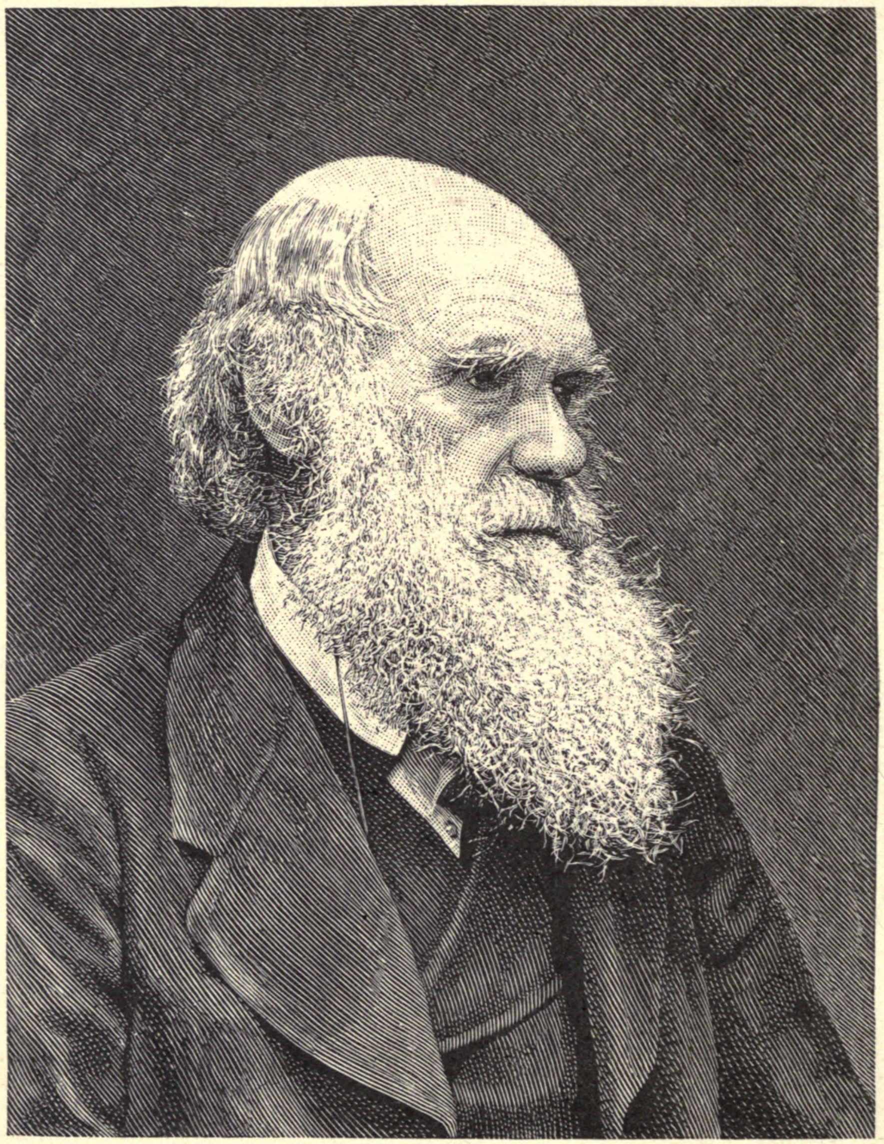

C. Darwin

FROM A PHOTOGRAPH BY ELLIOTT AND FRY.

NATURAL HISTORY

ITS RISE AND PROGRESS IN BRITAIN

AS DEVELOPED IN THE

Life and Labours of Leading Naturalists

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THE THEORY OF NATURAL SELECTION.

CHARLES DARWIN.

It remains to consider very briefly the leading points involved in the theory of 'the Origin of Species by means of Natural Selection,' which the world owes to the genius of Charles Darwin, and by which the entire science of zoology has been fundamentally altered. There is, indeed, no revolution so great as that effected by the introduction of a new *principle;* since that involves a reconstruction from the foundation upwards, and implies a much more serious change than the mere putting on of a roof, or the addition of a buttress or of any sort of pendicle, however important such may be in itself. Darwin, however, introduced a novel principle into biology; and in so doing he profoundly altered the entire attitude of naturalists and botanists towards the world of living beings. Moreover, when the organic world came to be viewed in the light of this new principle, it became at once evident that its complexities depended, to a large extent at any rate, upon causes which are open to our investigation, and are not wholly beyond our comprehension. The theory of the origin of species by special creation laboured under the inevitable defect that it 'closed the record,' and in many directions shut the door to further research. The theory of the origin of species by means of natural selection has not only brought to light a whole series of problems, many of which are of a most far-reaching character, but it has solved some of them, and has pointed out to us the way in which others may yet be solved at some future date.

