Little Masterpieces of Science

The Naturalist as Interpreter and Seer

George Iles

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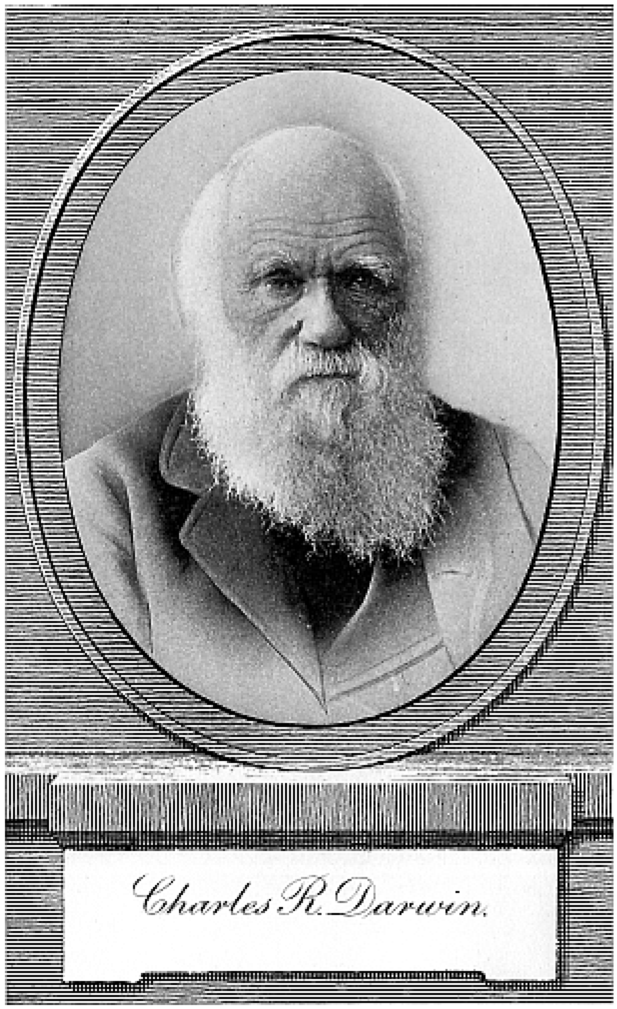

Charles R. Darwin.

Little Masterpieces of Science

Edited by George Iles

THE NATURALIST AS INTERPRETER AND SEER

By

Charles Darwin
Alfred R. Wallace
Thomas H. Huxley
Leland O. Howard
George Iles

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Obvious printer's errors have been silently corrected. Hyphenated and accented words have been standardized.

PREFACE

To gather stones and fallen boughs is soon to ask, what may be done with them, can they be piled and fastened together for shelter? So begins architecture, with the hut as its first step, with the Alhambra, St. Peter's, the capitol at Washington, as its last. In like fashion the amassing of fact suggests the ordering of fact: when observation is sufficiently full and varied it comes to the reasons for what it sees. The geologist delves from layer to layer of the earth beneath his tread, he finds as he compares their fossils that the more recent forms of life stand highest in the scale of being, that in the main the animals and plants of one era are more allied to those immediately next than to those of remoter times. He thus divines that he is but exploring the proofs of lineal descent, and with this thought in his mind he finds that the collections not only of his own district, but of every other, take on a new meaning. The great seers of science do not await every jot and tittle of evidence in such a case as this. They discern the drift of a fact here, a disclosure there, and with both wisdom and boldness assume that what they see is but a promise of what shall duly be revealed. Thus it was that Darwin early in his studies became convinced of the truth of organic evolution: the labours of a lifetime of all but superhuman effort, a judicial faculty never exceeded among men, served only to confirm his confidence that all the varied forms of life upon earth have come to be what they are through an intelligible process, mainly by "natural selection."

The present volume offers from the classic pages of Darwin his summary of the argument of "The Origin of Species," his account of how that book came to be written, and his recapitulation of "The Descent of Man." All this affords a supreme lesson as to the value of observation with a purpose. When Darwin was confronted with an organ or trait which puzzled him, he was wont to ask, What use can it have had? And always the answer was that every new peculiarity of plant, or beast, is seized upon and held whenever it confers advantage in the unceasing conflict for place and food. No hue of scale or plume, no curve of beak or note of song, but has served a purpose in the plot of life, or advanced the action in a drama where the penalty for failure is extinction.

As Charles Darwin stood first among the naturalists of the nineteenth century, his advocacy of evolution soon wrought conviction among the thinkers competent to follow his evidence and weigh his arguments. The opposition to his theories though short was sharp, and here he found a lieutenant of unflinching courage, of the highest expository power, in Professor Huxley. This great teacher came to America in 1876, and discoursed on the ancestry of the horse, as disclosed in fossils then recently discovered in the Far West, maintaining that they afforded unimpeachable proof of organic evolution. His principal lecture is here given.

In a remarkable field of “natural selection” Bates, Wallace and Poulton have explained the value of “mimicry” as an aid to beasts, birds, insects, as they elude their enemies or lie unsuspected on the watch for prey. The resemblances thus worked out through successive generations attest the astonishing plasticity of bodily forms, a plasticity which would be incredible were not its evidence under our eyes in every quarter of the globe. Insects have high economic importance as agents of destruction: we are learning how to pit one of them against another, so as to leave a clear field to the farmer and the fruit grower. In this department a leader is Professor Howard, who contributes a noteworthy chapter on the successful fight against the pest which threatened with ruin the orange groves of California.

To the every-day observer the most enticing field of natural history is that in which common flowers and common insects work out their unending co-partnery. A blossom by its scent, its beauty of tint, allures a moth or bee and thus, in effect, is able to take flight and find a mate across a county so as to perpetuate its race a hundred miles from home. Our volume closes with a sketch of the singular ties which thus bind together the fortunes of blossom and insect, so that at last the very form of a flower may be cast in the mould of its winged ally. A word is also spoken regarding the singular relations of late detected between the world of vegetation and minute forms once deemed parasitic. The pea and its kindred harbor on their rootlets certain tiny lodgers; the tenants pay a liberal rent in the form of nitrogen compounds, a striking interlacement of interests!

George Iles.

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THE NATURALIST AS INTERPRETER AND SEER

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Charles Darwin

[Charles Darwin, one of the greatest men of all time, did more to advance and prove the theory of evolution than anybody else who ever lived. This he accomplished by virtue of the highest gifts of observation, experiment, and generalization. His truthfulness, patience, and calmness of judgment have never been exceeded by mortal. His works are published by D. Appleton & Co., New York, together with his "Life and Letters," edited by his son Francis. From "The Origin of Species" the argument in summary is here given.]

On the view that species are only strongly marked and permanent varieties, and that each species first existed as a variety, we can see why it is that no line of demarcation can be drawn between species, commonly supposed to have been produced by special acts of creation, and varieties which are acknowledged to have been produced by secondary laws. On this same view we can understand how it is that in a region where many species of a genus have been produced, and where they now flourish, these same species should present many varieties; for where the manufactory of species has been active, we might expect, as a general rule, to find it still in action; and this is the case if varieties be incipient species. Moreover, the species of the larger genera, which afford the greater number of varieties or incipient species, retain to a certain degree the character of varieties; for they differ from each other by a less amount of difference than do the species of smaller genera. The closely allied species also of a larger genera apparently have restricted ranges, and in their affinities they are clustered in little groups round other species—in both respects resembling varieties. These are strange relations on the view that each species was independently created, but are intelligible if each existed first as a variety.

As each species tends by its geometrical rate of reproduction to increase inordinately in number; and as the modified descendants of each species will be enabled to increase by as much as they become more diversified in habits and structure, so as to be able to seize on many and widely different places in the economy of nature, there will be a constant tendency in natural selection to preserve the most divergent offspring of any one species. Hence, during a long-continued course of modification, the slight differences of characteristic of varieties of the same species, tend to be augmented into the greater differences characteristic of the species of the same genus. New and improved varieties will inevitably supplant and exterminate the older, less improved, and intermediate varieties; and thus species are rendered to a large extent defined and distinct objects. Dominant species belonging to the larger groups within each class tend to give birth to new and dominant forms; so that each large group tends to become still larger, and at the same time more divergent in character. But as all groups cannot thus go on increasing in size, for the world would not hold them, the more dominant groups beat the less dominant. This tendency in the large groups to go on increasing in size and diverging in character, together with the inevitable contingency of much extinction, explains the arrangement of all the forms of life in groups subordinate to groups, all within a few great classes, which has prevailed throughout all time. This grand fact of the grouping of all organic beings under what is called the Natural System, is utterly inexplicable on the theory of creation.

As natural selection acts solely by accumulating slight, successive, favourable variations, it can produce no great or sudden modifications; it can act only by short and slow steps. Hence, the canon of “Nature makes no leaps,” which every fresh addition to our knowledge tends to confirm, is on this theory intelligible. We can see why throughout nature the same general end is gained by an almost infinite diversity of means, for every peculiarity when once acquired is long inherited, and structures already modified in many different ways have to be adapted for the same general purpose. We can, in short, see why nature is prodigal in variety, though niggard in innovation. But why this should be a law of nature if each species has been independently created no man can explain.

Many other facts are, as it seems to me, explicable on this theory. How strange it is that a bird, under the form of a woodpecker, should prey on insects on the ground; that upland geese which rarely or never swim, would possess webbed feet; that a thrush-like bird should dive and feed on sub-aquatic insects; and that a petrel should have the habits and structure fitting it for the life of an auk! and so in endless other cases. But on the view of each species constantly trying to increase in number, with natural selection always ready to adapt the slowly varying descendants of each to any unoccupied or ill-occupied place in nature, these facts cease to be strange, or might even have been anticipated.

We can to a certain extent understand how it is that there is so much beauty throughout nature; for this may be largely attributed to the agency of selection. That beauty, according to our sense of it, is not universal, must be admitted by every one who will look at some venomous snakes, at some fishes, and at certain hideous bats with a distorted resemblance to the human face. Sexual selection has given the most brilliant colours, elegant patterns, and other ornaments to the males, and sometimes to both sexes of many birds, butterflies and other animals. With birds it has often rendered the voice of the male musical to the female, as well as to our ears. Flowers and fruit have been rendered conspicuous by brilliant colours in contrast with the green foliage, in order that the flowers may be easily seen, visited and fertilized by insects, and the seeds disseminated by birds. How it comes that certain colours, sounds and forms should give pleasure to man and the lower animals, that is, how the sense of beauty in its simplest form was first acquired, we do not know any more than how certain odours and flavours were first rendered agreeable.

As natural selection acts by competition, it adopts and improves the inhabitants of each country only in relation to their co-inhabitants; so that we need feel no surprise at the species of any one country, although on the ordinary view supposed to have been created and specially adapted for that country, being beaten and supplanted by the naturalized productions from another land. Nor ought we marvel if all the contrivances in nature be not, as far as we can judge, absolutely perfect, as in the case even of the human eye; or if some of them be abhorrent to our ideas of fitness. We need not marvel at the sting of the bee, when used against an enemy, causing the bee's own death; at drones being produced in such great numbers for one single act, and being then slaughtered by their sterile sisters; at the astonishing waste of pollen by our fir trees; at the instinctive hatred of the queen bee for her own fertile daughters; at ichneumonidæ feeding within the living bodies of caterpillars; or at other such cases. The wonder indeed, is, on the theory of natural selection, that more cases of the want of absolute perfection have not been detected.

The complex and little known laws governing production of varieties are the same, as far as we can judge, with the laws which have governed the production of distinct species. In both cases physical conditions seem to have produced some direct and definite effect, but how much we cannot say. Thus, when varieties enter any new station, they occasionally assume some of the characters proper to the species of that station. With both varieties and species, use and disuse seem to have produced a considerable effect; for it is impossible to resist this conclusion when we look, for instance, at the logger-headed duck, which has wings incapable of flight, in nearly the same condition as in the domestic duck; or when we look at the burrowing tucu-tucu, which is occasionally blind, and then at certain moles, which are habitually blind and have their eyes covered with skin; or when we look at the blind animals inhabiting the dark caves of America and Europe. With varieties and species, correlated variation seems to have played an important part, so that when one part has been modified other parts have been necessarily modified.

With both varieties and species, reversions to long-lost characters occasionally occur. How inexplicable on the theory of creation is the occasional appearance of stripes on the shoulders and legs of the several species of the horse-genus and of their hybrids! How simply is this fact explained if we believe that these species are all descended from a striped progenitor, in the same manner as the several domestic breeds of the pigeon are descended from the blue and barred rock pigeon!

On the ordinary view of each species having been independently created, why should specific characters, or those by which the species of the same genus differ from each other, be more variable than generic characters in which they all agree? Why, for instance, should the colour of a flower be more likely to vary in any one species of genus, if the other species possess differently coloured flowers, than if all possessed the same coloured flowers? If species are only well-marked varieties, of which the characters have become in a high degree permanent, we can understand this fact; for they have already varied since they branched off from a common progenitor in certain characters, by which they have come to be specifically different from each other; therefore these same characters would be more likely again to vary than the generic characters which have been inherited without change for an immense period. It is inexplicable on the theory of creation why a part developed in a very unusual manner in one species alone of a genus, and therefore, as we may naturally infer, of great importance to that species, should be eminently liable to variation; but, on our view, this part has undergone, since the several species branched off from a common progenitor, an unusual amount of variability and modification, and therefore we might expect the part generally to be still variable. But a part may be developed in the most unusual manner, like the wing of a bat, and yet not be more variable than any other structure, if the part be common to many subordinate forms, that is, if it has been inherited for a very long period; for in this case it will have been rendered constant by long-continued natural selection.

Glancing at instincts, marvellous as some are, they offer no greater difficulty than do corporeal structures on the theory of the natural selection of successive, slight, but profitable modifications. We can thus understand why nature moves by graduated steps in endowing certain animals of the same class with their several instincts. I have attempted to show how much light the principle of gradation throws on the admirable architectural powers of the hive-bee. Habit no doubt often comes into play in modifying instincts; but it certainly is not indispensable, as we see in the case of neuter insects, which leave no progeny to inherit the effects of long-continued habit. On the view of all the species of the same genus having descended from a common parent, and having inherited much in common, we can understand how it is that allied species, when placed under widely different conditions of life, yet follow nearly the same instincts; why the thrushes of temperate and tropical South America, for instance, line their nests with mud like our British species. On the view of instincts having been slowly acquired through natural selection, we need not marvel at some instincts being not perfect and liable to mistakes, and at many instincts causing other animals to suffer.

If species be only well-marked and permanent varieties, we can see at once why their crossed offspring should follow the same complex laws in their degrees and kinds of resemblance to their parents—in being absorbed into each other by successive crosses, and in other such points—as do the crossed offspring of acknowledged varieties. This similarity would be a strange fact, if species had been independently created and varieties had been produced through secondary laws.

If we admit that the geological record is imperfect to an extreme degree, then the facts, which the record does give, strongly support the theory of descent with modification. New species have come on the stage slowly and at successive intervals; and the amount of change after equal intervals of time, is widely different in different groups. The extinction of species and of whole groups of species, which has played so conspicuous a part in the history of the organic world, almost inevitably follows from the principle of natural selection; for old forms are supplanted by new and improved forms. Neither single species nor groups of species reappear when the chain of ordinary generation is once broken. The gradual diffusion of dominant forms, with the slow modification of their descendants, causes the forms of life, after long intervals of time, to appear as if they had changed simultaneously throughout the world. The fact of the fossil remains of each formation being in some degree intermediate in character between the fossils in the formations above and below, is simply explained by their intermediate position in the chain of descent. The grand fact that all extinct beings can be classed with all recent beings, naturally follows from the living and the extinct being the offspring of common parents. As species have generally diverged in character during their long course of descent and modification, we can understand why it is that the more ancient forms, or early progenitors of each group, so often occupy a position in some degree intermediate between existing groups. Recent forms are generally looked upon as being, on the whole, higher in the scale of organization than ancient forms; and they must be higher, in so far as the later and more improved forms have conquered the older and less improved forms in the struggle for life; they have also generally had their organs more specialized for different functions. This fact is perfectly compatible with numerous beings still retaining simple but little improved structures, fitted for simple conditions of life; it is likewise compatible with some forms having retrograded in organization, by having become at each stage of descent better fitted for new and degraded habits of life. Lastly, the wonderful law of the long endurance of allied forms on the same continent—of marsupials [as kangaroos] in Australia, of edentata [as armadillos, sloths, and anteaters] in America, and other such cases—is intelligible, for within the same country the existing and the extinct will be closely allied by descent.

Looking to geographical distribution, if we admit that there has been during the long course of ages much migration from one part of the world to another, owing to former climatical and geographical changes and to the many occasional and unknown means of dispersal, then we can understand, on the theory of descent with modification, most of the great leading facts in distribution. We can see why there should be so striking a parallelism in the distribution of organic beings throughout space, and in their geological succession throughout time; for in both cases the beings have been connected by the bond of ordinary generation, and the means of modification have been the same. We see the full meaning of the wonderful fact, which has struck every traveller, namely, that on the same continent, under the most diverse conditions, under heat and cold, on mountain and lowland, on deserts and marshes, most of the inhabitants within each great class are plainly related; for they are the descendants of the same progenitors and early colonists. On this same principle of former migration, combined in most cases with modification, we can understand by the aid of the Glacial period, the identity of some few plants and the close alliance of many others, on the most distant mountains, and in the northern and southern temperate zones; and likewise the close alliance of some of the inhabitants of the sea in the northern and southern temperate latitudes, though separated by the whole inter-tropical ocean. Although two countries may present physical conditions as closely similar as the same species ever acquire, we need feel no surprise at their inhabitants being widely different, if they have been for a long period completely sundered from each other; for as the relation of organism to organism is the most important of all relations, and as the two countries will have received colonists at various periods and in different proportions, from some other country or from each other, the course of modification in the two areas will inevitably have been different.

On this view of migration, with subsequent modification, we see why oceanic islands are inhabited by only few species, but of these, why many are peculiar or endemic forms. We clearly see why species belonging to those groups of animals which cannot cross wide spaces of the ocean, as frogs and terrestrial mammals, do not inhabit oceanic islands; and why, on the other hand, new and peculiar species of bats, animals which can traverse the ocean, are often found on islands far distant from any continent. Such cases as the presence of peculiar species of bats on oceanic islands and the absence of all other terrestrial mammals, are facts utterly inexplicable on the theory of independent acts of creation.

The existence of closely allied representative species in any two areas, implies on the theory of descent with modification, that the same parent-forms formerly inhabited both areas: and we almost invariably find that wherever many closely allied species inhabit two areas, some identical species are still common to both. Wherever many closely allied yet distant species occur, doubtful forms and varieties belonging to the same groups likewise occur. It is a rule of high generality that the inhabitants of each area are related to the inhabitants of the nearest source whence immigrants might have been derived. We see this in the striking relation of nearly all the plants and animals of the Galapagos Archipelago, of Juan Fernandez, and of the other American islands, to the plants and animals of the neighbouring American mainland; and of those of the Cape Verde Archipelago, and of the other African islands to the African mainland. It must be admitted that these facts receive no explanation on the theory of creation.

The fact, as we have seen, that all past and present organic beings can be arranged within a few great classes, in groups subordinate to groups, and with the extinct groups often falling in between the recent groups, is intelligible on the theory of natural selection with its contingencies of extinction and divergence of character. On these same principles we see how it is that the mutual affinities of the forms within each class are so complex and circuitous. We see why certain characters are far more serviceable than others for classification; why adaptive characters derived from rudimentary parts, though of no service to the beings, are often of high classificatory value; and why embryological characters are often the most valuable of all. The real affinities of all organic beings, in contradistinction to their adaptive resemblances, are due to inheritance or community of descent. The Natural System is a genealogical arrangement, with the acquired grades of difference, marked by the terms, varieties, species, genera, families, etc.; and we have to discover the lines of descent by the most permanent characters, whatever they may be, and of however slight vital importance.

The similar framework of bones in the hand of a man, wing of a bat, fin of the porpoise, and leg of the horse—the same number of vertebræ forming the neck of the giraffe and of the elephant—and innumerable other such facts, at once explain themselves on the theory of descent with slow and slight successive modifications. The similarity of pattern in the wing and in the leg of a bat, though used for such different purpose—in the jaws and legs of a crab—in the petals, stamens, and pistils of a flower, is likewise, to a large extent, intelligible on the view of the gradual modification of parts or organs, which were aboriginally alike in an early progenitor in each of these classes. On the principle of successive variations not always supervening at an early age, and being inherited at a corresponding not early period of life, we clearly see why the embryos of mammals, birds, reptiles, and fishes should be so closely similar, and so unlike the adult forms. We may cease marvelling at the embryo of an air-breathing mammal or bird having branchial slits and arteries running in loops, like those of a fish which has to breathe the air dissolved in water by the aid of well-developed branchiæ [gills].

Disuse, aided sometimes by natural selection, will often have reduced organs when rendered useless under changed habits or conditions of life; and we can understand on this view the meaning of rudimentary organs. But disuse and selection will generally act on each creature, when it has come to maturity and has to play its full part in the struggle for existence, and will thus have little power in an organ during early life; hence the organ will not be reduced or rendered rudimentary at this early age. The calf, for instance, has inherited teeth, which never cut through the gums of the upper jaw, from an early progenitor having well-developed teeth; and we may believe, that the teeth in the mature animal were formerly reduced by disuse, owing to the tongue and palate, or lips, having become excellently fitted through natural selection to browse without their aid; whereas in the calf, the teeth have been left unaffected, and on the principle of inheritance at corresponding ages have been inherited from a remote period to the present day. On the view of each organism with all its separate parts having been specially created, how utterly inexplicable is it that organs bearing the plain stamp of inutility, such as the teeth in the embryonic calf or the shrivelled wings under the soldered wing covers of many beetles, should so frequently occur. Nature may be said to have taken pains to reveal her scheme of modification, by means of rudimentary organs, of embryological and homologous [corresponding] structures, but we are too blind to understand her meaning.

I have now recapitulated the facts and considerations which have thoroughly convinced me that species have been modified, during a long course of descent. This has been effected chiefly through the natural selection of numerous successive, slight, favourable variations; aided in an important manner by the inherited effects of the use and disuse of parts; and in an unimportant manner, that is, in relation to adaptive structures, whether past or present, by the direct action of external conditions, and by variations which seem to us in our ignorance to arise spontaneously. It appears that I formerly underrated the frequency and value of these latter forms of variation, as leading to permanent modifications of structure independently of natural selection. But as my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous, position—namely, at the close of the Introduction—the following words: “I am convinced that natural selection has been the main but not the exclusive means of modification.” This has been of no avail. Great is the power of steady misrepresentation; but the history of science shows that fortunately this power does not long endure.

It can hardly be supposed that a false theory would explain, in so satisfactory a manner as does the theory of natural selection, the several large classes of facts above specified. It has recently been objected that this is an unsafe method of arguing; but it is a method used in judging the common events of life, and has often been used by the greatest natural philosophers. The undulatory theory of light has thus been arrived at; and the belief in the revolution of the earth on its own axis was until lately supported by hardly any direct evidence. It is no valid objection that science as yet throws no light on the far higher problems of the essence of the origin of life. Who can explain what is the essence of the attraction of gravity? No one now objects to following out the results consequent on this unknown element of attraction; notwithstanding that Leibnitz formerly accused Newton of introducing “occult qualities and miracles into philosophy.”

I see no good reasons why the views given in this volume should shock the religious feelings of any one. It is satisfactory, as showing how transient such impressions are, to remember that the greatest discovery ever made by man, namely, the law of the attraction of gravity, was also attacked by Leibnitz, “as subversive of natural, and inferentially of revealed religion.” A celebrated author and divine has written to me that “he has gradually learned to see that it is just as noble a conception of the Deity to believe that He created a few original forms capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws.”

