or to reversion to a primordial condition. Moquin-Tandon has remarked that the flowers which stand on the summit of the main stem or of a lateral branch are more liable to become peloric than those on the sides;[13] and he adduces, amongst other instances, that of *Teucrium campanulatum*. In another Labiate plant grown by me, viz., the *Galeobdolon luteum*, the peloric flowers were always produced on the summit of the stem, where flowers are not usually borne. In Pelargonium, a *single* flower in the truss is frequently peloric, and when this occurs I have during several years invariably observed it to be the central flower. This is of such frequent occurrence that one observer[14] gives the names of ten varieties flowering at the same time, in every one of which the central flower was peloric. Occasionally more than one flower in the truss is peloric, and then of course the additional ones must be lateral. These flowers are interesting as showing how the whole structure is correlated. In the common Pelargonium the upper sepal is produced into a nectary which coheres with the flower-peduncle; the two upper petals differ a little in shape from the three lower ones, and are marked with dark shades of colour; the stamens are graduated in length and upturned. In the peloric flowers, the nectary aborts; all the petals become alike both in shape and colour; the stamens are generally reduced in number and become straight, so that the whole flower resembles that of the allied genus Erodium. The correlation between these changes is well shown when one of the two upper petals alone loses its dark mark, for in this case the nectary does not entirely abort, but is usually much reduced in length.[15]

Morren has described[16] a marvellous flask-shaped flower of the Calceolaria, nearly four inches in length, which was almost completely peloric; it grew on the summit of the plant, with a normal flower on each side; Prof. Westwood also has described[17] three similar peloric flowers, which all occupied a central position on the flower-branches. In the Orchideous genus, Phalænopsis, the terminal flower has been seen to become peloric.

In a Laburnum-tree I observed that about a fourth part of the racemes produced terminal flowers which had lost their papilionaceous structure. These were produced after almost all the other flowers on the same racemes had withered. The most perfectly pelorised examples had six petals, each marked with black striae like those on the standard-petal. The keel seemed to resist the change more than the other petals. Dutrochet has described[18] an exactly similar case in France, and I believe these are the only two instances of pelorism in the laburnum which have been recorded. Dutrochet remarks that the racemes on this tree do not properly produce a terminal flower, so that (as in the case of the Galeobdolon) their position as well as structure are both anomalies, which no doubt are in some manner related. Dr. Masters has briefly described another leguminous plant,[19] namely, a species of clover, in which the uppermost and central flowers were regular or had lost their papilionaceous structure. In some of these plants the flower-heads were also proliferous.

Lastly, Linaria produces two kinds of peloric flowers, one having simple petals, and the other having them all spurred. The two forms, as Naudin remarks,[20] not rarely occur on the same plant, but in this case the spurred form almost invariably stands on the summit of the spike.

The tendency in the terminal or central flower to become peloric more frequently than the other flowers, probably results from "the bud which stands on the end of a shoot receiving the most sap; it grows out into a stronger shoot than those situated lower down."[21] I have discussed the connection between pelorism and a central position, partly because some few plants are known normally to produce a terminal flower different in structure from the lateral ones; but chiefly on account of the following case, in which we see a tendency to variability or to reversion connected with the same position. A great judge of Auriculas[22] states that when one throws up a side bloom it is pretty sure to keep its character; but that if it grows from the centre or heart of the plant, whatever the colour of the edging ought to be, "it is just as likely to come in any other class as in the one to which it properly belongs." This is so notorious a fact, that some florists regularly pinch off the central trusses of flowers. Whether in the highly improved varieties the departure of the central trusses from their proper type is due to reversion, I do not know. Mr. Dombrain insists that, whatever may be the commonest kind of imperfection in each variety, this is generally exaggerated in the central truss. Thus one variety "sometimes has the fault of producing a little green floret in the centre of the flower," and in central blooms these become excessive in size. In some central blooms, sent to me by Mr. Dombrain, all the organs of the flower were rudimentary in structure, of minute size, and of a green colour, so that by a little further change all would have been converted into small leaves. In this case we clearly see a tendency to prolification—a term which I may explain, for those who have never attended to botany, to mean the production of a branch or flower, or head of flowers, out of another flower. Now Dr. Masters[23] states that the central or uppermost flower on a plant is generally the most liable to prolification. Thus, in the varieties of the Auricula, the loss of their proper character and a tendency to prolification, also a tendency to prolification with pelorism, are all connected together, and are due either to arrested development, or to reversion to a former condition.

The following is a more interesting case; Metzger[24] cultivated in Germany several kinds of maize brought from the hotter parts of America, and he found, as previously described, that in two or three generations the grains became greatly changed in form, size, and colour; and with respect to two races he expressly states that in the first generation, whilst the lower grains on each head retained their proper character, the uppermost grains already began to assume that character which in the third generation all the grains acquired. As we do not know the aboriginal parent of the maize, we cannot tell whether these changes are in any way connected with reversion.

In the two following cases, reversion comes into play and is determined by the position of the seed in the capsule. The Blue Imperial pea is the offspring of the Blue Prussian, and has larger seed and broader pods than its parent. Now Mr. Masters, of Canterbury, a careful observer and a raiser of new varieties of the pea, states[25] that the

Blue Imperial always has a strong tendency to revert to its parent-stock, and the reversion "occurs in this manner: the last (or uppermost) pea in the pod is frequently much smaller than the rest; and if these small peas are carefully collected and sown separately, very many more, in proportion, will revert to their origin, than those taken from the other parts of the pod." Again, M. Chaté[26] says that in raising seedling stocks he succeeds in getting eighty per cent to bear double flowers, by leaving only a few of the secondary branches to seed; but in addition to this, "at the time of extracting the seeds, the upper portion of the pod is separated and placed aside, because it has been ascertained that the plants coming from the seeds situated in this portion of the pod, give eighty per cent of single flowers." Now the production of single-flowering plants from the seed of double-flowering plants is clearly a case of reversion. These latter facts, as well as the connection between a central position and pelorism and prolification, show in an interesting manner how small a difference—namely, a little greater or less freedom in the flow of sap towards one part of the plant—determines important changes of structure.

Analogous or Parallel Variation.—By this term I mean that similar characters occasionally make their appearance in the several varieties or races descended from the same species, and more rarely in the offspring of widely distinct species. We are here concerned, not as hitherto with the causes of variation, but with the results; but this discussion could not have been more conveniently introduced elsewhere. The cases of analogous variation, as far as their origin is concerned, may be grouped, disregarding minor subdivisions, under two main heads; firstly, those due to unknown causes acting on similarly constituted organisms, and which consequently have varied in a similar manner; and secondly, those due to the reappearance of characters which were possessed by a more or less remote progenitor. But these two main divisions can often be separated only conjecturally, and graduate, as we shall presently see, into each other.

Under the first head of analogous variations, not due to reversion, we have the many cases of trees belonging to quite different orders which have produced pendulous and fastigiate varieties. The beech, hazel, and barberry have given rise to purple-leaved varieties; and, as Bernhardi remarks,[27] a multitude of plants, as distinct as possible, have yielded varieties with deeply-cut or laciniated leaves. Varieties descended from three distinct species of Brassica have their stems, or so-called roots, enlarged into globular masses. The nectarine is the offspring of the peach; and the varieties of peaches and nectarines offer a remarkable parallelism in the fruit being white, red, or yellow fleshed—in being clingstones or freestones—in the flowers being large or small—in the leaves being serrated or crenated, furnished with globose or reniform glands, or quite destitute of glands. It should be remarked that each variety of the nectarine has not derived its character from a corresponding variety of the peach. The several varieties also of a closely allied genus, namely the apricot, differ from one another in nearly the same parallel manner. There is no reason to believe that any of these varieties have merely reacquired long-lost characters; and in most of them this certainly is not the case.

Three species of Cucurbita have yielded a multitude of races which correspond so closely in character that, as Naudin insists, they may be arranged in almost strictly parallel series. Several varieties of the melon are interesting from resembling, in important characters, other species, either of the same genus or of allied genera; thus, one variety has fruit so like, both externally and internally, the fruit of a perfectly distinct species, namely, the cucumber, as hardly to be distinguished from it; another has long cylindrical fruit twisting about like a serpent; in another the seeds adhere to portions of the pulp; in another the fruit, when ripe, suddenly cracks and falls into pieces; and all these highly remarkable peculiarities are characteristic of species belonging to allied genera. We can hardly account for the appearance of so many unusual characters by reversion to a single ancient form; but we must believe that all the members of the family have inherited a nearly similar constitution from an early progenitor. Our cereal and many other plants offer similar cases.

With animals we have fewer cases of analogous variation, independently of direct reversion. We see something of the kind in the resemblance between the short-muzzled races of the dog, such as the pug and bull-dog; in feather-footed races of the fowl, pigeon, and canary-bird; in horses of the most different races presenting the same range of colour; in all black-and-tan dogs having tan-coloured eye-spots and feet, but in this latter case reversion may possibly have played a part. Low has remarked[28] that several breeds of cattle are "sheeted,"—that is, have a broad band of white passing round their bodies like a sheet; this character is strongly inherited, and sometimes originates from a cross; it may be the first step in reversion to an early type, for, as was shown in the third chapter, white cattle with dark ears, dark feet and tip of tail, formerly existed, and now exist in feral or semi-feral condition in several quarters of the world.

Under our second main division, namely, of analogous variations due to reversion, the best cases are afforded by pigeons. In all the most distinct breeds, sub-varieties occasionally appear coloured exactly like the parent rock-pigeon, with black wing-bars, white loins, banded tail, etc.; and no one can doubt that these characters are due to reversion. So with minor details; turbits properly have white tails, but occasionally a bird is born with a dark-coloured and banded tail; pouters properly have their primary wing-feathers white, but not rarely a "sword-flighted" bird appears, that is, one with the few first primaries dark-coloured; and in these cases we have characters proper to the rock-pigeon, but new to the breed, evidently appearing from reversion. In some domestic varieties the wing-bars, instead of being simply black, as in the rock-pigeon, are beautifully edged with different zones of colour, and they then present a striking analogy with the wing-bars in certain natural species of the same family, such as *Phaps chalcoptera*; and this may probably be accounted for by all the species of the family being descended from the same remote progenitor and having a tendency to vary in the same manner. Thus, also, we can perhaps understand the fact of some Laugher-pigeons cooing almost like turtle-doves, and for several races having peculiarities in their flight, since certain natural species (viz., *C. torquatrix* and *palumbus*), display singular vagaries in this respect. In other cases a race, instead of imitating a distinct species, resembles some other race; thus, certain runts tremble and slightly elevate their tails, like fantails; and turbits inflate the upper part of their oesophagus, like pouter-pigeons.

It is a common circumstance to find certain coloured marks persistently characterising all the species of a genus, but differing much in tint; and the same thing occurs with the varieties of the pigeon: thus, instead of the general plumage being blue, with the wing-bars black, there are snow-white varieties with red bars, and black varieties with white bars; in other varieties the wing-bars, as we have seen, are elegantly zoned with different tints. The Spot pigeon is characterised by the whole plumage being white, excepting a spot on the forehead and the tail; but these parts may be red, yellow, or black. In the rock-pigeon and in many varieties the tail is blue, with the outer edges of the outer feathers white; but in the sub-variety of the monk-pigeon we have a reversed style of coloration, for the tail is white, except the outer edges of the outer feathers, which are black.[29]

With some species of birds, for instance with gulls, certain coloured parts appear as if almost washed out, and I have observed exactly the same appearance in the terminal dark tail-bar in certain pigeons, and in the whole plumage of certain varieties of the duck. Analogous facts in the vegetable kingdom could be given.

Many sub-varieties of the pigeon have reversed and somewhat lengthened feathers on the back part of their heads, and this is certainly not due to reversion to the parent-species, which shows no trace of such structure: but when we remember that sub-varieties of the fowl, turkey, canary-bird, duck, and goose, all have either topknots or reversed feathers on their heads; and when we remember that scarcely a single large natural group of birds can be named, in which some members have not a tuft of feathers on their heads, we may suspect that reversion to some extremely remote form has come into action.

Several breeds of the fowl have either spangled or pencilled feathers; and these cannot be derived from the parent-species, the *Gallus bankiva*; though of course it is possible that one early progenitor of this species may have been spangled, and another pencilled. But, as many gallinaceous birds are either spangled or pencilled, it is a more probable view that the several domestic breeds of the fowl have acquired this kind of plumage from all the members of the family inheriting a tendency to vary in a like manner. The same principle may account for the ewes in certain breeds of sheep being hornless, like the females of some other hollow-horned ruminants; it may account for certain domestic cats having slightly-tufted ears, like those of the lynx; and for the skulls of domestic rabbits often differing from one another in the same characters by which the skulls of the various species of the genus Lepus differ.

I will only allude to one other case, already discussed. Now that we know that the wild parent of the ass commonly has striped legs, we may feel confident that the occasional appearance of stripes on the legs of the domestic ass is due to reversion; but this will not account for the lower end of the shoulder-stripe being sometimes angularly bent or slightly forked. So, again, when we see dun and other coloured horses with stripes on the spine, shoulders, and legs, we are led, from reasons formerly given, to believe that they reappear through reversion to the wild parent-horse. But when horses have two or three shoulder-stripes, with one of them occasionally forked at the lower end, or when they have stripes on their faces, or are faintly striped as foals over nearly their whole bodies, with the stripes angularly bent one under the other on the forehead, or irregularly branched in other parts, it would be rash to attribute such diversified characters to the reappearance of those proper to the aboriginal wild horse. As three African species of the genus are much striped, and as we have seen that the crossing of the unstriped species often leads to the hybrid offspring being conspicuously striped—bearing also in mind that the act of crossing certainly causes the reappearance of long-lost characters—it is a more probable view that the above-specified stripes are due to reversion, not to the immediate wild parent-horse, but to the striped progenitor of the whole genus.

I have discussed this subject of analogous variation at considerable length, because it is well known that the varieties of one species frequently resemble distinct species—a fact in perfect harmony with the foregoing cases, and explicable on the theory of descent. Secondly, because these facts are important from showing, as remarked in a former chapter, that each trifling variation is governed by law, and is determined in a much higher degree by the nature of the organisation, than by the nature of the conditions to which the varying being has been exposed. Thirdly, because these facts are to a certain extent related to a more general law, namely, that which Mr. B. D. Walsh[30] has called the "Law of *Equable Variability*," or, as he explains it, "if any given character is very variable in one species of a group, it will tend to be variable in allied species; and if any given character is perfectly constant in one species of a group, it will tend to be constant in allied species."

This leads me to recall a discussion in the chapter on Selection, in which it was shown that with domestic races, which are now undergoing rapid improvement, those parts or characters vary the most, which are the most valued. This naturally follows from recently selected characters continually tending to revert to their former less improved standard, and from their being still acted on by the same agencies, whatever these may be, which first caused the characters in question to vary. The same principle is applicable to natural species, for, as stated in my 'Origin of Species' generic characters are less variable than specific characters; and the latter are those which have been modified by variation and natural selection, since the period when all the species belonging to the genus branched off from a common progenitor, whilst generic characters are those which have remained unaltered from a much more remote epoch, and accordingly are now less variable. This statement makes a near approach to Mr. Walsh’s law of Equable Variability. Secondary sexual characters, it may be added, rarely serve to characterise distinct genera, for they usually differ much in the species of the same genus, and they are highly variable in the individuals of the same species; we have also seen in the earlier chapters of this work how variable secondary sexual characters become under domestication.

Summary of the three previous Chapters on the Laws of Variation.

In the twenty-third chapter we saw that changed conditions occasionally, or even often, act in a definite manner on the organisation, so that all, or nearly all, the individuals thus exposed become modified in the same manner. But a far more frequent result of changed conditions, whether acting directly on the organisation or indirectly through the reproductive system, is indefinite and fluctuating variability. In the three last chapters, some of the laws by which such variability is regulated have been discussed.

Increased use adds to the size of muscles, together with the blood-vessels, nerves, ligaments, the crests of bone and the whole bones, to which they are attached. Increased functional activity increases the size of various glands, and strengthens the sense-organs. Increased and intermittent pressure thickens the epidermis. A change in the nature of the food sometimes modifies the coats of the stomach, and augments or decreases the length of the intestines. Continued disuse, on the other hand, weakens and diminishes all parts of the organisation. Animals which during many generations have taken but little exercise, have their lungs reduced in size, and as a consequence the bony fabric of the chest and the whole form of the body become modified. With our anciently domesticated birds, the wings have been little used, and they are slightly reduced; with their decrease, the crest of the sternum, the scapulae, coracoids, and furculum, have all been reduced.

With domesticated animals, the reduction of a part from disuse is never carried so far that a mere rudiment is left; whereas we have reason to believe that this has often occurred under nature; the effects of disuse in this latter case being aided by economy of growth, together with the intercrossing of many varying individuals. The cause of this difference between organisms in a state of nature, and under domestication, probably is that in the latter case there has not been time sufficient for any very great change, and that the principle of economy of growth does not come into action. On the contrary, structures which are rudimentary in the parent-species, sometimes become partially redeveloped in our domesticated productions. Such rudiments as occasionally make their appearance under domestication, seem always to be the result of a sudden arrest of development; nevertheless they are of interest, as showing that rudiments are the relics of organs once perfectly developed.

Corporeal, periodical, and mental habits, though the latter have been almost passed over in this work, become changed under domestication, and the changes are often inherited. Such changed habits in an organic being, especially when living a free life, would often lead to the augmented or diminished use of various organs, and consequently to their modification. From long-continued habit, and more especially from the occasional birth of individuals with a slightly different constitution, domestic animals and cultivated plants become to a certain extent acclimatised or adapted to a climate different from that proper to the parent-species.

Through the principle of correlated variability, taken in its widest sense, when one part varies other parts vary, either simultaneously, or one after the other. Thus, an organ modified during an early embryonic period affects other parts subsequently developed. When an organ, such as the beak, increases or decreases in length, adjoining or correlated parts, as the tongue and the orifice of the nostrils, tend to vary in the same manner. When the whole body increases or decreases in size, various parts become modified; thus, with pigeons the ribs increase or decrease in number and breadth. Homologous parts which are identical during their early development and are exposed to similar conditions, tend to vary in the same or in some connected manner,—as in the case of the right and left sides of the body, and of the front and hind limbs. So it is with the organs of sight and hearing; for instance, white cats with blue eyes are almost always deaf. There is a manifest relation throughout the body between the skin and various dermal appendages, such as hair, feathers, hoofs, horns, and teeth. In Paraguay, horses with curly hair have hoofs like those of a mule; the wool and the horns of sheep often vary together; hairless dogs are deficient in their teeth; men with redundant hair have abnormal teeth, either by deficiency or excess. Birds with long wing-feathers usually have long tail-feathers. When long feathers grow from the outside of the legs and toes of pigeons, the two outer toes are connected by membrane; for the whole leg tends to assume the structure of the wing. There is a manifest relation between a crest of feathers on the head and a marvellous amount of change in the skull of various fowls; and in a lesser degree, between the greatly elongated, lopping ears of rabbits and the structure of their skulls. With plants, the leaves, various parts of the flower, and the fruit, often vary together to a correlated manner.

In some cases we find correlation without being able even to conjecture what is the nature of the connection, as with various monstrosities and diseases. This is likewise the case with the colour of the adult pigeon, in connection with the presence of down on the young bird. Numerous curious instances have been given of peculiarities of constitution, in correlation with colour, as shown by the immunity of individuals of one colour from certain diseases, from the attacks of parasites and from the action of certain vegetable poisons.

Correlation is an important subject; for with species, and in a lesser degree with domestic races, we continually find that certain parts have been greatly modified to serve some useful purpose; but we almost invariably find that other parts have likewise been more or less modified, without our being able to discover any advantage in the change. No doubt great caution is necessary with respect to this latter point, for it is difficult to overrate our ignorance on the use of various parts of the organisation; but from what we have seen, we may believe that many modifications are of no direct service, having arisen in correlation with other and useful changes.