As has been seen, the theory that the present state of the natural world was the result of its evolution from a former state did not originate with Darwin. Like others of the profoundest conceptions of the human mind, it had been more or less clearly recognised by more than one earlier philosopher, and notably by Erasmus Darwin and Lamarck. The theory that the 'species' of animals and plants now in existence had been produced by the modification of pre-existing forms of life, and that species were therefore not immutable, also did not originate with Darwin. Lamarck had definitely promulgated this theory, and other writers—such as Erasmus Darwin and Goethe—in the early part of this century or the close of the last, had put forth similar ideas. Lamarck's views, however, had remained little more than a barren speculation—unheeded by most, and scoffed at by many—and no change had been produced in the generally accepted views as to the nature of 'species' by the publication of the 'Philosophie Zoologique.' To Darwin is incontestably due the pre-eminent merit of having established a theory which satisfactorily explains the *method* in which species have been produced by evolution from other previously existing forms. No naturalist at the present day, it may safely be said, doubts that the theory of the origin of species by means of natural selection is true so far as it goes, and that it satisfactorily explains the principal difficulties which it can be legitimately called upon to explain. 'Natural Selection' is, in other words, universally recognised as a *vera causa.* The chief point that can be said now to be at issue among naturalists is not whether it be a genuinely active cause, but only as to the extent to which it can be *applied*—some regarding it as the sole factor in the production of 'species,' while others look upon it as being only one of many concurrent factors.

Darwin's life need only be referred to here in the briefest way, and only for the purpose of showing how thoroughly it qualified him for the task of elaborating and establishing his great theory. Charles Darwin was born at Shrewsbury, on the 12th of February 1809. His father was Dr Robert Waring Darwin, a physician of Shrewsbury, and his grandfather was the celebrated Dr Erasmus Darwin, whose life and writings have been previously noticed. At sixteen years of age, Charles Darwin went to Edinburgh to study medicine; but he soon made up his mind that the pursuit of medicine as a profession would not be in accordance with his tastes, and he accordingly betook himself in 1828 to Cambridge, with a view to studying theology. The influences of the place, however, combined, we may presume, with his own unconscious bent and aptitudes, soon had the effect of so far awakening his early love of nature, that he ultimately threw himself almost entirely into scientific studies. This result was also in large part due to the intercourse which he enjoyed with Professor Henslow, the well-known botanist.

In 1831, Darwin graduated as Bachelor of Arts, and in the autumn of the same year his final life-course was determined for him by his appointment to the unpaid post of naturalist to the *Beagle*, a ten-gun brig, commanded by Captain (afterwards Admiral) Fitzroy, and then under orders to proceed on a long surveying voyage round the world. This cruise occupied five years of Darwin's life, and constituted 'the real great university in which he studied nature, and read for his degree.'* During this memorable voyage, he not only collected a vast amount of scientific material of all kinds, but he accumulated an endless store of observations which might, and ultimately did, serve as the groundwork for his *magnum opus* on the Origin of Species.

In October 1836, Darwin landed at Falmouth, after his long and profitable cruise in the *Beagle*. The next three years were spent by him in London, his hands being fully occupied with preparing his journals for publication, and in making the needful editorial arrangements for the description of the great scientific collections which he had brought home with him.† By the advice

* Grant Allen, 'Life of Charles Darwin.'

† Darwin's 'Journal of Researches into the Geology and Natural History of the various Countries visited by H.M.S. *Beagle*' was published in 1839. The descriptions of the scientific collections were ultimately published in 'The Zoology of H.M.S. *Beagle*,' which appeared in 1840–44. In this magnificent work, the fossil mammals were described by Owen, the living mammals by Waterhouse, the birds by Gould, the fishes by Jenyns, and the reptiles by Bell.

of his friend Sir Charles Lyell—advice which his freedom from pecuniary necessities fortunately enabled him to take—Darwin, on his return home, sought no official scientific appointment. In 1839, he married his cousin, Miss Emma Wedgewood, and finally established himself at Down House, near Orpington, in Kent, which continued to be his home to the end of his life.

After his long voyage in the *Beagle*, Darwin never left England again, not even to pay a brief visit to the Continent. From his settlement at Down in 1839 onwards, he lived a quiet unostentatious life in his own home, unremittingly occupied with his scientific pursuits. On the 18th of April 1882, the great naturalist was attacked by sudden illness, and at four o'clock in the afternoon of the next day he breathed his last. He was buried in Westminster Abbey, in the presence of most of the foremost representatives of science in Britain; and his death deprived the scientific world of the most prominent figure that this generation has seen.