Why, it may be asked, until recently did nearly all the most eminent living naturalists and geologists disbelieve in the mutability of species? It cannot be asserted that organic beings in a state of nature are subject to no variation; it cannot be proved that the amount of variation in the course of long ages is a limited quantity; no clear distinction has been, or can be, drawn between species and well-marked varieties. It cannot be maintained that species when intercrossed are invariably sterile and varieties invariably fertile; or that sterility is a special endowment and sign of creation. The belief that species were immutable productions was almost unavoidable as long as the history of the world was thought to be of short duration; and now that we have acquired some idea of the lapse of time, we are too apt to assume, without proof, that the geological record is so perfect that it would have afforded us plain evidence of the mutation of species, if they had undergone mutation.

But the chief cause of our natural unwillingness to admit that one species has given birth to other and distinct species, is that we are always slow in admitting great changes of which we do not see the steps. The difficulty is the same as that felt by so many geologists, when Lyell first insisted that long lines of inland cliffs had been formed, and great valleys excavated, by the agencies which we still see at work. The mind cannot possibly grasp the full meaning of the term of even a million years; it cannot add up and perceive the full effects of many slight variations, accumulated during an almost infinite number of generations.

Although I am fully convinced of the truth of the views given in this volume under the form of an abstract, I by no means expect to convince experienced naturalists whose minds are stocked with a multitude of facts all viewed, during a long course of years, from a point of view directly opposite to mine. It is so easy to hide our ignorance under such expressions as the “plan of creation,” “unity of design,” etc., and to think that we give an explanation when we only restate a fact. Any one whose disposition leads him to attach more weight to unexplained difficulties than to the explanation of a certain number of facts will certainly reject the theory. A few naturalists, endowed with much flexibility of mind, and who have already begun to doubt the immutability of species, may be influenced by this volume; but I look with confidence to the future, to young and rising naturalists, who will be able to view both sides of the question with impartiality. Whoever is led to believe that species are mutable will do good service by conscientiously expressing his conviction; for thus only can the load of prejudice by which this subject is overwhelmed be removed.

Several eminent naturalists have of late published their belief that a multitude of reputed species in each genus are not real species; but that other species are real, that is, have been independently created. This seems to me a strange conclusion to arrive at. They admit that a multitude of forms, which till lately they themselves thought were special creations, and which are still thus looked at by the majority of naturalists, and which consequently have all the external characteristic features of true species—they admit that these have been produced by variation, but they refuse to extend the same view to other and slightly different forms. Nevertheless, they do not pretend that they can define, or even conjecture, which are the created forms of life, and which are those produced by secondary laws. They admit variation as a true cause in one case, they arbitrarily reject it in another, without assigning any distinction in the two cases. The day will come when this will be given as a curious illustration of the blindness of preconceived opinion. These authors seem no more startled at a miraculous act of creation than at an ordinary birth. But do they really believe that at innumerable periods in the earth's history certain elemental atoms have been commanded suddenly to flash into living tissues? Do they believe that at each supposed act of creation one individual or many were produced? Were all the infinite numerous kinds of animals and plants created as eggs or seed, or as full grown? and in the case of mammals, were they created bearing the false marks of nourishment from the mother's womb? Undoubtedly some of these same questions cannot be answered by those who believe in the appearance or creation of only a few forms of life, or of some one form alone. It has been maintained by several authors that it is as easy to believe in the creation of a million beings as of one; but Maupertuis's philosophical axiom “of least action” leads the mind more willingly to admit the smaller number; and certainly we ought not to believe that innumerable beings within each great class have been created with plain, but deceptive, marks of descent from a single parent.

As a record of a former state of things, I have retained in the foregoing paragraphs, and elsewhere, several sentences which imply that naturalists believe in the separate creation of each species; and I have been much censured for having thus expressed myself. But undoubtedly this was the general belief when the first edition of the present work appeared. I formerly spoke to very many naturalists on the subject of evolution, and never once met with any sympathetic agreement. It is probable that some did then believe in evolution, but they were either silent or expressed themselves so ambiguously that it was not easy to understand their meaning. Now, things are wholly changed, and almost every naturalist admits the great principle of evolution. There are, however, some who still think that species have suddenly given birth, through quite unexplained means, to new and totally different forms. But, as I have attempted to show, weighty evidence can be opposed to the admission of great and abrupt modifications. Under a scientific point of view, and as leading to further investigation, but little advantage is gained by believing that new forms are suddenly developed in an inexplicable manner from old and widely different forms, over the old belief in the creation of species from the dust of the earth.

It may be asked how far I extend the doctrine of the modification of species. The question is difficult to answer, because the more distinct the forms are which we consider, by so much the arguments in favour of community of descent become fewer in number and less in force. But some arguments of the greatest weight extend very far. All the members of whole classes are connected together by a chain of affinities, and all can be classed on the same principle, in groups subordinate to groups. Fossil remains sometimes tend to fill up very wide intervals between existing orders.

Organs in a rudimentary condition plainly show that an early progenitor had the organ in a fully developed condition, and this in some cases implies an enormous amount of modification in the descendants. Throughout whole classes various structures are formed on the same pattern, and at a very early age the embryos closely resemble each other. Therefore I cannot doubt that the theory of descent with modification embraces all the members of the same great class or kingdom. I believe that animals are descended from at most only four or five progenitors, and plants from an equal or lesser number.

Analogy would lead me one step further, namely, to the belief that all animals and plants are descended from some one prototype. But analogy may be a deceitful guide. Nevertheless all living things have much in common, in their chemical composition, their cellular structure, their laws of growth, and their liability to injurious influences. We see this even in so trifling a fact as that the same poison often similarly affects plants and animals; or that the poison secreted by the gall-fly produces monstrous growths on the wild rose or oak tree. With all organic beings, excepting perhaps some of the very lowest, sexual reproduction seems to be essentially similar. With all, as far as is at present known, the germinal vesicle is the same; so that all organisms start from a common origin. If we look even to the two main divisions—namely, to the animal and vegetable kingdoms—certain low forms are so far intermediate in character that naturalists have disputed to which kingdom they should be referred. As Professor Asa Gray has remarked, “the spores and other reproductive bodies of many of the lower algæ may claim to have first a characteristically animal, and then an unequivocally vegetable existence.” Therefore, on the principle of natural selection with divergence of character, it does not seem incredible that, from some such low and intermediate form, both animals and plants may have been developed; and, if we admit this, we must likewise admit that all the organic beings which have ever lived on this earth may be descended from some one primordial form. But this inference is chiefly grounded on analogy, and it is immaterial whether or not it is accepted. No doubt it is possible, as Mr. G. H. Lewes has urged, that at the first commencement of life many different forms were evolved; but if so, we may conclude that only a very few have left modified descendants. For, as I have recently remarked in regard to the members of each great kingdom, such as the Vertebrata, Articulata, etc., we have distinct evidence in their embryological, homologous, and rudimentary structures, that within each kingdom all the members are descended from a single progenitor.

When the views advanced by me in this volume, and by Mr. Wallace, or when analogous views on the origin of species are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history. Systematists will be able to pursue their labours as at present; but they will not be incessantly haunted by the shadowy doubt whether this or that form be a true species. This, I feel sure and I speak after experience, will be no slight relief. The endless disputes whether or not some fifty species of British brambles are good species will cease. Systematists will have only to decide (not that this will be easy) whether any form be sufficiently constant and distinct from other forms, to be capable of definition; and if definable, whether the differences be sufficiently important to deserve a specific name. This latter point will become a far more essential consideration than it is at present; for differences, however slight, between any two forms, if not blended by intermediate gradations, are looked at by most naturalists as sufficient to raise both forms to the rank of species.

Hereafter we shall be compelled to acknowledge that the only distinction between species and well-marked varieties is, that the latter are known, or believed to be connected at the present day by intermediate gradations, whereas species were formerly thus connected. Hence, without rejecting the considerations of the present existence of intermediate gradations between any two forms, we shall be led to weigh more carefully and to value higher the actual amount of difference between them. It is quite possible that forms now generally acknowledged to be merely varieties may hereafter be thought worthy of specific names; and in this case scientific and common language will come into accordance. In short, we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species.

The other and more general departments of natural history will rise greatly in interest. The terms used by naturalists, of affinity, relationship, community of type, paternity, morphology [the science of organic form], adaptive characters, rudimentary and aborted organs, etc., will cease to be metaphorical and will have a plain signification. When we no longer look at an organic being as a savage looks at a ship, as something wholly beyond his comprehension; when we regard every production of nature as one which has had a long history; when we contemplate every complex structure and instinct as the summing up of many contrivances, each useful to the possessor, in the same way as any great mechanical invention is the summing up of the labour, the experience, the reason, and even the blunders of numerous workmen; when we thus view each organic being, how far more interesting—I speak from experience—does the study of natural history become!

A grand and almost untrodden field of inquiry will be opened, on the causes and laws of variation, on correlation, on the effects of use and disuse, on the direct action of external conditions, and so forth. The study of domestic productions will rise immensely in value. A new variety raised by man will be a more important and interesting subject for study than one more species added to the infinitude of already recorded species. Our classifications will come to be, as far as they can be so made, genealogies; and will then truly give what may be called the plan of creation. The rules for classifying will no doubt become simpler when we have a definite object in view. We possess no pedigree or armorial bearings; and we have to discover and trace the many diverging lines of descent in our natural genealogies, by characters of any kind which have long been inherited. Rudimentary[1] organs will speak infallibly with respect to the nature of long-lost structures. Species and groups of species which are called aberrant, and which may fancifully be called living fossils, will aid us in forming a picture of the ancient forms of life. Embryology will often reveal to us the structure, in some degree obscured, of the prototypes of each great class.

When we can feel assured that all the individuals of the same species, and all the closely allied species of most genera, have, within a not very remote period descended from one parent, and have migrated from some one birth-place; and when we better know the many means of migration, then, by the light which geology now throws, and will continue to throw, on former changes of climate and of the level of the land, we shall surely be enabled to trace in an admirable manner the former migrations of the inhabitants of the whole world. Even at present, by comparing the differences between the inhabitants of the sea on the opposite sides of a continent, and the nature of the various inhabitants on that continent in relation to their apparent means of immigration, some light can be thrown on ancient geography.

The noble science of geology loses glory from the extreme imperfection of the record. The crust of the earth, with its imbedded remains, must not be looked at as a well-filled museum, but as a poor collection made at hazard and at rare intervals. The accumulation of each great fossiliferous formation will be recognized as having depended on an unusual occurrence of favourable circumstances, and the blank intervals between the successive stages as having been of vast duration. But we shall be able to gauge with some security the duration of these intervals by a comparison of the preceding and succeeding organic forms. We must be cautious in attempting to correlate as strictly contemporaneous two formations, which do not include many identical species, by the general succession of the forms of life.

As species are produced and exterminated by slowly acting and still existing causes, and not by miraculous acts of creation; and as the most important of all causes of organic change is one which is almost independent of altered and perhaps suddenly altered physical conditions, namely, the mutual relation of organism to organism—the improvement of one organism entailing the improvement or the extermination of others; it follows, that the amount of organic change in the fossils of consecutive formations probably serves as a fair measure of the relative, though not actual lapse of time. A number of species, however, keeping in a body might remain for a long period unchanged, while within the same period, several of these species, by migrating into new countries and coming into competition with foreign associates, might become modified; so that we must not overrate the accuracy of organic change as a measure of time.

In the future I see open fields for far more important researches. Psychology will be securely based on the foundation already well laid by Mr. Herbert Spencer, that of the necessary acquirement of each mental power and capacity by gradation. Much light will be thrown on the origin of man and his history.

Authors of the highest eminence seem to be fully satisfied with the view that each species has been independently created. To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual. When I view all beings as not special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled. Judging from the past, we may safely infer that not one living species will transmit its unaltered likeness to a distant futurity. And of the species now living very few will transmit progeny of any kind to a far distant futurity; for the manner in which all organic beings are grouped, shows that the greater number of species in each genus, and all the species in many genera, have left no descendants, but have become utterly extinct. We can so far take a prophetic glance into futurity as to foretell that it will be the common and widely spread species, belonging to the larger and dominant groups within each class, which will ultimately prevail and procreate new and dominant species. As all the living forms of life are the lineal descendants of those which lived long before the Cambrian epoch, we may feel certain that the ordinary succession by generation has never once been broken, and that no cataclysm has desolated the whole world. Hence, we may look with some confidence to a secure future of great length. And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection.

It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us. These laws taken in the largest sense, being growth with reproduction; Inheritance which is almost implied by reproduction; Variability from the indirect and direct action of the conditions of life, and from use and disuse: a Ratio of Increase so high as to lead to a Struggle for Life, and as a consequence to Natural Selection, entailing divergence of Character and the Extinction of less improved forms. Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, while this planet has gone circling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved.

FOOTNOTES:

[1] *Vestigial* is now preferred to *rudimentary* as a term.—Ed.

HOW "THE ORIGIN OF SPECIES" CAME TO BE WRITTEN.

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[An extract from the autobiography of Charles Darwin, in "The Life and Letters of Charles Darwin," New York, D. Appleton & Co.]

From September, 1854, I devoted my whole time to arranging my huge pile of notes, to observing and to experimenting in relation to the transmutation of species. During the voyage of the *Beagle* I had been deeply impressed by discovering in the Pampean formation great fossil animals covered with armour like that on the existing armadillos; secondly, by the manner in which closely allied animals replace one another in proceeding southwards over the continent; and, thirdly, by the South American character of most of the productions of the Galapagos Archipelago, and more especially by the manner in which these differ slightly on each island of the group, none of these islands appearing to be very ancient in a geological sense.

It was evident that such facts as these, as well as many others, could only be explained on the supposition that species gradually become modified; and the subject haunted me. But it was equally evident that neither the action of the surrounding conditions, nor the will of the organisms (especially in the case of plants) could account for the innumerable cases in which organisms of every kind are beautifully adapted to their habits of life—for instance, a woodpecker or a tree-frog to climb trees, or a seed for dispersal by hooks or plumes. I had always been much struck by such adaptations, and until these could be explained it seemed to me almost useless to endeavour to prove by indirect evidence that species have been modified.

After my return to England it appeared to me that by following the example of Lyell in geology,[2] and by collecting all facts that bore in any way on the variation of animals and plants under domestication and nature, some light might perhaps be thrown on the whole subject. My first note-book was opened in July, 1837. I worked on true Baconian principles, and without any theory collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed enquiries, by conversation with skilful breeders and gardeners and by extensive reading. When I see the list of books of all kinds which I read and abstracted, including whole series of journals and translations, I am surprised at my industry. I soon perceived that selection was the keystone of man's success in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery to me.

In October, 1838, that is fifteen months after I had begun my systematic enquiry, I happened to read for amusement “Malthus on Population,” and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed. The result of this would be the formation of a new species. Here then I had at last got a theory by which to work; but I was so anxious to avoid prejudice that I determined not for some time to write even the briefest sketch of it. In June, 1842, I first allowed myself the satisfaction of writing a very brief abstract of my theory in pencil in 35 pages; and this was enlarged during the summer of 1844 into one of 230 pages, which I had fairly copied out and still possess.

But at that time I overlooked one problem of great importance; and it is astonishing to me, except on the principle of Columbus and his egg, how I could have overlooked it and its solution. This problem is the tendency in organic beings descended from the same stock to diverge in character as they become, modified. That they have diverged greatly is obvious from the manner in which species of all kinds can be classed under genera, genera under families, families under sub-orders and so forth; and I can remember the very spot on the road, whilst in my carriage, when to my joy the solution occurred to me; and this was long after I had come to Down. This solution, as I believe, is that the modified offspring of all dominant and increasing forms tend to become adapted to many and highly diversified places in the economy of nature.

Early in 1856 Lyell advised me to write out my views pretty fully, and I began at once to do so on a scale three or four times as extensive as that which was afterwards followed in my "Origin of Species;" yet it was only an abstract of the materials which I had collected and I got through about half the work on this scale. But my plans were overthrown, for early in the summer of 1858 Mr. Wallace, who was then in the Malay Archipelago, sent me an essay "On the tendency of varieties to depart indefinitely from the original type;" and this essay contained exactly the same theory as mine.[3] Mr. Wallace expressed the wish that if I thought well of his essay I should send it to Lyell for perusal.

The circumstances under which I consented at the request of Lyell and Hooker to allow of an abstract from my MS., together with a letter to Asa Gray, dated September 5, 1857, to be published at the same time with Wallace's essay, are given in the "Journal of the Proceedings of the Linnean Society," 1858, p. 45. I was at first very unwilling to consent, as I thought Mr. Wallace might consider my doing so unjustifiable, for I did not then know how generous and noble was his disposition. The extract from my MS. and the letter to Asa Gray had neither been intended for publication, and were badly written. Mr. Wallace's essay, on the other hand, was admirably expressed and quite clear. Nevertheless, our joint productions excited very little attention, and the only published notice of them which I can remember was by Professor Haughton of Dublin, whose verdict was that all that was new in them was false, and what was true was old. This shows how necessary it is that any new idea should be explained at considerable length in order to arouse public attention.

In September, 1858, I set to work by the strong advice of Lyell and Hooker to prepare a volume on the transmutation of species, but was often interrupted by ill health and short visits to Dr. Lane's delightful hydropathic establishment at Moor Park. I abstracted the MS. begun on a much larger scale in 1856, and completed the volume on the same reduced scale. It cost me thirteen months and ten days' hard labor. It was published under the title of the “Origin of Species,” in November, 1859. Though considerably added to and corrected in the later editions, it has remained substantially the same book.

It is no doubt the chief work of my life. It was from the first highly successful. The first small edition of 1,250 copies was sold on the day of publication, and a second edition of 3,000 copies soon afterwards. Sixteen thousand copies have now (1876) been sold in England; and considering how stiff a book it is, this is a large sale. It has been translated into almost every European tongue, even into such languages as Spanish, Bohemian, Polish and Russian. Even an essay in Hebrew has appeared on it, showing that the theory is contained in the Old Testament! The reviews were very numerous; for some time all that appeared on the “Origin” and on my related books, and these amount (excluding newspaper reviews) to 265; but after a time I gave up the attempt in despair. Many separate essays and books on the subject have appeared; and in Germany a catalogue or bibliography on “Darwinismus” has appeared every year or two.

The success of the “Origin” may, I think, be attributed in large part to my having long before written two condensed sketches and to my having abstracted a much larger manuscript, which was itself an abstract. By this means I was enabled to select the more striking facts and conclusions. I had also, during many years followed a golden rule, namely, that whenever a published fact, a new observation or thought came across me, which was opposed to my general results, to make a memorandum of it without fail and at once; for I had found by experience that such facts and thoughts were far more apt to escape from the memory than favourable ones. Owing to this habit very few objections were raised against my views which I had not at least noticed and attempted to answer.

It has sometimes been said that the success of the “Origin” proved “that the subject was in the air,” or “that men's minds were prepared for it.” I do not think that this is strictly true, for I occasionally sounded not a few naturalists, and never happened to come across a single one who seemed to doubt about the permanence of species. Even Lyell and Hooker, though they listened with interest to me, never seemed to agree. I tried once or twice to explain to able men what I meant by Natural Selection, but signally failed. What I believe was strictly true is that innumerable well-observed facts were stored in the minds of naturalists ready to take their proper places as soon as any theory which would receive them was sufficiently explained. Another element in the success of the book was its moderate size; and this I owe to the appearance of Mr. Wallace's essay; had I published on the scale on which I began to write in 1856, the book would have been four or five times as large as the “Origin,” and very few would have had the patience to read it.

I gained much by my delay an publishing from about, 1839, when the theory was clearly conceived, to 1859; and I lost nothing by it, for I cared very little whether men attributed most originality to me or Wallace; and his essay no doubt aided in the reception of the theory. I was forestalled in only one important point, which my vanity has always made me regret, namely, the explanation by means of the Glacial period of the presence of the same species of plants and of some few animals on distant mountain summits and in the arctic regions. This view pleased me so much that I wrote it out *in extenso*, and I believe that it was read by Hooker some years before E. Forbes published in 1846 his celebrated memoir on the subject. In the very few points in which we differed, I still think that I was in the right. I have never, of course, alluded in print to my having independently worked out this view.

Hardly any point gave me so much satisfaction when I was at work on the "Origin," as the explanation of the wide difference in many classes between the embryo and the adult animal, and of the close resemblance of the embryos within the same class. No notice of this point was taken, as far as I remember, in the early reviews of the "Origin," and I recollect expressing my surprise on this head in a letter to Asa Gray. Within late years several reviewers have given the whole credit to Fritz Muller and Haeckel, who undoubtedly have worked it out much more fully and in some respects more correctly than I did. I had materials for a whole chapter on the subject, and I ought to have made the discussion longer; for it is clear that I failed to impress my readers; and he who succeeds in doing so deserves, in my opinion, all the credit.

This leads me to remark that I have almost always been treated honestly by my reviewers, passing over those without scientific knowledge as not worthy of notice. My views have been grossly misrepresented, bitterly opposed and ridiculed, but this has been generally done as, I believe, in good faith. On the whole, I do not doubt that my works have been over and over again greatly overpraised. I rejoice that I have avoided controversies, and this I owe to Lyell, who many years ago, in reference to my geological works, strongly advised me never to get entangled in a controversy, as it rarely did any good and caused a miserable loss of time and temper.

Whenever I have found out that I have blundered, or that my work has been imperfect, and when I have been contemptuously criticised, and even when I have been overpraised, so that I have felt mortified, it has been my greatest comfort to say hundreds of times to myself that "I have worked as hard and as well as I could, and no man can do more than this." I remember when in Good Success Bay, in Tierra del Fuego, thinking (and, I believe, that I wrote home to the effect) that I could not employ my life better than in adding a little to Natural Science. This I have done to the best of my abilities, and critics may say what they like, but they can not destroy this conviction.

FOOTNOTES:

[2] See Masterpieces of Science, Vol. I, “Earth and Sky,” Sir Charles Lyell on Uniformity in geological change.

[3] The essay appears in “Natural Selection,” London, 1870.

THE DESCENT OF MAN

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Charles Darwin

[Concluding chapter of "The Descent of Man," New York, D. Appleton & Co.]

A brief summary will be sufficient to recall to the reader's mind the more salient points in this work. Many of the views which have been advanced are highly speculative, and some, no doubt, will prove erroneous; but I have in every case given the reasons which have led me to one view rather than to another. It seemed worth while to try how far the principle of evolution would throw light on some of the more complex problems in the natural history of man. False facts are highly injurious to the progress of science, for they often endure long; but false views, if supported by some evidence, do little harm, for every one takes a salutary pleasure in proving their falseness; and, when this is done, one path toward error is closed and the road to truth is often at the same time opened.

The main conclusion arrived at in this work, and now held by many naturalists who are well competent to form a sound judgment, is that man is descended from some less highly organized form. The grounds upon which this conclusion rests will never be shaken, for the close similarity between man and the lower animals in embryonic development, as well as in innumerable points of structure and constitution, both of high and of the most trifling importance—the rudiments which he retains, and the abnormal reversions to which he is occasionally liable—are facts which cannot be disputed. They have long been known, but, until recently, they told us nothing with respect to the origin of man. Now, when viewed by the light of our knowledge of the whole organic world, their meaning is unmistakable. The great principle of evolution stands up clear and firm when these groups of facts are considered in connection with others, such as the mutual affinities of the members of the same group, their geographical distribution in past and present times, and their geological succession. It is incredible that all these facts should speak falsely. He who is not content to look, like a savage, at the phenomena of Nature as disconnected, cannot any longer believe that man is the work of a separate act of creation. He will be forced to admit that the close resemblance of the embryo of man to that, for instance, of a dog—the construction of his skull, limbs and whole frame on the same plan with that of other mammals—the occasional appearance of various structures, for instance, of several distinct muscles, which man does not normally possess, but which are common to the Quadrumana—and a crowd of analogous facts—all point in the plainest manner to the conclusion that man is the co-descendant of other mammals of a common progenitor.

We have seen that man incessantly presents individual differences in all parts of his body and in his mental faculties. These differences or variations seem to be induced by the same general causes, and to obey the same laws as with the lower animals. In both cases similar laws of inheritance prevail. Man tends to increase at a greater rate than his means of subsistence; consequently he is occasionally subjected to a severe struggle for existence, and natural selection will have effected whatever lies within its scope. A succession of strongly marked variations of a similar nature is by no means requisite; slight fluctuating differences in the individual suffice in the work of natural selection. We may feel assured that the inherited effects of the long-continued use or disuse of parts will have done much in the same direction with natural selection. Modifications formerly of importance, though no longer of any special use, are long-inherited. When one part is modified other parts change through the principle of correlation, of which we have instances in many curious cases of correlated monstrosities. Something may be attributed to the direct and definite action of the surrounding conditions of life, such as abundant food, heat or moisture; and, lastly, many characters of slight physiological importance, some indeed of considerable importance, have been gained through sexual selection.