Homologous parts during their early development often become fused together. Multiple and homologous organs are especially liable to vary in number and probably in form. As the supply of organised matter is not unlimited, the principle of compensation sometimes comes into action; so that, when one part is greatly developed, adjoining parts are apt to be reduced; but this principle is probably of much less importance than the more general one of the economy of growth. Through mere mechanical pressure hard parts occasionally affect adjoining parts. With plants the position of the flowers on the axis, and of the seeds in the ovary, sometimes leads, through a more or less free flow of sap, to changes of structure; but such changes are often due to reversion. Modifications, in whatever manner caused, will be to a certain extent regulated by that co-ordinating power, or so-called *nisus formativus*, which is in fact a remnant of that simple form of reproduction, displayed by many lowly organised beings in their power of fissiparous generation and budding. Finally, the effects of the laws which directly or indirectly govern variability, may be largely regulated by man's selection, and will so far be determined by natural selection that changes advantageous to any race will be favoured, and disadvantageous changes will be checked.

Domestic races descended from the same species, or from two or more allied species, are liable to revert to characters derived from their common progenitor; and, as they inherit a somewhat similar constitution, they are liable to vary in the same manner. From these two causes analogous varieties often arise. When we reflect on the several foregoing laws, imperfectly as we understand them, and when we bear in mind how much remains to be discovered, we need not be surprised at the intricate and to us unintelligible manner in which our domestic productions have varied, and still go on varying.

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[8] ‘Mémoires du Muséum,’ etc., tom. viii. p. 178.

[9] Prichard, ‘Phys. Hist. of Mankind,’ 1851, vol. i. p. 324.

[10] ‘Annales des Sc. Nat.,’ 1st series, tom. xix. p. 327.

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[12] “Ueber fötale Rachites,” ‘Würzburger Medicin. Zeitschrift,’ 1860, B. i. s. 265.

[13] ‘Tératologie Vég.,’ p. 192.

[14] ‘Journal of Horticulture,’ July 2nd, 1861, p. 253.

[15] It would be worth trial to fertilise with the same pollen the central and lateral flowers of the pelargonium, or of other highly cultivated plants, protecting them of course from insects: then to sow the seed separately, and observe whether the one or the other lot of seedlings varied the most.

[16] Quoted in ‘Journal of Horticulture,’ Feb. 24th, 1863, p. 152.

[17] ‘Gardener’s Chronicle,’ 1866, p. 612. For the Phalænopsis, *see* ibid., 1867, p. 211.

[18] ‘Mémoires . . . des Végétaux,’ 1837, tom. ii. p. 170.

[19] ‘Journal of Horticulture,’ July 23rd, 1861, p. 311.

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[21] Hugo von Mohl, ‘The Vegetable Cell,’ Eng. translat., 1852, p. 76.

[22] The Rev. H. H. Dombrain, in ‘Journal of Horticulture,’ 1861, June 4th, p. 174; and June 25th, p. 234; 1862, April 29th, p. 83.

[23] ‘Transact. Linn. Soc.,’ vol. xxiii. 1861, p. 360.

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[25] ‘Gardener’s Chronicle,’ 1850, p. 198.

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[27] ‘Ueber den Begriff der Pflanzenart,’ 1834, s. 14.

[28] ‘Domesticated Animals,’ 1845, p. 351.

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CHAPTER XXVII. PROVISIONAL HYPOTHESIS OF PANGENESIS.

PRELIMINARY REMARKS—FIRST PART: THE FACTS TO BE CONNECTED UNDER A SINGLE POINT OF VIEW, NAMELY, THE VARIOUS KINDS OF REPRODUCTION—RE-GROWTH OF AMPUTATED PARTS—GRAFT-HYBRIDS—THE DIRECT ACTION OF THE MALE ELEMENT ON THE FEMALE—DEVELOPMENT—THE FUNCTIONAL INDEPENDENCE OF THE UNITS OF THE BODY—VARIABILITY—INHERITANCE—REVERSION—SECOND PART: STATEMENT OF THE HYPOTHESIS—HOW FAR THE NECESSARY ASSUMPTIONS ARE IMPROBABLE—EXPLANATION BY AID OF THE HYPOTHESIS OF THE SEVERAL CLASSES OF FACTS SPECIFIED IN THE FIRST PART—CONCLUSION.

In the previous chapters large classes of facts, such as those bearing on bud-variation, the various forms of inheritance, the causes and laws of variation, have been discussed; and it is obvious that these subjects, as well as the several modes of reproduction, stand in some sort of relation to one another. I have been led, or rather forced, to form a view which to a certain extent connects these facts by a tangible method. Every one would wish to explain to himself, even in an imperfect manner, how it is possible for a character possessed by some remote ancestor suddenly to reappear in the offspring; how the effects of increased or decreased use of a limb can be transmitted to the child; how the male sexual element can act not solely on the ovules, but occasionally on the mother-form; how a hybrid can be produced by the union of the cellular tissue of two plants independently of the organs of generation; how a limb can be reproduced on the exact line of amputation, with neither too much nor too little added; how the same organism may be produced by such widely different processes, as budding and true seminal generation; and, lastly, how of two allied forms, one passes in the course of its development through the most complex metamorphoses, and the other does not do so, though when mature both are alike in every detail of structure. I am aware that my view is merely a provisional hypothesis or speculation; but until a better one be advanced, it will serve to bring together a multitude of facts which are at present left disconnected by any efficient cause. As Whewell, the historian of the inductive sciences, remarks:—“Hypotheses may often be of service to science, when they involve a certain portion of incompleteness, and even of error.” Under this point of view I venture to advance the hypothesis of Pangenesis, which implies that every separate part of the whole organisation reproduces itself. So that ovules, spermatozoa, and pollen-grains,—the fertilised egg or seed, as well as buds,—include and consist of a multitude of germs thrown off from each separate part or unit.[1]

In the First Part I will enumerate as briefly as I can the groups of facts which seem to demand connection; but certain subjects, not hitherto discussed, must be treated at disproportionate length. In the Second Part the hypothesis will be given; and after considering how far the necessary assumptions are in themselves improbable, we shall see whether it serves to bring under a single point of view the various facts.

PART I.

Reproduction may be divided into two main classes, namely, sexual and asexual. The latter is effected in many ways—by the formation of buds of various kinds, and by fissiparous generation, that is by spontaneous or artificial division. It is notorious that some of the lower animals, when cut into many pieces, reproduce so many perfect individuals: Lyonnet cut a Nais or freshwater worm into nearly forty pieces, and these all reproduced perfect animals.[2] It is probable that segmentation could be carried much further in some of the protozoa; and with some of the lowest plants each cell will reproduce the parent-form. Johannes Müller thought that there was an important distinction between gemmation and fission; for in the latter case the divided portion, however small, is more fully developed than a bud, which also is a younger formation; but most physiologists are now convinced that the two processes are essentially alike.[3] Prof. Huxley remarks, “fission is little more than a peculiar mode of budding,” and Prof. H. J. Clark shows in detail that there is sometimes “a compromise between self-division and budding.” When a limb is amputated, or when the whole body is bisected, the cut extremities are said to bud forth;[4] and as the papilla, which is first formed, consists of undeveloped cellular tissue like that forming an ordinary bud, the expression is apparently correct. We see the connection of the two processes in another way; for Trembley observed with the hydra, that the reproduction of the head after amputation was checked as soon as the animal put forth reproductive gemmæ.[5]

Between the production, by fissiparous generation, of two or more complete individuals, and the repair of even a very slight injury, there is so perfect a gradation, that it is impossible to doubt that the two processes are connected. As at each stage of growth an amputated part is replaced by one in the same state of development, we must also follow Sir J. Paget in admitting, “that the powers of development from the embryo, are identical with those exercised for the restoration from injuries: in other words, that the powers are the same by which perfection is first achieved, and by which, when lost, it is recovered.”[6] Finally, we may conclude that the several forms of budding, fissiparous generation, the repair of injuries, and development, are all essentially the results of one and the same power.

Sexual Generation.—The union of the two sexual elements seems at first sight to make a broad distinction between sexual and asexual generation. But the conjugation of algæ, by which process the contents of two cells unite into a single mass capable of development, apparently gives us the first step towards sexual union: and Pringsheim, in his memoir on the pairing of Zoospores,[7] shows that conjugation graduates into true sexual reproduction. Moreover, the now well-ascertained cases of Parthenogenesis prove that the distinction between sexual and asexual generation is not nearly so great as was formerly thought; for ova occasionally, and even in some cases frequently, become developed into perfect beings, without the concourse of the male. With most of the lower animals and even with mammals, the ova show a trace of parthenogenetic power, for without being fertilised they pass through the first stages of segmentation.[8] Nor can pseudova which do not need fertilisation, be distinguished from true ova, as was first shown by Sir J. Lubbock, and is now admitted by Siebold. So, again, the germ-balls in the larvæ of Cecidomyia are said by Leuckart[9] to be formed within the ovarium, but they do not require to be fertilised. It should also be observed that in sexual generation, the ovules and the male element have equal power of transmitting every single character possessed by either parent to their offspring. We see this clearly when hybrids are paired *inter se,* for the characters of both grandparents often appear in the progeny, either perfectly or by segments. It is an error to suppose that the male transmits certain characters and the female other characters; although no doubt, from unknown causes, one sex sometimes has a much stronger power of transmission than the other.

It has, however, been maintained by some authors that a bud differs essentially from a fertilised germ, in always reproducing the perfect character of the parent-stock; whilst fertilised germs give birth to variable beings. But there is no such broad distinction as this. In the eleventh chapter numerous cases were advanced showing that buds occasionally grow into plants having quite new characters; and the varieties thus produced can be propagated for a length of time by buds, and occasionally by seed. Nevertheless, it must be admitted that beings produced sexually are much more liable to vary than those produced asexually; and of this fact a partial explanation will hereafter be attempted. The variability in both cases is determined by the same general causes, and is governed by the same laws. Hence new varieties arising from buds cannot be distinguished from those arising from seed. Although bud-varieties usually retain their character during successive bud-generations, yet they occasionally revert, even after a long series of bud-generations, to their former character. This tendency to reversion in buds, is one of the most remarkable of the several points of agreement between the offspring from bud and seminal reproduction.

But there is one difference between organisms produced sexually and asexually, which is very general. The former pass in the course of their development from a very low stage to their highest stage, as we see in the metamorphoses of insects and of many other animals, and in the concealed metamorphoses of the vertebrata. Animals propagated asexually by buds or fission, on the other hand, commence their development at that stage at which the budding or self-dividing animal may happen to be, and therefore do not pass through some of the lower developmental stages.[10] Afterwards, they often advance in organisation, as we see in the many cases of "alternate generation." In thus speaking of alternate generation, I follow those naturalists who look at this process as essentially one of internal budding or of fissiparous generation. Some of the lower plants, however, such as mosses and certain algæ, according to Dr. L. Radlkofer,[11] when propagated asexually, do undergo a retrogressive metamorphosis. As far as the final cause is concerned, we can to a certain extent understand why beings propagated by buds should not pass through all the early stages of development; for with each organism the structure acquired at each stage must be adapted to its peculiar habits; and if there are places for the support of many individuals at some one stage, the simplest plan will be that they should be multiplied at this stage, and not that they should first retrograde in their development to an earlier or simpler structure, which might not be fitted for the then surrounding conditions.

From the several foregoing considerations we may conclude that the difference between sexual and asexual generation is not nearly so great as at first appears; the chief difference being that an ovule cannot continue to live and to be fully developed unless it unites with the male element; but even this difference is far from invariable, as shown by the many cases of parthenogenesis. We are therefore naturally led to inquire what the final cause can be of the necessity in ordinary generation for the concourse of the two sexual elements.

Seeds and ova are often highly serviceable as the means of disseminating plants and animals, and of preserving them during one or more seasons in a dormant state; but unimpregnated seeds or ova, and detached buds, would be equally serviceable for both purposes. We can, however, indicate two important advantages gained by the concourse of the two sexes, or rather of two individuals belonging to opposite sexes; for, as I have shown in a former chapter, the structure of every organism appears to be especially adapted for the concurrence, at least occasionally, of two individuals. When species are rendered highly variable by changed conditions of life, the free intercrossing of the varying individuals tends to keep each form fitted for its proper place in nature; and crossing can be effected only by sexual generation; but whether the end thus gained is of sufficient importance to account for the first origin of sexual intercourse is extremely doubtful. Secondly, I have shown from a large body of facts, that, as a slight change in the conditions of life is beneficial to each creature, so, in an analogous manner, is the change effected in the germ by sexual union with a distinct individual; and I have been led, from observing the many widely-extended provisions throughout nature for this purpose, and from the greater vigour of crossed organisms of all kinds, as proved by direct experiments, as well as from the evil effects of close interbreeding when long continued, to believe that the advantage thus gained is very great.

Why the germ, which before impregnation undergoes a certain amount of development, ceases to progress and perishes, unless it be acted on by the male element; and why conversely the male element, which in the case of some insects is enabled to keep alive for four or five years, and in the case of some plants for several years, likewise perishes, unless it acts on or unites with the germ, are questions which cannot be answered with certainty. It is, however, probable that both sexual elements perish, unless brought into union, simply from including too little formative matter for independent development. Quatrefages has shown in the case of the Teredo,[12] as did formerly Prevost and Dumas with other animals, that more than one spermatozoon is requisite to fertilise an ovum. This has likewise been shown by Newport,[13] who proved by numerous experiments, that, when a very small number of spermatozoa are applied to the ova of Batrachians, they are only partially impregnated, and an embryo is never fully developed. The rate also of the segmentation of the ovum is determined by the number of the spermatozoa. With respect to plants, nearly the same results were obtained by Kölreuter and Gärtner. This last careful observer, after making successive trials on a Malva with more and more pollen-grains, found,[14] that even thirty grains did not fertilise a single seed; but when forty grains were applied to the stigma, a few seeds of small size were formed. In the case of Mirabilis the pollen grains are extraordinarily large, and the ovarium contains only a single ovule; and these circumstances led Naudin[15] to make the following experiments: a flower was fertilised by three grains and succeeded perfectly; twelve flowers were fertilised by two grains, and seventeen flowers by a single grain, and of these one flower alone in each lot perfected its seed: and it deserves especial notice that the plants produced by these two seeds never attained their proper dimensions, and bore flowers of remarkably small size. From these facts we clearly see that the quantity of the peculiar formative matter which is contained within the spermatozoa and pollen-grains is an all-important element in the act of fertilisation, not only for the full development of the seed, but for the vigour of the plant produced from such seed. We see something of the same kind in certain cases of parthenogenesis, that is, when the male element is wholly excluded; for M. Jourdan[16] found that, out of about 58,000 eggs laid by unimpregnated silk-moths, many passed through their early embryonic stages, showing that they were capable of self-development, but only twenty-nine out of the whole number produced caterpillars. The same principle of quantity seems to hold good even in artificial fissiparous reproduction, for Hackel[17] found that by cutting the segmented and fertilised ova or larva of Siphonophoræ (jelly-fishes) into pieces, the smaller the pieces were, the slower was the rate of development, and the larvæ thus produced were by so much the more imperfect and inclined to monstrosity. It seems, therefore, probable that with the separate sexual elements deficient quantity of formative matter is the main cause of their not having the capacity for prolonged existence and development, unless they combine and thus increase each other's bulk. The belief that it is the function of the spermatozoa to communicate life to the ovule seems a strange one, seeing that the unimpregnated ovule is already alive and generally undergoes a certain amount of independent development. Sexual and asexual reproduction are thus seen not to differ essentially; and we have already shown that asexual reproduction, the power of re-growth and development are all parts of one and the same great law.

Re-growth of amputated parts.—This subject deserves a little further discussion. A multitude of the lower animals and some vertebrates possess this wonderful power. For instance, Spallanzani cut off the legs and tail of the same salamander six times successively, and Bonnet[18] did so eight times; and on each occasion the limbs were reproduced on the exact line of amputation, with no part deficient or in excess. An allied animal, the axolotl, had a limb bitten off, which was reproduced in an abnormal condition, but when this was amputated it was replaced by a perfect limb.[19] The new limbs in these cases bud forth, and are developed in the same manner as during the regular development of a young animal. For instance, with the *Amblystoma lurida*, three toes are first developed, then the fourth, and on the hind-feet the fifth, and so it is with a reproduced limb.[20]

The power of re-growth is generally much greater during the youth of an animal or during the earlier stages of its development than during maturity. The larvæ or tadpoles of the Batrachians are capable of reproducing lost members, but not so the adults.[21] Mature insects have no power of re-growth, excepting in one order, whilst the larvæ of many kinds have this power. Animals low in the scale are able, as a general rule, to reproduce lost parts far more easily than those which are more highly organised. The myriapods offer a good illustration of this rule; but there are some strange exceptions to it—thus Nemerteans, though lowly organised, are said to exhibit little power of re-growth. With the higher vertebrata, such as birds and mammals, the power is extremely limited.[22]

In the case of those animals which may be bisected or chopped into pieces, and of which every fragment will reproduce the whole, the power of re-growth must be diffused throughout the whole body. Nevertheless there seems to be much truth in the view maintained by Prof. Lessona,[23] that this capacity is generally a localised and special one, serving to replace parts which are eminently liable to be lost in each particular animal. The most striking case in favour of this view, is that the terrestrial salamander, according to Lessona, cannot reproduce lost parts, whilst another species of the same genus, the aquatic salamander, has extraordinary powers of re-growth, as we have just seen; and this animal is eminently liable to have its limbs, tail, eyes and jaws bitten off by other tritons.[24] Even with the aquatic salamander the capacity is to a certain extent localised, for when M. Philipeaux[25] extirpated the entire fore limb together with the scapula, the power of re-growth was completely lost. It is also a remarkable fact, standing in opposition to a very general rule, that the young of the aquatic salamander do not possess the power of repairing their limbs in an equal degree with the adults[26] but I do not know that they are more active, or can otherwise better escape the loss of their limbs, than the adults. The walking-stick insect, *Diapheromera femorata*, like other insects of the same order, can reproduce its legs in the mature state, and these from their great length must be liable to be lost: but the capacity is localised (as in the case of the salamander), for Dr. Scudder found,[27] that if the limb was removed within the trochanto-femoral articulation, it was never renewed. When a crab is seized by one of its legs, this is thrown off at the basal joint, being afterwards replaced by a new leg; and it is generally admitted that this is a special provision for the safety of the animal. Lastly, with gasteropod molluscs, which are well known to have the power of reproducing their heads, Lessona shows that they are very liable to have their heads bitten off by fishes; the rest of the body being protected by the shell. Even with plants we see something of the same kind, for non-deciduous leaves and young stems have no power of re-growth, these parts being easily replaced by growth from new buds; whilst the bark and subjacent tissues of the trunks of trees have great power of re-growth, probably on account of their increase in diameter, and of their liability to injury from being gnawed by animals.

Graft-hybrids.—It is well known from innumerable trials made in all parts of the world, that buds may be inserted into a stock, and that the plants thus raised are not affected in a greater degree than can be accounted for by changed nutrition. Nor do the seedlings raised from such inserted buds partake of the character of the stock, though they are more liable to vary than are seedlings from the same variety growing on its own roots. A bud, also, may sport into a new and strongly-marked variety without any other bud on the same plant being in the least degree affected. We may therefore infer, in accordance with the common view, that each bud is a distinct individual, and that its formative elements do not spread beyond the parts subsequently developed from it. Nevertheless, we have seen in the abstract on graft-hybridisation in the eleventh chapter that buds certainly include formative matter, which can occasionally combine with that included in the tissues of a distinct variety or species; a plant intermediate between the two parent-forms being thus produced. In the case of the potato we have seen that the tubers produced from a bud of one kind inserted into another are intermediate in colour, size, shape and state of surface; that the stems, foliage, and even certain constitutional peculiarities, such as precocity, are likewise intermediate. With these well-established cases, the evidence that graft-hybrids have also been produced with the laburnum, orange, vine, rose, etc., seems sufficient. But we do not know under what conditions this rare form of reproduction is possible. From these several cases we learn the important fact that formative elements capable of blending with those of a distinct individual (and this is the chief characteristic of sexual generation), are not confined to the reproductive organs, but are present in the buds and cellular tissue of plants; and this is a fact of the highest physiological importance.