No doubt man, as well as every other animal, presents structures, which, as far as we can judge with our little knowledge, are not now of any service to him, nor to have been so during any former period of his existence, either in relation to his general conditions of life, or of one sex to the other. Such structures cannot be accounted for by any form of selection, or by the inherited effects of the use and disuse of parts. We know, however, that many strange and strongly marked peculiarities of structure occasionally appear in our domesticated productions, and if the unknown causes which produce them were to act more uniformly, they would probably become common to all the individuals of the species. We may hope hereafter to understand something about the causes of such occasional modifications, especially through the study of monstrosities; hence, the labours of experimentalists, such as those of M. Camille Dareste, are full of promise for the future. In general we can only say that the cause of each slight variation and of each monstrosity lies much more in the constitution of the organism than in the nature of the surrounding conditions; though new and changed conditions certainly play an important part in exciting organic changes of many kinds.

Through the means just specified, aided perhaps by others as yet undiscovered, man has been raised to his present state. But since he attained to the rank of manhood, he has diverged into distinct races, or, as they may be more fitly called, subspecies. Some of these, such as the negro and European, are so distinct that, if specimens had been brought to a naturalist without any further information, they would undoubtedly have been considered by him as good and true species. Nevertheless, all the races agree in so many unimportant details of structure and in so many mental peculiarities, that these can be accounted for only by inheritance from a common progenitor; and a progenitor thus characterized would probably deserve to rank as man.

It must not be supposed that the divergence of each race from the other races, and of all from a common stock, can be traced back to any one pair of progenitors. On the contrary, at every stage in the process of modification, all the individuals which were in any way best fitted for their conditions of life, though in different degrees, would have survived in greater numbers than the less well-fitted. The process would have been like that followed by man, when he does not intentionally select particular individuals, but breeds from all the superior individuals and neglects all the inferior individuals. He thus slowly but surely modifies his stock and unconsciously forms a new strain. So with respect to modifications acquired independently of selection, and due to variations arising from the nature of the organism and the action of the surrounding conditions, or from changed habits of life, no single pair will have been modified in a much greater degree than the other pairs which inhabit the same country, for all will have been continually blended through free intercrossing.

By considering the embryological structure of man—the homologies [parallels] which he presents with the lower animals—the rudiments which he retains—and the reversions to which he is liable, we can partly recall in imagination the former condition of our early progenitors; and can approximately place them in their proper place in the zoological series. We thus learn that man is descended from a hairy, tailed quadruped, probably arboreal in its habits [living on or among trees] and an inhabitant of the Old World. This creature, if its whole structure had been examined by a naturalist, would have been classed among the Quadrumana, as surely as the still more ancient progenitor of the Old and New World monkeys. The Quadrumana and all the higher mammals are probably derived from an ancient marsupial animal [usually provided with a pouch for the reception and nourishment of the young, as in the case of the kangaroo] and this through a long line of diversified forms, from some reptile-like or some amphibian-like creature, and this again from some fish-like animal. In the dim obscurity of the past we can see that the early progenitor of all the Vertebrata must have been an aquatic animal, provided with branchiæ [gills], with the two sexes united in the same individual, and with the most important organs of the body (such as the brain and heart) imperfectly or not at all developed. This animal seems to have been more like the larvæ of the existing marine Ascidians than any other known form.

The greatest difficulty which presents itself when we are driven to the above conclusion on the origin of man is the high standard of intellectual power and of moral disposition which he has attained. But every one who admits the principle of evolution must see that the mental powers of the higher animals, which are the same in kind with those of man, though so different in degree, are capable of advancement. Thus the interval between the mental powers of one of the higher apes and of a fish, or between those of an ant and scale-insect, is immense; yet their development does not offer any special difficulty; for with our domesticated animals the mental faculties are certainly variable, and the variations are inherited. No one doubts that they are of the utmost importance to animals in a state of nature. Therefore, the conditions are favourable for their development through natural selection.

The same conclusion may be extended to man; the intellect must have been all-important to him, even at a very remote period, as enabling him to invent and use language, to make weapons, tools, traps, etc., whereby with the aid of his social habits he long ago became the most dominant of all living creatures.

A great stride in the development of the intellect will have followed, as soon as the half-art and half-instinct of language came into use; for the continued use of language will have reacted on the brain and produced an inherited effect; and this again will have reacted on the improvement of language. As Mr. Chauncey Wright has well remarked, the largeness of the brain in man relatively to his body, compared with the lower animals, may be attributed in chief part to the early use of some simple form of language—that wonderful engine which affixes signs to all sorts of objects and qualities, and excites trains of thought which would never arise from the mere impression of the senses, or if they did arise could not be followed out. The higher intellectual powers of man, such as those of ratiocination, abstraction, self-consciousness, etc., will have followed from the continued improvement of other mental faculties; but without considerable culture of the mind, both in the race and in the individual, it is doubtful whether these high powers would be exercised and thus fully attained.

The development of the moral qualities is a more interesting problem. The foundation lies in the social instincts, including under this term the family ties. These instincts are highly complex, and in the case of the lower animals give special tendencies toward certain definite actions; but the more important elements are love and the distinct emotion of sympathy. Animals endowed with the social instincts take pleasure in one another's company, warn one another of danger, defend and aid one another in many ways. These instincts do not extend to all the individuals of the species, but only to those of the same community. As they are highly beneficial to the species they have in all probability been acquired through natural selection.

A moral being is one who is capable of reflecting on his past actions and their motives—of approving of some and disapproving of others; and the fact that man is the one being who certainly deserves this designation is the greatest of all distinctions between him and the lower animals. But in the fourth chapter I have endeavoured to show that the moral sense follows, firstly, from the enduring and ever-present nature of the social instincts; secondly, from man's appreciation of the approbation and disapprobation of his fellows; and, thirdly, from the high activity of his mental faculties, with past impressions extremely vivid; and in these latter respects he differs from the lower animals. Owing to this condition of mind, man cannot avoid looking both backward and forward and comparing past impressions. Hence, after some temporary desire or passion has mastered his social instincts, he reflects and compares the now weakened impression of such past impulses with the ever-present social instincts; and he then feels that sense of dissatisfaction which all unsatisfied instincts leave behind them, he therefore resolves to act differently for the future—and this is conscience. Any instinct permanently stronger or more enduring than another gives rise to a feeling which we express by saying that it ought to be obeyed. A pointer dog if able to reflect on his past conduct would say to himself, I ought (as indeed we say of him) to have pointed at that hare and not have yielded to the passing temptation of hunting it.

Social animals are impelled partly by a wish to aid the members of their community in a general manner, but more commonly to perform certain definite actions. Man is impelled by the same general wish to aid his fellows; but has few or no special instincts. He differs also from the lower animals in the power of expressing his desires by words, which thus become a guide to the aid required and bestowed. The motive to give aid is likewise much modified in man; it no longer consists solely of a blind instinctive impulse, but is much influenced by the praise or blame of his fellows. The appreciation and bestowal of praise and blame both rest on sympathy; and this emotion, as we have seen, is one of the most important elements of the social instincts. Sympathy, though gained as an instinct, is also much strengthened by exercise or habit. As all men desire their own happiness, praise or blame is bestowed on actions or motives according as they lead to this end; and as happiness is an essential part of the general good the greatest-happiness principle indirectly serves as a nearly safe standard of right and wrong. As the reasoning powers advance and experience is gained the remoter effects of certain lines of conduct on the character of the individual and on the general good are perceived; and then the self-regarding virtues come within the scope of public opinion and receive praise and their opposites blame. But with the less civilized nations reason often errs, and many bad customs and base superstitions come within the same scope and are then esteemed as high virtues and their breach as heavy crimes.

The moral faculties are generally and justly esteemed as of higher value than the intellectual powers. But we should bear in mind that the activity of the mind in vividly recalling past impressions is one of the fundamental though secondary bases of conscience. This affords the strongest argument for educating and stimulating in all possible ways the intellectual faculties of every human being. No doubt, a man with a torpid mind, if his social affections and sympathies are well developed, will be led to good actions and may have a fairly sensitive conscience. But whatever renders the imagination more vivid and strengthens the habit of recalling and comparing past impressions will make the conscience more sensitive, and may even somewhat compensate for weak social affections and sympathies.

The moral nature of man has reached its present standard partly through the advancement of his reasoning powers and consequently of a just public opinion, but especially from his sympathies having been rendered more tender and widely diffused through the effects of habit, example, instruction and reflection. It is not improbable that after long practice virtuous tendencies may be inherited. With the more civilized races the conviction of the existence of an all-seeing Deity has had a potent influence on the advance of morality. Ultimately man does not accept the praise or blame of his fellows as his sole guide, though few escape this influence, but his habitual convictions, controlled by reason, afford him the safest rule. His conscience then becomes the supreme judge and monitor. Nevertheless, the first foundation or origin of the moral sense lies in the social instincts, including sympathy; and these instincts, no doubt, were primarily gained, as in the case of the lower animals, through natural selection.

The belief in God has often been advanced as not only the greatest but the most complete of all the distinctions between man and the lower animals. It is, however, impossible, as we have seen, to maintain that this belief is innate or instinctive in man. On the other hand, a belief in all-pervading spiritual agencies seems to be universal, and apparently follows from a considerable advance in man's reason and from a still greater advance in his faculties of imagination, curiosity and wonder. I am aware that the assumed instinctive belief in God has been used by many persons as an argument for His existence. But this is a rash judgment, as we should thus be compelled to believe in the existence of many cruel and malignant spirits, only a little more powerful than man; for the belief in them is far more general than in a beneficent Deity. The idea of a universal and beneficent Creator does not seem to arise in the mind of man until he has been elevated by long-continued culture.

He who believes in the advancement of man from some low organized form will naturally ask, How does this bear on the belief in the immortality of the soul? The barbarous races of man, as Sir J. Lubbock has shown, possess no clear belief of this kind; but arguments derived from the primeval beliefs of savages are, as we have just seen, of little or no avail. Few persons feel any anxiety from the impossibility of determining at what precise period in the development of the individual, from the first trace of a minute germinal vesicle, man becomes an immortal being; and there is no greater cause for anxiety because the period in the gradually ascending organic scale cannot possibly be determined.

I am aware that the conclusions arrived at in this work will be denounced by some as highly irreligious; but he who denounces them is bound to show why it is more irreligious to explain the origin of man as a distinct species by descent from some lower form, through the laws of variation and natural selection, than to explain the birth of the individual through the laws of ordinary reproduction. The birth both of the species and of the individual are equally parts of that grand sequence of events, which our minds refuse to accept as the result of blind chance. The understanding revolts at such a conclusion, whether or not we are able to believe that every slight variation of structure, the union of each pair in marriage, the dissemination of each seed, and other such events have all been ordained for some special purpose.

Sexual selection has been treated at great length in this work; for, as I have attempted to show, it has played an important part in the history of the organic world. I am aware that much remains doubtful, but I have endeavoured to give a fair view of the whole case. In the lower divisions of the animal kingdom sexual selection seems to have done nothing; such animals are often affixed for life to the same spot, or have the sexes combined in the same individual, or, what is still more important, their perceptive and intellectual faculties are not sufficiently advanced to allow of the feelings of love and jealousy, or of the exertion of choice. When, however, we come to the Arthropoda and Vertebrata, even to the lowest classes in these two great sub-kingdoms, sexual selection has effected much; and it deserves notice that we here find the intellectual faculties developed, but in two very distinct lines, to the highest standard, namely in the Hymenoptera [ants, bees, etc.], among the Arthropoda [many insects, spiders, etc.], and in the Mammalia, including man, among the Vertebrata.

In the most distinct classes of the animal kingdom—in mammals, birds, fishes, insects and even crustaceans—the differences between the sexes follow almost exactly the same rules. The males are almost always the wooers; and they alone are armed with special weapons for fighting with their rivals. They are generally stronger and larger than the females, and are endowed with the requisite qualities of courage and pugnacity. They are provided, either exclusively or in a much higher degree than the females, with organs for vocal or instrumental music, and with odoriferous glands. They are ornamented with infinitely diversified appendages and with the most brilliant or conspicuous colors, often arranged in elegant patterns, while the females are unadorned. When the sexes differ in more important structures it is the male which is provided with special sense-organs for discovering the female, with locomotive organs for reaching her, and often with prehensile organs for holding her. These various structures for charming or securing the female are often developed in the male during only part of the year; namely, the breeding season. They have in many cases been transferred in a greater or less degree to the females; and in the latter case they often appear in her as mere rudiments. They are lost or never gained by the males after emasculation. Generally they are not developed in the male during early youth, but appear a short time before the age for reproduction. Hence, in most cases the young of both sexes resemble each other; and the female somewhat resembles her young offspring throughout life. In almost every great class a few anomalous cases occur, where there has been an almost complete transposition of the characters proper to the two sexes; the females assuming characters which properly belong to the males. This surprisingly uniformity in the laws regulating the differences between the sexes in so many and such widely separated classes is intelligible if we admit the action throughout all the higher divisions of the animal kingdom of one common cause; namely, sexual selection.

Sexual selection depends on the success of certain individuals over others of the same sex, in relation to the propagation of the species; while natural selection depends on the success of both sexes, at all ages, in relation to the general conditions of life. The sexual struggle is of two kinds; in the one it is between the individuals of the same sex, generally the males, in order to drive away or kill their rivals, the females remaining passive; while in the other, the struggle is likewise between the individuals of the same sex, in order to excite or charm those of the opposite sex, generally the females, which no longer remain passive, but select the more agreeable partners. This latter kind of selection is closely analogous to that which man unintentionally, yet effectually, brings to bear on his domesticated productions, when he preserves during a long period the most pleasing or useful individuals, without any wish to modify the breed.

The laws of inheritance determine whether characters gained through sexual selection by either sex shall be transmitted to the same sex, or to both; as well as the age at which they shall be developed. It appears that variations arising late in life are commonly transmitted to one and the same sex. Variability is the necessary basis for the action of selection and is wholly independent of it. It follows from this that variations of the same general nature have often been taken advantage of and accumulated through sexual selection in relation to the propagation of the species, as well as through natural selection in relation to the general purposes of life. Hence secondary sexual characters, when equally transmitted to both sexes, can be distinguished from ordinary specific characters only by the light of analogy. The modifications acquired through sexual selection are often so strongly pronounced that the two sexes have frequently been ranked as distinct species, or even as distinct genera. Such strongly marked differences must be in some manner highly important; and we know that they have been acquired in some instances at the cost not only of inconvenience, but of exposure to actual danger.

The belief in the power of sexual selection rests chiefly on the following considerations: The characters which we have the best reasons for supposing to have been thus acquired are confined to one sex; and this alone renders it probable that in most cases they are connected with the act of reproduction. These characters in innumerable instances are fully developed only at maturity; and often during only a part of the year, which is always the breeding season. The males (passing over a few exceptional cases) are the more active in courtship; they are the best armed, and are rendered the most attractive in various ways. It is to be especially observed that the males display their attractions with elaborate care in the presence of the females; and that they rarely or never display them excepting during the season of love. It is incredible that all this should be purposeless. Lastly, we have distinct evidence with some quadrupeds and birds that the individuals of one sex are capable of feeling a strong antipathy or preference for certain individuals of the other sex.

Bearing in mind these facts and not forgetting the marked results of man's unconscious selection, it seems to me almost certain that if the individuals of one sex were during a long series of generations to prefer pairing with certain individuals of the other sex, characterized in some peculiar manner, the offspring would slowly but surely become modified in this same manner. I have not attempted to conceal that, excepting when the males are more numerous than the females, or when polygamy prevails, it is doubtful how the more attractive males succeed in leaving a larger number of offspring to inherit their superiority in ornaments or other charms than the less attractive males; but I have shown that this would probably follow from the females—especially the more vigorous ones, which would be the first to breed—preferring not only the more attractive but at the same time the more vigorous and victorious males.

Although we have some positive evidence that birds appreciate bright and beautiful objects, as with the bower-birds of Australia, and although they certainly appreciate the power of song, yet I fully admit that it is astonishing that the females of many birds and some mammals should be endowed with sufficient taste to appreciate ornaments, which we have reason to attribute to sexual selection; and this is even more astonishing in the case of reptiles, fish and insects. But we really know little about the minds of the lower animals. It cannot be supposed, for instance, that male birds of paradise or peacocks should take such pains in erecting, spreading and vibrating their beautiful plumes before the males for no purpose. We should remember the fact given on excellent authority in a former chapter that several peahens, when debarred from an admired male, remained widows during a whole season rather than pair with another bird.

Nevertheless, I know of no fact in natural history more wonderful than that the female Argus pheasant should appreciate the exquisite shading of the ball-and-socket ornaments and the elegant patterns on the wing feathers of the male. He who thinks that the male was created as he now exists must admit that the great plumes, which prevent the wings from being used for flight and which, as well as the primary feathers, are displayed in a manner quite peculiar to this one species during the act of courtship, and at no other time, were given to him as an ornament. If so, he must likewise admit that the female was created and endowed with the capacity of appreciating such ornaments. I differ only in the conviction that the male Argus pheasant acquired his beauty gradually, through the females having preferred during many generations the more highly ornamented males; the esthetic capacity of the females having been advanced through exercise or habit just as our own taste is gradually improved. In the male, through the fortunate chance of a few feathers not having been modified, we can distinctly see how simple spots with a little fulvous [tawny] shading on one side may have been developed by small steps into the wonderful ball-and-socket ornaments; and it is probable that they were actually thus developed.

Every one who admits the principle of evolution, and yet feels great difficulty in admitting that female mammals, birds, reptiles and fish, could have acquired the high taste implied by the beauty of the males, and which generally coincides with our own standard, should reflect that the nerve-cells of the brain in the highest as well as in the lowest members of the Vertebrate series, are derived from those of the common progenitor of the whole group. It thus becomes intelligible that the brain and mental faculties should be capable under similar conditions of nearly the same course of development, and consequently of performing nearly the same functions.

The reader who has taken the trouble to go through the several chapters devoted to sexual selection will be able to judge how far the conclusions at which I have arrived are supported by sufficient evidence. If he accepts these conclusions he may, I think, safely extend them to mankind; but it would be superfluous here to repeat what I have so lately said on the manner in which sexual selection apparently has acted on man, both on the male and female side, causing the two sexes of man to differ in body and mind, and the several races to differ from each other in various characters, as well as from their ancient and lowly organized progenitors.

He who admits the principle of sexual selection will be led to the remarkable conclusion that the cerebral system not only regulates most of the existing functions of the body, but has indirectly influenced the progressive development of various bodily structures and of certain mental qualities. Courage, pugnacity, perseverance, strength and size of body, weapons of all kinds, musical organs, both vocal and instrumental, bright colours, stripes and marks, and ornamental appendages, have all been indirectly gained by the one sex or the other, through the influence of love and jealousy, through the appreciation of the beautiful in sound, colour or form, and through the exertion of a choice; and those powers of the mind manifestly depend on the development of the cerebral system.

Man scans with scrupulous care the character and pedigree of his horses, cattle and dogs before he matches them; but when he comes to his own marriage he rarely, or never takes any such care. He is impelled by nearly the same motives as the lower animals when left to their own free choice, though he is in so far superior to them that he highly values mental charms and virtues. On the other hand he is strongly attracted by mere wealth or rank. Yet he might by selection do something not only for the bodily constitution and frame of his offspring, but for their intellectual and moral qualities. Both sexes ought to refrain from marriage if they are in any marked degree inferior in body or mind; but such hopes are Utopian and will never be even partially realized until the laws of inheritance are thoroughly known. All do good service who aid toward this end. When the principles of breeding and inheritance are better understood, we shall not hear ignorant members of our legislature rejecting with scorn a plan for ascertaining whether or not consanguineous marriages are injurious to man.

The advancement of the welfare of mankind is a most intricate problem; all ought to refrain from marriage who cannot avoid abject poverty for their children; for poverty is not only a great evil, but tends to its own increase by leading to recklessness in marriage. On the other hand, as Mr. Galton has remarked, if the prudent avoid marriage, while the reckless marry, the inferior members tend to supplant the better members of society. Man, like every other animal, has no doubt advanced to his present high condition through a struggle for existence consequent on his rapid multiplication; and if he is to advance still higher, he must remain subject to a severe struggle. Otherwise he would sink into indolence, and the more gifted men would not be more successful in the battle of life than the less gifted. Hence our natural rate of increase, though leading to many and obvious evils, must not be greatly diminished by any means. There should be open competition for all men; and the most able should not be prevented by laws or customs from succeeding best and rearing the largest number of offspring. Important as the struggle for existence has been and even still is, yet as far as the highest part of man's nature is concerned there are other agencies more important. For the moral qualities are advanced, either directly or indirectly, much more through the effects of habit, the reasoning powers, instruction, religion, etc., than through natural selection; though to this latter agency the social instincts, which afforded the basis for the development of the moral sense, may be safely attributed.

The main conclusion arrived at in this work, namely, that man is descended from some lowly organized form, will, I regret to think, be highly distasteful to many. But there can hardly be a doubt that we are descended from barbarians. The astonishment I felt on first seeing a party of Fuegians on a wild and broken shore will never be forgotten by me, for the reflection at once rushed into my mind—such were our ancestors. These men were absolutely naked and bedaubed with paint, their long hair was tangled, their mouths frothed with excitement, and their expression was wild, startled and distrustful. They possessed hardly any arts, and like wild animals lived on what they could catch; they had no government, and were merciless to every one not of their own small tribe. He who has seen a savage in his native land will not feel much shame, if forced to acknowledge that the blood of some more humble creature flows in his veins. For my own part I would as soon be descended from that heroic little monkey who braved his dreaded enemy in order to save the life of his keeper; or from that old baboon, who, descending from the mountains, carried away in triumph his young comrade from a crowd of astonished dogs—as from a savage who delights to torture his enemies, offers up bloody sacrifices, practises infanticide without remorse, treats his wives like slaves, knows no decency, and is haunted by the grossest superstitions.

Man may be excused for feeling some pride at having risen, though not through his own exertions, to the very summit of the organic scale; and the fact of his having thus risen, instead of having been aboriginally placed there, may give him hope for a still higher destiny in the distant future. But we are not here concerned with hopes or fears, only with the truth as far as our reason permits us to discover it. I have given the evidence to the best of my ability, and we must acknowledge, as it seems to me, that man, with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his godlike intellect which has penetrated into the movements and constitution of the solar system—with all these exalted powers—Man still bears in his bodily frame the indelible stamp of his lowly origin.

MIMICRY AND OTHER PROTECTIVE RESEMBLANCES AMONG ANIMALS

Top

ALFRED RUSSEL WALLACE

[Mr. Wallace, one of the greatest naturalists of the age, discovered the law of natural selection independently of Darwin, and about the same time. Among his works are "The Malay Archipelago," "Island Life," and "Darwinism." From "Natural Selection," which was published by Macmillan & Co., 1871, the following extracts are taken. The theme has received important development at the hands of Professor E. B. Poulton, in his "The Colours of Animals," International Scientific Series, 1890: and in F. E. Beddard's "Animal Colouration"; London, Swan Sonnenschein; N. Y., Macmillan, 1892.]

There is no more convincing proof of the truth of a comprehensive theory, than its power of absorbing and finding a place for new facts, and its capability of interpreting phenomena which had been previously looked upon as unaccountable anomalies. It is thus that the law of universal gravitation and the undulatory theory of light have become established and universally accepted by men of science. Fact after fact has been brought forward as being apparently inconsistent with them, and one after another these very facts have been shown to be the consequences of the laws they were at first supposed to disprove. A false theory will never stand this test. Advancing knowledge brings to light whole groups of facts which it cannot deal with, and its advocates steadily decrease in numbers, notwithstanding the ability and scientific skill with which it has been supported. The course of a true theory is very different, as may be well seen by the progress of opinion on the subject of natural selection. In less than eight years "The Origin of Species" has produced conviction in the minds of a majority of the most eminent living men of science. New facts, new problems, new difficulties as they arise are accepted, solved or removed by this theory; and its principles are illustrated by the progress and conclusions of every well established branch of human knowledge. It is the object of the present essay to show how it has recently been applied to connect together and explain a variety of curious facts which had long been considered as inexplicable anomalies.