Direct Action of the Male Element on the Female.—In the eleventh chapter, abundant proofs were given that foreign pollen occasionally affects in a direct manner the mother-plant. Thus, when Gallesio fertilised an orange-flower with pollen from the lemon, the fruit bore stripes of perfectly characterised lemon-peel. With peas, several observers have seen the colour of the seed-coats and even of the pod directly affected by the pollen of a distinct variety. So it has been with the fruit of the apple, which consists of the modified calyx and upper part of the flower-stalk. In ordinary cases these parts are wholly formed by the mother-plant. We here see that the formative elements included within the male element or pollen of one variety can affect and hybridise, not the part which they are properly adapted to affect, namely, the ovules, but the partially-developed tissues of a distinct variety or species. We are thus brought half-way towards a graft-hybrid, in which the formative elements included within the tissues of one individual combine with those included in the tissues of a distinct variety or species, thus giving rise to a new and intermediate form, independently of the male or female sexual organs.

With animals which do not breed until nearly mature, and of which all the parts are then fully developed, it is hardly possible that the male element should directly affect the female. But we have the analogous and perfectly well-ascertained case of the male element affecting (as with the quagga and Lord Morton's mare) the female or her ova, in such a manner that when she is impregnated by another male her offspring are affected and hybridised by the first male. The explanation would be simple if the spermatozoa could keep alive within the body of the female during the long interval which has sometimes elapsed between the two acts of impregnation; but no one will suppose that this is possible with the higher animals.

Development.—The fertilised germ reaches maturity by a vast number of changes: these are either slight and slowly effected, as when the child grows into the man, or are great and sudden, as with the metamorphoses of most insects. Between these extremes we have every gradation, even within the same class; thus, as Sir J. Lubbock has shown[28] there is an Ephemerous insect which moults above twenty times, undergoing each time a slight but decided change of structure; and these changes, as he further remarks, probably reveal to us the normal stages of development, which are concealed and hurried through or suppressed in most other insects. In ordinary metamorphoses, the parts and organs appear to become changed into the corresponding parts in the next stage of development; but there is another form of development, which has been called by Professor Owen metagenesis. In this case "the new parts are not moulded upon the inner surface of the old ones. The plastic force has changed its course of operation. The outer case, and all that gave form and character to the precedent individual, perish and are cast off; they are not changed into the corresponding parts of the new individual. These are due to a new and distinct developmental process," etc.[29] Metamorphosis, however, graduates so insensibly, into metagenesis, that the two processes cannot be distinctly separated. For instance, in the last change which Cirripedes undergo, the alimentary canal and some other organs are moulded on pre-existing parts; but the eyes of the old and the young animal are developed in entirely different parts of the body;

the tips of the mature limbs are formed within the larval limbs, and may be said to be metamorphosed from them; but their basal portions and the whole thorax are developed in a plane at right angles to the larval limbs and thorax; and this may be called metagenesis. The metagenetic process is carried to an extreme point in the development of some Echinoderms, for the animal in the second stage of development is formed almost like a bud within the animal of the first stage, the latter being then cast off like an old vestment, yet sometimes maintaining for a short period an independent vitality.[30]

If, instead of a single individual, several were to be thus developed metagenetically within a pre-existing form, the process would be called one of alternate generation. The young thus developed may either closely resemble the encasing parent-form, as with the larvæ of Cecidomyia, or may differ to an astonishing degree, as with many parasitic worms and jelly-fishes; but this does not make any essential difference in the process, any more than the greatness or abruptness of the change in the metamorphoses of insects.

The whole question of development is of great importance for our present subject. When an organ, the eye, for instance, is metagenetically formed in a part of the body where during the previous stage of development no eye existed, we must look at it as a new and independent growth. The absolute independence of new and old structures, although corresponding in structure and function, is still more obvious when several individuals are formed within a previous form, as in the cases of alternate generation. The same important principle probably comes largely into play even in the case of apparently continuous growth, as we shall see when we consider the inheritance of modifications at corresponding ages.

We are led to the same conclusion, namely, the independence of parts successively developed, by another and quite distinct group of facts. It is well known that many animals belonging to the same order, and therefore not differing widely from each other, pass through an extremely different course of development. Thus certain beetles, not in any way remarkably different from others of the same order, undergo what has been called a hyper-metamorphosis—that is, they pass through an early stage wholly different from the ordinary grub-like larva. In the same sub-order of crabs, namely, the Macroura, as Fritz Müller remarks, the river cray-fish is hatched under the same form which it ever afterwards retains; the young lobster has divided legs, like a Mysis; the Palæmon appears under the form of a Zoea, and Peneus under the Nauplius-form; and how wonderfully these larval forms differ from one another, is known to every naturalist.[31] Some other crustaceans, as the same author observes, start from the same point and arrive at nearly the same end, but in the middle of their development are widely different from one another. Still more striking cases could be given with respect to the Echinodermata. With the Medusæ or jelly-fishes Professor Allman observes, “The classification of the Hydroida would be a comparatively simple task if, as has been erroneously asserted, generically-identical medusoids always arose from generically-identical polypoids; and, on the other hand, that generically-identical polypoids always gave origin to generically-identical medusoids." So again, Dr. Strethill Wright remarks, "In the life-history of the Hydroidæ any phase, planuloid, polypoid, or medusoid, may be absent."[32]

According to the belief now generally accepted by our best naturalists, all the members of the same order or class, for instance, the Medusæ or the Macrourous crustaceans, are descended from a common progenitor. During their descent they have diverged much in structure, but have retained much in common; and this has occurred, though they have passed through and still pass through marvellously different metamorphoses. This fact well illustrates how independent each structure is from that which precedes and that which follows it in the course of development.

The Functional Independence of the Elements or Units of the Body.—Physiologists agree that the whole organism consists of a multitude of elemental parts, which are to a great extent independent of one another. Each organ, says Claude Bernard,[33] has its proper life, its autonomy; it can develop and reproduce itself independently of the adjoining tissues. A great German authority, Virchow,[34] asserts still more emphatically that each system consists of an "enormous mass of minute centres of action. . . . Every element has its own special action, and even though it derive its stimulus to activity from other parts, yet alone effects the actual performance of duties. . . . Every single epithelial and muscular fibre-cell leads a sort of parasitical existence in relation to the rest of the body. . . . Every single bone-corpuscle really possesses conditions of nutrition peculiar to itself." Each element, as Sir J. Paget remarks, lives its appointed time and then dies, and is replaced after being cast off or absorbed.[35] I presume that no physiologist doubts that, for instance, each bone-corpuscle of the finger differs from the corresponding corpuscle in the corresponding joint of the toe; and there can hardly be a doubt that even those on the corresponding sides of the body differ, though almost identical in nature. This near approach to identity is curiously shown in many diseases in which the same exact points on the right and left sides of the body are similarly affected; thus Sir J. Paget[36] gives a drawing of a diseased pelvis, in which the bone has grown into a most complicated pattern, but "there is not one spot or line on one side which is not represented, as exactly as it would be in a mirror, on the other."

Many facts support this view of the independent life of each minute element of the body. Virchow insists that a single bone-corpuscle or a single cell in the skin may become diseased. The spur of a cock, after being inserted into the ear of an ox, lived for eight years, and acquired a weight of 396 grammes (nearly fourteen ounces), and the astonishing length of twenty-four centimetres, or about nine inches; so that the head of the ox appeared to bear three horns.[37] The tail of a pig has been grafted into the middle of its back, and reacquired sensibility. Dr. Ollier[38] inserted a piece of periosteum from the bone of a young dog under the skin of a rabbit, and true bone was developed. A multitude of similar facts could be given. The frequent presence of hairs and of perfectly developed teeth, even teeth of the second dentition, in ovarian tumours,[39] are facts leading to the same conclusion. Mr. Lawson Tait refers to a tumour in which "over 300 teeth were found, resembling in many respects milk-teeth;" and to another tumour, "full of hair which had grown and been shed from one little spot of skin not bigger than the tip of my little finger. The amount of hair in the sac, had it grown from a similarly sized area of the scalp, would have taken almost a lifetime to grow and be shed."

Whether each of the innumerable autonomous elements of the body is a cell or the modified product of a cell, is a more doubtful question, even if so wide a definition be given to the term, as to include cell-like bodies without walls and without nuclei.[40] The doctrine of *omnis cellula e cellulâ* is admitted for plants, and widely prevails with respect to animals.[41] Thus Virchow, the great supporter of the cellular theory, whilst allowing that difficulties exist, maintains that every atom of tissue is derived from cells, and these from pre-existing cells, and these primarily from the egg, which he regards as a great cell. That cells, still retaining the same nature, increase by self-division or proliferation, is admitted by every one. But when an organism undergoes great changes of structure during development, the cells, which at each stage are supposed to be directly derived from previously existing cells, must likewise be greatly changed in nature; this change is attributed by the supporters of the cellular doctrine to some inherent power which the cells possess, and not to any external agency. Others maintain that cells and tissues of all kinds may be formed, independently of pre-existing cells, from plastic lymph or blastema. Whichever view may be correct, every one admits that the body consists of a multitude of organic units, all of which possess their own proper attributes, and are to a certain extent independent of all others. Hence it will be convenient to use indifferently the terms cells or organic units, or simply units.

Variability and Inheritance.—We have seen in the twenty-second chapter that variability is not a principle co-ordinate with life or reproduction, but results from special causes, generally from changed conditions acting during successive generations. The fluctuating variability thus induced is apparently due in part to the sexual system being easily affected, so that it is often rendered impotent; and when not so seriously affected, it often fails in its proper function of transmitting truly the characters of the parents to the offspring. But variability is not necessarily connected with the sexual system, as we see in the cases of bud-variation. Although we are seldom able to trace the nature of the connection, many deviations of structure no doubt result from changed conditions acting directly on the organisation, independently of the reproductive system. In some instances we may feel sure of this, when all, or nearly all the individuals which have been similarly exposed are similarly and definitely affected, of which several instances have been given. But it is by no means clear why the offspring should be affected by the exposure of the parents to new conditions, and why it is necessary in most cases that several generations should have been thus exposed.

How, again, can we explain the inherited effects of the use or disuse of particular organs? The domesticated duck flies less and walks more than the wild duck, and its limb-bones have become diminished and increased in a corresponding manner in comparison with those of the wild duck. A horse is trained to certain paces, and the colt inherits similar consensual movements. The domesticated rabbit becomes tame from close confinement; the dog, intelligent from associating with man; the retriever is taught to fetch and carry; and these mental endowments and bodily powers are all inherited. Nothing in the whole circuit of physiology is more wonderful. How can the use or disuse of a particular limb or of the brain affect a small aggregate of reproductive cells, seated in a distant part of the body, in such a manner that the being developed from these cells inherits the characters of either one or both parents? Even an imperfect answer to this question would be satisfactory.

In the chapters devoted to inheritance it was shown that a multitude of newly acquired characters, whether injurious or beneficial, whether of the lowest or highest vital importance, are often faithfully transmitted—frequently even when one parent alone possesses some new peculiarity; and we may on the whole conclude that inheritance is the rule, and non-inheritance the anomaly. In some instances a character is not inherited, from the conditions of life being directly opposed to its development; in many instances, from the conditions incessantly inducing fresh variability, as with grafted fruit-trees and highly-cultivated flowers. In the remaining cases the failure may be attributed to reversion, by which the child resembles its grandparents or more remote progenitors, instead of its parents.

Inheritance is governed by various laws. Characters which first appear at any particular age tend to reappear at a corresponding age. They often become associated with certain seasons of the year, and reappear in the offspring at a corresponding season. If they appear rather late in life in one sex, they tend to reappear exclusively in the same sex at the same period of life.

The principle of reversion, recently alluded to, is one of the most wonderful of the attributes of Inheritance. It proves to us that the transmission of a character and its development, which ordinarily go together and thus escape discrimination, are distinct powers; and these powers in some cases are even antagonistic, for each acts alternately in successive generations. Reversion is not a rare event, depending on some unusual or favourable combination of circumstances, but occurs so regularly with crossed animals and plants, and so frequently with uncrossed breeds, that it is evidently an essential part of the principle of inheritance. We know that changed conditions have the power of evoking long-lost characters, as in the case of animals becoming feral. The act of crossing in itself possesses this power in a high degree. What can be more wonderful than that characters, which have disappeared during scores, or hundreds, or even thousands of generations, should suddenly reappear perfectly developed, as in the case of pigeons and fowls, both when purely bred and especially when crossed; or as with the zebrine stripes on dun-coloured horses, and other such cases? Many monstrosities come under this same head, as when rudimentary organs are redeveloped, or when an organ which we must believe was possessed by an early progenitor of the species, but of which not even a rudiment is left, suddenly reappears, as with the fifth stamen in some Scrophulariaceæ. We have already seen that reversion acts in bud-reproduction;

and we know that it occasionally acts during the growth of the same individual animal, especially, but not exclusively, if of crossed parentage,—as in the rare cases described of fowls, pigeons, cattle, and rabbits, which have reverted to the colours of one of their parents or ancestors as they advanced in years.

We are led to believe, as formerly explained, that every character which occasionally reappears is present in a latent form in each generation, in nearly the same manner as in male and female animals the secondary characters of the opposite sex lie latent and ready to be evolved when the reproductive organs are injured. This comparison of the secondary sexual characters which lie latent in both sexes, with other latent characters, is the more appropriate from the case recorded of a Hen, which assumed some of the masculine characters, not of her own race, but of an early progenitor; she thus exhibited at the same time the redevelopment of latent characters of both kinds. In every living creature we may feel assured that a host of long-lost characters lie ready to be evolved under proper conditions. How can we make intelligible and connect with other facts, this wonderful and common capacity of reversion,—this power of calling back to life long-lost characters?

PART II.

I have now enumerated the chief facts which every one would desire to see connected by some intelligible bond. This can be done, if we make the following assumptions, and much may be advanced in favour of the chief one. The secondary assumptions can likewise be supported by various physiological considerations. It is universally admitted that the cells or units of the body increase by self-division or proliferation, retaining the same nature, and that they ultimately become converted into the various tissues and substances of the body. But besides this means of increase I assume that the units throw off minute granules which are dispersed throughout the whole system; that these, when supplied with proper nutriment, multiply by self-division, and are ultimately developed into units like those from which they were originally derived. These granules may be called gemmules. They are collected from all parts of the system to constitute the sexual elements, and their development in the next generation forms a new being; but they are likewise capable of transmission in a dormant state to future generations and may then be developed. Their development depends on their union with other partially developed or nascent cells which precede them in the regular course of growth. Why I use the term union, will be seen when we discuss the direct action of pollen on the tissues of the mother-plant. Gemmules are supposed to be thrown off by every unit, not only during the adult state, but during each stage of development of every organism; but not necessarily during the continued existence of the same unit. Lastly, I assume that the gemmules in their dormant state have a mutual affinity for each other, leading to their aggregation into buds or into the sexual elements. Hence, it is not the reproductive organs or buds which generate new organisms, but the units of which each individual is composed. These assumptions constitute the provisional hypothesis which I have called Pangenesis. Views in many respects similar have been propounded by various authors.[42]

Before proceeding to show, firstly, how far these assumptions are in themselves probable, and secondly, how far they connect and explain the various groups of facts with which we are concerned, it may be useful to give an illustration, as simple as possible, of the hypothesis. If one of the Protozoa be formed, as it appears under the microscope, of a small mass of homogeneous gelatinous matter, a minute particle or gemmule thrown off from any part and nourished under favourable circumstances would reproduce the whole; but if the upper and lower surfaces were to differ in texture from each other and from the central portion, then all three parts would have to throw off gemmules, which when aggregated by mutual affinity would form either buds or the sexual elements, and would ultimately be developed into a similar organism. Precisely the same view may be extended to one of the higher animals; although in this case many thousand gemmules must be thrown off from the various parts of the body at each stage of development; these gemmules being developed in union with pre-existing nascent cells in due order of succession.

Physiologists maintain, as we have seen, that each unit of the body, though to a large extent dependent on others, is likewise to a certain extent independent or autonomous, and has the power of increasing by self-division. I go one step further, and assume that each unit casts off free gemmules which are dispersed throughout the system, and are capable under proper conditions of being developed into similar units. Nor can this assumption be considered as gratuitous and improbable. It is manifest that the sexual elements and buds include formative matter of some kind, capable of development; and we now know from the production of graft-hybrids that similar matter is dispersed throughout the tissues of plants, and can combine with that of another and distinct plant, giving rise to a new being, intermediate in character. We know also that the male element can act directly on the partially developed tissues of the mother-plant, and on the future progeny of female animals. The formative matter which is thus dispersed throughout the tissues of plants, and which is capable of being developed into each unit or part, must be generated there by some means; and my chief assumption is that this matter consists of minute particles or gemmules cast off from each unit or cell.[43]

But I have further to assume that the gemmules in their undeveloped state are capable of largely multiplying themselves by self-division, like independent organisms. Delpino insists that to "admit of multiplication by fissiparity in corpuscles, analogous to seeds or buds . . . is repugnant to all analogy." But this seems a strange objection, as Thuret[44] has seen the zoospore of an alga divide itself, and each half germinated. Haeckel divided the segmented ovum of a siphonophora into many pieces, and these were developed. Nor does the extreme minuteness of the gemmules, which can hardly differ much in nature from the lowest and simplest organisms, render it improbable that they should grow and multiply. A great authority, Dr. Beale,[45] says "that minute yeast cells are capable of throwing off buds or gemmules, much less than the 1/100000 of an inch in diameter;" and these he thinks are "capable of subdivision practically ad infinitum."

A particle of small-pox matter, so minute as to be borne by the wind, must multiply itself many thousandfold in a person thus inoculated; and so with the contagious matter of scarlet fever.[46] It has recently been ascertained[47] that a minute portion of the mucous discharge from an animal affected with rinderpest, if placed in the blood of a healthy ox, increases so fast that in a short space of time "the whole mass of blood, weighing many pounds, is infected, and every small particle of that blood contains enough poison to give, within less than forty-eight hours, the disease to another animal."

The retention of free and undeveloped gemmules in the same body from early youth to old age will appear improbable, but we should remember how long seeds lie dormant in the earth and buds in the bark of a tree. Their transmission from generation to generation will appear still more improbable; but here again we should remember that many rudimentary and useless organs have been transmitted during an indefinite number of generations. We shall presently see how well the long-continued transmission of undeveloped gemmules explains many facts.

As each unit, or group of similar units, throughout the body, casts off its gemmules, and as all are contained within the smallest ovule, and within each spermatozoon or pollen-grain, and as some animals and plants produce an astonishing number of pollen-grains and ovules,[48] the number and minuteness of the gemmules must be something inconceivable. But considering how minute the molecules are, and how many go to the formation of the smallest granule of any ordinary substance, this difficulty with respect to the gemmules is not insuperable. From the data arrived at by Sir W. Thomson, my son George finds that a cube of 1/10000 of an inch of glass or water must consist of between 16 million millions, and 131 thousand million million molecules. No doubt the molecules of which an organism is formed are larger, from being more complex, than those of an inorganic substance, and probably many molecules go to the formation of a gemmule; but when we bear in mind that a cube of 1/10000 of an inch is much smaller than any pollen-grain, ovule or bud, we can see what a vast number of gemmules one of these bodies might contain.

The gemmules derived from each part or organ must be thoroughly dispersed throughout the whole system. We know, for instance, that even a minute fragment of a leaf of a Begonia will reproduce the whole plant; and that if a fresh-water worm is chopped into small pieces, each will reproduce the whole animal. Considering also the minuteness of the gemmules and the permeability of all organic tissues, the thorough dispersion of the gemmules is not surprising. That matter may be readily transferred without the aid of vessels from part to part of the body, we have a good instance in a case recorded by Sir J. Paget of a lady, whose hair lost its colour at each successive attack of neuralgia and recovered it again in the course of a few days. With plants, however, and probably with compound animals, such as corals, the gemmules do not ordinarily spread from bud to bud, but are confined to the parts developed from each separate bud; and of this fact no explanation can be given.