Perhaps no principle has ever been announced so fertile in results as that which Mr. Darwin so earnestly impresses upon us, and which is indeed a necessary deduction from the theory of natural selection, namely—that none of the definite facts of organic nature, no special organ, no characteristic form or marking, no peculiarities of instinct or of habit, no relations between species or between groups of species—can exist, but which must now be or once have been *useful* to the individuals or races which possess them. This great principle gives us a clue which we can follow out in the study of many recondite phenomena, and leads us to seek a meaning and a purpose of some definite character in minutiæ which we should be otherwise almost sure to pass over as insignificant or unimportant.

The adaptation of the external colouring of animals to their conditions of life has long been recognized, and has been imputed either to an originally created specific peculiarity, or to the direct action of climate, soil, or food. Where the former explanation has been accepted, it has completely checked inquiry, since we could never get any further than the fact of the adaptation. There was nothing more to be known about the matter. The second explanation was soon found to be quite inadequate to deal with all the varied phases of the phenomena, and to be contradicted by many well-known facts. For example, wild rabbits are always of gray or brown tints well suited for concealment among grass and fern. But when these rabbits are domesticated, without any change of climate or food, they vary into white or black, and these varieties may be multiplied to any extent, forming white or black races. Exactly the same thing has occurred with pigeons; and in the case of rats and mice, the white variety has not been shown to be at all dependent on alteration of climate, food or other external conditions. In many cases the wings of an insect not only assume the exact tint of the bark or leaf it is accustomed to rest on, but the form and veining of the leaf or the exact rugosity of the bark is imitated; and these detailed modifications cannot be reasonably imputed to climate or food, since in many cases the species does not feed on the substance it resembles, and when it does, no reasonable connection can be shown to exist between the supposed cause and the effect produced. It was reserved for the theory of natural selection to solve all these problems, and many others which were not at first supposed to be directly connected with them. To make these latter intelligible, it will be necessary to give a sketch of the whole series of phenomena which may be classed under the head of useful or protective resemblances.

Concealment, more or less complete, is useful to many animals, and absolutely essential to some. Those which have numerous enemies from which they cannot escape by rapidity of motion, find safety in concealment. Those which prey upon others must also be so constituted as not to alarm them by their presence or their approach, or they would soon die of hunger. Now, it is remarkable in how many cases nature gives this boon to the animal, by colouring it with such tints as may best serve to enable it to escape from its enemies or to entrap its prey. Desert animals as a rule are desert-coloured. The lion is a typical example of this, and must be almost invisible when crouched upon the sand or among desert rocks and stones. Antelopes are all more or less sandy-coloured. The camel is pre-eminently so. The Egyptian cat and the Pampas cat are sandy or earth-coloured. The Australian kangaroos are of the same tints, and the original colour of the wild horse is supposed to have been a sandy or clay-colour.

The desert birds are still more remarkably protected by their assimilative hues. The stone-chats, the larks, the quails, the goatsuckers and the grouse, which abound in the North African and Asiatic deserts, are all tinted and mottled so as to resemble with wonderful accuracy the average colour and aspect of the soil in the district they inhabit. The Rev. H. Tristram, in his account of the ornithology of North Africa in the first volume of the “Ibis,” says: “In the desert, where neither trees, brushwood, nor even undulation of the surface afford the slightest protection to its foes, a modification of colour which shall be assimilated to that of the surrounding country is absolutely necessary. Hence *without exception* the upper plumage of *every bird*, whether lark, chat, sylvain, or sand-grouse, and also the fur of *all the smaller mammals*, and the skin of *all the snakes and lizards*, is of one uniform isabelline or sand colour.” After the testimony of so able an observer it is unnecessary to adduce further examples of the protective colours of desert animals.

Almost equally striking are the cases of arctic animals possessing the white colour that best conceals them upon snowfields and icebergs. The polar bear is the only bear that is white, and it lives constantly among snow and ice. The arctic fox, the ermine and the alpine hare change to white in winter only, because in summer white would be more conspicuous than any other colour, and therefore a danger rather than a protection; but the American polar hare, inhabiting regions of almost perpetual snow, is white all the year round. Other animals inhabiting the same northern regions do not, however, change colour. The sable is a good example, for throughout the severity of a Siberian winter it retains its rich brown fur. But its habits are such that it does not need the protection of colour, for it is said to be able to subsist on fruits and berries in winter, and to be so active upon the trees as to catch small birds among the branches. So also the woodchuck of Canada has a dark-brown fur; but then it lives in burrows and frequents river banks, catching fish and small animals that live in or near the water.

Among birds, the ptarmigan is a fine example of protective colouring. Its summer plumage so exactly harmonizes with the lichen-coloured stones among which it delights to sit, that a person may walk through a flock of them without seeing a single bird; while in winter its white plumage is an almost equal protection. The snow-bunting, the jerfalcon, and the snowy owl are also white-coloured birds inhabiting the arctic regions, and there can be little doubt but that their colouring is to some extent protective.

Nocturnal animals supply us with equally good illustrations. Mice, rats, bats, and moles possess the least conspicuous of hues, and must be quite invisible at times when any light colour would be instantly seen. Owls and goatsuckers are of those dark mottled tints that will assimilate with bark and lichen, and thus protect them during the day, and at the same time be inconspicuous in the dusk.

It is only in the tropics, among forests which never lose their foliage, that we find whole groups of birds whose chief colour is green. The parrots are the most striking example, but we have also a group of green pigeons in the East; and the barbets, leaf-thrushes, bee-eaters, white-eyes, turacos, and several smaller groups, have so much green in their plumage as to tend greatly to conceal them among the foliage.

The conformity of tint which has been so far shown to exist between animals and their habitations is of somewhat general character; we will now consider the cases of more special adaptation. If the lion is enabled by his sandy colour readily to conceal himself by merely crouching down in the desert, how, it may be asked, do the elegant markings of the tiger, the jaguar, and the other large cats agree with this theory? We reply that these are generally cases of more or less special adaptation. The tiger is a jungle animal, and hides himself among tufts of grass or of bamboos, and in these positions the vertical stripes with which his body is adorned must so assimilate with the vertical stems of the bamboo, as to assist greatly in concealing him from his approaching prey. How remarkable it is that besides the lion and tiger, almost all the other large cats are arboreal in their habits, and almost all have ocellated or spotted skins, which must certainly tend to blend them with the background of foliage; while the one exception, the puma, has an ashy-brown uniform fur, and has the habit of clinging so closely to a limb of a tree while waiting for his prey to pass beneath as to be hardly distinguishable from the bark.

Among birds, the ptarmigan, already mentioned, must be considered a remarkable case of special adaptation. Another is a South American goatsucker (Caprimulgus rupestris) which rests in the bright sunshine on little bare rocky islets in the upper Rio Negro, where its unusually light colours so closely resemble those of the rock and sand, that it can scarcely be detected until trodden upon.

The Duke of Argyll, in his “Reign of Law,” has pointed out the admirable adaptation of the colours of the woodcock to its protection. The various browns and yellows and pale ash-colour that occur on fallen leaves are all reproduced in its plumage, so that when according to its habit it rests upon the ground under trees, it is almost impossible to detect it. In snipes the colours are modified so as to be equally in harmony with the prevalent forms and colours of marshy vegetation. Mr. J. M. Lester, in a paper read before the Rugby School Natural History Society observes:—“The wood-dove, when perched amongst the branches of its favourite *fir*, is scarcely discernible; whereas, were it among some lighter foliage the blue and purple tints in its plumage would far sooner betray it. The robin redbreast, too, although it might be thought that the red on its breast made it much easier to be seen, is in reality not at all endangered by it, since it generally contrives to get among some russet or yellow fading leaves, where the red matches very well with the autumn tints, and the brown of the rest of the body with the bare branches.”

Reptiles offer us many similar examples. The most arboreal lizards, the iguanas, are as green as the leaves they feed upon, and the slender whip-snakes are rendered almost invisible as they glide among the foliage by a similar colouration. How difficult it is sometimes to catch sight of the little green tree-frogs sitting on the leaves of a small plant enclosed in a glass case in the Zoological Gardens; yet how much better concealed they must be among the fresh green damp foliage of a marshy forest. There is a North American frog found on lichen-covered rocks and walls, which is so coloured as exactly to resemble them, and as long as it remains quiet would certainly escape detection. Some of the geckos which cling motionless on the trunks of trees in the tropics, are of such curiously marbled colours as to match exactly with the bark they rest upon.

In every part of the tropics there are tree snakes that twist among boughs and shrubs, or lie coiled up in the dense masses of foliage. These are of many distinct groups, and comprise both venomous and harmless genera; but almost all of them are of a beautiful green colour, sometimes more or less adorned with white or dusky bands and spots. There can be little doubt that this colour is doubly useful to them, since it will tend to conceal them from their enemies, and will lead their prey to approach them unconscious of danger. Dr. Gunthner informs me that there is only one genus of true arboreal snakes (Dipsas) whose colours are rarely green, but are of various shades of black, brown, and olive, and these are all nocturnal reptiles, and there can be little doubt conceal themselves during the day in holes, so that the green protective tint would be useless to them, and they accordingly retain the more usual reptilian hues.

Fishes present similar instances. Many flat fish, as, for example, the flounder and the skate, are exactly the colour of the gravel or sand on which they habitually rest. Among the marine flower gardens of an Eastern coral reef the fishes present every variety of gorgeous colour, while the river fish even of the tropics rarely if ever have gay or conspicuous markings. A very curious case of this kind of adaptation occurs in the sea-horse (Hippocampus) of Australia, some of which bear long foliaceous appendages resembling seaweed, and are of a brilliant red colour; and they are known to live among seaweed of the same hue, so that when at rest they must be quite invisible. There are now in the aquarium of the Zoological Society some slender green pipe-fish which fasten themselves to any object at the bottom by their prehensile tails, and float about with the current, looking exactly like some cylindrical algæ.

It is, however, in the insect world that this principle of the adaptation of animals to their environment is most fully and strikingly developed. In order to understand how general this is, it is necessary to enter somewhat into details, as we shall thereby be better able to appreciate the significance of the still more remarkable phenomena we shall presently have to discuss. It seems to be in proportion to their sluggish motions or the absence of other means of defence, that insects possess the protective colouring. In the tropics there are thousands of species of insects which rest during the day clinging to the bark of dead or fallen trees; and the greater portion of these are delicately mottled with gray and brown tints, which though symmetrically disposed and infinitely varied, yet blend so completely with the usual colours of the bark that at two or three feet distance they are quite undistinguishable. In some cases a species is known to frequent only one species of tree. This is the case with the common South American long-horned beetle (Onychocerus scorpio) which, Mr. Bates informed me, is found only on a rough-barked tree, called Tapiriba, on the Amazon. It is very abundant, but so exactly does it resemble the bark in colour and rugosity, and so closely does it cling to the branches, that until it moves it is absolutely invisible! An allied species (O. concentricus) is found only at Para, on a distinct species of tree, the bark of which it resembles with equal accuracy. Both these insects are abundant, and we may fairly conclude that the protection they derive from this strange concealment is at least one of the causes that enable the race to flourish.

Many of the species of Cicindela, or tiger beetle, will illustrate this mode of protection. Our common Cicindela campestris frequents grassy banks and is of a beautiful green colour, while C. maritima, which is found only on sandy sea-shores, is of a pale bronzy yellow, so as to be almost invisible. A great number of the species found by myself in the Malay islands are similarly protected. The beautiful Cicindela gloriosa, of a very deep velvety green colour, was only taken upon wet mossy stones in the bed of a mountain stream, where it was with the greatest difficulty detected. A large brown species (C. heros) was found chiefly on dead leaves in forest paths; and one which was never seen except on the wet mud of salt marshes was of a glossy olive so exactly the colour of the mud as only to be distinguished when the sun shone, by its shadow! Where the sandy beach was coralline and nearly white, I found a very pale Cicindela; wherever it was volcanic and black, a dark species of the same genus was sure to be met with.

There are in the East small beetles of the family Buprestidæ which generally rest on the midrib of a leaf, and the naturalist often hesitates before picking them off, so closely do they resemble pieces of bird's dung. Kirby and Spence mention the small beetle Onthophilus sulcatus as being like the seed of an umbelliferous plant; and another small weevil, which is much persecuted by predatory beetles of the genus Harpalus, is of the exact colour of loamy soil, and was found to be particularly abundant in loam pits. Mr. Bates mentions a small beetle (Chlamys pilula) which was undistinguishable by the eye from the dung of caterpillars, while some of the Cassidæ, from their hemispherical forms and pearly gold-colour, resemble glittering dew-drops upon the leaves.

A number of our small brown and speckled weevils at the approach of any object roll off the leaf they are sitting on, at the same time drawing in their legs and antennæ, which fit so perfectly into cavities for their reception that the insect becomes a mere oval brownish lump, which it is hopeless to look for among the similarly coloured little stones and earth pellets among which it lies motionless.

The distribution of colour in butterflies and moths respectively is very instructive from this point of view. The former have all their brilliant colouring on the upper surface of all four wings, while the under surface is almost always soberly coloured, and often very dark and obscure. The moths on the contrary have generally their chief colour on the hind wings only, the upper wings being of dull, sombre, and often imitative tints, and these generally conceal the hind wings when the insects are in repose. This arrangement of the colours is therefore eminently protective, because the butterfly always rests with his wings raised so as to conceal the dangerous brilliancy of his upper surface. It is probable that if we watched their habits sufficiently we should find the under surface of the wings of butterflies very frequently imitative and protective. Mr. T. W. Wood has pointed out that the little orange-tip butterfly often rests in the evening on the green and white flower heads of an umbelliferous plant, and that when observed in this position the beautiful green and white mottling of the under surface completely assimilates with the flower heads and renders the creature very difficult to be seen. It is probable that the rich dark colouring of the under side of our peacock, tortoiseshell, and red-admiral butterflies answers a similar purpose.

Two curious South American butterflies that always settle on the trunks of trees (Gynecia dirce and Callizona acesta) have the under surface curiously striped and mottled, and when viewed obliquely must closely assimilate with the appearance of the furrowed bark of many kinds of trees. But the most wonderful and undoubted case of protective resemblance in a butterfly which I have ever seen, is that of the common Indian Kallima inachis, and its Malayan ally, Kallima paralekta. The upper surface of these insects is very striking and showy, as they are of a large size, and are adorned with a broad band of rich orange on a deep bluish ground. The under side is very variable in colour, so that out of fifty specimens no two can be found exactly alike, but every one of them will be of some shade of ash or brown or ochre, such as are found among dead, dry or decaying leaves. The apex of the upper wings is produced into an acute point, a very common form in the leaves of tropical shrubs and trees, and the lower wings are also produced into a short, narrow tail. Between these two points runs a dark curved line exactly representing the midrib of a leaf, and from this radiate on each side a few oblique lines, which serve to indicate the lateral veins of a leaf. These marks are more clearly seen on the outer portion of the base of the wings, and on the inner side towards the middle and apex, and it is very curious to observe how the usual marginal and transverse striæ of the group are here modified and strengthened so as to become adapted for an imitation of the venation of a leaf. We come now to a still more extraordinary part of the imitation, for we find representations of leaves in every stage of decay, variously blotched and mildewed and pierced with powdery black dots gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves that is it impossible to avoid thinking at first sight that the butterflies themselves have been attacked by real fungi.

But this resemblance, close as it is, would be little use if the habits of the insect did not accord with it. If the butterfly sat upon leaves or upon flowers, or opened its wings so as to expose the upper surface, or exposed and moved its head and antennæ as many other butterflies do, its disguise would be of little avail. We might be sure, however, from the analogy of many other cases, that the habits of the insect are such as still further to aid its deceptive garb; but we are not obliged to make any such supposition, since I myself had the good fortune to observe scores of Kallima paralekta, in Sumatra, and to capture many of them, and can vouch for the accuracy of the following details: These butterflies frequent dry forests and fly very swiftly. They were never seen to settle on a flower or a green leaf, but were many times lost sight of in a bush or tree of dead leaves. On such occasions they were generally searched for in vain, for while gazing intently at the very spot where one had disappeared, it would often suddenly dart out and again vanish twenty or fifty yards further on. On one or two occasions the insect was detected reposing, and it could then be seen how completely it assimilates itself to the surrounding leaves. It sits on a nearly upright twig, the wings fitting closely back to back, concealing the antennæ and head, which are drawn up between their bases. The little tails of the hind wings touch the branch and form a perfect stalk to the leaf, which is supported in its place by the claws of the middle pair of feet, which are slender and inconspicuous. The irregular outline of the wings gives exactly the perspective effect of a shrivelled leaf. We thus have size, colour, form, markings, and habits, all combining together to produce a disguise which may be said to be absolutely perfect; and the protection which it affords is sufficiently indicated by the abundance of the individuals that possess it....

We will now endeavour to show how these wonderful resemblances have most probably been brought about. Returning to the higher animals, let us consider the remarkable fact of the rarity of white colouring in the mammalia or birds of the temperate or tropical zones in a state of nature. There is not a single white land-bird or quadruped in Europe, except the few arctic or alpine species to which white is a protective colour. Yet in many of these creatures there seems to be no inherent tendency to avoid white, for directly they are domesticated white varieties arise, and appear to thrive as well as others. We have white mice and rats, white cats, horses, dogs, and cattle, white poultry, pigeons, turkeys, and ducks, and white rabbits. Some of these animals have been domesticated for a long period, others only for a few centuries; but in almost every case in which an animal has been thoroughly domesticated, parti-coloured and white varieties are produced and become permanent.

It is also well known that animals in a state of nature produce white varieties occasionally. Blackbirds, starlings, and crows are occasionally seen white, as well as elephants, deer, tigers, hares, moles, and many other animals; but in no case is a permanent white race produced. Now there are no statistics to show that the normal-coloured parents produce white offspring oftener under domestication than in a state of nature, and we have no right to make such an assumption if the facts can be accounted for without it. But if the colours of animals do really, in the various instances already adduced, serve for their concealment and preservation, then white or any other conspicuous colour must be hurtful, and must in most cases shorten an animal's life. A white rabbit would be more surely the prey of hawk or buzzard, and the white mole, or field mouse, could not long escape from the vigilant owl. So, also, any deviation from those tints best adapted to conceal a carnivorous animal would render the pursuit of its prey much more difficult, would place it at a disadvantage among its fellows and in a time of scarcity would probably cause it to starve to death. On the other hand, if an animal spreads from a temperate into an arctic district, the conditions are changed. During a large portion of the year, and just when the struggle for existence is most severe, white is the prevailing tint of nature, and dark colours will be the most conspicuous. The white varieties will now have an advantage; they will escape from their enemies or will secure food, while their brown companions will be devoured or will starve; and “as like produces like” is the established rule in nature, the white race will become permanently established, and dark varieties, when they occasionally appear, will soon die out from their want of adaptation to their environment. In each case the fittest will survive, and a race will be eventually produced adapted to the conditions in which it lives.

We have here an illustration of the simple and effectual means by which animals are brought into harmony with the rest of nature. That slight amount of variability in every species, which we often look upon as something accidental or abnormal, or so insignificant as to be hardly worthy of notice, is yet the foundation of all those wonderful and harmonious resemblances which play such an important part in the economy of nature. Variation is generally very small in amount, but it is all that is required, because the change in the external conditions to which an animal is subject is generally very slow and intermittent. When these changes have taken place too rapidly, the result has often been the extinction of species; but the general rule is, that climatal and geological changes go on slowly, and the slight but continual variations in the colour, form and structure of all animals, has furnished individuals adapted to these changes, and who have become the progenitors of modified races. Rapid multiplication, incessant slight variation, and survival of the fittest—these are the laws which ever keep the organic world in harmony with the inorganic and with itself. These are the laws which we believe have produced all the cases of protective resemblance already adduced, as well as those still more curious examples we have yet to bring before our readers.

It must always be borne in mind that the more wonderful examples, in which there is not only a general but a special resemblance as in the walking leaf, the mossy phasma, and the leaf-winged butterfly—represent those few instances in which the process of modification has been going on during an immense series of generations. They all occur in the tropics, where the conditions of existence are the most favourable, and where climatic changes have for long periods been hardly perceptible. In most of them favourable variations both of colour, form, structure, and instinct or habit, must have occurred to produce the perfect adaptation we now behold. All these are known to vary, and favourable variations when not accompanied by others that are unfavourable, would certainly survive. At one time a little step might be made in this direction, at another time in that—a change of conditions might sometimes render useless that which it had taken ages to produce—great and sudden physical modifications might often produce the extinction of a race just as it was approaching perfection, and a hundred checks of which we can know nothing may have retarded the progress towards perfect adaptation; so that we can hardly wonder at there being so few cases in which a completely successful result has been attained as shown by the abundance and wide diffusion of the creatures so protected.

[Here are given many detailed examples of insects which gainfully mimic one another.]

We will now adduce a few cases in which beetles imitate other insects, and insects of other orders imitate beetles.

Charis melipona, a South American Longicorn of the family Necydalidæ, has been so named from its resemblance to a small bee of the genus Melipona. It is one of the most remarkable cases of mimicry, since the beetle has the thorax and body densely hairy like the bee, and the legs are tufted in a manner most unusual in the order Coleoptera. Another Longicorn, Odontocera odyneroides, has the abdomen banded with yellow, and constricted at the base, and is altogether so exactly like a small common wasp of the genus Odynerus, that Mr. Bates informs us he was afraid to take it out of his net with his fingers for fear of being stung. Had Mr. Bates's taste for insects been less omnivorous than it was, the beetle's disguise might have saved it from his pin, as it had no doubt often done from the beak of hungry birds. A larger insect, Sphecomorpha chalybea, is exactly like one of the large metallic blue wasps, and like them has the abdomen connected with the thorax by a pedicle, rendering the deception most complete and striking. Many Eastern species of Longicorns of the genus Oberea, when on the wing exactly resemble Tenthredinidæ, and many of the small species of Hesthesis run about on timber, and cannot be distinguished from ants. There is one genus of South American Longicorns that appears to mimic the shielded bugs of the genus Scutellera. The Gymnocerous capucinus is one of these, and is very like Pachyotris fabricii, one of the Scutelleridæ. The beautiful Gymnocerous dulcissimus is also very like the same group of insects, though there is no known species that exactly corresponds to it; but this is not to be wondered at, as the tropical Hemiptera have been comparatively so little cared for by collectors.

The most remarkable case of an insect of another order mimicking a beetle is that of the Condylodera tricondyloides, one of the cricket family from the Philippine Islands, which is so exactly like a Tricondyla (one of the tiger beetles), that such an experienced entomologist as Professor Westwood placed it among them in his cabinet, and retained it there a long time before he discovered his mistake! Both insects run along the trunks of trees, and whereas Tricondylas are very plentiful, the insect that mimics it is, as in all other cases, very rare. Mr. Bates also informs us that he found at

Santarem on the Amazon, a species of locust which mimicked one of the tiger beetles of the genus Odontocheila, and was found on the same trees which they frequented.

There are a considerable number of Diptera, or two-winged flies, that closely resemble wasps and bees, and no doubt derive much benefit from the wholesome dread which those insects excite. The Midas dives, and other species of large Brazilian flies, have dark wings and metallic blue elongate bodies, resembling the large stinging Sphegidæ of the same country; and a very large fly of the genus Asilus has black-banded wings and the abdomen tipped with rich orange, so as exactly to resemble the fine bee Euglossa dimidiata, and both are found in the same parts of South America. We have also in our own country species of Bombylius which are almost exactly like bees. In these cases the end gained by the mimicry is no doubt freedom from attack, but it has sometimes an altogether different purpose. There are a number of parasitic flies whose larvæ feed upon the larvæ of bees, such as the British genus Volucella and many of the tropical Bombylii, and most of these are exactly like the particular species of bee they prey upon, so that they can enter their nests unsuspected to deposit their eggs. There are also bees that mimic bees. The cuckoo bees of the genus Nomada are parasitic on the Andrenidæ, and they resemble either wasps or species of Andrena; and the parasitic humble-bees of the genus Apathus almost exactly resemble the species of humble-bees in whose nests they are reared. Mr. Bates informs us that he found numbers of these “cuckoo” bees and flies on the Amazon, which all wore the livery of working bees peculiar to the same country.