The assumed elective affinity of each gemmule for that particular cell which precedes it in due order of development is supported by many analogies. In all ordinary cases of sexual reproduction, the male and female elements certainly have a mutual affinity for each other: thus, it is believed that about ten thousand species of Compositæ exist, and there can be no doubt that if the pollen of all these species could be simultaneously or successively placed on the stigma of any one species, this one would elect with unerring certainty its own pollen. This elective capacity is all the more wonderful, as it must have been acquired since the many species of this great group of plants branched off from a common progenitor. On any view of the nature of sexual reproduction, the formative matter of each part contained within the ovules and the male element act on each other by some law of special affinity, so that corresponding parts affect one another; thus, a calf produced from a short-horned cow by a long-horned bull has its horns affected by the union of the two forms, and the offspring from two birds with differently coloured tails have their tails affected.

The various tissues of the body plainly show, as many physiologists have insisted,[49] an affinity for special organic substances, whether natural or foreign to the body. We see this in the cells of the kidneys attracting urea from the blood; in curare affecting certain nerves; *Lytta vesicatoria* the kidneys; and the poisonous matter of various diseases, as small-pox, scarlet-fever, hooping-cough, glanders, and hydrophobia, affecting certain definite parts of the body.

It has also been assumed that the development of each gemmule depends on its union with another cell or unit which has just commenced its development, and which precedes it in due order of growth. That the formative matter within the pollen of plants, which by our hypothesis consists of gemmules, can unite with and modify the partially developed cells of the mother-plant, we have clearly seen in the section devoted to this subject. As the tissues of plants are formed, as far as is known, only by the proliferation of pre-existing cells, we must conclude that the gemmules derived from the foreign pollen do not become developed into new and separate cells, but penetrate and modify the nascent cells of the mother-plant. This process may be compared with what takes place in the act of ordinary fertilisation, during which the contents of the pollen-tubes penetrate the closed embryonic sac within the ovule, and determine the development of the embryo. According to this view, the cells of the mother-plant may almost literally be said to be fertilised by the gemmules derived from the foreign pollen. In this case and in all others the proper gemmules must combine in due order with pre-existing nascent cells, owing to their elective affinities. A slight difference in nature between the gemmules and the nascent cells would be far from interfering with their mutual union and development, for we well know in the case of ordinary reproduction that such slight differentiation in the sexual elements favours in a marked manner their union and subsequent development, as well as the vigour of the offspring thus produced.

Thus far we have been able by the aid of our hypothesis to throw some obscure light on the problems which have come before us; but it must be confessed that many points remain altogether doubtful. Thus it is useless to speculate at what period of development each unit of the body casts off its gemmules, as the whole subject of the development of the various tissues is as yet far from clear. We do not know whether the gemmules are merely collected by some unknown means at certain seasons within the reproductive organs, or whether after being thus collected they rapidly multiply there, as the flow of blood to these organs at each breeding season seems to render probable. Nor do we know why the gemmules collect to form buds in certain definite places, leading to the symmetrical growth of trees and corals. We have no means of deciding whether the ordinary wear and tear of the tissues is made good by means of gemmules, or merely by the proliferation of pre-existing cells. If the gemmules are thus consumed, as seems probable from the intimate connection between the repair of waste, re-growth, and development, and more especially from the periodical changes which many male animals undergo in colour and structure, then some light would be thrown on the phenomena of old age, with its lessened power of reproduction and of the repair of injuries, and on the obscure subject of longevity. The fact of castrated animals, which do not cast off innumerable gemmules in the act of reproduction, not being longer-lived than perfect males, seems opposed to the belief that gemmules are consumed in the ordinary repair of wasted tissues; unless indeed the gemmules after being collected in small numbers within the reproductive organs are there largely multiplied.[50]

That the same cells or units may live for a long period and continue multiplying without being modified by their union with free gemmules of any kind, is probable from such cases as that of the spur of a cock which grew to an enormous size when grafted into the ear of an ox. How far units are modified during their normal growth by absorbing peculiar nutriment from the surrounding tissues, independently of their union with gemmules of a distinct nature, is another doubtful point.[51] We shall appreciate this difficulty by calling to mind what complex yet symmetrical growths the cells of plants yield when inoculated by the poison of a gall-insect. With animals various polypoid excrescences and tumours are generally admitted[52] to be the direct product, through proliferation, of normal cells which have become abnormal. In the regular growth and repair of bones, the tissues undergo, as Virchow remarks,[53] a whole series of permutations and substitutions. “The cartilage cells may be converted by a direct transformation into marrow-cells, and continue as such; or they may first be converted into osseous and then into medullary tissue; or lastly, they may first be converted into marrow and then into bone. So variable are the permutations of these tissues, in themselves so nearly allied, and yet in their external appearance so completely distinct.” But as these tissues thus change their nature at any age, without any obvious change in their nutrition, we must suppose in accordance with our hypothesis that gemmules derived from one kind of tissue combine with the cells of another kind, and cause the successive modifications.

We have good reason to believe that several gemmules are requisite for the development of one and the same unit or cell; for we cannot otherwise understand the insufficiency of a single or even of two or three pollen-grains or spermatozoa. But we are far from knowing whether the gemmules of all the units are free and separate from one another, or whether some are from the first united into small aggregates. A feather, for instance, is a complex structure, and, as each separate part is liable to inherited variations, I conclude that each feather generates a large number of gemmules; but it is possible that these may be aggregated into a compound gemmule. The same remark applies to the petals of flowers, which are sometimes highly complex structures, with each ridge and hollow contrived for a special purpose, so that each part must have been separately modified, and the modifications transmitted; consequently, separate gemmules, according to our hypothesis, must have been thrown off from each cell or unit. But, as we sometimes see half an anther or a small portion of a filament becoming petali-form, or parts or mere stripes of the calyx assuming the colour and texture of the corolla, it is probable that with petals the gemmules of each cell are not aggregated together into a compound gemmule, but are free and separate. Even in so simple a case as that of a perfect cell, with its protoplasmic contents, nucleus, nucleolus, and walls, we do not know whether or not its development depends on a compound gemmule derived from each part.[54]

Having now endeavoured to show that the several foregoing assumptions are to a certain extent supported by analogous facts, and having alluded to some of the most doubtful points, we will consider how far the hypothesis brings under a single point of view the various cases enumerated in the First Part. All the forms of reproduction graduate into one another and agree in their product; for it is impossible to distinguish between organisms produced from buds, from self-division, or from fertilised germs; such organisms are liable to variations of the same nature and to reversions of the same kind; and as, according to our hypothesis, all the forms of reproduction depend on the aggregation of gemmules derived from the whole body, we can understand this remarkable agreement. Parthenogenesis is no longer wonderful, and if we did not know that great good followed from the union of the sexual elements derived from two distinct individuals, the wonder would be that parthenogenesis did not occur much oftener than it does. On any ordinary theory of reproduction the formation of graft-hybrids, and the action of the male element on the tissues of the mother-plant, as well as on the future progeny of female animals, are great anomalies; but they are intelligible on our hypothesis. The reproductive organs do not actually create the sexual elements; they merely determine the aggregation and perhaps the multiplication of the gemmules in a special manner. These organs, however, together with their accessory parts, have high functions to perform. They adapt one or both elements for independent temporary existence, and for mutual union. The stigmatic secretion acts on the pollen of a plant of the same species in a wholly different manner to what it does on the pollen of one belonging to a distinct genus or family. The spermatophores of the Cephalopoda are wonderfully complex structures, which were formerly mistaken for parasitic worms; and the spermatozoa of some animals possess attributes which, if observed in an independent animal, would be put down to instinct guided by sense-organs,—as when the spermatozoa of an insect find their way into the minute micropyle of the egg.

The antagonism which has long been observed,[55] with certain exceptions, between growth and the power of sexual reproduction[56]—between the repair of injuries and gemmation—and with plants, between rapid increase by buds, rhizomes, etc., and the production of seed, is partly explained by the gemmules not existing in sufficient numbers for these processes to be carried on simultaneously.

Hardly any fact in physiology is more wonderful than the power of re-growth; for instance, that a snail should be able to reproduce its head, or a salamander its eyes, tail, and legs, exactly at the points where they have been cut off. Such cases are explained by the presence of gemmules derived from each part, and disseminated throughout the body. I have heard the process compared with that of the repair of the broken angles of a crystal by re-crystallisation; and the two processes have this much in common, that in the one case the polarity of the molecules is the efficient cause, and in the other the affinity of the gemmules for particular nascent cells. But we have here to encounter two objections which apply not only to the re-growth of a part, or of a bisected individual, but to fissiparous generation and budding. The first objection is that the part which is reproduced is in the same stage of development as that of the being which has been operated on or bisected; and in the case of buds, that the new beings thus produced are in the same stage as that of the budding parent. Thus a mature salamander, of which the tail has been cut off, does not reproduce a larval tail; and a crab does not reproduce a larval leg. In the case of budding it was shown in the first part of this chapter that the new being thus produced does not retrograde in development,—that is, does not pass through those earlier stages, which the fertilised germ has to pass through. Nevertheless, the organisms operated on or multiplying themselves by buds must, by our hypothesis, include innumerable gemmules derived from every part or unit of the earlier stages of development; and why do not such gemmules reproduce the amputated part or the whole body at a corresponding early stage of development?

The second objection, which has been insisted on by Delpino, is that the tissues, for instance, of a mature salamander or crab, of which a limb has been removed, are already differentiated and have passed through their whole course of development; and how can such tissues in accordance with our hypothesis attract and combine with the gemmules of the part which is to be reproduced? In answer to these two objections we must bear in mind the evidence which has been advanced, showing that at least in a large number of cases the power of re-growth is a localised faculty, acquired for the sake of repairing special injuries to which each particular creature is liable; and in the case of buds or fissiparous generation, for the sake of quickly multiplying the organism at a period of life when it can be supported in large numbers. These considerations lead us to believe that in all such cases a stock of nascent cells or of partially developed gemmules are retained for this special purpose either locally or throughout the body, ready to combine with the gemmules derived from the cells which come next in due succession. If this be admitted we have a sufficient answer to the above two objections. Anyhow, pangenesis seems to throw a considerable amount of light on the wonderful power of re-growth.

It follows, also, from the view just given, that the sexual elements differ from buds in not including nascent cells or gemmules in a somewhat advanced stage of development, so that only the gemmules belonging to the earliest stages are first developed. As young animals and those which stand low in the scale generally have a much greater capacity for re-growth than older and higher animals, it would also appear that they retain cells in a nascent state, or partially developed gemmules, more readily than do animals which have already passed through a long series of developmental changes. I may here add that although ovules can be detected in most or all female animals at an extremely early age, there is no reason to doubt that gemmules derived from parts modified during maturity can pass into the ovules.

With respect to hybridism, pangenesis agrees well with most of the ascertained facts. We must believe, as previously shown, that several gemmules are requisite for the development of each cell or unit. But from the occurrence of parthenogenesis, more especially from those cases in which an embryo is only partially formed, we may infer that the female element generally includes gemmules in nearly sufficient number for independent development, so that when united with the male element the gemmules are superabundant. Now, when two species or races are crossed reciprocally, the offspring do not commonly differ, and this shows that the sexual elements agree in power, in accordance with the view that both include the same gemmules. Hybrids and mongrels are also generally intermediate in character between the two parent-forms, yet occasionally they closely resemble one parent in one part and the other parent in another part, or even in their whole structure: nor is this difficult to understand on the admission that the gemmules in the fertilised germ are superabundant in number, and that those derived from one parent may have some advantage in number, affinity, or vigour over those derived from the other parent. Crossed forms sometimes exhibit the colour or other characters of either parent in stripes or blotches; and this occurs in the first generation, or through reversion in succeeding bud and seminal generations, of which fact several instances were given in the eleventh chapter. In these cases we must follow Naudin[57] and admit that the "essence" or "element" of the two species,—terms which I should translate into the gemmules,—have an affinity for their own kind, and thus separate themselves into distinct stripes or blotches; and reasons were given, when discussing in the fifteenth chapter the incompatibility of certain characters to unite, for believing in such mutual affinity. When two forms are crossed, one is not rarely found to be prepotent in the transmission of its characters over the other; and this we can explain by again assuming that the one form has some advantage over the other in the number, vigour, or affinity of its gemmules. In some cases, however, certain characters are present in the one form and latent in the other; for instance, there is a latent tendency in all pigeons to become blue, and, when a blue pigeon is crossed with one of any other colour, the blue tint is generally prepotent. The explanation of this form of prepotency will be obvious when we come to the consideration of Reversion.

When two distinct species are crossed, it is notorious that they do not yield the full or proper number of offspring; and we can only say on this head that, as the development of each organism depends on such nicely-balanced affinities between a host of gemmules and nascent cells, we need not feel at all surprised that the commixture of gemmules derived from two distinct species should lead to partial or complete failure of development. With respect to the sterility of hybrids produced from the union of two distinct species, it was shown in the nineteenth chapter that this depends exclusively on the reproductive organs being specially affected; but why these organs should be thus affected we do not know, any more than why unnatural conditions of life, though compatible with health, should cause sterility; or why continued close interbreeding, or the illegitimate unions of heterostyled plants, induce the same result. The conclusion that the reproductive organs alone are affected, and not the whole organisation, agrees perfectly with the unimpaired or even increased capacity in hybrid plants for propagation by buds; for this implies, according to our hypothesis, that the cells of the hybrids throw off hybridised gemmules, which become aggregated into buds, but fail to become aggregated within the reproductive organs, so as to form the sexual elements. In a similar manner many plants, when placed under unnatural conditions, fail to produce seed, but can readily be propagated by buds. We shall presently see that pangenesis agrees well with the strong tendency to reversion exhibited by all crossed animals and plants.

Each organism reaches maturity through a longer or shorter course of growth and development: the former term being confined to mere increase of size, and development to changed structure. The changes may be small and insensibly slow, as when a child grows into a man, or many, abrupt, and slight, as in the metamorphoses of certain ephemerous insects, or, again, few and strongly-marked, as with most other insects. Each newly formed part may be moulded within a previously existing and corresponding part, and in this case it will appear, falsely as I believe, to be developed from the old part; or it may be formed within a distinct part of the body, as in the extreme cases of metagenesis. An eye, for instance, may be developed at a spot where no eye previously existed. We have also seen that allied organic beings in the course of their metamorphoses sometimes attain nearly the same structure after passing through widely different forms; or conversely, after passing through nearly the same early forms, arrive at widely different mature forms. In these cases it is very difficult to accept the common view that the first-formed cells or units possess the inherent power, independently of any external agency, of producing new structures wholly different in form, position, and function. But all these cases become plain on the hypothesis of pangenesis. The units, during each stage of development, throw off gemmules, which, multiplying, are transmitted to the offspring. In the offspring, as soon as any particular cell or unit becomes partially developed, it unites with (or, to speak metaphorically, is fertilised by) the gemmule of the next succeeding cell, and so onwards. But organisms have often been subjected to changed conditions of life at a certain stage of their development, and in consequence have been slightly modified; and the gemmules cast off from such modified parts will tend to reproduce parts modified in the same manner. This process may be repeated until the structure of the part becomes greatly changed at one particular stage of development, but this will not necessarily affect other parts, whether previously or subsequently formed. In this manner we can understand the remarkable independence of structure in the successive metamorphoses, and especially in the successive metageneses of many animals. In the case, however, of diseases which supervene during old age, subsequently to the ordinary period of procreation, and which, nevertheless, are sometimes inherited, as occurs with brain and heart complaints, we must suppose that the organs were affected at an early age and threw off at this period affected gemmules; but that the affection became visible or injurious only after the prolonged growth, in the strict sense of the word, of the part. In all the changes of structure which regularly supervene during old age, we probably see the effects of deteriorated growth, and not of true development.

The principle of the independent formation of each part, owing to the union of the proper gemmules with certain nascent cells, together with the superabundance of the gemmules derived from both parents, and the subsequent self-multiplication of the gemmules, throws light on a widely different group of facts, which on any ordinary view of development appears very strange. I allude to organs which are abnormally transposed or multiplied. For instance, a curious case has been recorded by Dr. Elliott Coues[58] of a monstrous chicken with a perfect additional *right* leg articulated to the *left* side of the pelvis. Gold-fish often have supernumerary fins placed on various parts of their bodies. When the tail of a lizard is broken off, a double tail is sometimes reproduced; and when the foot of the salamander was divided longitudinally by Bonnet, additional digits were occasionally formed. Valentin injured the caudal extremity of an embryo, and three days afterwards it produced rudiments of a double pelvis and of double hind-limbs.[59] When frogs, toads, etc., are born with their limbs doubled, as sometimes happens, the doubling, as Gervais remarks,[60] cannot be due to the complete fusion of two embryos, with the exception of the limbs, for the larvæ are limbless. The same argument is applicable[61] to certain insects produced with multiple legs or antennæ, for these are metamorphosed from apodal or antennæ-less larvæ. Alphonse Milne-Edwards[62] has described the curious case of a crustacean in which one eye-peduncle supported, instead of a complete eye, only an imperfect cornea, and out of the centre of this a portion of an antenna was developed. A case has been recorded[63] of a man who had during both dentitions a double tooth in place of the left second incisor, and he inherited this peculiarity from his paternal grandfather. Several cases are known[64] of additional teeth having been developed in the orbit of the eye, and, more especially with horses, in the palate. Hairs occasionally appear in strange situations, as "within the substance of the brain."[65] Certain breeds of sheep bear a whole crowd of horns on their foreheads. As many as five spurs have been seen on both legs of certain Game-fowls. In the Polish fowl the male is ornamented with a topknot of hackles like those on his neck, whilst the female has a top-knot formed of common feathers. In feather-footed pigeons and fowls, feathers like those on the wing arise from the outer side of the legs and toes. Even the elemental parts of the same feather may be transposed; for in the Sebastopol goose, barbules are developed on the divided filaments of the shaft. Imperfect nails sometimes appear on the stumps of the amputated fingers of man[66] and it is an interesting fact that with the snake-like Saurians, which present a series with more and more imperfect limbs, the terminations of the phalanges first disappear, "the nails becoming transferred to their proximal remnants, or even to parts which are not phalanges."[67]

Analogous cases are of such frequent occurrence with plants that they do not strike us with sufficient surprise. Supernumerary petals, stamens, and pistils, are often produced. I have seen a leaflet low down in the compound leaf of *Vicia sativa* replaced by a tendril; and a tendril possesses many peculiar properties, such as spontaneous movement and irritability. The calyx sometimes assumes, either wholly or by stripes, the colour and texture of the corolla. Stamens are so frequently converted into petals, more or less completely, that such cases are passed over as not deserving notice; but as petals have special functions to perform, namely, to protect the included organs, to attract insects, and in not a few cases to guide their entrance by well-adapted contrivances, we can hardly account for the conversion of stamens into petals merely by unnatural or superfluous nourishment. Again, the edge of a petal may occasionally be found including one of the highest products of the plant, namely, pollen; for instance, I have seen the pollen-mass of an Ophrys, which is a very complex structure, developed in the edge of an upper petal. The segments of the calyx of the common pea have been observed partially converted into carpels, including ovules, and with their tips converted into stigmas. Mr. Salter and Dr. Maxwell Masters have found pollen within the ovules of the passion-flower and of the rose. Buds may be developed in the most unnatural positions, as on the petal of a flower. Numerous analogous facts could be given.[68]

I do not know how physiologists look at such facts as the foregoing. According to the doctrine of pangenesis, the gemmules of the transposed organs become developed in the wrong place, from uniting with wrong cells or aggregates of cells during their nascent state; and this would follow from a slight modification in their elective affinities. Nor ought we to feel much surprise at the affinities of cells and gemmules varying, when we remember the many curious cases given in the seventeenth chapter, of plants which absolutely refuse to be fertilised by their own pollen, though abundantly fertile with that of any other individual of the same species, and in some cases only with that of a distinct species. It is manifest that the sexual elective affinities of such plants—

to use the term employed by Gärtner—have been modified. As the cells of adjoining or homologous parts will have nearly the same nature, they will be particularly liable to acquire by variation each other's elective affinities; and we can thus understand to a certain extent such cases as a crowd of horns on the heads of certain sheep, of several spurs on the legs of fowls, hackle-like feathers on the heads of the males of other fowls, and with the pigeon wing-like feathers on their legs and membrane between their toes, for the leg is the homologue of the wing. As all the organs of plants are homologous and spring from a common axis, it is natural that they should be eminently liable to transposition. It ought to be observed that when any compound part, such as an additional limb or an antenna, springs from a false position, it is only necessary that the few first gemmules should be wrongly attached; for these whilst developing would attract other gemmules in due succession, as in the re-growth of an amputated limb. When parts which are homologous and similar in structure, as the vertebræ of snakes or the stamens of polyandrous flowers, etc., are repeated many times in the same organism, closely allied gemmules must be extremely numerous, as well as the points to which they ought to become united; and, in accordance with the foregoing views, we can to a certain extent understand Isid. Geoffroy Saint-Hilaire's law, that parts, which are already multiple, are extremely liable to vary in number.