There is a genus of small spiders in the tropics which feed on ants, and they are exactly like ants themselves, which no doubt gives them more opportunity of seizing their prey; and Mr. Bates found on the Amazon a species of Mantis which exactly resembled the white ants which it fed upon, as well as several species of crickets (Saphura), which resembled in a wonderful manner different sand-wasps of large size, which are constantly on the search for crickets with which to provision their nests.

Perhaps the most wonderful case of all is the large caterpillar mentioned by Mr. Bates, which startled him by its close resemblance to a small snake. The first three segments behind the head were dilatable at the will of the insect, and had on each side a large black pupillated spot, which resembled the eye of the reptile. Moreover, it resembled a poisonous viper, not a harmless species of snake, as was proved by the imitation of keeled scales on the crown produced by the recumbent feet, as the caterpillar threw itself backward!

The attitudes of many of the tropical spiders are most extraordinary and deceptive, but little attention has been paid to them. They often mimic other insects, and some, Mr. Bates assures us, are exactly like flower buds, and take their station in the axils of leaves, where they remain motionless waiting for their prey.

I have now completed a brief, and necessarily very imperfect, survey of the various ways in which the external form and colouring of animals is adapted to be useful to them, either by concealing them from their enemies or from the creatures they prey upon. It has, I hope, been shown that the subject is one of much interest, both as regard a true comprehension of the place each animal fills in the economy of nature, and the means by which it is enabled to maintain that place; and also as teaching us how important a part is played by the minutest details in the structure of animals, and how complicated and delicate is the equilibrium of the organic world.

My exposition of the subject having been necessarily somewhat lengthy and full of details, it will be as well to recapitulate its main points.

There is a general harmony in nature between the colours of an animal and those of its habitation. Arctic animals are white, desert animals are sand-coloured; dwellers among leaves and grass are green; nocturnal animals are dusky. These colours are not universal, but are very general, and are seldom reversed. Going on a little further, we find birds, reptiles and insects, so tinted and mottled as exactly to match the rock, or bark, or leaf, or flower they are accustomed to rest upon—and thereby effectually concealed.

Another step in advance, and we have insects which are formed as well as coloured so as exactly to resemble particular leaves, or sticks, or mossy twigs, or flowers; and in these cases very peculiar habits and instincts come into play to aid in the deception and render the concealment more complete. We now enter upon a new phase of the phenomena, and come to creatures whose colours neither conceal them nor make them like vegetable or mineral substances; on the contrary, they are conspicuous enough, but they completely resemble some other creature of a quite different group, while they differ much in outward appearance from those with which all essential parts of their organization show them to be really closely allied. They appear like actors or masqueraders dressed up and painted for amusement, or like swindlers endeavouring to pass themselves off for well-known and respectable members of society. What is the meaning of this strange travesty? Does nature descend to imposture or masquerade? We answer, she does not. Her principles are too severe. There is a use in every detail of her handiwork. The resemblance of one animal to another is of exactly the same essential nature as the resemblance to a leaf, or to bark, or to desert sand, and answers exactly the same purpose. In the one case the enemy will not attack the leaf or the bark, and so the disguise is a safeguard; in the other case it is found that for various reasons the creature resembled is passed over, and not attacked by the usual enemies of its order, and thus the creature that resembles it has an equally effectual safeguard. We are plainly shown that the disguise is of the same nature in the two cases, by the occurrence in the same group of one species resembling a vegetable substance, while another resembles a living animal of another group; and we know that the creatures resembled possess an immunity from attack, by their being always very abundant, by their being conspicuous and not concealing themselves, and by their having generally no visible means of escape from their enemies; while, at the same time, the particular quality that makes them disliked is often very clear, such as a nasty taste or an indigestible hardness. Further examination reveals the fact that, in several cases of both kinds of disguise, it is the female only that is thus disguised; and as it can be shown that the female needs protection much more than the male, and that her preservation for a much longer period is absolutely necessary for the continuance of the race, we have an additional indication that the resemblance is in all cases subservient to a great purpose—the preservation of the species.

In endeavouring to explain these phenomena as having been brought about by variation and natural selection, we start with the fact that white varieties frequently occur, and when protected from enemies show no incapacity for continued existence and increase. We know, further, that varieties of many other tints occasionally occur; and as "the survival of the fittest" must inevitably weed out those whose colours are prejudicial and preserve those whose colours are a safeguard, we require no other mode of accounting for the protective tints of arctic and desert animals. But this being granted, there is such a perfectly continuous and graduated series of examples of every kind of protective imitation, up to the most wonderful cases of what is termed "mimicry," that we can find no place at which to draw the line and say,—so far variation and natural selection will account for the phenomena, but for all the rest we require a more potent cause. The counter theories that have been proposed, that of the "special creation" of each imitative form, that of the action of similar "conditions of existence" for some of the cases, and of the laws of "hereditary descent and the reversion to ancestral forms" for others,—have all been shown to be beset with difficulties, and the two latter to be directly contradicted by some of the most constant and most remarkable of the facts to be accounted for.

The important part that protective "resemblance" has played in determining the colours and markings of many groups of animals will enable us to understand the meaning of one of the most striking facts in nature, the uniformity in the colours of the vegetable as compared with the wonderful diversity of the animal world. There appears no good reason why trees and shrubs should not have been adorned with as many varied hues and as strikingly designed patterns as birds and butterflies, since the gay colours of flowers show that there is no incapacity in vegetable tissues to exhibit them. But even flowers themselves present us with none of those wonderful designs, those complicated arrangements of stripes and dots and patches of colour, that harmonious blending of hues in lines and bands and shaded spots, which are so general a feature in insects. It is the opinion of Mr. Darwin that we owe much of the beauty of flowers to the necessity of attracting insects to aid in their fertilization, and that much of the development of colour in the animal world is due to "sexual selection," colour being universally attractive, and thus leading to its propagation and increase; but while fully admitting this, it will be evident from the facts and arguments here brought forward, that very much of the *variety* both of colour and markings among animals is due to the supreme importance of concealment, and thus the various tints of minerals and vegetables have been directly reproduced in the animal kingdom, and again and again modified as more special protection became necessary. We shall thus have two causes for the development of colour in the animal world and shall be better enabled to understand how, by their combined and separate action, the immense variety we now behold has been produced. Both causes, however, will come under the general law of "Utility," the advocacy of which, in its broadest sense, we owe almost entirely to Mr. Darwin. A more accurate knowledge of the varied phenomena connected with this subject may not improbably give us some information both as to the senses and the mental faculties of the lower animals. For it is evident that if colours which please us also attract them, and if the various disguises which have been here enumerated are equally deceptive to them as to ourselves, then both their powers of vision and their faculties of perception and emotion, must be essentially of the same nature as our own—a fact of high philosophical importance in the study of our own nature and our true relations to the lower animals.[4]

FOOTNOTES:

[4] The author continues this study in Chapter ix of "Darwinism": New York, Macmillan Co., 1889.—Ed.

THE EVOLUTION OF THE HORSE

Top

Thomas Henry Huxley

[Professor Huxley as a naturalist, educator, and controversialist was one of the commanding figures of the nineteenth century. To physiology and morphology his researches added much of importance: as an expositor he stood unapproached. As the bold and witty champion of Darwinism he gave natural selection an acceptance much more early and wide than it would otherwise have enjoyed. In 1876 he delivered in America three lectures on Evolution: the third of the series is here given. All three are copyrighted and published by D. Appleton & Co., New York, in a volume which also contains a lecture on the study of biology. Since 1876 the arguments of Professor Huxley have been reinforced by the discovery of many fossils connecting not only the horse, but other quadrupeds, with species widely different and now extinct. The most comprehensive collection illustrating the descent of the horse is to be seen at the American Museum of Natural History, New York, where also the evolution of tapirs, camels, llamas, rhinoceroses, dinosaurs, great ground sloths and other animals are clearly to be traced—in most cases by remains discovered in America. A capital book on the theme broached by Professor Huxley is "Animals of the Past," by Frederic A. Lucas, Curator of the Division of Comparative Anatomy, United States National Museum, Washington, D. C., published by McClure, Phillips & Co., New York.

"The Life and Letters of Professor Huxley," edited by his son, Leonard Huxley, is a work of rare interest: it is published by D. Appleton & Co., New York.]

The occurrence of historical facts is said to be demonstrated, when the evidence that they happened is of such a character as to render the assumption that they did not happen in the highest degree improbable; and the question I now have to deal with is, whether evidence in favour of the evolution of animals of this degree of cogency is, or is not, obtainable from the record of the succession of living forms which is presented to us by fossil remains.

Those who have attended to the progress of palæontology are aware that evidence of the character which I have defined has been produced in considerable and continually-increasing quantity during the last few years. Indeed, the amount and the satisfactory nature of that evidence are somewhat surprising, when we consider the conditions under which alone we can hope to obtain it.

It is obviously useless to seek for such evidence, except in localities in which the physical conditions have been such as to permit of the deposit of an unbroken, or but rarely interrupted, series of strata through a long period of time; in which the group of animals to be investigated has existed in such abundance as to furnish the requisite supply of remains; and in which, finally, the materials composing the strata are such as to insure the preservation of these remains in a tolerably perfect and undisturbed state.

It so happens that the case which, at present, most nearly fulfils all these conditions is that of the series of extinct animals which culminates in the horses; by which term I mean to denote not merely the domestic animals with which we are all so well acquainted, but their allies, the ass, zebra, quagga, and the like. In short, I use “horses” as the equivalent of the technical name *Equidæ*, which is applied to the whole group of existing equine animals.

The horse is in many ways a remarkable animal; not least so in the fact that it presents us with an example of one of the most perfect pieces of machinery in the living world. In truth, among the works of human ingenuity it cannot be said that there is any locomotive so perfectly adapted to its purposes, doing so much work with so small a quantity of fuel, as this machine of nature's manufacture—the horse. And, as a necessary consequence of any sort of perfection, of mechanical perfection as of others, you find that the horse is a beautiful creature, one of the most beautiful of all land animals. Look at the perfect balance of its form, and the rhythm and force of its action. The locomotive machinery is, as you are aware, resident in its slender fore and hind limbs; they are flexible and elastic levers, capable of being moved by very powerful muscles; and, in order to supply the engines which work these levers with the force which they expend, the horse is provided with a very perfect apparatus for grinding its food and extracting therefrom the requisite fuel.

Without attempting to take you very far into the region of osteological detail, I must nevertheless trouble you with some statements respecting the anatomical structure of the horse; and, more especially, will it be needful to obtain a general conception of the structure of its fore and hind limbs, and of its teeth. But I shall only touch upon these points which are absolutely essential to our inquiry.

Let us turn in the first place to the fore-limb. In most quadrupeds, as in ourselves, the fore-arms contains distinct bones called the radius and the ulna. The corresponding region in the horse seem at first to possess but one bone. Careful observation, however, enables us to distinguish in this bone a part which clearly answers to the upper end of the ulna. This is closely united with the chief mass of the bone which represents the radius, and runs out into a slender shaft which may be traced for some distance downwards upon the back of the radius, and then in most cases thins out and vanishes. It takes still more trouble to make sure of what is nevertheless the fact, that a small part of the lower end of the bone of the horse's fore-arm, which is only distinct in a very young foal, is really the lower extremity of the ulna.

What is commonly called the knee of a horse is its wrist. The “cannon bone” answers to the middle bone of the five metacarpal bones, which support the palm of the hand in ourselves. The “pastern,” “coronary,” and “coffin” bones of veterinarians answer to the joints of our middle fingers, while the hoof is simply a greatly enlarged and thickened nail. But if what lies below the horse's “knee” thus corresponds to the middle finger in ourselves, what has become of the four other fingers or digits? We find in the places of the second and fourth digits only two slender splint-like bones, about two-thirds as long as the cannon bone, which gradually taper to their lower ends and bear no finger joints, or, as they are termed, phalanges. Sometimes, small bony or gristly nodules are to be found at the bases of these two metacarpal splints, and it is probable that these represent rudiments of the first and fifth toes. Thus, the part of the horse's skeleton, which corresponds with that of the human hand, contains one overgrown middle digit, and at least two imperfect lateral digits; and these answer, respectively, to the third, the second and the fourth fingers in man.

Corresponding modifications are found in the hind limb. In ourselves, and in most quadrupeds, the leg contains two distinct bones, a large bone, the tibia, and a smaller and more slender bone, the fibula. But, in the horse, the fibula seems, at first, to be reduced to its upper end; a short slender bone united with the tibia and ending in a point below, occupying its place. Examination of the lower end of a young foal's shin-bone, however, shows a distinct portion of osseous matter, which is the lower end of the fibula; so that the, apparently single, lower end of the shin-bone is really made up of the coalesced ends of the tibia and fibula, just as the, apparently single, lower end of the fore-arm bone is composed of the coalesced radius and ulna.

The heel of the horse is the part commonly known as the hock. The hinder cannon bone answers to the middle metatarsal bone of the human foot, the pastern, coronary, and coffin bones, to the middle toe bones; the hind hoof to the nail; as in the fore-foot. And, as in the fore-foot, there are merely two splints to represent the second and the fourth toes. Sometimes a rudiment of a fifth toe appears to be traceable.

The teeth of a horse are not less peculiar than its limbs. The living engine, like all others, must be well stoked if it is to do its work; and the horse, if it is to make good its wear and tear, and to exert the enormous amount of force required for its propulsion, must be well and rapidly fed. To this end good cutting instruments and powerful and lasting crushers are needful. Accordingly, the twelve cutting teeth of a horse are close-set and concentrated in the fore-part of its mouth, like so many adzes or chisels. The grinders or molars are large, and have an extremely complicated structure, being composed of a number of different substances of unequal hardness. The consequence of this is that they wear away at different rates; and, hence, the surface of each grinder is always as uneven as that of a good millstone.

I have said that the structure of the grinding teeth is very complicated, the harder and the softer parts being, as it were, interlaced with one another. The result of this is that, as the tooth wears, the crown presents a peculiar pattern, the nature of which is not very easily deciphered at first, but which it is important we should understand clearly. Each grinding tooth of the upper jaw has an *outer wall* so shaped that, on the worn crown, it exhibits the form of two crescents, one in front and one behind, with their concave sides turned outwards. From the inner side of the front crescent, a crescentic *front ridge* passes inwards and backwards, and its inner face enlarges into a strong longitudinal fold or *pillar*. From the front part of the hinder crescent, a *back ridge* takes a like direction, and also has its *pillar*.

The deep interspaces or *valleys* between these ridges and the outer wall are filled by bony substance, which is called *cement*, and coats the whole tooth.

The pattern of the worn face of each grinding tooth of the lower jaw is quite different. It appears to be formed of two crescent-shaped ridges, the convexities of which are turned outwards. The free extremity of each crescent has a *pillar*, and there is a large double *pillar* where the two crescents meet. The whole structure is, as it were, imbedded in cement, which fills up the valleys, as in the upper grinders.

If the grinding faces of an upper and of a lower molar of the same side are applied together, it will be seen that the opposed ridges are nowhere parallel, but that they frequently cross; and that thus, in the act of mastication, a hard surface in the one is constantly applied to a soft surface in the other, and *vice versa*. They thus constitute a grinding apparatus of great efficiency, and one which is repaired as fast as it wears, owing to the long-continued growth of the teeth.

Some other peculiarities of the dentition of the horse must be noticed, as they bear upon what I shall have to say by and by. Thus the crowns of the cutting teeth have a peculiar deep pit, which gives rise to the well-known “mark” of the horse. There is a large space between the outer incisors and the front grinders. In this space the adult male horse presents, near the incisors on each side, above and below, a canine or “tush,” which is commonly absent in mares. In a young horse, moreover, there is not unfrequently to be seen, in front of the first grinder, a very small tooth, which soon falls out. If this small tooth be counted as one, it will be found that there are seven teeth behind the canine on each side; namely, the small tooth in question, and the six great grinders, among which, by an unusual peculiarity, the foremost tooth is rather larger than those which follow it.

I have now enumerated those characteristic structures of the horse which are of most importance for the purpose we have in view.

To any one who is acquainted with the morphology [comparative forms] of vertebrated animals, they show that the horse deviates widely from the general structure of mammals; and that the horse type is, in many respects, an extreme modification of the general mammalian plan. The least modified mammals, in fact, have the radius and ulna, the tibia and fibula, distinct and separate. They have five distinct and complete digits on each foot, and no one of these digits is very much larger than the rest. Moreover, in the least modified mammals the total number of the teeth is very generally forty-four, while in horses the usual number is forty, and in the absence of the canines it may be reduced to thirty-six; the incisor teeth are devoid of the fold seen in those of the horse: the grinders regularly diminish in size from the middle of the series to its front end; while their crowns are short, early attain their full length, and exhibit simple ridges or tubercles, in place of the complex foldings of the horse's grinders.

Hence the general principles of the hypothesis of evolution lead to the conclusion that the horse must have been derived from some quadruped which possessed five complete digits on each foot; which had the bones of the fore-arm and of the leg complete and separate; and which possessed forty-four teeth, among which the crowns of the incisors and grinders had a simple structure; while the latter gradually increased in size from before backwards, at any rate in the anterior part of the series, and had short crowns.

And if the horse has been thus evolved, and the remains of the different stages of its evolution have been preserved, they ought to present us with a series of forms in which the number of the digits becomes reduced; the bones of the fore-arm and leg gradually take on the equine condition; and the form and arrangement of the teeth successively approximate to those which obtain in existing horses.

Let us turn to the facts, and see how far they fulfil these requirements of the doctrine of evolution.

In Europe abundant remains of horses are found in the Quaternary and later Tertiary strata as far as the Pliocene formation. But these horses, which are so common in the cave-deposits and in the gravels of Europe, are in all essential respects like existing horses. And that is true of all the horses of the latter part of the Pliocene epoch. But in deposits which belong to the earlier Pliocene and later Miocene epochs, and which occur in Britain, in France, in Germany, in Greece, in India, we find animals which are extremely like horses—which, in fact, are so similar to horses that you may follow descriptions given in works upon the anatomy of the horse upon the skeletons of these animals—but which differ in some important particulars. For example, the structure of their fore and hind limbs is somewhat different. The bones which, in the horse, are represented by two splints, imperfect below, are as long as the middle metacarpal and metatarsal bones; and attached to the extremity of each is a digit with three joints of the same general character as those of the middle digit, only very much smaller. These small digits are so disposed that they could have had but very little functional importance, and they must have been rather of the nature of the dew-claws, such as are to be found in many ruminant animals. The *Hipparion*, as the extinct European three-toed horse is called, in fact, presents a foot similar to that of the American *Protohippus* (Fig. 9), except that in the *Hipparion* the smaller digits are situated farther back and are of smaller proportional size than in the *Protohippus*.

The ulna is slightly more distinct than in the horse; and the whole length of it, as a very slender shaft intimately united with the radius, is completely traceable. The fibula appears to be in the same condition as in the horse. The teeth of the *Hipparion* are essentially similar to those of the horse, but the pattern of the grinders is in some respects a little more complex, and there is a depression on the face of the skull in front of the orbit, which is not seen in existing horses.

In the earlier Miocene, and perhaps the later Eocene deposits of some parts of Europe, another extinct animal has been discovered, which Cuvier, who first described some fragments of it, considered to be a *Palæotherium*. But as further discoveries threw new light on its structure, it was recognized as a distinct genus under the name of *Anchitherium*.

In its general characters, the skeleton of *Anchitherium* is very similar to that of the horse. In fact, Lartet and De Blainville called it *Palæotherium equinum* or *hippoides*; and De Christol, in 1847, said that it differed from *Hipparion* in little more than the characters of its teeth, and gave it the name of *Hipparitherium*. Each foot possesses three complete toes; while the lateral toes are much larger in proportion to the middle toe than in *Hipparion*, and doubtless rested on the ground in ordinary locomotion.

The ulna is complete and quite distinct from that radius, though firmly united with the latter. The fibula seems also to have been complete. Its lower end, though intimately united with that of the tibia, is clearly marked off from the latter bone.

There are forty-four teeth. The incisors have no strong pit. The canines seem to have been well developed in both sexes. The first of the seven grinders, which, as I have said, is frequently absent, and when it does exist, is small in the horse, is a good-sized and permanent tooth, while the grinder which follows it is but little larger than the hinder ones. The crowns of the grinders are short, and though the fundamental pattern of the horse-tooth is discernible, the front and back ridges are less curved, the accessory pillars, are wanting, and the valleys, much shallower, are not filled up with cement.

Seven years ago, when I happened to be looking critically into the bearing of palæontological facts upon the doctrine of evolution, it appeared to me that the *Anchitherium*, the *Hipparion*, and the modern horses, constitute a series in which the modifications of structure coincide with the order of chronological occurrence, in the manner in which they must coincide, if the modern horses really are the result of the gradual metamorphosis, in the course of the Tertiary epoch, of a less specialized ancestral form. And I found by correspondence with the late eminent French anatomist and palæontologist, M. Lartet, that he had arrived at the same conclusion from the same data.

That the *Anchitherium* type had become metamorphosed into the *Hipparion* type, and the latter into the *Equine* type,[5] in the course of that period of time which is represented by the latter half of the Tertiary deposits, seemed to me to be the only explanation of the facts for which there was even a shadow of probability.

And, hence, I have ever since held that these facts afford evidence of the occurrence of evolution, which, in the sense already defined, may be termed demonstrative.

All who have occupied themselves with the structure of *Anchitherium*, from Cuvier onwards, have acknowledged its many points of likeness to a well-known genus of extinct Eocene mammals, *Palæotherium*. Indeed, as we have seen, Cuvier regarded his remains of *Anchitherium* as those of a species of *Palæotherium*.

Hence, in attempting to trace the pedigree of the horse beyond the Miocene epoch and the Anchitheroid form, I naturally sought among the various species of Palæotheroid animals for its nearest ally, and I was led to the conclusion that the *Palæotherium minus* (*Plagiolophus*) represented the next step more nearly than any form then known.

I think that this opinion was fully justifiable; but the progress of investigation has thrown an unexpected light on the question, and has brought us much nearer than could have been anticipated to a knowledge of the true series of the progenitors of the horse.

You are all aware that, when your country was first discovered by Europeans, there were no traces of the existence of the horse on any part of the American Continent. The accounts of the conquest of Mexico dwell upon the astonishment of the natives of that country when they first became acquainted with that astounding phenomenon—a man seated upon a horse. Nevertheless, the investigations of American geologists have proved that the remains of horses occur in the most superficial deposits of both North and South America, just as they do in Europe. Therefore, for some reason or other—no feasible suggestion on that subject, so far as I know, has been made—the horse must have died out on this continent at some period preceding the discovery of America. Of late years there has been discovered in your Western Territories that marvellous accumulation of deposits, admirably adapted for the preservation of organic remains, to which I referred the other evening, and which furnishes us with a consecutive series of records of the fauna of the older half of the Tertiary epoch, for which we have no parallel in Europe. They have yielded fossils in an excellent state of conservation and in unexampled numbers and variety. The researches of Leidy and others have shown that forms allied to the *Hipparion* and the *Anchitherium* are to be found among these remains. But it is only recently that the admirably conceived and most thoroughly and patiently worked-out investigations of Professor Marsh have given us a just idea of the vast fossil wealth, and of the scientific importance, of these deposits. I have had the advantage of glancing over the collections in Yale Museum; and I can truly say, that so far as my knowledge extends, there is no collection from any one region and series of strata comparable, for extent, or for the care with which the remains have been got together, or for their scientific importance, to the series of fossils which he has deposited there. This vast collection has yielded evidence bearing upon the question of the pedigree of the horse of the most striking character. It tends to show that we must look to America, rather than to Europe, for the original seat of the equine series; and that the archaic forms and successive modifications of the horse's ancestry are far better preserved here than in Europe.