Variability often depends, as I have attempted to show, on the reproductive organs being injuriously affected by changed conditions; and in this case the gemmules derived from the various parts of the body are probably aggregated in an irregular manner, some superfluous and others deficient. Whether a superabundance of gemmules would lead to the increased size of any part cannot be told; but we can see that their partial deficiency, without necessarily leading to the entire abortion of the part, might cause considerable modifications; for in the same manner as plants, if their own pollen be excluded, are easily hybridised, so, in the case of cells, if the properly succeeding gemmules were absent, they would probably combine easily with other and allied gemmules, as we have just seen with transposed parts.

In variations caused by the direct action of changed conditions, of which several instances have been given, certain parts of the body are directly affected by the new conditions, and consequently throw off modified gemmules, which are transmitted to the offspring. On any ordinary view it is unintelligible how changed conditions, whether acting on the embryo, the young or the adult, can cause inherited modifications. It is equally or even more unintelligible on any ordinary view, how the effects of the long-continued use or disuse of a part, or of changed habits of body or mind, can be inherited. A more perplexing problem can hardly be proposed; but on our view we have only to suppose that certain cells become at last structurally modified; and that these throw off similarly modified gemmules. This may occur at any period of development, and the modification will be inherited at a corresponding period; for the modified gemmules will unite in all ordinary cases with the proper preceding cells, and will consequently be developed at the same period at which the modification first arose. With respect to mental habits or instincts, we are so profoundly ignorant of the relation between the brain and the power of thought that we do not know positively whether a fixed habit induces any change in the nervous system, though this seems highly probable; but when such habit or other mental attribute, or insanity, is inherited, we must believe that some actual modification is transmitted;[69] and this implies, according to our hypothesis, that gemmules derived from modified nerve-cells are transmitted to the offspring.

It is generally necessary that an organism should be exposed during several generations to changed conditions or habits, in order that any modification thus acquired should appear in the offspring. This may be partly due to the changes not being at first marked enough to catch attention, but this explanation is insufficient; and I can account for the fact only by the assumption, which we shall see under the head of reversion is strongly supported, that gemmules derived from each unmodified unit or part are transmitted in large numbers to successive generations, and that the gemmules derived from the same unit after it has been modified go on multiplying under the same favourable conditions which first caused the modification, until at last they become sufficiently numerous to overpower and supplant the old gemmules.

A difficulty may be here noticed; we have seen that there is an important difference in the frequency, though not in the nature, of the variations in plants propagated by sexual and asexual generation. As far as variability depends on the imperfect action of the reproductive organs under changed conditions, we can at once see why plants propagated asexually should be far less variable than those propagated sexually. With respect to the direct action of changed conditions, we know that organisms produced from buds do not pass through the earlier phases of development; they will therefore not be exposed, at that period of life when structure is most readily modified, to the various causes inducing variability in the same manner as are embryos and young larval forms; but whether this is a sufficient explanation I know not.

With respect to variations due to reversion, there is a similar difference between plants propagated from buds and seeds. Many varieties can be propagated securely by buds, but generally or invariably revert to their parent-forms by seed. So, also, hybridised plants can be multiplied to any extent by buds, but are continually liable to reversion by seed,—that is, to the loss of their hybrid or intermediate character. I can offer no satisfactory explanation of these facts. Plants with variegated leaves, phloxes with striped flowers, barberries with seedless fruit, can all be securely propagated by buds taken from the stem or branches; but buds from the roots of these plants almost invariably lose their character and revert to their former condition. This latter fact is also inexplicable, unless buds developed from the roots are as distinct from those on the stem, as is one bud on the stem from another, and we know that these latter behave like independent organisms.

Finally, we see that on the hypothesis of pangenesis variability depends on at least two distinct groups of causes. Firstly, the deficiency, superabundance, and transposition of gemmules, and the redevelopment of those which have long been dormant; the gemmules themselves not having undergone any modification; and such changes will amply account for much fluctuating variability. Secondly, the direct action of changed conditions on the organisation, and of the increased use or disuse of parts; and in this case the gemmules from the modified units will be themselves modified, and, when sufficiently multiplied, will supplant the old gemmules and be developed into new structures.

Turning now to the laws of Inheritance. If we suppose a homogeneous gelatinous protozoon to vary and assume a reddish colour, a minute separated particle would naturally, as it grew to full size, retain the same colour; and we should have the simplest form of inheritance.[70] Precisely the same view may be extended to the infinitely numerous and diversified units of which the whole body of one of the higher animals is composed; the separated particles being our gemmules. We have already sufficiently discussed by implication, the important principle of inheritance at corresponding ages. Inheritance as limited by sex and by the season of the year (for instance with animals becoming white in winter) is intelligible if we may believe that the elective affinities of the units of the body are slightly different in the two sexes, especially at maturity, and in one or both sexes at different seasons, so that they unite with different gemmules. It should be remembered that, in the discussion on the abnormal transposition of organs, we have seen reason to believe that such elective affinities are readily modified. But I shall soon have to recur to sexual and seasonal inheritance. These several laws are therefore explicable to a large extent through pangenesis, and on no other hypothesis which has as yet been advanced.

But it appears at first sight a fatal objection to our hypothesis that a part or organ may be removed during several successive generations, and if the operation be not followed by disease, the lost part reappears in the offspring. Dogs and horses formerly had their tails docked during many generations without any inherited effect; although, as we have seen, there is some reason to believe that the tailless condition of certain sheep-dogs is due to such inheritance. Circumcision has been practised by the Jews from a remote period, and in most cases the effects of the operation are not visible in the offspring; though some maintain that an inherited effect does occasionally appear. If inheritance depends on the presence of disseminated gemmules derived from all the units of the body, why does not the amputation or mutilation of a part, especially if effected on both sexes, invariably affect the offspring? The answer in accordance with our hypothesis probably is that gemmules multiply and are transmitted during a long series of generations—as we see in the reappearance of zebrine stripes on the horse—in the reappearance of muscles and other structures in man which are proper to his lowly organised progenitors, and in many other such cases. Therefore the long-continued inheritance of a part which has been removed during many generations is no real anomaly, for gemmules formerly derived from the part are multiplied and transmitted from generation to generation.

We have as yet spoken only of the removal of parts, when not followed by morbid action: but when the operation is thus followed, it is certain that the deficiency is sometimes inherited. In a former chapter instances were given, as of a cow, the loss of whose horn was followed by suppuration, and her calves were destitute of a horn on the same side of their heads. But the evidence which admits of no doubt is that given by Brown-Séquard with respect to guinea-pigs, which after their sciatic nerves had been divided, gnawed off their own gangrenous toes, and the toes of their offspring were deficient in at least thirteen instances on the corresponding feet. The inheritance of the lost part in several of these cases is all the more remarkable as only one parent was affected; but we know that a congenital deficiency is often transmitted from one parent alone—for instance, the offspring of hornless cattle of either sex, when crossed with perfect animals, are often hornless. How, then, in accordance with our hypothesis can we account for mutilations being sometimes strongly inherited, if they are followed by diseased action? The answer probably is that all the gemmules of the mutilated or amputated part are gradually attracted to the diseased surface during the reparative process, and are there destroyed by the morbid action.

A few words must be added on the complete abortion of organs. When a part becomes diminished by disuse prolonged during many generations, the principle of economy of growth, together with intercrossing, will tend to reduce it still further as previously explained, but this will not account for the complete or almost complete obliteration of, for instance, a minute papilla of cellular tissue representing a pistil, or of a microscopically minute nodule of bone representing a tooth. In certain cases of suppression not yet completed, in which a rudiment occasionally reappears through reversion, dispersed gemmules derived from this part must, according to our view, still exist; we must therefore suppose that the cells, in union with which the rudiment was formerly developed, fail in their affinity for such gemmules, except in the occasional cases of reversion. But when the abortion is complete and final, the gemmules themselves no doubt perish; nor is this in any way improbable, for, though a vast number of active and long-dormant gemmules are nourished in each living creature, yet there must be some limit to their number; and it appears natural that gemmules derived from reduced and useless parts would be more liable to perish than those freshly derived from other parts which are still in full functional activity.

The last subject that need be discussed, namely, Reversion, rests on the principle that transmission and development, though generally acting in conjunction, are distinct powers; and the transmission of gemmules with their subsequent development shows us how this is possible. We plainly see the distinction in the many cases in which a grandfather transmits to his grandson, through his daughter, characters which she does not, or cannot, possess. But before proceeding, it will be advisable to say a few words about latent or dormant characters. Most, or perhaps all, of the secondary characters, which appertain to one sex, lie dormant in the other sex; that is, gemmules capable of development into the secondary male sexual characters are included within the female;

and conversely female characters in the male: we have evidence of this in certain masculine characters, both corporeal and mental, appearing in the female, when her ovaria are diseased or when they fail to act from old age. In like manner female characters appear in castrated males, as in the shape of the horns of the ox, and in the absence of horns in castrated stags. Even a slight change in the conditions of life due to confinement sometimes suffices to prevent the development of masculine characters in male animals, although their reproductive organs are not permanently injured. In the many cases in which masculine characters are periodically renewed, these are latent at other seasons; inheritance as limited by sex and season being here combined. Again, masculine characters generally lie dormant in male animals until they arrive at the proper age for reproduction. The curious case formerly given of a Hen which assumed the masculine characters, not of her own breed but of a remote progenitor, illustrates the close connection between latent sexual characters and ordinary reversion.

With those animals and plants which habitually produce several forms, as with certain butterflies described by Mr. Wallace, in which three female forms and one male form co-exist, or, as with the trimorphic species of Lythrum and Oxalis, gemmules capable of reproducing these different forms must be latent in each individual.

Insects are occasionally produced with one side or one quarter of their bodies like that of the male, with the other half or three-quarters like that of the female. In such cases the two sides are sometimes wonderfully different in structure, and are separated from each other by a sharp line. As gemmules derived from every part are present in each individual of both sexes, it must be the elective affinities of the nascent cells which in these cases differ abnormally on the two sides of the body. Almost the same principle comes into play with those animals, for instance, certain gasteropods and Verruca amongst cirripedes, which normally have the two sides of the body constructed on a very different plan; and yet a nearly equal number of individuals have either side modified in the same remarkable manner.

Reversion, in the ordinary sense of the word, acts so incessantly, that it evidently forms an essential part of the general law of inheritance. It occurs with beings, however propagated, whether by buds or seminal generation, and sometimes may be observed with advancing age even in the same individual. The tendency to reversion is often induced by a change of conditions, and in the plainest manner by crossing. Crossed forms of the first generation are generally nearly intermediate in character between their two parents; but in the next generation the offspring commonly revert to one or both of their grandparents, and occasionally to more remote ancestors. How can we account for these facts? Each unit in a hybrid must throw off, according to the doctrine of pangenesis, an abundance of hybridised gemmules, for crossed plants can be readily and largely propagated by buds; but by the same hypothesis dormant gemmules derived from both pure parent-forms are likewise present; and as these gemmules retain their normal condition, they would, it is probable, be enabled to multiply largely during the lifetime of each hybrid. Consequently the sexual elements of a hybrid will include both pure and hybridised gemmules; and when two hybrids pair, the combination of pure gemmules derived from the one hybrid with the pure gemmules of the same parts derived from the other, would necessarily lead to complete reversion of character; and it is, perhaps, not too bold a supposition that unmodified and undeteriorated gemmules of the same nature would be especially apt to combine. Pure gemmules in combination with hybridised gemmules would lead to partial reversion. And lastly, hybridised gemmules derived from both parent-hybrids would simply reproduce the original hybrid form.[71] All these cases and degrees of reversion incessantly occur.

It was shown in the fifteenth chapter that certain characters are antagonistic to each other or do not readily blend; hence, when two animals with antagonistic characters are crossed, it might well happen that a sufficiency of gemmules in the male alone for the reproduction of his peculiar characters, and in the female alone for the reproduction of her peculiar characters, would not be present; and in this case dormant gemmules derived from the same part in some remote progenitor might easily gain the ascendancy, and cause the reappearance of the long-lost character. For instance, when black and white pigeons, or black and white fowls, are crossed,—colours which do not readily blend,—blue plumage in the one case, evidently derived from the rock-pigeon, and red plumage in the other case, derived from the wild jungle-cock, occasionally reappear. With uncrossed breeds the same result follows, under conditions which favour the multiplication and development of certain dormant gemmules, as when animals become feral and revert to their pristine character. A certain number of gemmules being requisite for the development of each character, as is known to be the case from several spermatozoa or pollen-grains being necessary for fertilisation, and time favouring their multiplication, will perhaps account for the curious cases, insisted on by Mr. Sedgwick, of certain diseases which regularly appear in alternate generations. This likewise holds good, more or less strictly, with other weakly inherited modifications. Hence, as I have heard it remarked, certain diseases appear to gain strength by the intermission of a generation. The transmission of dormant gemmules during many successive generations is hardly in itself more improbable, as previously remarked, than the retention during many ages of rudimentary organs, or even only of a tendency to the production of a rudiment; but there is no reason to suppose that dormant gemmules can be transmitted and propagated for ever. Excessively minute and numerous as they are believed to be, an infinite number derived, during a long course of modification and descent, from each unit of each progenitor, could not be supported or nourished by the organism. But it does not seem improbable that certain gemmules, under favourable conditions, should be retained and go on multiplying for a much longer period than others. Finally, on the view here given, we certainly gain some insight into the wonderful fact that the child may depart from the type of both its parents, and resemble its grandparents, or ancestors removed by many hundreds of generations.

Conclusion.

The hypothesis of Pangenesis, as applied to the several great classes of facts just discussed, no doubt is extremely complex, but so are the facts. The chief assumption is that all the units of the body, besides having the universally admitted power of growing by self-division, throw off minute gemmules which are dispersed through the system. Nor can this assumption be considered as too bold, for we know from the cases of graft-hybridisation that formative matter of some kind is present in the tissues of plants, which is capable of combining with that included in another individual, and of reproducing every unit of the whole organism. But we have further to assume that the gemmules grow, multiply, and aggregate themselves into buds and the sexual elements; their development depending on their union with other nascent cells or units. They are also believed to be capable of transmission in a dormant state, like seeds in the ground, to successive generations.

In a highly-organised animal, the gemmules thrown off from each different unit throughout the body must be inconceivably numerous and minute. Each unit of each part, as it changes during development, and we know that some insects undergo at least twenty metamorphoses, must throw off its gemmules. But the same cells may long continue to increase by self-division, and even become modified by absorbing peculiar nutriment, without necessarily throwing off modified gemmules. All organic beings, moreover, include many dormant gemmules derived from their grandparents and more remote progenitors, but not from all their progenitors. These almost infinitely numerous and minute gemmules are contained within each bud, ovule, spermatozoon, and pollen-grain. Such an admission will be declared impossible; but number and size are only relative difficulties. Independent organisms exist which are barely visible under the highest powers of the microscope, and their germs must be excessively minute. Particles of infectious matter, so small as to be wafted by the wind or to adhere to smooth paper, will multiply so rapidly as to infect within a short time the whole body of a large animal. We should also reflect on the admitted number and minuteness of the molecules composing a particle of ordinary matter. The difficulty, therefore, which at first appears insurmountable, of believing in the existence of gemmules so numerous and small as they must be according to our hypothesis, has no great weight.

The units of the body are generally admitted by physiologists to be autonomous. I go one step further and assume that they throw off reproductive gemmules. Thus an organism does not generate its kind as a whole, but each separate unit generates its kind. It has often been said by naturalists that each cell of a plant has the potential capacity of reproducing the whole plant; but it has this power only in virtue of containing gemmules derived from every part. When a cell or unit is from some cause modified, the gemmules derived from it will be in like manner modified. If our hypothesis be provisionally accepted, we must look at all the forms of asexual reproduction, whether occurring at maturity or during youth, as fundamentally the same, and dependent on the mutual aggregation and multiplication of the gemmules. The re-growth of an amputated limb and the healing of a wound is the same process partially carried out. Buds apparently include nascent cells, belonging to that stage of development at which the budding occurs, and these cells are ready to unite with the gemmules derived from the next succeeding cells. The sexual elements, on the other hand, do not include such nascent cells; and the male and female elements taken separately do not contain a sufficient number of gemmules for independent development, except in the cases of parthenogenesis. The development of each being, including all the forms of metamorphosis and metagenesis, depends on the presence of gemmules thrown off at each period of life, and on their development, at a corresponding period, in union with preceding cells. Such cells may be said to be fertilised by the gemmules which come next in due order of development. Thus the act of ordinary impregnation and the development of each part in each being are closely analogous processes. The child, strictly speaking, does not grow into the man, but includes germs which slowly and successively become developed and form the man. In the child, as well as in the adult, each part generates the same part. Inheritance must be looked at as merely a form of growth, like the self-division of a lowly-organised unicellular organism. Reversion depends on the transmission from the forefather to his descendants of dormant gemmules, which occasionally become developed under certain known or unknown conditions. Each animal and plant may be compared with a bed of soil full of seeds, some of which soon germinate, some lie dormant for a period, whilst others perish. When we hear it said that a man carries in his constitution the seeds of an inherited disease, there is much truth in the expression. No other attempt, as far as I am aware, has been made, imperfect as this confessedly is, to connect under one point of view these several grand classes of facts. An organic being is a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven.

REFERENCES

[1] This hypothesis has been severely criticised by many writers, and it will be fair to give references to the more important articles. The best essay which I have seen is by Prof. Delpino, entitled ‘Sulla Darwiniana Teoria della Pangenesi, 1869,’ of which a translation appeared in ‘Scientific Opinion,’ Sept. 29th, 1869, and the succeeding numbers. He rejects the hypothesis, but criticises it fairly, and I have found his criticisms very useful. Mr. Mivart (‘Genesis of Species,’ 1871, chap. x.) follows Delpino, but adds no new objections of any weight. Dr. Bastian (‘The Beginnings of Life,’ 1872, vol. ii. p. 98) says that the hypothesis “looks like a relic of the old rather than a fitting appanage of the new evolution philosophy.” He shows that I ought not to have used the term “pangenesis,” as it had been previously used by Dr. Gros in another sense. Dr. Lionel Beale (‘Nature,’ May 11th, 1871, p. 26) sneers at the whole doctrine with much acerbity and some justice. Prof. Wigand (‘Schriften der Gesell. der gesammt. Naturwissen. zu Marburg,’ B. ix. 1870) considers the hypothesis as unscientific and worthless. Mr. G. H. Lewes (‘Fortnightly Review,’ Nov. 1st, 1868, p. 503) seems to consider that it may be useful: he makes many good criticisms in

a perfectly fair spirit. Mr. F. Galton, after describing his valuable experiments (‘Proc. Royal Soc.,’ vol. xix. p. 393) on the intertransfusion of the blood of distinct varieties of the rabbit, concludes by saying that in his opinion the results negative beyond all doubt the doctrine of Pangenesis. He informs me that subsequently to the publication of his paper he continued his experiments on a still larger scale for two more generations, without any sign of mongrelism showing itself in the very numerous offspring. I certainly should have expected that gemmules would have been present in the blood, but this is no necessary part of the hypothesis, which manifestly applies to plants and the lowest animals. Mr. Galton, in a letter to ‘Nature’ (April 27th, 1871, p. 502), also criticises various incorrect expressions used by me. On the other hand, several writers have spoken favourably of the hypothesis, but there would be no use in giving references to their articles. I may, however, refer to Dr. Ross’ work, ‘The Graft Theory of Disease; being an application of Mr. Darwin’s hypothesis of Pangenesis,’ 1872, as he gives several original and ingenious discussions.