Professor Marsh's kindness has enabled me to put before you a diagram, every figure of which is an actual representation of some specimen which is to be seen at Yale at this present time (Fig. 9).

The succession of forms which he has brought together carries us from the top to the bottom of the Tertiaries. Firstly, there is the true horse. Next we have the American Pliocene form of the horse (*Pliohippus*); in the conformation of its limbs it presents some very slight deviations from the ordinary horse, and the crowns of the grinding teeth are shorter. Then comes the *Protohippus*, which represents the European *Hipparion*, having one large digit and two small ones on each foot, and the general characters of the fore-arm and leg to which I have referred. But it is more valuable than the European *Hipparion* for the reason that it is devoid of some of the peculiarities of that form—peculiarities which tend to show that the European *Hipparion* is rather a member of a collateral branch, than a form in the direct line of succession. Next, in the backward order in time, is the *Miohippus*, which corresponds pretty nearly with the *Anchitherium* of Europe. It presents three complete toes—one large median and two smaller lateral ones; and there is a rudiment of that digit, which answers to the little finger of the human hand.

The European record of the pedigree of the horse stops here; in the American Tertiaries, on the contrary, the series of ancestral equine forms is continued into the Eocene formations. An older Miocene form, termed *Mesohippus*, has three toes in front, with a large splint-like rudiment representing the little finger; and three toes behind. The radius and ulna, the tibia and the fibula, are distinct, and the short crowned molar teeth are anchitheroid in pattern.

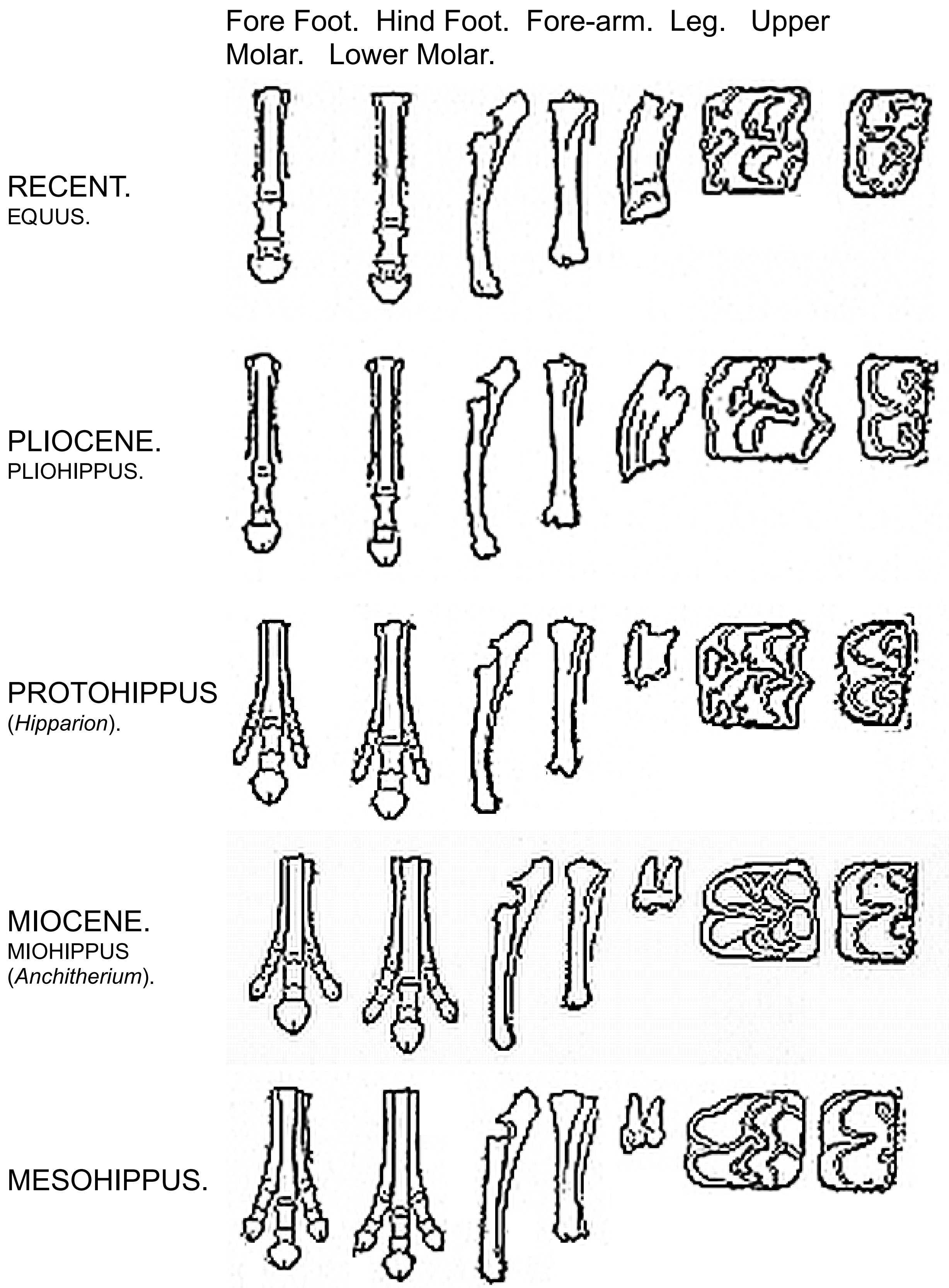
But the most important discovery of all is the *Orohippus*, which comes from the Eocene formation, and which is the oldest member of the equine series, as yet known. Here we find four complete toes on the front-limb, three toes on the hind-limb, a well-developed ulna, a well-developed fibula, and short-crowned grinders of simple pattern.

Thus, thanks to these important researches, it has become evident that, so far as our present knowledge extends, the history of the horse-type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution. And the knowledge we now possess justifies us completely in the anticipation, that when the still lower Eocene deposits, and those which belong to the Cretaceous epoch, have yielded up their remains of ancestral equine animals, we shall find, first, a form with four complete toes and a rudiment of the innermost or first digit in front, with probably, a rudiment of the fifth digit in the hind foot;[6] while, in still older forms, the series of the digits will be more and more complete, until we come to the five-toed animals, in which, if the doctrine of evolution is well founded, the whole series must have taken its origin.

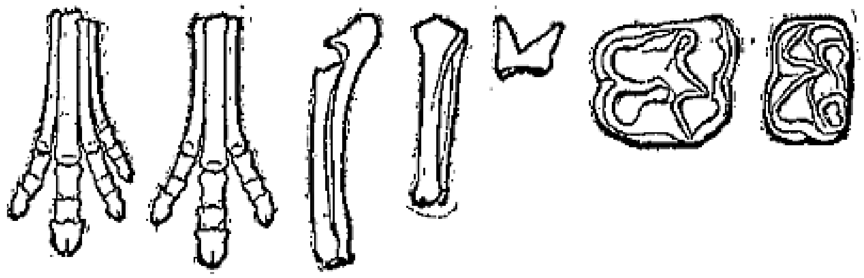
That is what I mean by demonstrative evidence of evolution. An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it. If that is not scientific proof, there are no merely inductive conclusions which can be said to be proved. And the doctrine of evolution, at the present time, rests upon exactly as secure a foundation as the Copernican theory of the motions of the heavenly bodies did at the time of its promulgation. Its logical basis is precisely of the same character—the coincidence of the observed facts with theoretical requirements.

The only way of escape, if it be a way of escape, from the conclusions which I have just indicated, is the supposition that all these different equine forms have been created separately at separate epochs of time; and, I repeat, that of such an hypothesis as this there neither is, nor can be, any scientific evidence; and, assuredly, so far as I know, there is none which is supported, or pretends to be supported, by evidence or authority of any other kind. I can but think that the time will come when such suggestions as these, such obvious attempts to escape the force of demonstration, will be put upon the same footing as the supposition made by some writers, who are, I believe, not completely extinct at present, that fossils are mere simulacra [images], are no indications of the former existence of the animals to which they seem to belong; but that they are either sports of Nature, or special creations, intended—as I heard suggested the other day—to test our faith.

In fact, the whole evidence is in favour of evolution, and there is none against it. And I say this, although perfectly well aware of the seeming difficulties which have been built up upon what appears to the uninformed to be a solid foundation. I meet constantly with the argument that the doctrine of evolution cannot be well founded because it requires the lapse of a very vast period of time; while the duration of life upon the earth, thus implied, is inconsistent with the conclusions arrived at by the astronomer and the physicist. I may venture to say that I am familiar with those conclusions, inasmuch as some years ago, when president of the Geological Society of London, I took the liberty of criticising them, and of showing in what respects, as it appeared to me, they lacked complete and thorough demonstration. But, putting that point aside, suppose that, as the astronomers, or some of them, and some physical philosophers tell us, it is impossible that life could have endured upon the earth for so long a period as is required by the doctrine of evolution—supposing that to be proved—I desire to be informed, what is the foundation for the statement that evolution does require so great a time? The biologist knows nothing whatever of the amount of time which may be required for the process of evolution. It is a matter of fact that the equine forms, which I have described to you, occur, in the order stated, in the Tertiary formations. But I have not the slightest means of guessing whether it took a million of years, or ten millions, or a hundred millions, or a thousand millions of years, to give rise to that series of changes. A biologist has no means of arriving at any conclusions as to the amount of time which may be needed for a certain quantity of organic change. He takes his time from the geologist. The geologist, considering the rate at which deposits are formed and the rate at which denudation goes on upon the surface of the earth, arrives at more or less justifiable conclusions as to the time which is required for the deposit of a certain thickness of rocks; and if he tells me that the Tertiary formations required 500,000,000 years for their deposit, I suppose he has good ground for what he says, and I take that as a measure of the duration of the evolution of the horse from the *Orohippus* up to its present condition. And, if he is right, undoubtedly evolution is a very slow process, and requires a great deal of time. But suppose now, that an astronomer or a physicist—for instance, my friend Sir William Thomson—tells me that my geological authority is quite wrong; and that he has weighty evidence to show that life could not possibly have existed upon the surface of the earth 500,000,000 years ago, because the earth would have then been too hot to allow of life, my reply is: “That is not my affair; settle that with the geologist, and when you have come to an agreement among yourselves I will adopt your conclusions.” We take our time from the geologists and physicists, and it is monstrous that, having taken our time from the physical philosopher's clock, the physical philosopher should turn round upon us, and say we are too fast or too slow. What we desire to know is, is it a fact that evolution took place? As to the amount of time which evolution may have occupied, we are in the hands of the physicist and the astronomer, whose business it is to deal with those questions.


Fore Foot. Hind Foot. Fore-arm. Leg. Upper Molar. Lower Molar.
RECENT.
EQUUS.
PLIOCENE.
PLIOHIPPUS.
PROTOHIPPUS
(*Hipparion*).
MIOCENE.
MIOHIPPUS
(*Anchitherium*).
MESOHIPPUS.

EOCENE.
OROHIPPUS.



FOOTNOTES:

[5] I use the word “type” because it is highly probable that many of the forms of *Anchitherium*-like and *Hipparion*-like animals existed in the Miocene and Pliocene epochs, just as many species of the horse tribe exist now; and it is highly improbable that the particular species of *Anchitherium* or *Hipparion*, which happen to have been discovered, should be precisely those which have formed part of the direct line of the horse's pedigree.

[6] Since this lecture was delivered, Professor Marsh has discovered a new genus of equine mammals (*Eohippus*) from the lowest Eocene deposits of the West, which corresponds very nearly to this description.—*American Journal of Science*, November, 1876.

FIGHTING PESTS WITH INSECT ALLIES

Top

Leland O. Howard

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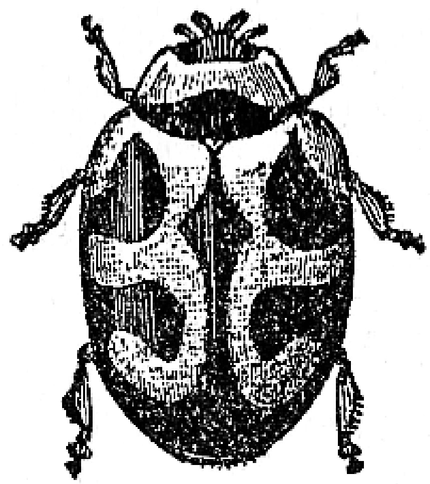
Some twenty-five years ago there appeared suddenly upon certain acacia trees at Menlo Park, California, a very destructive scale bug. It rapidly increased and spread from tree to tree, attacking apples, figs, pomegranates, quinces, and roses, and many other trees and plants, but seeming to prefer to all other food the beautiful orange and lemon trees which grow so luxuriantly on the Pacific Coast, and from which a large share of the income of so many fruit-growers is gained. This insect, which came to be known as the *white scale* or *fluted scale* or the *Icerya* (from its scientific name), was an insignificant creature in itself, resembling a small bit of fluted wax a little more than a quarter of an inch long. But when the scales had once taken possession of a tree, they swarmed over it until the bark was hidden; they sucked its sap through their minute beaks until the plant became so feeble that the leaves and young fruit dropped off, a hideous black smut-fungus crept over the young twigs, and the weakened tree gradually died.

In this way orchard after orchard of oranges, worth a thousand dollars or more an acre, was utterly destroyed; the best fruit-growing sections of the State were invaded, and ruin stared many a fruit-grower in the face.

This spread of the pest was gradual, extending through a series of years, and not until 1886 did it become so serious a matter as to attract national attention.

In this year an investigation was begun by the late Professor C. V. Riley, the Government entomologist then connected with the Department of Agriculture at Washington. He sent two agents to California, both of whom immediately began to study the problem of remedies. In 1887 he visited California himself, and during that year published an elaborate report giving the results of the work up to that point. The complete life-history of the insect had been worked out, and a number of washes had been discovered which could be applied to the trees in the form of a spray, and which would kill a large proportion of the pests at a comparatively small expense. But it was soon found that the average fruit-grower would not take the trouble to spray his trees, largely from the fact that he had experimented for some years with inferior washes and quack nostrums, and from lack of success had become disgusted with the whole idea of using liquid compounds. Something easier, something more radical was necessary in his disheartened condition.

Meantime, after much sifting of evidence and much correspondence with naturalists in many parts of the world, Professor Riley had decided that the white scale was a native of Australia, and had been first brought over to California accidentally upon Australian plants. In the same way it was found to have reached South Africa and New Zealand, in both of which colonies it had greatly increased, and had become just such a pest as it is in California. In Australia, however, its native home, it did not seem to be abundant, and was not known as a pest—a somewhat surprising state of affairs, which put the entomologist on the track of the results which proved of such great value to California. He reasoned that, in his native home, with the same food plants upon which it flourished abroad in such great abundance, it would undoubtedly do the same damage that it does in South Africa, New Zealand, and California, if there were not in Australia some natural enemy, probable some insect parasite or predatory beetle, which killed it off. It became therefore important to send a trained man to Australia to investigate this promising line.



Vedalia, or Australian Ladybird

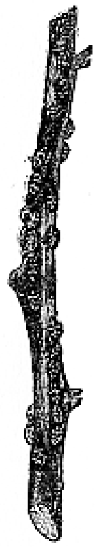
After many difficulties in arranging preliminaries relating to the payment of expenses (in which finally the Department of State kindly assisted), one of Professor Riley's assistants, a young German named Albert Koebele, who had been with him for a number of years, sailed for Australia in August, 1888. Koebele was a skilled collector and an admirable man for the purpose. He at once found that Professor Riley's supposition was correct: there existed in Australia small flies which laid their eggs in the white scales, and these eggs hatched into grubs which devoured the pests. He also found a remarkable little ladybird, a small, reddish-brown convex beetle, which breeds with marvellous rapidity and which, with voracious appetite, and at the same time with discriminating taste, devours scale after scale, but eats fluted scales only—does not attack other insects. This beneficial creature, now known as the Australian ladybird, or the Vedalia, Mr. Koebele at once began to collect in large numbers, together with several other insects found doing the same work. He packed many hundreds of living specimens of the ladybird, with plenty of food, in tin boxes, and had them placed on ice in the ice-box of the steamer at Sydney; they were carried carefully to California, where they were liberated upon orange trees at Los Angeles.

These sendings were repeated for several months, and Mr. Koebele, on his return in April, 1889, brought with him many more living specimens which he had collected on his way home in New Zealand, where the same Vedalia had been accidentally introduced a year or so before.

Larvæ of Vedalia eating White Scale

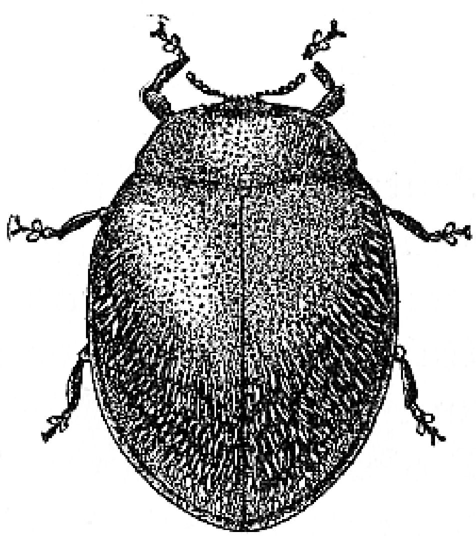
The result more than justified the most sanguine expectations. The ladybirds reached Los Angeles alive, and, with appetites sharpened by their long ocean voyage, immediately fell upon the devoted scales and devoured them one after another almost without rest. Their hunger temporarily satisfied, they began to lay eggs. These eggs hatched in a few days into active grub-like creatures—the larvæ of the beetles—and these grubs proved as voracious as their parents. They devoured the scales right and left, and in less than a month transformed once more to beetles.

And so the work of extermination went on. Each female beetle laid on an average 300 eggs, and each of these eggs hatched into a hungry larva. Supposing that one-half of these larvæ produced female beetles, a simple calculation will show that in six months a single ladybird became the ancestor of 75,000,000,000 of other ladybirds, each capable of destroying very many scale insects.



Twig of olive infected with Black Scale

Is it any wonder, then, that the fluted scales soon began to disappear? Is it any wonder that orchard after orchard was entirely freed from the pest, until now over a large section of the State hardly an Icerya is to be found? And could a more striking illustration of the value of the study of insects possibly be instanced? In less than a year from the time when the first of these hungry Australians was liberated from his box in Los Angeles the orange trees were once more in bloom and were resuming their old-time verdure—the Icerya had become practically a thing of the past.



Rhizobius, the imported enemy of the Black Scale

This wonderful success encouraged other efforts in the same direction. The State of California some years later sent the same entomologist, Koebele, to Australia to search for some insect enemy of the black scale, an insect which threatened the destruction of the extensive olive orchards of California. He found and successfully introduced another ladybird beetle, known as *Rhizobius ventralis*, a little dark-coloured creature which has thrived in the California climate, especially near the seacoast, and in the damp air of those regions has successfully held the black scale in check. It was found, however, that back from the seacoast this insect did not seem to thrive with the same vigor, and the black scale held its own. Then a spirited controversy sprung up among the olive-growers, those near the seacoast contending that the *Rhizobius* was a perfect remedy for the scale, while those inland insisted that it was worthless. A few years later it was discovered that this olive enemy in South Europe is killed by a little caterpillar, which burrows through scale after scale eating out their contents, and an effort was made to introduce the caterpillar into California, but these efforts failed. Within the past two years it has been found that a small parasitic fly exists in South Africa which lays its eggs in the same black scale, and its grub-like larvæ eat out the bodies of the scales and destroy them. The climate of the region in which this parasite exists is dry through a large part of the year, and therefore this little parasitic fly, known as *Scutellista*, was thought to be the needed insect for the dry California regions. With the help of Mr. C. P. Lounsbury, the Government entomologist of Cape Colony, living specimens of this fly were brought to this country, and were colonized in the Santa Clara Valley, near San José, California, where they have perpetuated themselves and destroyed many of the black scales, and promise to be most successful in their warfare against the injurious insect.

This same *Scutellista* parasite had, curiously enough, been previously introduced in an accidental manner into Italy, probably from India, and probably in scale-insects living on ornamental plants brought from India. But in Italy it lives commonly in another scale insect, and with the assistance of the learned Italian, Professor Antonio Berlese, the writer made an unsuccessful attempt to introduce and establish it a year earlier in some of our Southern States, where it was hoped it would destroy certain injurious insects known as “wax scales.”

In the meantime the United States, not content with keeping all the good things to herself, has spread the first ladybird imported—the *Vedalia*—to other countries. Four years ago the white scale was present in enormous numbers in orange groves on the left bank of the river Tagus, in Portugal, and threatened to wipe out the orange-growing industry in that country. The California people, in pursuance of a far-sighted policy, had with great difficulty, owing to lack of food, kept alive some colonies of the beneficial beetle, and specimens were sent to Portugal which reached there alive and flourishing. They were tended for a short time, and then liberated in the orange groves, with precisely the same result as in California. In a few months the scale insects were almost entirely destroyed, and the Portuguese orange-growers saved from enormous loss.

This good result in Portugal was not accomplished without opposition. It was tried experimentally at the advice of the writer, and in the face of great incredulity on the part of certain Portuguese newspapers and of some officials. By many prominent persons the account published of the work of the insect in the United States was considered as untrustworthy, and simply another instance of American boasting. But the opposition was overruled, and the triumphant result silenced all opposition. It is safe to say that the general opinion among Portuguese orange-growers to-day is very favourable to American enterprise and practical scientific acumen.

The *Vedalia* was earlier sent to the people in Alexandria and Cairo, Egypt, where a similar scale was damaging the fig trees and other valuable plants, and the result was again the same, the injurious insects were destroyed. This was achieved only after extensive correspondence and several failures. The active agent in Alexandria was Rear Admiral Blomfield, of the British Royal Navy, a man apparently of wide information, good judgment, and great energy.

The same thing occurred when the California people sent this saviour of horticulture to South Africa, where the white scale had also made its appearance.

It is not only beneficial insects, however, which are being imported, but diseases of injurious insects. In South Africa the colonists suffer severely from swarms of migratory grasshoppers, which fly from the north and destroy their crops. They have discovered out there a fungus disease, which under favorable conditions kills off the grasshoppers in enormous numbers. At the Bacteriological Institute in Grahamstown, Natal, they have cultivated this fungus in culture tubes, and have carried it successfully throughout the whole year; and they have used it practically by distributing these culture tubes wherever swarms of grasshoppers settle and lay their eggs. The disease, once started in an army of young grasshoppers, soon reduces them to harmless numbers. The United States Government last year secured culture tubes of this disease, and experiments carried on in Colorado and in Mississippi show that the vitality of the fungus had not been destroyed by its long ocean voyage, and many grasshoppers were killed by its spread. During the past winter other cultures were brought over from Cape Colony, and the fungus is being propagated in the Department of Agriculture for distribution during the coming summer in parts of the country where grasshoppers may prove to be destructively abundant.

Grasshopper dying from Fungus Disease

Although we practically no longer have those tremendous swarms of migratory grasshoppers which used to come down like devastating armies in certain of our Western States and in a night devour everything green, still, almost every year, and especially in the West and South, there is somewhere a multiplication of grasshoppers to a very injurious degree, and it is hoped that the introduced fungus can be used in such cases.

Persons officially engaged in searching for remedies for injurious insects all over the world have banded themselves together in a society known as the Association of Economic Entomologists. They are constantly interchanging ideas regarding the destruction of insects, and at present active movements are on foot in this direction of interchanging beneficial insects. Entomologists in Europe will try the coming summer to send to the United States living specimens of a tree-inhabiting beetle which eats the caterpillar of the gipsy moth, and which will undoubtedly also eat the caterpillar so common upon the shade-trees of our principal Eastern cities, which is known as the Tussock moth caterpillar. An entomologist from the United States, Mr. C. L. Marlatt, has started for Japan, China, and Java, for the purpose of trying to find the original home of the famous San José scale—an insect which has been doing enormous damage in the apple, pear, peach, and plum orchards of the United States—and if he finds the original home of this scale, it is hoped that some natural enemy or parasite will be discovered which can be introduced into the United States to the advantage of our fruit-growers. Professor Berlese of Italy, and Dr. Reh, of Germany, will attempt the introduction into Europe of some of the parasites of injurious insects which occur in the United States, and particularly those of the woolly root-louse of the apple, known in Europe as the "American blight"—one of the few injurious insects which probably went to Europe from this country, and which in the United States is not so injurious as it is in Europe.

It is a curious fact, by the way, that while we have had most of our very injurious insects from Europe, American insects, when accidentally introduced into Europe, do not seem to thrive. The insect just mentioned, and the famous grape-vine *Phylloxera*, a creature which caused France a greater economic loss than the enormous indemnity which she had to pay to Germany after the Franco-Prussian War, are practically the only American insects with which we have been able to repay Europe for the insects which she has sent us. Climatic differences, no doubt, account for this strange fact, and our longer and warmer summers are the principal factor.

It is not alone the parasitic and predaceous insects which are beneficial. A new industry has been brought into the United States during the past two years by the introduction and acclimatization of the little insect which fertilizes the Smyrna fig in Mediterranean countries. The dried-fig industry in this country has never amounted to anything. The Smyrna fig has controlled the dried-fig markets of the world, but in California the Smyrna fig has never held its fruit, the young figs dropping from the trees without ripening. It was found that in Mediterranean regions a little insect, known as the *Blastophaga*, fertilizes the flowers of the Smyrna fig with pollen from the wild fig which it inhabits. The United States Department of Agriculture in the spring of 1899 imported successfully some of these insects through one of its travelling agents, Mr. W. T. Swingle, and the insect was successfully established at Fresno in the San Joaquin Valley. A far-sighted fruit-grower, Mr. George C. Roeding, of Fresno, had planted some years previously an orchard of 5,000 Smyrna fig trees and wild fig trees, and his place was the one chosen for the successful experiment. The little insect multiplied with astonishing rapidity, was carried successfully through the winter of 1899-1900, and in the summer of 1900 was present in such great numbers that it fertilized thousands of figs, and fifteen tons of them ripened. When these figs were dried and packed it was discovered that they were superior to the best imported figs. They contained more sugar and were of a finer flavor than those brought from Smyrna and Algeria. The *Blastophaga* has come to stay, and the prospects for a new and important industry are assured.

With all these experiments the criticism is constantly made that unwittingly new and serious enemies to agriculture may be introduced. The unfortunate introduction of the English sparrow into this country is mentioned, and the equally unfortunate introduction of the East Indian mongoose into the West Indies as well. The fear is expressed that the beneficial parasitic insects, after they have destroyed the injurious insects, will either themselves attack valuable crops or do something else of an equally harmful nature. But there is no reason for such alarm. The English sparrow feeds on all sorts of things, and the East Indian mongoose, while it was introduced into Jamaica to kill snakes, was found, too late, to be also a very general feeder. As a matter of fact, after the snakes were destroyed, and even before, it attacked young pigs, kids, lambs, calves, puppies, and kittens, and also destroyed bananas, pineapples, corn, sweet potatoes, cocoanuts, peas, sugar corn, meat, and salt provisions and fish. But with the parasitic and predatory insects the food habits are definite and fixed. They can live on nothing but their natural food, and in its absence they die. The Australian ladybird originally imported, for example, will feed upon nothing but scale insects of a particular genus, and, as a matter of fact, as soon as the fluted scales became scarce the California officials had the greatest difficulty in keeping the little beetles alive, and were actually obliged to cultivate for food the very insects which they were formerly so anxious to wipe out of existence! With the *Scutellista* parasite the same fact holds. The fly itself does not feed, and its young feed only upon certain scale insects, and so with all the rest.

All of these experiments are being carried on by men learned in the ways of insects, and only beneficial results, or at the very least negative ones, can follow. And even where only one such experiment out of a hundred is successful, what a saving it will mean!

We do not expect the time to come when the farmer, finding Hessian fly in his wheat, will have only to telegraph the nearest experiment station, “Send at once two dozen first-class parasites;” but in many cases, and with a number of different kinds of injurious insects, especially those introduced from foreign countries, it is probable that we can gain much relief by the introduction of their natural enemies from their original home.

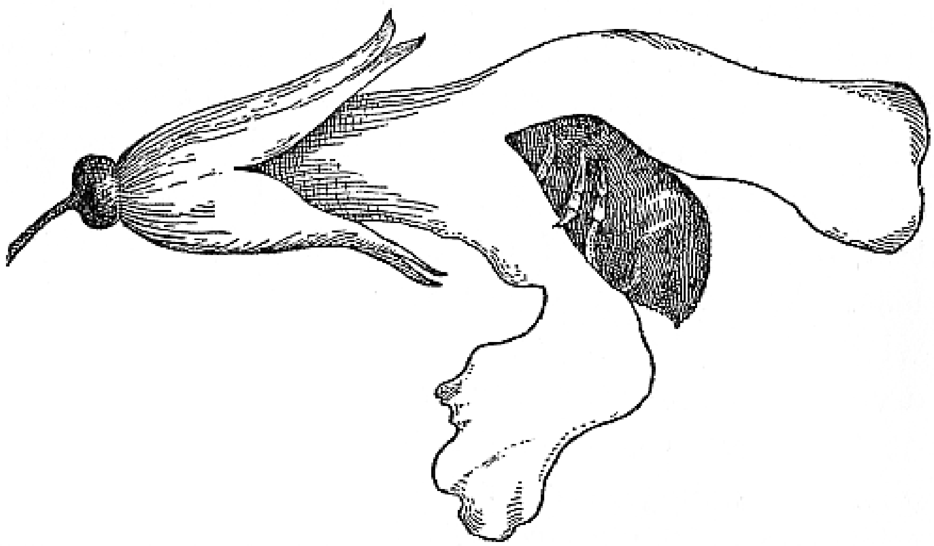
THE STRANGE STORY OF THE FLOWERS

Top

George Iles

[From "The Wild Flowers of America," copyright by G. H. Buek & Co., New York, 1894, by their kind permission. The American edition is out of print: the Canadian edition, "Wild Flowers of Canada," is published by Graham & Co., Montreal, Canada. The work describes and illustrates in their natural tints nearly three hundred beautiful flowers.]

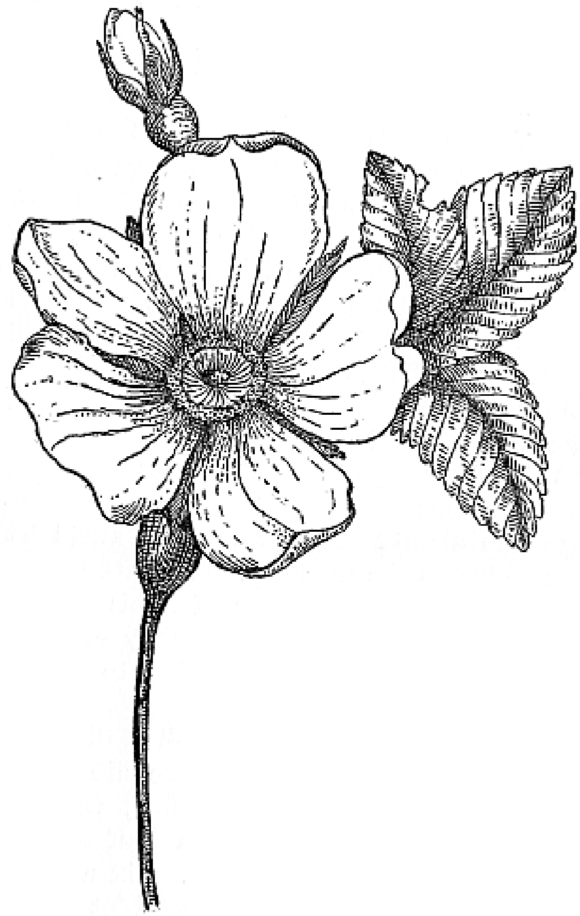
Imagine a Venetian doge, a French crusader, a courtier of the time of the second Charles, an Ojibway chief, a Justice of the Supreme Court, in the formal black of evening dress, and how much each of them would lose! Where there is beauty, strength or dignity, dress can heighten it; where all these are lacking, their absence is kept out of mind by raiment in itself worthy to be admired. If dress artificial has told for much in the history of human-kind, dress natural has told for yet more in the lesser world of plant and insect life. In some degree the tiny folk that reign in the air, like ourselves, are drawn by grace of form, by charm of colour; of elaborate display of their attractions moths, butterflies and beetles are just as fond as any belles of the ball-room. Now let us bear in mind that of all the creatures that share the earth with man, the one that stands next to him in intelligence is neither a biped nor a quadruped, but that king of the insect tribe, the ant, which can be a herdsman and warehouse-keeper, an engineer and builder, an explorer and a general. With all his varied powers the ant lacks a peculiarity in his costume which has denied him enlistment in a task of revolution in which creatures far his inferiors have been able to change the face of the earth. And the marvel of this peculiarity of garb which has meant so much, is that it consists in no detail of graceful outline, or beauty of tint, but solely in the minor matter of texture. The ant, warrior that he is, wears smooth and shining armour; the bee, the moth and the butterfly are clad in downy vesture, and simply because thus enabled to catch dust on their clothes these insects, as weavers of the web of life, have counted for immensely more than the ant with all his brains and character. To understand the mighty train of consequences set in motion by this mere shagginess of coat, let us remember that, like a human babe, every flowering plant has two parents. These two parents, though a county's breadth divide them, are wedded the instant that pollen from the anther of one of them meets the stigma of the other. Many flowers find their mates upon their own stem; but, as in the races of animals, too close intermarriage is hurtful, and union with a distant stock promotes both health and vigor. Hence the great gain which has come to plants by engaging the wind as their matchmaker—as every summer shows us in its pollen-laden air, the oaks, the pines, the cottonwoods, and a host of other plants commit to the breeze the winged atoms charged with the continuance of their kind. Nevertheless, long as the wind has been employed at this work, it has not yet learned to do it well; nearly all the pollen entrusted to it is wasted, and this while its production draws severely upon the strength of a plant. As good fortune will have it, a great many flowers close to their pollen yield an ample supply of nectar: a food esteemed delicious by the whole round of insects, winged and wingless. While ants might sip this nectar of ages without plants being any the better or the worse; a very different result has followed upon the visits of bees, wasps, and other hairy-coated callers. These, as they devour nectar, dust themselves with the pollen near by. Yellowed or whitened with this freightage, moth and butterfly, as they sail through the air, know not that they are publishing the banns of marriage between two blossoms acres or, it may be, miles apart. Yet so it is. Alighting on a new flower the insect rubs a pollen grain on a stigma ready to receive it, and lo! the rites of matrimony are solemnized then and there. Unwittingly the little visitor has wrought a task bigger with fate than many an act loudly trumpeted among the mightiest deeds of men! On the threshold of a Lady's Slipper a bee may often be detected in the act of entrance. In the Sage-flower he finds an anther of the stamen which, pivoted on its spring, dusts him even more effectually.



Sage-flower and Bee

Bountifully to spread a table is much, but not enough, for without invitation how can hospitality be dispensed? To the feast of nectar the blossoms join their bidding; and those most conspicuously borne and massed, gayest of hue, richest in odor, secure most guests, and are therefore most likely to transmit to their kind their own excellences as hosts and entertainers. Thus all the glories of the blossoms have arisen in doing useful work; their beauty is not mere ornament, but the sign and token of duty well performed. Our opportunity to admire the radiancy and perfume of a jessamine or a pond-lily is due to the previous admiration of uncounted winged attendants. If a winsome maid adorns herself with a wreath from the garden, and carries a posy gathered at the brookside, it is for the second time that their charms are impressed into service; for the flowers' own ends of attraction all their scent and loveliness were called into being long before.

Let us put flowers of the blue flag beside those of the maple, and we shall have a fair contrast between the brilliancy of blossoms whose marrier has been an insect, and the dinginess of flowers indebted to the services of the wind. Can it be that both kinds of flowers are descended from forms resembling each other in want of grace and colour? Such, indeed, is the truth. But how, as the generations of the flowers succeeded one another, did differences so striking come about? In our rambles afield let us seek a clue to the mystery. It is late in springtime, and near the border of a bit of swamp we notice a clump of violets: they are pale of hue, and every stalk of them rises to an almost weedy height.



Wild Rose, Single

Twenty paces away, on a knoll of dry ground, we find more violets, but these are in much deeper tints of azure and yellow, while their stalks are scarcely more than half as tall as their brethren near the swamp. Six weeks pass by. This time we walk to a wood-lot close to a brimming pond. At its edge are more than a score wild-rose bushes. On the very first of them we see that some of the blossoms are a light pink, others a pink so deep as to seem dashed with vivid red. And while a flower here and there is decidedly larger and more vigorous than its fellows, a few of the blossoms are undersized and puny: the tide of life flows high and merrily in a fortunate rose or two, it seems to ebb and falter by the time it reaches one or two of their unhappy mates. As we search bush after bush we are at last repaid for sundry scratches from their thorns by securing a double rose, a "sport," as the gardener would call it. And in the broad meadow between us and home we well know that for the quest we can have not only four-leaved clovers, but perchance a handful of five and six-leaved prizes. The secret is out. Flowers and leaves are not cast like bullets in rigid moulds, but differ from their parents much as children do. Usually the difference is slight, at times it is as marked as in our double rose. Whenever the change in a flower is for the worse, as in the sickly violets and roses we have observed, that particular change ends there—with death. But when the change makes a healthy flower a little more attractive to its insect ministers, it will naturally be chosen by them for service, and these choosings, kept up year after year, and century upon century, have at last accomplished much the same result as if the moth, the bee, and the rest of them had been given power to create blossoms of the most welcome forms, the most alluring tints, the most bewitching perfumes.

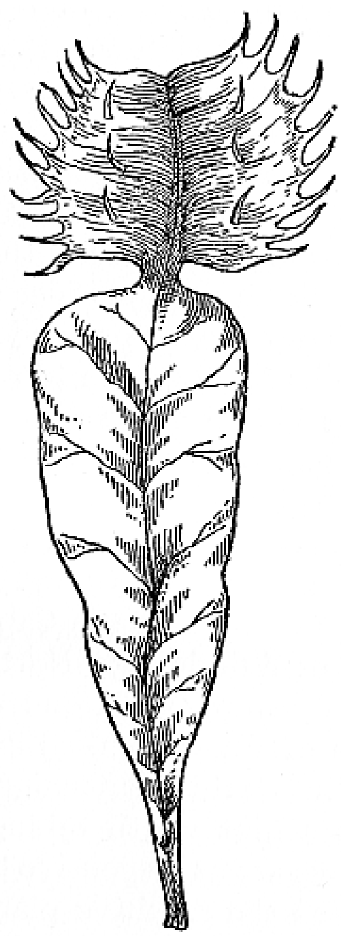
In farther jaunts afield we shall discover yet more. It is May, and a heavy rainstorm has caused the petals of a trillium to forget themselves and return to their primitive hue of leafy green. A month later we come upon a buttercup, one of whose sepals has grown out as a small but perfect leaf. Later still in summer we find a rose in the same surprising case, while not far off is a columbine bearing pollen on its spurs instead of its anthers. What family tie is betrayed in all this? No other than that sepals, petals, anthers and pistils are but leaves in disguise, and that we have detected nature returning to the form from which ages ago she began to transmute the parts of flowers in all their teeming diversity. The leaf is the parent not only of all these but of delicate tendrils, which save a vine the cost of building a stem stout enough to lift it to open air and sunshine. However thoroughly, or however long, a habit may be impressed upon a part of a plant, it may on occasion relapse into a habit older still, resume a shape all but forgotten, and thus tell a story of its past that otherwise might remain forever unsuspected. Thus it is with the somewhat rare “sport” that gives us a morning glory or a harebell in its primitive form of unjoined petals. The bell form of these and similar flowers has established itself by being much more effective than the original shape in dusting insect servitors with pollen. Not only the forms of flowers but their massing has been determined by insect preferences; a wide profusion of blossoms grow in spikes, umbels, racemes and other clusters, all economizing the time of winged allies, and attracting their attention from afar as scattered blossoms would fail to do. Besides this massing, we have union more intimate still as in the dandelion, the sun-flower and the marigold. These and their fellow composites each seem an individual; a penknife discloses each of them to be an aggregate of blossoms. So gainful has this kind of co-operation proved that composites are now dominant among plants in every quarter of the globe. As to how composites grew before they learned that union is strength, a hint is dropped in the “sport” of the daisy known as “the hen and chickens,” where perhaps as many as a dozen florets, each on a stalk of its own, ray out from a mother flower.

While for the most part insects have been mere choosers from among various styles of architecture set before them by plants, they have sometimes risen to the dignity of builders on their own account, and without ever knowing it. The buttress of the larkspur has sprung forth in response to the pressure of one bee's weight after another, and many a like structure has had the very same origin,—or shall we say, provocation? In these and in other examples unnumbered, culminating in the marvellous orchids and their ministers, there has come about the closest adaptation of flower-shape to insect-form, the one now clearly the counterpart of the other.

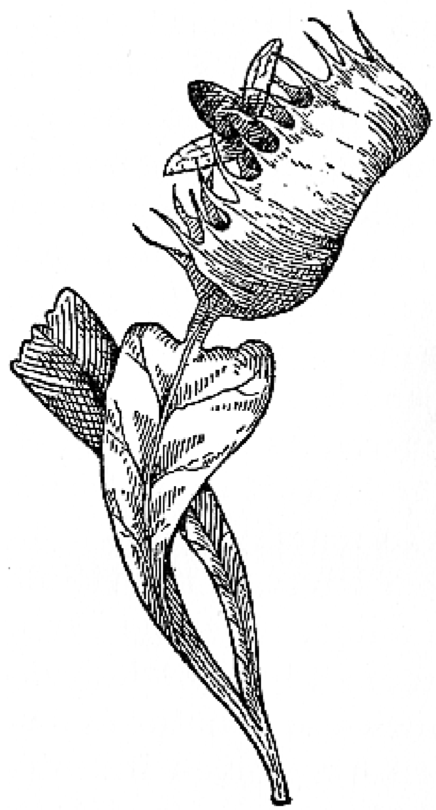
We must not forget that the hospitality of a flower is after all the hospitality of an inn-keeper who earns and requires payment. Vexed as flowers are apt to be by intruders that consume their stores without requital, no wonder that they present so ample an array of repulsion and defence. Best of all is such a resource as that of the red clover, which hides its honey at the bottom of a tube so deep that only a friendly bumblebee can sip it. Less effective, but well worth a moment's examination, are the methods by which leaves are opposed as fences for the discouragement of thieves. Here, in a Bellwort, is a perfoliate leaf that encircles the stem upon which it grows; and there in a Honeysuckle is a connate leaf on much the same plan, formed of two leaves, stiff and strong, soldered at their bases. Sometimes the pillager meets prickles that sting him, as in the roses and briers; and if he is a little fellow he is sure to regard him with intense disgust, a bristly guard of wiry hair—hence the commonness of that kind of fortification. Against enemies of larger growth a tree or shrub will often aim sharp thorns—another piece of masquerade, for thorns are but branches checked in growth, and frowning with a barb in token of disappointment at not being able to smile in a blossom. In every jot and tittle of barb and prickle, of the glossiness which disheartens or the gumminess which ensnares, we may be sure that equally with all the lures of hue, form and scent, nothing, however trifling it may seem, is as we find it, except through usefulness long tested and approved. In flowers, much that at first glance looks like idle decoration, on closer scrutiny reveals itself as service in disguise. In penetrating these disguises and many more of other phases, the student of flowers delights to busy himself. He loves, too, to detect the cousinship of plants through all the change of dress and habit due to their rearing under widely different skies and nurture, to their being surrounded by strangely contrasted foes and friends. Often he can link two plants together only by going into partnership with a student of the rocks, by turning back the records of the earth until he comes upon a flower long extinct, a plant which ages ago found the struggle for life too severe for it. He ever takes care to observe his flowers accurately and fully, but chiefly that he may rise from observation to explanation, from bare facts to their causes, from declaring What, to understanding, Whence and How.

One of the stock resources of novelists, now somewhat out of date, was the inn-keeper who beamed in welcome of his guest, grasped his hand in gladness, and loaded a table for him in tempting array, and all with intent that later in the day (or night) he might the more securely plunge a dagger into his victim's heart—if, indeed, he had not already improved an opportunity to offer to that victim's lips a poisoned cup. This imagined treachery might well have been suggested by the behaviour of certain alluring plants that so far from repelling thieves, or discouraging pillagers, open their arms to all comers—with purpose of the deadliest. Of these betrayers the chief is the round-leaved sun-dew, which plies its nefarious vocation all the way from Labrador to Florida. Its favourite site is a peat-bog or a bit of swampy lowland, where in July and August we can see its pretty little white blossoms beckoning to wayfaring flies and moths their token of good cheer! Circling the flower-stalk, in rosette fashion, are a dozen or more round leaves, each of them wearing scores of glands, very like little pins, a drop of gum glistening on each and every pin by way of head. This appetizing gum is no other than a fatal stick-fast, the raying pins closing in its aid the more certainly to secure a hapless prisoner. Soon his prison-house becomes a stomach for his absorption. Its duty of digestion done, the leaf in all seeming guilessness once more expands itself for the enticement of a dupe. To see how much the sun-dew must depend upon its meal of insects we have only to pull it up from the ground. A touch suffices—it has just root enough to drink by; the soil in which it makes, and perhaps has been obliged to make, its home has nothing else but drink to give it.

Less accomplished in its task of assassination is the common butterwort to be found on wet rocks in scattered districts of Canada and the States adjoining Canada. Surrounding its pretty violet flowers, of funnel shape, are gummy leaves which close upon their all too trusting guests, but with less expertness than the sun-dew's. The butterwort is but a 'prentice hand in the art of murder, and its intended victims often manage to get away from it. Built on a very different model is the bladderwort, busy in stagnant ponds near the sea coast from Nova Scotia to Texas. Its little white spongy bladders, about a tenth of an inch across, encircle the flowering stem by scores. From each bladder a bunch of twelve or fifteen hairy prongs protrude, giving the structure no slight resemblance to an insect form. These prongs hide a valve which, as many an unhappy little swimmer can attest, opens inward easily enough, but opens outward never. As in the case of its cousinry a-land, the bladderwort at its leisure dines upon its prey.



Venus' Fly Trap—Open with a Welcome



Shut for Slaughter

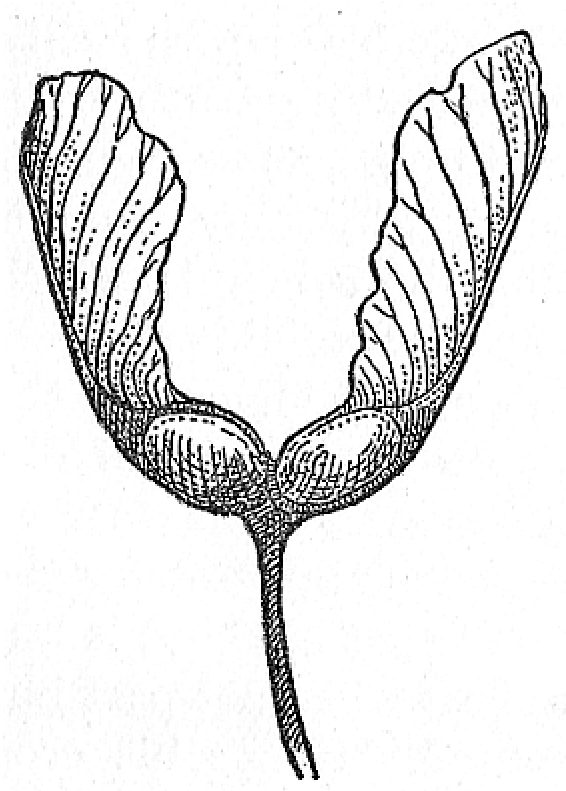
In marshy places near the mouth of the Cape Fear River, in the vicinity of Wilmington, North Carolina, grows the Venus' fly-trap, most wonderful of all the death-dealers of vegetation. Like much else in nature's handiwork this plant might well have given inventors a hint worth taking. The hairy fringes of its leaves are as responsive to a touch from moth or fly as the sensitive plant itself. And he must be either a very small or a particularly sturdy little captive that can escape through the sharp opposed teeth of its formidable snare. It is one of the unexplained puzzles of plant life that the Venus' fly-trap, so marvellous in its ingenuity, should not only be confined to a single district, but should seem to be losing its hold of even that small kingdom. Of still another type is the pitcher plant, or side-saddle flower, which flaunts its deep purple petals in June in many a peat-bog from Canada southward to Louisiana and Florida. Its leaves develop themselves into lidded cups, half-filled with sweetish juice, which first lures a fly or ant, then makes him tipsy, and then despatches him. The broth resulting is both meat and drink to the plant, serving as a store and reservoir against times of drought and scarcity.