[2] Quoted by Paget, ‘Lectures on Pathology,’ 1853, p. 159.

[3] Dr. Lachmann, also, observes (‘Annals and Mag. of Nat. History,’ 2nd series, vol. xix. 1857, p. 231) with respect to infusoria, that “fissation and gemmation pass into each other almost imperceptibly.” Again, Mr. W. C. Minor (‘Annals and Mag. of Nat. Hist.,’ 3rd series, vol. xi. p. 328) shows that with Annelids the distinction that has been made between fission and budding is not a fundamental one. *See also* Professor Clark’s work ‘Mind in Nature,’ New York, 1865, pp. 62, 94.

[4] *See* Bonnet, ‘Œuvres d’Hist. Nat.,’ tom. v., 1781, p. 339, for remarks on the budding-out of the amputated limbs of Salamanders.

[5] Paget, ‘Lectures on Pathology,’ 1853, p. 158.

[6] Ibid., pp. 152, 164.

[7] Translated in ‘Annals and Mag. of Nat. Hist.,’ April 1870, p. 272.

[8] Bischoff, as quoted by von Siebold, “Ueber Parthenogenesis,” ‘Sitzung der math. phys. Classe.’ Munich, Nov. 4th, 1871, p. 240. *See also* Quatrefages, ‘Annales des Sc. Nat. Zoolog.,’ 3rd series, 1850, p. 138.

[9] ‘On the Asexual Reproduction of Cecidomyide Larvæ,’ translated in ‘Annals and Mag. of Nat. Hist.,’ March 1866, pp. 167, 171.

[10] Prof. Allman speaks (‘Transact. R. Soc. of Edinburgh,’ vol. xxvi., 1870, p. 102) decisively on this head with respect to the Hydroida: he says, “It is a universal law in the succession of zooids, that no retrogression ever takes place in the series.”

[11] ‘Annals and Mag. of Nat. Hist.,’ 2nd series, vol. xx., 1857, pp. 153-455.

[12] ‘Annales des Sc. Nat.,’ 3rd series, 1850, tom. xiii.

[13] ‘Transact. Phil. Soc.,’ 1851, pp. 196, 208, 210; 1853 pp. 245, 247.

[14] ‘Beitrage zur Kenntniss,’ etc., 1844, s. 345.

[15] ‘Nouvelles Archives du Muséum,’ tom. i. p. 27.

[16] As quoted by Sir J. Lubbock in ‘Nat. Hist. Review,’ 1862, p. 345. Weijenbergh also raised (‘Nature,’ Dec. 21st, 1871, p. 149) two successive generations from unimpregnated females of another lepidopterous insect, *Liparis dispar*. These females did not produce at most one-twentieth of their full complement of eggs, and many of the eggs were worthless. Moreover the caterpillars raised from these unfertilised eggs “possessed far less vitality” than those from fertilised eggs. In the third parthenogenetic generation not a single egg yielded a caterpillar.

[17] ‘Entwickelungsgeschichte der Siphonophora,’ 1869, p. 73.

[18] Spallanzani, ‘An Essay on Animal Reproduction,’ translated by Dr. Maty, 1769, p. 79. Bonnet, ‘Œuvres d’Hist. Nat.,’ tom. v., part i., 4to. edit., 1781, pp. 343, 350.

[19] Vulpian, as quoted by Prof. Faivre, ‘La Variabilité des Espèces,’ 1868, p. 112.

[20] Dr. P. Hoy, ‘The American Naturalist,’ Sept. 1871, p. 579.

[21] Dr. Gunther, in Owen’s ‘Anatomy of Vertebrates,’ vol. i., 1866, p. 567. Spallanzani has made similar observations.

[22] A thrush was exhibited before the British Association at Hull in 1853 which had lost its tarsus, and this member, it was asserted, had been thrice reproduced; having been lost, I presume, each time by disease. Sir J. Paget informs me that he feels some doubt about the facts recorded by Sir J. Simpson (‘Monthly Journal of Medical Science,’ Edinburgh, 1848, new series, vol. ii., p. 890) of the re-growth of limbs in the womb in the case of man.

[23] ‘Atti della Soc. Ital. di Sc. Nat.,’ vol. xi., 1869, p. 493.

[24] Lessona states that this is so in the paper just referred to. *See also* ‘The American Naturalist,’ Sept. 1871, p. 579.

[25] ‘Comptes Rendus,’ Oct. 1st, 1866, and June, 1867.

[26] Bonnet, ‘Oeuvres Hist. Nat.,’ vol. v., p. 294, as quoted by Prof. Rolleston in his remarkable address to the 36th annual meeting of the British Medical Association.

[27] ‘Proc. Boston Soc. of Nat. Hist.,’ vol. xii., 1868-69, p. 1.

[28] ‘Transact. Linn. Soc.,’ vol. xxiv., 1863, p. 62.

[29] ‘Parthenogenesis,’ 1849, pp. 25, 26. Prof. Huxley has some excellent remarks (‘Medical Times,’ 1856, p. 637) on this subject in reference to the development of star-fishes, and shows how curiously metamorphosis graduates into gemmation or zoid-formation, which is in fact the same as metagenesis.

[30] Prof. J. Reay Greene, in Günther’s ‘Record of Zoolog. Lit.,’ 1865, p. 625.

[31] Fritz Müller, ‘Für Darwin,’ 1864, s. 65, 71. The highest authority on crustaceans, Prof. Milne-Edwards, insists (‘Annal. des Sci. Nat.,’ 2nd series, Zoolog., tom. iii., p. 322) on the difference in the metamorphosis of closely-allied genera.

[32] Prof. Allman, in ‘Annals and Mag. of Nat. Hist.,’ 3rd series, vol. xiii., 1864, p. 348; Dr. S. Wright, ibid., vol. viii., 1861, p. 127. *See also* p. 358 for analogous statements by Sars.

[33] ‘Tissus Vivants,’ 1866, p. 22.

[34] ‘Cellular Pathology,’ translated by Dr. Chance, 1860, pp. 14, 18, 83, 460.

[35] Paget, ‘Surgical Pathology,’ vol. i., 1853, pp. 12-14.

[36] Ibid., p. 19.

[37] *See* Prof. Mantegazza’s interesting work, ‘Degli innesti Animali,’ etc., Milano, 1865, p. 51, tab. 3.

[38] ‘De la Production Artificielle des Os,’ p. 8.

[39] Isidore Geoffroy Saint-Hilaire, ‘Hist. des Anomalies,’ tom. ii., pp. 549, 560, 562; Virchow, ibid., p. 484. Lawson Tait, ‘The Pathology of Diseases of the Ovaries,’ 1874, pp. 61, 62.

[40] For the most recent classification of cells, *see* Ernst Hackel, ‘Generelle Morpholog.,’ B. ii., 1866, s. 275.

[41] Dr. W. Turner, ‘The Present Aspect of Cellular Pathology,’ ‘Edinburgh Medical Journal,’ April 1863.

[42] Mr. G. H. Lewes (‘Fortnightly Review,’ Nov. 1st, 1868, p. 506) remarks on the number of writers who have advanced nearly similar views. More than two thousand years ago Aristotle combated a view of this kind, which, as I hear from Dr. W. Ogle, was held by Hippocrates and others. Ray, in his ‘Wisdom of God’ (2nd edit., 1692, p. 68), says that “every part of the body seems to club and contribute to the seed.” The “organic molecules” of Buffon (‘Hist. Nat. Gen.,’ edit. of 1749, tom. ii., pp. 54, 62, 329, 333, 420,

425) appear at first sight to be the same as the gemmules of my hypothesis, but they are essentially different. Bonnet (‘Œuvres d’Hist. Nat.,’ tom. v., part i., 1781, 4to edit., p. 334) speaks of the limbs having germs adapted for the reparation of all possible losses; but whether these germs are supposed to be the same with those within buds and the sexual organs is not clear. Prof. Owen says (‘Anatomy of Vertebrates,’ vol. iii., 1868, p. 813) that he fails to see any fundamental difference between the views which he propounded in his ‘Parthenogenesis’ (1849, pp. 5-8), and which he now considers as erroneous, and my hypothesis of pangenesis: but a reviewer (‘Journal of Anat. and Phys.,’ May 1869, p. 441) shows how different they really are. I formerly thought that the “physiological units” of Herbert Spencer (‘Principles of Biology,’ vol. i., chaps. iv. and viii., 1863-64) were the same as my gemmules, but I now know that this is not the case. Lastly, it appears from a review of the present work by Prof. Mantegazza (‘Nuova Antologia, Maggio,’ 1868), that he (in his ‘Elementi di Igiene,’ Ediz. iii., p. 540) clearly foresaw the doctrine of pangenesis.

[43] Mr. Lowne has observed (‘Journal of Queckett Microscopical Club,’ Sept. 23rd, 1870) certain remarkable changes in the tissues of the larva of a fly, which makes him believe “it possible that organs and organisms are sometimes developed by the aggregation of excessively minute gemmules, such as those which Mr. Darwin’s hypothesis demands.”

[44] ‘Annales des Sc. Nat.,’ 3rd series, Bot., tom. xiv., 1850, p. 244.

[45] ‘Disease Germs,’ p. 20.

[46] *See* some very interesting papers on this subject by Dr. Beale, in ‘Medical Times and Gazette,’ Sept. 9th, 1865, pp. 273, 330.

[47] Third Report of the R. Comm. on the Cattle Plague, as quoted in ‘Gardener’s Chronicle,’ 1866, p. 446.

[48] Mr. F. Buckland found 6,867,840 eggs in a cod-fish (‘Land and Water,’ 1868, p. 62). An Ascaris produces about 64,000,000 eggs (Carpenter’s ‘Comp. Phys.,’ 1854, p. 590). Mr. J. Scott, of the Royal Botanic Garden of Edinburgh, calculated, in the same manner as I have done for some British Orchids (‘Fertilisation of Orchids,’ p. 344), the number of seeds in a capsule of an Acropera and found the number to be 371,250. Now this plant produces several flowers on a raceme, and many racemes during a season. In an allied genus, Gongora, Mr. Scott has seen twenty capsules produced on a single raceme; ten such racemes on the Acropera would yield above seventy-four millions of seed.

[49] Paget, ‘Lectures on Pathology,’ p. 27; Virchow, ‘Cellular Pathology,’ translated by Dr. Chance, pp. 123, 126, 294. Claude Bernard, ‘Des Tissus Vivants,’ pp. 177, 210, 337; Müller, ‘Physiology,’ Eng. translat., p. 290.

[50] Prof. Ray Lankester has discussed several of the points here referred to as bearing on pangenesis, in his interesting essay, ‘On Comparative Longevity in Man and the Lower Animals,’ 1870, pp. 33, 77, etc.

[51] Dr. Ross refers to this subject in his ‘Graft Theory of Disease,’ 1872, p. 53.

[52] Virchow, ‘Cellular Pathology,’ translated by Dr. Chance, 1860, pp. 60, 162, 245, 441, 454.

[53] Ibid., pp. 412-426.

[54] *See* some good criticisms on this head by Delpino and by Mr. G. H. Lewes in the ‘Fortnightly Review,’ Nov. 1st, 1868, p. 509.

[55] Mr. Herbert Spencer (‘Principles of Biology,’ vol. ii., p. 430) has fully discussed this antagonism.

[56] The male salmon is known to breed at a very early age. The Triton and Siredon, whilst retaining their larval branchiæ, according to Filippi and Duméril (‘Annals and Mag. of Nat. Hist.,’ 3rd series, 1866, p. 157) are capable of reproduction. Ernst Haeckel has recently (‘Monatsbericht Akad. Wiss. Berlin,’ Feb. 2nd, 1865) observed the surprising case of a medusa, with its reproductive organs active, which produces by budding a widely different form of medusa; and this latter also has the power of sexual reproduction. Krohn has shown (‘Annals and Mag. of Nat. Hist.,’ 3rd series, vol. xix., 1862, p. 6) that certain other medusæ, whilst sexually mature, propagate by gemmæ. *See also* Kolliker, ‘Morphologie und Entwickelungsgeschichte des Pennatulidenstammes,’ 1872, p. 12.

[57] *See* his excellent discussion on this subject in ‘Nouvelles Archives du Museum,’ tom. i., p. 151.

[58] ‘Proc. Boston Soc. of Nat. Hist.,’ republished in ‘Scientific Opinion,’ Nov. 10th, 1869, p. 488.

[59] Todd’s ‘Cyclop. of Anat. and Phys.,’ vol. iv., 1849-52, p. 975.

[60] ‘Compte Rendus,’ Nov. 14th, 1865, p. 800.

[61] As previously remarked by Quatrefages, in his ‘Métamorphoses de l’Homme,’ etc., 1862, p. 129.

[62] Günther’s ‘Zoological Record,’ 1864, p. 279.

[63] Sedgwick, ‘Medico-Chirurg. Review,’ April 1863, p. 454.

[64] Isid. Geoffroy Saint-Hilaire, ‘Hist. des Anomalies,’ tom. i., 1832, pp. 435, 657; and tom. ii., p. 560.

[65] Virchow, ‘Cellular Pathology,’ 1860, p. 66.

[66] Müller’s ‘Phys.,’ Eng. Translat., vol. i., 1833, p. 407. A case of this kind has lately been communicated to me.

[67] Dr. Fürbringer, 'Die Knochen etc. bei den schlangenähnlichen Sauriern,' as reviewed in 'Journal of Anat. and Phys.,' May 1870, p. 286.

[68] Moquin-Tandon, 'Tératologie Vég.,' 1841, pp. 218, 220, 353. For the case of the pea, *see* 'Gardener's Chronicle,' 1866, p. 897. With respect to pollen within ovules, *see* Dr. Masters in 'Science Review,' Oct. 1873, p. 369. The Rev. J. M. Berkeley describes a bud developed on a petal of a Clarkia, in 'Gardener's Chronicle,' April 28th, 1866.

[69] *See* some remarks to this effect by Sir H. Holland in his 'Medical Notes,' 1839, p. 32.

[70] This is the view taken by Prof. Haeckel, in his 'Generelle Morphologie' (B. ii. s. 171), who says: "Lediglich die partielle Identität der specifisch constituirten Materie im elterlichen und im kindlichen Organismus, die Theilung dieser Materie bei der Fortpflanzung, ist die Ursache der Erblichkeit."

[71] In these remarks I, in fact, follow Naudin, who speaks of the elements or essences of the two species which are crossed. *See* his excellent memoir in the 'Nouvelles Archives du Muséum,' tom. i., p. 151.

CHAPTER XXVIII.
CONCLUDING REMARKS.

DOMESTICATION—NATURE AND CAUSES OF VARIABILITY—SELECTION—DIVERGENCE AND DISTINCTNESS OF CHARACTER—EXTINCTION OF RACES—CIRCUMSTANCES FAVOURABLE TO SELECTION BY MAN—ANTIQUITY OF CERTAIN RACES—THE QUESTION WHETHER EACH PARTICULAR VARIATION HAS BEEN SPECIALLY PREORDAINED.

As summaries have been added to nearly all the chapters, and as, in the chapter on pangenesis, various subjects, such as the forms of reproduction, inheritance, reversion, the causes and laws of variability, etc., have been recently discussed, I will here only make a few general remarks on the more important conclusions which may be deduced from the multifarious details given throughout this work.

Savages in all parts of the world easily succeed in taming wild animals; and those inhabiting any country or island, when first visited by man, would probably have been still more easily tamed. Complete subjugation generally depends on an animal being social in its habits, and on receiving man as the chief of the herd or family. In order that an animal should be domesticated it must be fertile under changed conditions of life, and this is far from being always the case. An animal would not have been worth the labour of domestication, at least during early times, unless of service to man. From these circumstances the number of domesticated animals has never been large. With respect to plants, I have shown in the ninth chapter how their varied uses were probably first discovered, and the early steps in their cultivation. Man could not have known, when he first domesticated an animal or plant, whether it would flourish and multiply when transported to other countries, therefore he could not have been thus influenced in his choice. We see that the close adaptation of the reindeer and camel to extremely cold and hot countries has not prevented their domestication. Still less could man have foreseen whether his animals and plants would vary in succeeding generations and thus give birth to new races; and the small capacity of variability in the goose has not prevented its domestication from a remote epoch.

With extremely few exceptions, all animals and plants which have been long domesticated have varied greatly. It matters not under what climate, or for what purpose they are kept, whether as food for man or beast, for draught or hunting, for clothing or mere pleasure,—under all these circumstances races have been produced which differ more from one another than do the forms which in a state of nature are ranked as different species. Why certain animals and plants have varied more under domestication than others we do not know, any more than why some are rendered more sterile than others under changed conditions of life. But we have to judge of the amount of variation which our domestic productions have undergone, chiefly by the number and amount of difference between the races which have been formed, and we can often clearly see why many and distinct races have not been formed, namely, because slight successive variations have not been steadily accumulated; and such variations will never be accumulated if an animal or plant be not closely observed, much valued, and kept in large numbers.

The fluctuating, and, as far as we can judge, never-ending variability of our domesticated productions,—the plasticity of almost their whole organisation,--is one of the most important lessons which we learn from the numerous details given in the earlier chapters of this work. Yet domesticated animals and plants can hardly have been exposed to greater changes in their conditions of life than have many natural species during the incessant geological, geographical, and climatal changes to which the world has been subject; but domesticated productions will often have been exposed to more sudden changes and to less continuously uniform conditions. As man has domesticated so many animals and plants belonging to widely different classes, and as he certainly did not choose with prophetic instinct those species which would vary most, we may infer that all natural species, if exposed to analogous conditions, would, on an average, vary to the same degree. Few men at the present day will maintain that animals and plants were created with a tendency to vary, which long remained dormant, in order that fanciers in after ages might rear, for instance, curious breeds of the fowl, pigeon, or canary-bird.

From several causes it is difficult to judge of the amount of modification which our domestic productions have undergone. In some cases the primitive parent-stock has become extinct; or it cannot be recognised with certainty, owing to its supposed descendants having been so much modified. In other cases two or more closely-allied forms, after being domesticated, have crossed; and then it is difficult to estimate how much of the character of the present descendants ought to be attributed to variation, and how much to the influence of the several parent-stocks. But the degree to which our domesticated breeds have been modified by the crossing of distinct species has probably been much exaggerated by some authors. A few individuals of one form would seldom permanently affect another form existing in greater numbers; for, without careful selection, the stain of the foreign blood would soon be obliterated, and during early and barbarous times, when our animals were first domesticated, such care would seldom have been taken.

There is good reason to believe in the case of the dog, ox, pig, and of some other animals, that several of our races are descended from distinct wild prototypes; nevertheless the belief in the multiple origin of our domesticated animals has been extended by some few naturalists and by many breeders to an unauthorised extent. Breeders refuse to look at the whole subject under a single point of view; I have heard it said by a man, who maintained that our fowls were descended from at least half-a-dozen aboriginal species, that the evidence of the common origin of pigeons, ducks and rabbits, was of no avail with respect to fowls. Breeders overlook the improbability of many species having been domesticated at an early and barbarous period. They do not consider the improbability of species having existed in a state of nature which, if they resembled our present domestic breeds, would have been highly abnormal in comparison with all their congeners. They maintain that certain species, which formerly existed, have become extinct, or are now unknown, although formerly known. The assumption of so much recent extinction is no difficulty in their eyes; for they do not judge of its probability by the facility or difficulty of the extinction of other closely-allied wild forms. Lastly, they often ignore the whole subject of geographical distribution as completely as if it were the result of chance.