Now the question is, How came about this strange and somewhat horrid means of livelihood? How did plants of so diverse families turn the tables on the insect world, and learn to eat instead of being themselves devoured? A beginner in the builder's art finds it much more gainful to examine the masonry of foundations, the rearing of walls, the placing of girders and joists, the springing of arches and buttresses, than to look at a cathedral, a courthouse, or a bank, finished and in service. In like manner a student of insect-eating plants tries to find their leaves in the making, in all the various stages which bridge their common forms with the shapes they assume when fully armed and busy. Availing himself of the relapses into old habits which plants occasionally exhibit under cultivation, Mr. Dickson has taught us much regarding the way the pitcher plant of Australia, the *Cephalotus*, has come to be what it is. He has arranged in a connected series all the forms of its leaf from that of a normal leaf with a mere dimple in it, to the deeply pouched and lidded pitcher ready for deceitful hospitalities. And similar transformations have without doubt taken place in the pitcher plants of America. Observers in the Cape of Good Hope have noted two plants *Roridula dentata* and *Biblys gigantea*, which are evidently following in the footsteps of the sundews, and may be expected in the fulness of years to be their equal partners in crime. But why need we wander so far as South Africa to find the germs of this strange rapacity when we can see at home a full dozen species of catch-fly, sedums, primulas, and geraniums pouring out glutinous juices in which insects are entangled? Let stress of hunger, long continued, force any of these to turn its attention to the dietary thus proffered, and how soon might not the plant find in felony the sustenance refused to honest toil?

But after all the plants that have meat for dinner are only a few. The greater part of the vegetable kingdom draws its supplies from the air and the soil. Those plants, and they are many, that derive their chief nourishment from the atmosphere have a decidedly thin diet. Which of us would thrive on milk at the rate of a pint to five hogsheads of water? Such is the proportion in which air contains carbonic acid gas, the main source of strength for many thousands of trees, shrubs, and other plants. No wonder that they array themselves in so broad an expanse of leafage. An elm with a spread of seventy feet is swaying in the summer breeze at least five acres of foliage as its lungs and stomach. Beyond the shade of elms and maples let us stroll past yonder stretch of pasture and we shall notice how the grass in patches here and there deepens into green of the richest—a plain token of moisture in the hollows—a blessing indeed in this dry weather. In the far West and Northwest the buffalo grass has often to contend with drought for months together, so that it has learned to strike deep in quest of water to quench its thirst. It is a by-word among the ranchmen that the roots go clear through the earth and are clinched as they sprout from the ground in China. Joking apart, they have been found sixty-eight feet below the surface of the prairie, and often in especially dry seasons cattle would perish were not these faithful little well-diggers and pumpers constantly at work for them. In the river valleys of Arizona although the air is dry the subsoil water is near the surface of the ground. Here flourishes the mesquit tree, *Prosopis juliflora*, with a tale to tell well worth knowing. When a mesquit seems stunted, it is because its strength is withdrawn for the task of delving to find water; where a tree grows tall with goodly branches, it betokens success in reaching moisture close at hand. Thus in shrewdly reading the landscape a prospector can choose the spot where with least trouble he can sink his well. And plants discover provender in the soil as well as drink. Nearer home than Arizona we have only to dislodge a beach pea from the ground to see how far in search of food its roots have dug amid barren stones and pebbles. Often one finds a plant hardly a foot high with roots extending eight feet from its stem.

And beyond the beaches where the beach peas dig so diligently are the seaweeds—with a talent for picking and choosing all their own. Dr. Julius Sachs, a leading German botanist, believes that the parts of plants owe their form, as crystals do, to their peculiarities of substance; that just as salt crystallizes in one shape and sugar in another, so a seaweed or a tulip is moulded by the character of its juices. Something certainly of the crystal's faculty for picking out particles akin to itself, and building with them, is shown by the kelp which attracts from the ocean both iodine and bromine—often dissolved though they are in a million times their bulk of sea water. This trait of choosing this or that dish from the feast afforded by sea or soil or air is not peculiar to the seaweeds; every plant displays it. Beech trees love to grow on limestone and thus declare to the explorer the limestone ridge he seeks. In the Horn silver mine, of Utah, the zinc mingled with the silver ore is betrayed by the abundance of the zinc violet, a delicate and beautiful cousin of the pansy. In Germany this little flower is admittedly a signal of zinc in the earth, and zinc is found in its juices. The late Mr. William Dorn, of South Carolina, had faith in a bush, of unrecorded name, as betokening gold-bearing veins beneath it. That his faith was not without foundation is proved by the large fortune he won as a gold miner in the Blue Ridge country—his guide the bush aforesaid. Mr. Rossiter W. Raymond, the eminent mining engineer of New York, has given some attention to this matter of “indicative plants.” He is of the opinion that its unwritten lore among practical miners, prospectors, hunters, and Indians is well worth sifting. Their observations, often faulty, may occasionally be sound and valuable enough richly to repay the trouble of separating truth from error. When we see how important as signs of water many plants can be, why may we not find other plants denoting the minerals which they especially relish as food or condiment?

Of more account than gold or silver are the harvests of wheat and corn that ripen in our fields. There the special appetites of plants have much more than merely curious interest for the farmer. He knows full well that his land is but a larder which serves him best when not part but all its stores are in demand. Hence his crop “rotation,” his succession of wheat to clover, of grass to both. Were he to grow barley every year he would soon find his soil bared of all the food that barley asks, while fare for peas or clover stood scarcely broached. If he insists on planting barley always, then he must perforce restore to the land the food for barley constantly withdrawn.



Maple Seed, with pair of wings

A plant may diligently find food and drink, pour forth delicious nectar, array itself with flowers as gayly as it can, and still behold its work unfinished. Its seed may be produced in plenty, and although as far as that goes it is well, it is not enough. Of what avail is all this seed if it falls as it ripens upon soil already overcrowded with its kind? Hence the vigorous emigration policy to be observed in plants of every name. Hence the fluffy sails set to catch the passing breeze by the dandelion, the thistle and by many more, including the southern plant of snowy wealth whose wings are cotton. With the same intent of seeking new fields are the hooks of the burdock, the unicorn plant, and the bur-parsley which impress as carriers the sheep and cattle upon a thousand hills. The Touch-me-not and the herb Robert adopt a different plan, and convert their seed-cases into pistols for the firing of seeds at as wide range as twenty feet or more. The maple, the ash, the hornbeam, the elm and the birch have yet another method of escape from the home acre. Their seeds are winged, and torn off in a gale are frequently borne two hundred yards away. And stronger wings than these are plied in the cherry tree's service. The birds bide the time when a blush upon the fruit betrays its ripeness. Then the cherries are greedily devoured, and their seed, preserved from digestion in their stony cases are borne over hill, dale, and river to some islet or brookside where a sprouting cherry plant will be free from the stifling rivalries suffered by its parent. Yoked in harness with sheep, ox, and bird as planter is yonder nimble squirrel. We need not begrudge him the store of nuts he hides. He will forget some of them, he will be prevented by fright or frost from nibbling yet more, and so without intending it he will ensure for others and himself a sure succession of acorns and butternuts.

Very singular are the seeds that have come to resemble beetles; among these may be mentioned the seeds of the castor-oil plant and of the *Iatropha*. The pod of the *Biserrula* looks like a worm, and a worm half-coiled might well have served as a model for the mimicry of the *Scorpiurus vermiculata*. All these are much more likely to enlist the services of birds than if their resemblances to insects were less striking.

Nature elsewhere rich in hints to the gardener and the farmer is not silent here. A lesson plainly taught in all this apparatus for the dispersal of seeds is that the more various the planting the fuller the harvest. Now that from the wheat fields comes a cry of disappearing gains, it is time to heed the story told in the unbroken prairie that diversity in sowing means wealth in reaping.

In a field of growing flax we can find—somewhat oftener than the farmer likes—a curious tribe of plants, the dodders. Their stems are thin and wiry, and their small white flowers, globular in shape, make the azure blossoms of the flax all the lovelier by contrast. As their cousins the morning glories are to this day, the dodders in their first estate were true climbers. Even now they begin life in an honest kind of way with roots of their own that go forth as roots should, seeking food where it is to be found in the soil. But if we pull up one of these little club-shaped roots we shall see that it has gone to work feebly and doubtfully; it seems to have a skulking expectation of dinner without having to dig and delve for it in the rough dirty ground. Nor is this expectation unfounded. Watch the stem of a sister dodder as it rises from the earth day by day, and it will be observed to clasp a stalk of flax very tightly; so tightly that its suckers will absorb the juices of its unhappy host. When, so very easily, it can regale itself with food ready to hand why should it take the trouble to drudge for a living?

Like many another pauper demoralized by being fed in idleness, the plant now abandons honest toil, its roots from lack of exercise wither away, and for good and all it ceases to claim any independence whatever. Indeed, so deep is the dodder's degradation that if it cannot find a stem of flax, or hop, or other plant whereon to climb and thrive, it will simply shrivel and die rather than resume habits of industry so long renounced as to be at last forgotten.

Like the lowly dodder the mistletoe is a climber that has discovered large opportunities of theft in ascending the stem of a supporting plant. On this continent the mistletoe scales a wide variety of trees and shrubs, preferring poplars and apple trees, where these are to be had. Its extremely slender stem, its meagre leaves, its small flowers, greenish and leathery, are all eloquent as to the loss of strength and beauty inevitable to a parasite. Rising as this singular plant does out of the branches of another with a distinct life all its own, it is no other than a natural graft, and it is very probable that from the hint it so unmistakably gives the first gardeners were not slow to adopt grafts artificial—among the resources which have most enriched and diversified both flowers and fruits. The dodders and mistletoes rob juices from the stem and branches of their unfortunate hosts; more numerous still are the unbidden guests that fasten themselves upon the roots of their prey. The broom-rape, a comparatively recent immigrant from Europe, lays hold of the roots of thyme in preference to other place of entertainment; the Yellow Rattle, the Lousewort, and many more attach themselves to the roots of grasses—frequently with a serious curtailment of crop.

Yet in this very department of hers Nature has for ages hidden away what has been disclosed within twenty years as one of her least suspected marvels. It is no other than that certain parasites of field and meadow so far from being hurtful, are well worth cultivating for the good they do. For a long time the men who devoted themselves to the study of peas, beans, clovers, and other plants of the pulse family, were confronted with a riddle they could not solve. These plants all manage to enrich themselves with compounds of nitrogen, which make them particularly valuable as food, and these compounds often exist in a degree far exceeding the rate at which their nitrogen comes out of the soil. And this while they have no direct means of seizing upon the nitrogen contained in its great reservoir—the atmosphere. Upon certain roots of beans and peas it was noted that there were little round excrescences about the size of a small pin's head. These excrescences on examination with a microscope proved to be swarming with bacteria of minute dimensions. Further investigation abundantly showed that these little guests paid a handsome price for their board and lodging—while they subsisted in part on the juices of their host they passed into the bean or pea certain valuable compounds of nitrogen which they built from common air. At the Columbian Exposition, of 1893, one of the striking exhibits in the Agricultural Building set this forth in detail. Vials were shown containing these tiny subterranean aids to the farmer, and large photographs showed in natural size the vast increase of crop due to the farmer's taking bacteria into partnership. To-day these little organisms are cultivated of set purpose, and quest is being made for similar bacteria suitable to be harnessed in producing wheat, corn, and other harvests.

These are times when men of science are discontented with mere observation. They wish to pass from watching things as nature presents them to putting them into relations wholly new. In 1866 DeBary, a close observer of lichens, felt confident that a lichen was not the simple growth it seems, but a combination of fungus and algæ. This opinion, so much opposed to honoured tradition, was scouted, but not for long. Before many months had passed Stahl took known algæ, and upon them sowed a known fungus, the result was a known lichen! The fungus turns out to be no other than a slave-driver that captures algæ in colonies and makes them work for him. He is, however, a slave-driver of an intelligent sort; his captives thrive under his mastery, and increase more rapidly for the healthy exercise he insists that they shall take.

It is an afternoon in August and the sultry air compels us to take shelter in a grove of swaying maples. Beneath their shade every square yard of ground bears a score of infant trees, very few of them as much as a foot in stature. How vain their expectation of one day enjoying an ample spread of branch and root, of rising to the free sunshine of upper air! The scene, with its quivering rounds of sunlight, seems peace itself, but the seeming is only a mask for war as unrelenting as that of weaponed armies. For every ray of the sunbeam, for every atom of food, for every inch of standing room, there is deadly rivalry. To begin the fight is vastly easier than to maintain it, and not one in a hundred of these bantlings will ever know maturity. We have only to do what Darwin did—count the plants that throng a foot of sod in spring, count them again in summer, and at the summer's end, to find how great the inexorable carnage in this unseen combat, how few its survivors. So hard here is the fight for a foothold, for daily bread, that the playfulness inborn in every healthy plant can peep out but timidly and seldom. But when strife is exchanged for peace, when a plant is once safely sheltered behind a garden fence, then the struggles of the battlefield give place to the diversions of the garrison—diversions not infrequently hilarious enough. Now food abounds and superabounds; henceforth neither drought nor deluge can work their evil will; insect foes, as well as may be, are kept at bay; there is room in plenty instead of dismal overcrowding. The grateful plant repays the care bestowed upon it by bursting into a sportiveness unsuspected, and indeed impossible, amidst the alarms and frays incessant in the wilderness. It departs from parental habits in most astonishing fashion, puts forth blossoms of fresh grace of form, of new dyes, of doubled magnitude. The gardener's opportunity has come. He can seize upon such of these “sports” as he chooses and make them the confirmed habits of his wards. Take a stroll through his parterres and greenhouses, where side by side he shows you pansies of myriad tints and the modest little wild violets of kindred to the pansies' ancestral stock.

Let him contrast for you roses, asters, tuberous begonias, hollyhocks, dahlias, pelargoniums, before cultivation and since. Were wild flowers clay, were the gardener both painter and sculptor, he could not have wrought marvels more glorious than these. In a few years the brethren of his guild have brought about a revolution for which, if possible at all to her, nature in the open fields would ask long centuries. And the gardener's experiments with these strange children of his have all the charm of surprise. No passive chooser is he of “sports” of promise, but an active matchmaker between flowers often brought together from realms as far apart as France and China. Sometimes his experiment is an instant success. Mr. William Paul, a famous creator of splendid flowers, tells us that at a time when climbing roses were either white or yellow, he thought he would like to produce one of bright dark colour. Accordingly he mated the Rose Athelin, of vivid crimson, with Russelliana, a hardy climber, and lo, the flower he had imagined and longed for stood revealed! But this hitting the mark at the first shot is uncommon good fortune with the gardener. No experience with primrose or chrysanthemum is long and varied enough to tell him how the crossing of two different stocks will issue. A rose which season after season opposes only indifference to all his pains may be secretly gathering strength for a bound beyond its ancestral paths which will carry it much farther than his hopes, or, perhaps, his wishes.

Most flowers are admired for their own sweet sake, but who thinks less of an apple or cherry blossom because it bears in its beauty the promise of delicious fruit? Put a red Astrachan beside a sorry crab, a Bartlett pear next a tough, diminutive wild pear such as it is descended from, an ear of milky corn in contrast with an ear one-fourth its size, each grain of which, small and dry, is wrapped in a sheath by itself; and rejoice that fruits and grains as well as flowers can learn new lessons and remember them. At Concord, Massachusetts, in an honoured old age, dwells Mr. Ephraim W. Bull. In his garden he delights to show the mother vine of the Concord grape which he developed from a native wild grape planted as long ago as 1843. Another “sport” of great value was the nectarine, which was seized upon as it made its appearance on a peach bough.

Throughout America are scattered experiment stations, part of whose business it is to provoke fresh varieties of wheat, or corn, or other useful plant, and make permanent such of them as show special richness of yield; earliness in ripening; stoutness of resistance to Jack Frost, or blight, or insect pests. Suppose that dire disaster swept from off the earth every cereal used as food. Professor Goodale, Professor Asa Gray's successor at Harvard University, has so much confidence in the experiment stations of America that he deems them well able to repair the loss we have imagined; within fifty years, he thinks, from plants now uncultivated the task could be accomplished. Among the men who have best served the world by hastening nature's steps in the improvement of flowers and fruits, stands Mr. Vilmorin, of Paris. He it was who in creating the sugar beet laid the foundation for one of the chief industries of our time. One of his rules is to select at first not the plant which varies most in the direction he wishes, but the plant that varies most in any direction whatever. From it, from the instability of its very fibres, its utter forgetfulness of ancestral traditions, he finds it easiest in the long run to obtain and to establish the character he seeks of sweetness, or size, or colour.

Of flowering plants there are about 110,000, of these the farmer and the gardener between them have scarcely tamed and trained 1,000. What new riches, therefore, may we not expect from the culture of the future? Already in certain northern flower-pots the trillium, the bloodroot, the dog's-tooth violet, and the celandine are abloom in May; as June advances, the wild violet, the milkweed, the wild lily-of-the-valley, unfold their petals; later in summer the dog-rose displays its charms and breathes its perfume. All respond kindly to care, and were there more of this hospitality, were the wild roses which the botanist calls *blanda* and *lucida*, were the cardinal flowers, the May flowers, and many more of the treasures of glen and meadow, made welcome with thoughtful study of their wants and habits, much would be done to extend the wealth of our gardens. Let a hepatica be plucked from its home in a rocky crevice where one marvels how it ever contrived to root itself and find subsistence. Transplant it to good soil, give it a little care—it asks none—and it will thrive as it never throve before; proving once again that plants do not grow where they like, but where they can. The Russian columbine rewards its cultivator with a wealth of blossoms that plainly say how much it rejoices in his nurture of it, in its escape from the frost and tempest that have assailed it for so many generations.

But here we must be content to take a leaf out of nature's book, and look for small results unless our experiments are broadly planned. It is in great nurseries and gardens, not in little door-yards that “sports” are likely to arise, and to meet the skill which can confirm them as new varieties.

Japan has much to teach us with regard to flowers: nowhere else on earth are they so sedulously cultivated, or so faithfully studied in all their changeful beauty. Perhaps the most striking revelation of the Japanese gardener is his treatment of flowering shrubs and flowering trees disposed in masses. Happy the visitors to Tokio who sees in springtime the cherry blossoms ready to lend their witchery to the Empress's reception! Much is done to extend the reign of beauty in a garden when it is fitly bordered with berry-bearers. Rows of mountain ash, snow-berry, and hawthorn trees give colour just when colour is most effective, at the time when most flowers are past and gone.

In the practical bit of ground where the kitchen garden meets the flowers, Japan has long since enlarged its bill of fare with the tuber of a cousin of our common hedge nettle, with the roots of the large burdock, commoner still. In Florida, the calla lily has use as well as beauty; it is cultivated for its potato-like tubers.

Much as the study of flowers heightens our interest in them, their first, their chief enduring charm consists in their simple beauty—their infinitely varied grace of form, their exhaustless wealth of changeful tints. Off we go with delight from desk and book to a breezy field, a wimpling brook, a quiet pond in woodland shade. A dozen rambles from May to October will show us all the floral procession, which, beginning with the trilliums and the violets, ends at the approach of frost with the golden-rod and aster. But who ever formed an engaging acquaintance without wishing it might become a close friendship? Never yet did the observant culler of bloodroot and columbine rest satisfied with merely knowing their names, and how can more be known unless flowers are set up in a portrait gallery of their own for the leisurely study of their lineaments and lineage?

A word then as to the best way to gather wild flowers. A case for them in the form of a round tube, closed at the ends, with a hinged cover, can be made by a tinsmith at small cost. Its dimensions should be about thirty inches in length by five inches in diameter, with a strap attached to carry it by. At still less expense a frame can be made, or bought, formed of two boards, one-eighth of an inch thick, twenty-four inches long and eighteen inches broad, with two thin battens fastened across them to prevent warping. A quire of soft brown paper, newspaper will do, and a strap to hold all together, complete the outfit.

Our gathered treasures at home, we may wish to deck a table or a mantel with a few of them. The lives of impressed blossoms can be, much prolonged by exercising a little care. Punch holes in a round of cardboard and put the stalks through these holes before placing the flowers in a vase. This prevents the stalks touching each other, and so decaying before their time. A little charcoal in the water tends to keep it pure; the water should be changed daily.

A flower will fade at last be it tended ever so carefully. If we wish to preserve it dried we can best do so as soon as we bring it home, by placing it between sheets of absorbent paper (newspaper will do) well weighted down, the paper to be renewed if the plants are succulent and if there is any risk of mildew. But a dried plant after all is only a mummy. Its colours are gone; its form bruised and crumpled, gives only a faint suggestion of it as it lived and breathed. Other and more pleasant reminders of our summer rambles can be ours. With a camera of fair size it is easy to take pictures of flowers at their best; these pictures can be coloured in their natural tints with happy effect. In this art Mrs. Cornelius Van Brunt, of New York, has attained extraordinary success. Or, instead of the camera, why not at first invoke the brush and colour-box? Only a little skill in handling them is enough for a beginning. Practice soon increases deftness in this art as in every other, and in a few short weeks floral portraits are painted with a truth to nature denied the unaided pencil. For what flower, however meek and lowly, could ever tell its story in plain black and white?

The amateur painter of flowers learns a good many things by the way; at the very outset, that drawing accurate and clear must be the groundwork of any painting worthy the name. Both in the use of pencil and brush there must be a degree of painstaking observation, wholesome as a discipline and delightful in its harvests. How many of us, unused to the task of careful observation, can tell the number of the musk-mallow's petals, or mark on paper the depth of fringe on a gentian, or match from a series of dyed silks the hues of a common buttercup? Drawing and painting sharpen the eye, and make the fingers its trained and ready servants. From the very beginning of one's task in limning bud and blossom, we see them richer in grace and loveliness than ever before. When wild flowers are sketched as they grow it is often easy to give them a new interest by adding the portraits of their insect servitors. Amateurs who are so fortunate as to visit the West Indies have an opportunity to paint the wonderful blossoms of the Marcgravia, whose minister, a humming bird, quivers above it like a bit of rainbow loosened from the sky.

Early in the history of art the wild flowers lent their aid to decoration. The acanthus which gave its leaves to crest the capital of the Corinthian column, the roses conventionalized in the rich fabrics of ancient Persia, until they have been thought sheer inventions of the weaver, are among the first items of an indebtedness which has steadily grown in volume until to-day, when the designers who find their inspiration in the flowers are a vast and increasing host. In a modern mansion of the best type the outer walls are enriched with the leonine beauty of the sun-flower; within, the mosaic floors, the silk, and paper hangings, repeat themes suggested by the vine, the wild clematis and the Mayflower. The stained glass windows from New York, where their manufacture excels that of any other city in the world, are exquisite with boldly treated lilies, poppies, and columbines. In the drawing-room are embroideries designed by two young women of Salem, Massachusetts, who have established a thriving industry in transferring the glow of wild flowers to the adornment of noble houses such as this. As one goes from studio to studio, it is cheering to find so many men and women busy at work which is more joyful than play,—which in many cases first taken up as a recreation disclosed a vein of genuine talent and so pointed to a career more delightful than any other,—because it chimes in with the love of beauty and the power of giving it worthy expression.

Transcriber's Note:

Unable to locate “partnery” nor “tucu-tucu”, but they have been left as in the original.

The word “sylvain” has been verified as a valid word, and therefore it has been left as in the original.