Although from the reasons just assigned it is often difficult to judge accurately of the amount of change which our domesticated productions have undergone, yet this can be ascertained in the cases in which all the breeds are known to be descended from a single species,—as with the pigeon, duck, rabbit, and almost certainly with the fowl; and by the aid of analogy this can be judged of to a certain extent with domesticated animals descended from several wild stocks. It is impossible to read the details given in the earlier chapters and in many published works, or to visit our various exhibitions, without being deeply impressed with the extreme variability of our domesticated animals and cultivated plants. No part of the organisation escapes the tendency to vary. The variations generally affect parts of small vital or physiological importance, but so it is with the differences which exist between closely-allied species. In these unimportant characters there is often a greater difference between the breeds of the same species than between the natural species of the same genus, as Isidore Geoffroy has shown to be the case with size, and as is often the case with the colour, texture, form, etc., of the hair, feathers, horns, and other dermal appendages.

It has often been asserted that important parts never vary under domestication, but this is a complete error. Look at the skull of the pig in any one of the highly improved breeds, with the occipital condyles and other parts greatly modified; or look at that of the niata ox. Or, again, in the several breeds of the rabbit, observe the elongated skull, with the differently shaped occipital foramen, atlas, and other cervical vertebrae. The whole shape of the brain, together with the skull, has been modified in Polish fowls; in other breeds of the fowl the number of the vertebrae and the forms of the cervical vertebrae have been changed. In certain pigeons the shape of the lower jaw, the relative length of the tongue, the size of the nostrils and eyelids, the number and shape of the ribs, the form and size of the oesophagus, have all varied. In certain quadrupeds the length of the intestines has been much increased or diminished. With plants we see wonderful differences in the stones of various fruits. In the Cucurbitaceae several highly important characters have varied, such as the sessile position of the stigmas on the ovarium, the position of the carpels, and the projection of the ovarium out of the receptacle. But it would be useless to run through the many facts given in the earlier chapters.

It is notorious how greatly the mental disposition, tastes, habits, consensual movements, loquacity or silence, and tone of voice have varied and been inherited in our domesticated animals. The dog offers the most striking instance of changed mental attributes, and these differences cannot be accounted for by descent from distinct wild types.

New characters may appear and old ones disappear at any stage of development, being inherited at a corresponding stage. We see this in the difference between the eggs, the down on the chickens and the first plumage of the various breeds of the fowl; and still more plainly in the differences between the caterpillars and cocoons of the various breeds of the silk-moth. These facts, simple as they appear, throw light on the differences between the larval and adult states of allied natural species, and on the whole great subject of embryology. New characters first appearing late in life are apt to become attached exclusively to that sex in which they first arose, or they may be developed in a much higher degree in this than in the other sex; or again, after having become attached to one sex, they may be transferred to the opposite sex. These facts, and more especially the circumstance that new characters seem to be particularly liable, from some unknown cause, to become attached to the male sex, have an important bearing on the acquirement of secondary sexual characters by animals in a state of nature.

It has sometimes been said that our domestic races do not differ in constitutional peculiarities, but this cannot be maintained. In our improved cattle, pigs, etc., the period of maturity, including that of the second dentition, has been much hastened. The period of gestation varies much, and has been modified in a fixed manner in one or two cases. In some breeds of poultry and pigeons the period at which the down and the first plumage are acquired, differs. The number of moults through which the larvae of silk-moths pass, varies. The tendency to fatten, to yield much milk, to produce many young or eggs at a birth or during life, differs in different breeds. We find different degrees of adaptation to climate, and different tendencies to certain diseases, to the attacks of parasites, and to the action of certain vegetable poisons. With plants, adaptation to certain soils, the power of resisting frost, the period of flowering and fruiting, the duration of life, the period of shedding the leaves or of retaining them throughout the winter, the proportion and nature of certain chemical compounds in the tissues or seeds, all vary.

There is, however, one important constitutional difference between domestic races and species; I refer to the sterility which almost invariably follows, in a greater or less degree, when species are crossed, and to the perfect fertility of the most distinct domestic races, with the exception of a very few plants, when similarly crossed. It is certainly a most remarkable fact that many closely-allied species, which in appearance differ extremely little, should yield when crossed only a few more or less sterile offspring, or none at all; whilst domestic races which differ conspicuously from each other are, when united, remarkably fertile, and yield perfectly fertile offspring. But this fact is not in reality so inexplicable as it at first appears. In the first place, it was clearly shown in the nineteenth chapter that the sterility of crossed species does not depend chiefly on differences in their external structure or general constitution, but on differences in the reproductive system, analogous to those which cause the lessened fertility of the illegitimate unions of dimorphic and trimorphic plants. In the second place, the Pallasian doctrine, that species after having been long domesticated lose their natural tendency to sterility when crossed, has been shown to be highly probable or almost certain. We cannot avoid this conclusion when we reflect on the parentage and present fertility of the several breeds of the dog, of the Indian or humped and European cattle, and of the two chief kinds of pigs. Hence it would be unreasonable to expect that races formed under domestication should acquire sterility when crossed, whilst at the same time we admit that domestication eliminates the normal sterility of crossed species. Why with closely-allied species their reproductive systems should almost invariably have been modified in so peculiar a manner as to be mutually incapable of acting on each other—though in unequal degrees in the two sexes, as shown by the difference in fertility between reciprocal crosses of the same species—we do not know, but may with much probability infer the cause to be as follows. Most natural species have been habituated to nearly uniform conditions of life for an incomparably longer time than have domestic races; and we positively know that changed conditions exert an especial and powerful influence on the reproductive system. Hence this difference may well account for the difference in the power of reproduction between domestic races when crossed and species when crossed. It is probably in chief part owing to the same cause that domestic races can be suddenly transported from one climate to another, or placed under widely different conditions, and yet retain in most cases their fertility unimpaired; whilst a multitude of species subjected to lesser changes are rendered incapable of breeding.

The offspring of crossed domestic races and of crossed species resemble each other in most respects, with the one important exception of fertility; they often partake in the same unequal degree of the characters of their parents, one of which is often prepotent over the other; and they are liable to reversion of the same kind. By successive crosses one species may be made to absorb completely another, and so it notoriously is with races. The latter resemble species in many other ways. They sometimes inherit their newly-acquired characters almost or even quite as firmly as species. The conditions leading to variability and the laws governing its nature appear to be the same in both. Varieties can be classed in groups under groups, like species under genera, and these under families and orders; and the classification may be either artificial,—that is, founded on any arbitrary character,—or natural. With varieties a natural classification is certainly founded, and with species is apparently founded, on community of descent, together with the amount of modification which the forms have undergone. The characters by which domestic varieties differ from one another are more variable than those distinguishing species, though hardly more so than with certain polymorphic species; but this greater degree of variability is not surprising, as varieties have generally been exposed within recent times to fluctuating conditions of life, and are much more liable to have been crossed; they are also in many cases still undergoing, or have recently undergone, modification by man’s methodical or unconscious selection.

Domestic varieties as a general rule certainly differ from one another in less important parts than do species; and when important differences occur, they are seldom firmly fixed; but this fact is intelligible, if we consider man’s method of selection. In the living animal or plant he cannot observe internal modifications in the more important organs; nor does he regard them as long as they are compatible with health and life. What does the breeder care about any slight change in the molar teeth of his pigs, or for an additional molar tooth in the dog; or for any change in the intestinal canal or other internal organ? The breeder cares for the flesh of his cattle being well marbled with fat, and for an accumulation of fat within the abdomen of his sheep, and this he has effected. What would the floriculturist care for any change in the structure of the ovarium or of the ovules? As important internal organs are certainly liable to numerous slight variations, and as these would probably be transmitted, for many strange monstrosities are inherited, man could undoubtedly effect a certain amount of change in these organs. When he has produced any modification in an important part, he has generally done so unintentionally, in correlation with some other conspicuous part. For instance, he has given ridges and protuberances to the skulls of fowls, by attending to the form of the comb, or to the plume of feathers on the head. By attending to the external form of the pouter-pigeon, he has enormously increased the size of the oesophagus, and has added to the number of the ribs, and given them greater breadth. With the carrier-pigeon, by increasing through steady selection the wattles on the upper mandible, he has greatly modified the form of the lower mandible; and so in many other cases. Natural species, on the other hand, have been modified exclusively for their own good, to fit them for infinitely diversified conditions of life, to avoid enemies of all kinds, and to struggle against a host of competitors. Hence, under such complex conditions, it would often happen that modifications of the most varied kinds, in important as well as in unimportant parts, would be advantageous or even necessary; and they would slowly but surely be acquired through the survival of the fittest. Still more important is the fact that various indirect modifications would likewise arise through the law of correlated variation.

Domestic breeds often have an abnormal or semi-monstrous character, as amongst dogs, the Italian greyhound, bulldog, Blenheim spaniel, and bloodhound,—some breeds of cattle and pigs,—several breeds of the fowl,—and the chief breeds of the pigeon. In such abnormal breeds, parts which differ but slightly or not at all in the allied natural species, have been greatly modified. This may be accounted for by man’s often selecting, especially at first, conspicuous and semi-monstrous deviations of structure. We should, however, be cautious in deciding what deviations ought to be called monstrous: there can hardly be a doubt that, if the brush of horse-like hair on the breast of the turkey-cock had first appeared in the domesticated bird, it would have been considered as a monstrosity; the great plume of feathers on the head of the Polish cock has been thus designated, though plumes are common on the heads of many kinds of birds; we might call the wattle or corrugated skin round the base of the beak of the English carrier-pigeon a monstrosity, but we do not thus speak of the globular fleshy excrescence at the base of the beak of the *Carpophaga oceanica*.

Some authors have drawn a wide distinction between artificial and natural breeds; although in extreme cases the distinction is plain, in many other cases it is arbitrary; the difference depending chiefly on the kind of selection which has been applied. Artificial breeds are those which have been intentionally improved by man; they frequently have an unnatural appearance, and are especially liable to lose their characters through reversion and continued variability. The so-called natural breeds, on the other hand, are those which are found in semi-civilised countries, and which formerly inhabited separate districts in nearly all the European kingdoms. They have been rarely acted on by man’s intentional selection; more frequently by unconscious selection, and partly by natural selection, for animals kept in semi-civilised countries have to provide largely for their own wants. Such natural breeds will also have been directly acted on by the differences, though slight, in the surrounding conditions.

There is a much more important distinction between our several breeds, namely, in some having originated from a strongly-marked or semi-monstrous deviation of structure, which, however, may subsequently have been augmented by selection; whilst others have been formed in so slow and insensible a manner, that if we could see their early progenitors we should hardly be able to say when or how the breed first arose. From the history of the racehorse, greyhound, gamecock, etc., and from their general appearance, we may feel nearly confident that they were formed by a slow process of improvement; and we know that this has been the case with the carrier-pigeon, as well as with some other pigeons. On the other hand, it is certain that the ancon and mauchamp breeds of sheep, and almost certain that the niata cattle, turnspit, and pug-dogs, jumper and frizzled fowls, short-faced tumbler pigeons, hook-billed ducks, etc., suddenly appeared in nearly the same state as we now see them. So it has been with many cultivated plants. The frequency of these cases is likely to lead to the false belief that natural species have often originated in the same abrupt manner. But we have no evidence of the appearance, or at least of the continued procreation, under nature, of abrupt modifications of structure; and various general reasons could be assigned against such a belief.

On the other hand, we have abundant evidence of the constant occurrence under nature of slight individual differences of the most diversified kinds; and we are thus led to conclude that species have generally originated by the natural selection of extremely slight differences. This process may be strictly compared with the slow and gradual improvement of the racehorse, greyhound, and gamecock. As every detail of structure in each species has to be closely adapted to its habits of life, it will rarely happen that one part alone will be modified; but, as was formerly shown, the co-adapted modifications need not be absolutely simultaneous. Many variations, however, are from the first connected by the law of correlation. Hence it follows that even closely-allied species rarely or never differ from one another by one character alone; and the same remark is to a certain extent applicable to domestic races; for these, if they differ much, generally differ in many respects.

Some naturalists boldly insist[1] that species are absolutely distinct productions, never passing by intermediate links into one another; whilst they maintain that domestic varieties can always be connected either with one another or with their parent-forms. But if we could always find the links between the several breeds of the dog, horse, cattle, sheep, pigs, etc., there would not have been such incessant doubts whether they were descended from one or several species. The greyhound genus, if such a term may be used, cannot be closely connected with any other breed, unless, perhaps, we go back to the ancient Egyptian monuments. Our English bulldog also forms a very distinct breed. In all these cases crossed breeds must of course be excluded, for distinct natural species can thus be likewise connected. By what links can the Cochin fowl be closely united with others? By searching for breeds still preserved in distant lands, and by going back to historical records, tumbler-pigeons, carriers, and barbs can be closely connected with the parent rock-pigeon; but we cannot thus connect the turbit or the pouter. The degree of distinctness between the various domestic breeds depends on the amount of modification which they have undergone, and more especially on the neglect and final extinction of intermediate and less-valued forms.

It has often been argued that no light is thrown on the changes which natural species are believed to undergo from the admitted changes of domestic races, as the latter are said to be mere temporary productions, always reverting, as soon as they become feral, to their pristine form. This argument has been well combated by Mr. Wallace[2] and full details were given in the thirteenth chapter, showing that the tendency to reversion in feral animals and plants has been greatly exaggerated, though no doubt it exists to a certain extent. It would be opposed to all the principles inculcated in this work, if domestic animals, when exposed to new conditions and compelled to struggle for their own wants against a host of foreign competitors, were not modified in the course of time. It should also be remembered that many characters lie latent in all organic beings, ready to be evolved under fitting conditions; and in breeds modified within recent times, the tendency to reversion is particularly strong. But the antiquity of some of our breeds clearly proves that they remain nearly constant as long as their conditions of life remain the same.

It has been boldly maintained by some authors that the amount of variation to which our domestic productions are liable is strictly limited; but this is an assertion resting on little evidence. Whether or not the amount of change in any particular direction is limited, the tendency to general variability is, as far as we can judge, unlimited. Cattle, sheep, and pigs have varied under domestication from the remotest period, as shown by the researches of Rutimeyer and others; yet these animals have been improved to an unparalleled degree, within quite recent times, and this implies continued variability of structure. Wheat, as we know from the remains found in the Swiss lake-dwellings, is one of the most anciently cultivated plants, yet at the present day new and better varieties frequently arise. It may be that an ox will never be produced of larger size and finer proportions, or a racehorse fleeter, than our present animals, or a gooseberry larger than the London variety; but he would be a bold man who would assert that the extreme limit in these respects has been finally attained. With flowers and fruit it has repeatedly been asserted that perfection has been reached, but the standard has soon been excelled. A breed of pigeons may never be produced with a beak shorter than that of the present short-faced tumbler, or with one longer than that of the English carrier, for these birds have weak constitutions and are bad breeders; but shortness and length of beak are the points which have been steadily improved during the last 150 years, and some of the best judges deny that the goal has yet been reached. From reasons which could be assigned, it is probable that parts which have now reached their maximum development, might, after remaining constant during a long period, vary again in the direction of increase under new conditions of life. But there must be, as Mr. Wallace has remarked with much truth,[3] a limit to change in certain directions both with natural and domestic productions; for instance, there must be a limit to the fleetness of any terrestrial animal, as this will be determined by the friction to be overcome, the weight to be carried, and the power of contraction in the muscular fibres. The English racehorse may have reached this limit; but it already surpasses in fleetness its own wild progenitor and all other equine species. The short-faced tumbler-pigeon has a beak shorter, and the carrier a beak longer, relatively to the size of their bodies, than that of any natural species of the family. Our apples, pears and gooseberries bear larger fruit than those of any natural species of the same genera; and so in many other cases.

It is not surprising, seeing the great difference between many domestic breeds, that some few naturalists have concluded that each is descended from a distinct aboriginal stock, more especially as the principle of selection has been ignored, and the high antiquity of man, as a breeder of animals, has only recently become known. Most naturalists, however, freely admit that our various breeds, however dissimilar, are descended from a single stock, although they do not know much about the art of breeding, cannot show the connecting links, nor say where and when the breeds arose. Yet these same naturalists declare, with an air of philosophical caution, that they will never admit that one natural species has given birth to another until they behold all the transitional steps. Fanciers use exactly the same language with respect to domestic breeds; thus, an author of an excellent treatise on pigeons says he will never allow that the carrier and fantail are the descendants of the wild rock-pigeon, until the transitions have "actually been observed, and can be repeated whenever man chooses to set about the task." No doubt it is difficult to realise that slight changes added up during long centuries can produce such great results; but he who wishes to understand the origin of domestic breeds or of natural species must overcome this difficulty.

The causes which excite and the laws which govern variability have been discussed so lately, that I need here only enumerate the leading points. As domesticated organisms are much more liable to slight deviations of structure and to monstrosities than species living under their natural conditions, and as widely-ranging species generally vary more than those which inhabit restricted areas, we may infer that variability mainly depends on changed conditions of life. We must not overlook the effects of the unequal combination of the characters derived from both parents, or reversion to former progenitors. Changed conditions have an especial tendency to render the reproductive organs more or less impotent, as shown in the chapter devoted to this subject; and these organs consequently often fail to transmit faithfully the parental characters. Changed conditions also act directly and definitely on the organisation, so that all or nearly all the individuals of the same species thus exposed become modified in the same manner; but why this or that part is especially affected we can seldom or ever say. In most cases, however, a change in the conditions seems to act indefinitely, causing diversified variations in nearly the same manner as exposure to cold or the absorption of the same poison affects different individuals in different ways. We have reason to suspect that an habitual excess of highly-nutritious food, or an excess relatively to the wear and tear of the organisation from exercise, is a powerful exciting cause of variability. When we see the symmetrical and complex outgrowths, caused by a minute drop of the poison of a gall-insect, we may believe that slight changes in the chemical nature of the sap or blood would lead to extraordinary modifications of structure.

The increased use of a muscle with its various attached parts, and the increased activity of a gland or other organ, lead to their increased development. Disuse has a contrary effect. With domesticated productions, although their organs sometimes become rudimentary through abortion, we have no reason to suppose that this has ever followed solely from disuse. With natural species, on the contrary, many organs appear to have been rendered rudimentary through disuse, aided by the principle of the economy of growth together with intercrossing. Complete abortion can be accounted for only by the hypothesis given in the last chapter, namely, the final destruction of the germs or gemmules of useless parts. This difference between species and domestic varieties may be partly accounted for by disuse having acted on the latter for an insufficient length of time, and partly from their exemption from any severe struggle for existence entailing rigid economy in the development of each part, to which all species under nature are subjected. Nevertheless the law of compensation or balancement, which likewise depends on the economy of growth, apparently has affected to a certain extent our domesticated productions.

As almost every part of the organisation becomes highly variable under domestication, and as variations are easily selected both consciously and unconsciously, it is very difficult to distinguish between the effects of the selection of indefinite variations and the direct action of the conditions of life. For instance, it is possible that the feet of our water-dogs and of the American dogs which have to travel much over the snow, may have become partially webbed from the stimulus of widely extending their toes; but it is more probable that the webbing, like the membrane between the toes of certain pigeons, spontaneously appeared and was afterwards increased by the best swimmers and the best snow-travellers being preserved during many generations. A fancier who wished to decrease the size of his bantams or tumbler-pigeons would never think of starving them, but would select the smallest individuals which spontaneously appeared. Quadrupeds are sometimes born destitute of hair and hairless breeds have been formed, but there is no reason to believe that this is caused by a hot climate. Within the tropics heat often causes sheep to lose their fleeces; on the other hand, wet and cold act as a direct stimulus to the growth of hair; but who will pretend to decide how far the thick fur of arctic animals, or their white colour, is due to the direct action of a severe climate, and how far to the preservation of the best-protected individuals during a long succession of generations?

Of all the laws governing variability, that of correlation is one of the most important. In many cases of slight deviations of structure as well as of grave monstrosities, we cannot even conjecture what is the nature of the bond of connexion. But between homologous parts—between the fore and hind limbs—between the hair, hoofs, horns, and teeth—which are closely similar during their early development and which are exposed to similar conditions, we can see that they would be eminently liable to be modified in the same manner. Homologous parts, from having the same nature, are apt to blend together, and, when many exist, to vary in number.

Although every variation is either directly or indirectly caused by some change in the surrounding conditions, we must never forget that the nature of the organisation which is acted on, is by far the more important factor in the result. We see this in different organisms, which when placed under similar conditions vary in a different manner, whilst closely-allied organisms under dissimilar conditions often vary in nearly the same manner. We see this, in the same modification frequently reappearing in the same variety at long intervals of time, and likewise in the several striking cases given of analogous or parallel variations. Although some of these latter cases are due to reversion, others cannot thus be accounted for.

From the indirect action of changed conditions on the organisation, owing to the reproductive organs being thus affected—from the direct action of such conditions, and these will cause the individuals of the same species either to vary in the same manner, or differently in accordance with slight differences in their constitution—from the effects of the increased or decreased use of parts—and from correlation,—the variability of our domesticated productions is complicated to an extreme degree. The whole organisation becomes slightly plastic. Although each modification must have its own exciting cause, and though each is subjected to law, yet we can so rarely trace the precise relation between cause and effect, that we are tempted to speak of variations as if they arose spontaneously. We may even call them accidental, but this must be only in the sense in which we say that a fragment of rock dropped from a height owes its shape to accident.

It may be worth while briefly to consider the result of the exposure to unnatural conditions of a large number of animals of the same species and allowed to cross freely with no selection of any kind, and afterwards to consider the result when selection is brought into play. Let us suppose that 500 wild rock-pigeons were confined in their native land in an aviary and fed in the same manner as pigeons usually are; and that they were not allowed to increase in number. As pigeons propagate so rapidly, I suppose that a thousand or fifteen hundred birds would have to be annually killed. After several generations had been thus reared, we may feel sure that some of the young birds would vary, and the variations would tend to be inherited; for at the present day slight deviations of structure often occur and are inherited. It would be tedious even to enumerate the multitude of points which still go on varying or have recently varied. Many variations would occur in correlation with one another, as the length of the wing and tail feathers—the number of the primary wing-feathers, as well as the number and breadth of the ribs, in correlation with the size and form of the body—the number of the scutellae with the size of the feet—the length of the tongue with the length of the beak—the size of the nostrils and eyelids and the form of lower jaw in correlation with the development of wattle—the nakedness of the young with the future colour of the plumage—the size of the feet with that of the beak, and other such points. Lastly, as our birds are supposed to be confined in an aviary, they would use their wings and legs but little, and certain parts of the skeleton, such as the sternum, scapulae and feet, would in consequence become slightly reduced in size.

As in our assumed case many birds have to be indiscriminately killed every year, the chances are against any new variety surviving long enough to breed. And as the variations which arise are of an extremely diversified nature, the chances are very great against two birds pairing which have varied in the same manner; nevertheless, a varying bird even when not thus paired would occasionally transmit its character to its young; and these would not only be exposed to the same conditions which first caused the variation in question to appear, but would in addition inherit from their modified parent a tendency again to vary in the same manner. So that, if the conditions decidedly tended to induce some particular variation, all the birds might in the course of time become similarly modified. But a far commoner result would be, that one bird would vary in one way and another bird in another way; one would be born with a beak a little longer, and another with a shorter beak; one would gain some black feathers, another some white or red feathers. And as these birds would be continually intercrossing, the final result would be a body of individuals differing from each other in many ways, but only slightly; yet more than did the original rock-pigeons. But there would not be the least tendency towards the formation of several distinct breeds.

If two separate lots of pigeons were treated in the manner just described, one in England and the other in a tropical country, the two lots being supplied with different kinds of food, would they after many generations differ? When we reflect on the cases given in the twenty-third chapter, and on such facts as the difference in former times between the breeds of cattle, sheep, etc., in almost every district of Europe, we are strongly inclined to admit that the two lots would be differently modified through the influence of climate and food. But the evidence on the definite action of changed conditions is in most cases insufficient; and, with respect to pigeons, I have had the opportunity of examining a large collection of domesticated kinds, sent to me by Sir W. Elliot from India, and they varied in a remarkably similar manner with our European birds.

If two distinct breeds were mingled together in equal numbers, there is reason to suspect that they would to a certain extent prefer pairing with their own kind; but they would often intercross. From the greater vigour and fertility of the crossed offspring, the whole body would by this means become interblended sooner than would otherwise have occurred. From certain breeds being prepotent over others, it does not follow that the interblended progeny would be strictly intermediate in character. I have, also, proved that the act of crossing in itself gives a strong tendency to reversion, so that the crossed offspring would tend to revert to the state of the aboriginal rock-pigeon; and in the course of time they would probably be not much more heterogeneous in character than in our first case, when birds of the same breed were confined together.

I have just said that the crossed offspring would gain in vigour and fertility. From the facts given in the seventeenth chapter there can be no doubt of this fact; and there can be little doubt, though the evidence on this head is not so easily acquired, that long-continued close interbreeding leads to evil results. With hermaphrodites of all kinds, if the sexual elements of the same individual habitually acted on each other, the closest possible interbreeding would be perpetual. But we should bear in mind that the structure of all hermaphrodite animals, as far as I can learn, permits and frequently necessitates a cross with a distinct individual. With hermaphrodite plants we incessantly meet with elaborate and perfect contrivances for this same end. It is no exaggeration to assert that, if the use of the talons and tusks of a carnivorous animal, or of the plumes and hooks on a seed, may be safely inferred from their structure, we may with equal safety infer that many flowers are constructed for the express purpose of ensuring a cross with a distinct plant. From these various considerations, not to mention the result of a long series of experiments which I have tried, the conclusion arrived at in the chapter just referred to—namely, that great good of some kind is derived from the sexual concourse of distinct individuals—must be admitted.

To return to our illustration: we have hitherto assumed that the birds were kept down to the same number by indiscriminate slaughter; but if the least choice be permitted in their preservation, the whole result will be changed. Should the owner observe any slight variation in one of his birds, and wish to obtain a breed thus characterised, he would succeed in a surprisingly short time by careful selection. As any part which has once varied generally goes on varying in the same direction, it is easy, by continually preserving the most strongly marked individuals, to increase the amount of difference up to a high, predetermined standard of excellence. This is methodical selection.

If the owner of the aviary, without any thought of making a new breed, simply admired, for instance, short-beaked more than long-beaked birds, he would, when he had to reduce the number, generally kill the latter; and there can be no doubt that he would thus in the course of time sensibly modify his stock. It is improbable, if two men were to keep pigeons and act in this manner, that they would prefer exactly the same characters; they would, as we know, often prefer directly opposite characters, and the two lots would ultimately come to differ. This has actually occurred with strains or families of cattle, sheep, and pigeons, which have been long kept and carefully attended to by different breeders, without any wish on their part to form new and distinct sub-breeds. This unconscious kind of selection will more especially come into action with animals which are highly serviceable to man; for every one tries to get the best dogs, horses, cows, or sheep, without thinking about their future progeny, yet these animals would transmit more or less surely their good qualities to their offspring. Nor is any one so careless as to breed from his worst animals. Even savages, when compelled from extreme want to kill some of their animals, would destroy the worst and preserve the best. With animals kept for use and not for mere amusement, different fashions prevail in different districts, leading to the preservation, and consequently to the transmission, of all sorts of trifling peculiarities of character. The same process will have been pursued with our fruit-trees and vegetables, for the best will always have been the most largely cultivated, and will occasionally have yielded seedlings better than their parents.

The different strains, just alluded to, which have been actually produced by breeders without any wish on their part to obtain such a result, afford excellent evidence of the power of unconscious selection. This form of selection has probably led to far more important results than methodical selection, and is likewise more important under a theoretical point of view from closely resembling natural selection. For during this process the best or most valued individuals are not separated and prevented from crossing with others of the same breed, but are simply preferred and preserved; yet this inevitably leads to their gradual modification and improvement; so that finally they prevail, to the exclusion of the old parent-form.

With our domesticated animals natural selection checks the production of races with any injurious deviation of structure. In the case of animals which, from being kept by savages or semi-civilised people, have to provide largely for their own wants under different circumstances, natural selection will have played a more important part. Hence it probably is that they often closely resemble natural species.

As there is no limit to man's desire to possess animals and plants more and more useful in any respect, and as the fancier always wishes, owing to fashions running into extremes, to produce each character more and more strongly pronounced, there is, through the prolonged action of methodical and unconscious selection, a constant tendency in every breed to become more and more different from its parent-stock; and when several breeds have been produced and are valued for different qualities, to differ more and more from each other. This leads to Divergence of Character. As improved sub-varieties and races are slowly formed, the older and less improved breeds are neglected and decrease in number. When few individuals of any breed exist within the same locality, close interbreeding, by lessening their vigour and fertility, aids in their final extinction. Thus the intermediate links are lost, and the remaining breeds gain in Distinctness of Character.

In the chapters on the Pigeon, it was proved by historical evidence and by the existence of connecting sub-varieties in distant lands that several breeds have steadily diverged in character, and that many old and intermediate sub-breeds have been lost. Other cases could be adduced of the extinction of domestic breeds, as of the Irish wolf-dog, the old English hound, and of two breeds in France, one of which was formerly highly valued.[4] Mr. Pickering remarks[5] that "the sheep figured on the most ancient Egyptian monuments is unknown at the present day; and at least one variety of the bullock, formerly known in Egypt, has in like manner become extinct." So it has been with some animals and with several plants cultivated by the ancient inhabitants of

Europe during the neolithic period. In Peru, Von Tschudi[6] found in certain tombs, apparently prior to the dynasty of the Incas, two kinds of maize not now known in the country. With our flowers and culinary vegetables, the production of new varieties and their extinction has incessantly recurred. At the present time improved breeds sometimes displace older breeds at an extraordinarily rapid rate; as has recently occurred throughout England with pigs. The Longhorn cattle in their native home were "suddenly swept away as if by some murderous pestilence," by the introduction of Shorthorns.[7]

What grand results have followed from the long-continued action of methodical and unconscious selection, regulated to a certain extent by natural selection, we see on every side of us. Compare the many animals and plants which are displayed at our exhibitions with their parent-forms when these are known, or consult old historical records with respect to their former state. Most of our domesticated animals have given rise to numerous and distinct races, but those which cannot be easily subjected to selection must be excepted—such as cats, the cochineal insect, and the hive-bee. In accordance with what we know of the process of selection, the formation of our many races has been slow and gradual. The man who first observed and preserved a pigeon with its oesophagus a little enlarged, its beak a little longer, or its tail a little more expanded than usual, never dreamed that he had made the first step in the creation of a pouter, carrier, and fantail-pigeon. Man can create not only anomalous breeds, but others having their whole structure admirably co-ordinated for certain purposes, such as the racehorse and dray-horse, or the greyhound and bulldog. It is by no means necessary that each small change of structure throughout the body, leading towards excellence, should simultaneously arise and be selected. Although man seldom attends to differences in organs which are important under a physiological point of view, yet he has so profoundly modified some breeds, that assuredly, if found wild, they would be ranked as distinct genera.

The best proof of what selection has effected is perhaps afforded by the fact that whatever part or quality in any animal, and more especially in any plant, is most valued by man, that part or quality differs most in the several races. This result is well seen by comparing the amount of difference between the fruits produced by the several varieties of fruit-trees, between the flowers of our flower-garden plants, between the seeds, roots, or leaves of our culinary and agricultural plants, in comparison with the other and not valued parts of the same varieties. Striking evidence of a different kind is afforded by the fact ascertained by Oswald Heer[8] namely, that the seeds of a large number of plants,—wheat, barley, oats, peas, beans, lentils, poppies,—cultivated for their seed by the ancient Lake-inhabitants of Switzerland, were all smaller than the seeds of our existing varieties. Rütimeyer has shown that the sheep and cattle which were kept by the earlier Lake-inhabitants were likewise smaller than our present breeds. In the middens of Denmark, the earliest dog of which the remains have been found was the weakest; this was succeeded during the Bronze age by a stronger kind, and this again during the Iron age by one still stronger. The sheep of Denmark during the Bronze period had extraordinarily slender limbs, and the horse was smaller than our present animal.[9] No doubt in most of these cases the new and larger breeds were introduced from foreign lands by the immigration of new hordes of men. But it is not probable that each larger breed, which in the course of time has supplanted a previous and smaller breed, was the descendant of a distinct and larger species; it is far more probable that the domestic races of our various animals were gradually improved in different parts of the great Europaeo-Asiatic continent, and thence spread to other countries. This fact of the gradual increase in size of our domestic animals is all the more striking as certain wild or half-wild animals, such as red-deer, aurochs, park-cattle, and boars[10] have within nearly the same period decreased in size.

The conditions favourable to selection by man are,—the closest attention to every character,—long-continued perseverance,—facility in matching or separating animals,—and especially a large number being kept, so that the inferior individuals may be freely rejected or destroyed, and the better ones preserved. When many are kept there will also be a greater chance of the occurrence of well-marked deviations of structure. Length of time is all-important; for as each character, in order to become strongly pronounced, has to be augmented by the selection of successive variations of the same kind, this can be effected only during a long series of generations. Length of time will, also, allow any new feature to become fixed by the continued rejection of those individuals which revert or vary, and by the preservation of those which still inherit the new character. Hence, although some few animals have varied rapidly in certain respects under new conditions of life, as dogs in India and sheep in the West Indies, yet all the animals and plants which have produced strongly marked races were domesticated at an extremely remote epoch, often before the dawn of history. As a consequence of this, no record has been preserved of the origin of our chief domestic breeds. Even at the present day new strains or sub-breeds are formed so slowly that their first appearance passes unnoticed. A man attends to some particular character, or merely matches his animals with unusual care, and after a time a slight difference is perceived by his neighbours;—the difference goes on being augmented by unconscious and methodical selection, until at last a new sub-breed is formed, receives a local name, and spreads; but by this time its history is almost forgotten. When the new breed has spread widely, it gives rise to new strains and sub-breeds, and the best of these succeed and spread, supplanting other and older breeds; and so always onwards in the march of improvement.

When a well-marked breed has once been established, if not supplanted by still further improved sub-breeds, and if not exposed to greatly changed conditions of life inducing further variability or reversion to long-lost characters, it may apparently last for an enormous period. We may infer that this is the case from the high antiquity of certain races; but some caution is necessary on this head, for the same variation may appear independently after long intervals of time, or in distant places. We may safely assume that this has occurred with the turnspit-dog, of which one is figured on the ancient Egyptian monuments—with the solid-hoofed swine[11] mentioned by Aristotle—with five-toed fowls described by Columella—and certainly with the nectarine. The dogs represented on the Egyptian monuments, about 2000 B.C., show us that some of the chief breeds then existed, but it is extremely doubtful whether any are identically the same with our present breeds. A great mastiff sculptured on an Assyrian tomb, 640 B.C., is said to be the same with the dog still imported from Thibet into the same region. The true greyhound existed during the Roman classical period. Coming down to a later period, we have seen that, though most of the chief breeds of the pigeon existed between two and three centuries ago, they have not all retained exactly the same character to the present day; but this has occurred in certain cases in which no improvement was desired, for instance, in the case of the Spot and Indian ground-tumbler.

De Candolle[12] has fully discussed the antiquity of various races of plants; he states that the black seeded poppy was known in the time of Homer, the white-seeded sesamum by the ancient Egyptians, and almonds with sweet and bitter kernels by the Hebrews; but it does not seem improbable that some of these varieties may have been lost and reappeared. One variety of barley and apparently one of wheat, both of which were cultivated at an immensely remote period by the Lake-inhabitants of Switzerland, still exist. It is said[13] that "specimens of a small variety of gourd which is still common in the market of Lima were exhumed from an ancient cemetery in Peru." De Candolle remarks that, in the books and drawings of the sixteenth century, the principal races of the cabbage, turnip, and gourd can be recognised: this might have been expected at so late a period, but whether any of these plants are absolutely identical with our present sub-varieties is not certain. It is, however, said that the Brussels sprout, a variety which in some places is liable to degeneration, has remained genuine for more than four centuries in the district where it is believed to have originated.[14]

In accordance with the views maintained by me in this work and elsewhere, not only the various domestic races, but the most distinct genera and orders within the same great class—for instance, mammals, birds, reptiles, and fishes—are all the descendants of one common progenitor, and we must admit that the whole vast amount of difference between these forms has primarily arisen from simple variability. To consider the subject under this point of view is enough to strike one dumb with amazement. But our amazement ought to be lessened when we reflect that beings almost infinite in number, during an almost infinite lapse of time, have often had their whole organisation rendered in some degree plastic, and that each slight modification of structure which was in any way beneficial under excessively complex conditions of life has been preserved, whilst each which was in any way injurious has been rigorously destroyed. And the long-continued accumulation of beneficial variations will infallibly have led to structures as diversified, as beautifully adapted for various purposes and as excellently co-ordinated, as we see in the animals and plants around us. Hence I have spoken of selection as the paramount power, whether applied by man to the formation of domestic breeds, or by nature to the production of species. I may recur to the metaphor given in a former chapter: if an architect were to rear a noble and commodious edifice, without the use of cut stone, by selecting from the fragments at the base of a precipice wedge-formed stones for his arches, elongated stones for his lintels, and flat stones for his roof, we should admire his skill and regard him as the paramount power. Now, the fragments of stone, though indispensable to the architect, bear to the edifice built by him the same relation which the fluctuating variations of organic beings bear to the varied and admirable structures ultimately acquired by their modified descendants.

Some authors have declared that natural selection explains nothing, unless the precise cause of each slight individual difference be made clear. If it were explained to a savage utterly ignorant of the art of building, how the edifice had been raised stone upon stone, and why wedge-formed fragments were used for the arches, flat stones for the roof, etc.; and if the use of each part and of the whole building were pointed out, it would be unreasonable if he declared that nothing had been made clear to him, because the precise cause of the shape of each fragment could not be told. But this is a nearly parallel case with the objection that selection explains nothing, because we know not the cause of each individual difference in the structure of each being.

The shape of the fragments of stone at the base of our precipice may be called accidental, but this is not strictly correct; for the shape of each depends on a long sequence of events, all obeying natural laws; on the nature of the rock, on the lines of deposition or cleavage, on the form of the mountain, which depends on its upheaval and subsequent denudation, and lastly on the storm or earthquake which throws down the fragments. But in regard to the use to which the fragments may be put, their shape may be strictly said to be accidental. And here we are led to face a great difficulty, in alluding to which I am aware that I am travelling beyond my proper province. An omniscient Creator must have foreseen every consequence which results from the laws imposed by Him. But can it be reasonably maintained that the Creator intentionally ordered, if we use the words in any ordinary sense, that certain fragments of rock should assume certain shapes so that the builder might erect his edifice? If the various laws which have determined the shape of each fragment were not predetermined for the builder's sake, can it be maintained with any greater probability that He specially ordained for the sake of the breeder each of the innumerable variations in our domestic animals and plants;—many of these variations being of no service to man, and not beneficial, far more often injurious, to the creatures themselves? Did He ordain that the crop and tail-feathers of the pigeon should vary in order that the fancier might make his grotesque pouter and fantail breeds? Did He cause the frame and mental qualities of the dog to vary in order that a breed might be formed of indomitable ferocity, with jaws fitted to pin down the bull for man's brutal sport? But if we give up the principle in one case,—if we do not admit that the variations of the primeval dog were intentionally guided in order that the greyhound, for instance, that perfect image of symmetry and vigour, might be formed,—no shadow of reason can be assigned for the belief that variations, alike in nature and the result of the same general laws, which have been the groundwork through natural selection of the formation of the most perfectly adapted animals in the world, man included, were intentionally and specially guided. However much we may wish it, we can hardly follow Professor Asa Gray in his belief "that variation has been led along certain beneficial lines," like a stream "along definite and useful lines of irrigation." If we assume that each particular variation was from the beginning of all time preordained, then that plasticity of organisation, which leads to many injurious deviations of structure, as well as the redundant power of reproduction which inevitably leads to a struggle for existence, and, as a consequence, to the natural selection or survival of the fittest, must appear to us superfluous laws of nature. On the other hand, an omnipotent and omniscient Creator ordains everything and foresees everything. Thus we are brought face to face with a difficulty as insoluble as is that of free will and predestination.

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