With regard to the vast mass of scientific work which Darwin produced, nothing further can be attempted here than merely to mention the titles of his larger works. His 'Journal' of researches made in the voyage of the *Beagle* was, as we have seen, published in 1839. Other fruits of the long series of observations which he made on the same voyage were published later under the names of 'The Structure and Distribution of Coral-Reefs' (1842), 'Geological Observations on Volcanic Islands' (1844), and 'Geological Observations on South America' (1846). Many of Darwin's geological observations (such as those on cleavage and foliation, on the structure of the 'pampas' of South America, and on volcanic islands) are of the highest importance and of permanent value; and his theory of the Origin of Coral-reefs obtained a world-wide reputation. Darwin, as previously mentioned, also edited the 'Zoology of the Voyage of the *Beagle*.' Subsequently to his return to England, he engaged in special zoological researches, and published his classical 'Monograph of the Cirripedia,' printed by the Ray Society in 1853; with a companion volume on the fossil species of the same group, which appeared under the auspices of the Palæontographical Society. In 1859 appeared the first edition of the 'Origin of Species by means of Natural Selection,' which rendered his name at once famous over the whole civilised world, and which gave rise to more discussion than perhaps has ever been produced by any other scientific book whatever. This work has been translated into almost all European languages, and the English edition now generally used is the sixth, published in 1872. Among the works which proceeded from the pen of Dr Darwin during his later years may be enumerated 'The Fertilisation of Orchids' (1862); the 'Variations of Animals and Plants under Domestication' (1867); 'The Descent of Man and Selection in Relation to Sex' (1871); and 'The Expression of the Emotions in Man and Animals' (1873).

The great principle which Darwin established in connection with the highly complex problem of the Origin of Species, is what is known as 'the Theory of Natural Selection, or the Preservation of Favoured Races in the

Struggle for Life.' Mr Alfred Russell Wallace has a conjoint claim to the discovery of this principle, as he published similar views to those of Mr Darwin in a memoir entitled 'On the Tendency of Varieties to depart indefinitely from the Original Type,' which appeared in the Journal of the Linnean Society in 1859, in the same year as the first edition of the 'Origin of Species' was given to the world. It is, as has been seen, an error to regard Mr Darwin as the originator of the theory of *Evolution*, as applied to animals and plants. It is the 'Theory of Natural Selection'—a theory which explains *how* evolution has taken place—with which his name will be always associated; and it is this theory alone of which we propose here to give a general outline.

The bases of the 'Theory of Natural Selection' may be laid down in the following propositions:

(1) The first proposition in the Theory of Natural Selection embraces what has been called the 'Malthusian law of increase'—the law, namely, that all living beings tend to increase more rapidly than their means of subsistence. The tendency of living beings, in fact, is to increase in a geometrical ratio, and this is true not only of all animals but also of all plants. In support of this law it is not necessary to take the cases of animals so prolific as the cod, the female of which produces annually about ten millions of ova; for the same law is exemplified quite as well by the elephant, which is considered to be the slowest breeder of all animals. Upon this point Darwin has made an interesting calculation. The elephant begins to bear young

at thirty years of age, and continues to produce offspring till it is ninety years old, during which time it has six young ones. The average age of the elephant may be calculated at about one hundred years, though this is often exceeded. On this basis, Darwin calculates that at the end of about seven hundred and fifty years the offspring of the first pair of elephants would amount to about nineteen millions of then living individuals.

(2) In consequence of this geometrical rate of increase among all living beings, it necessarily follows that there arises a 'Struggle for Existence' among animals and plants. Each organism fills a certain place in the world of nature, occupies a particular area, feeds on a particular kind of food, requires, in short, a particular set of conditions. As, however, every kind of animal and plant is constantly bringing into the world more young than can be accommodated, or for which suitable food can be provided, it follows that there arises among the young of each species a *competition*, a struggle both for a proper place and for proper food. This competition, which is seen quite as much in plants as in animals, is what is understood as the 'struggle for existence.' In using this term, Darwin premises that he does so 'in a large and metaphorical sense, including dependence of one being on another, and including (what is more important) not only the life of the individual, but success in leaving progeny. Two canine animals, in a time of dearth, may be truly said to struggle with each other which shall get food and live. But a plant on the edge of the desert is said to struggle for life against the drought, though more properly it should be said to be dependent

on the moisture. A plant which annually produces a thousand seeds, of which only one on an average comes to maturity, may be more truly said to struggle with the plants of the same and other kinds which already clothe the ground. The mistletoe is dependent on the apple and a few other trees, but can only in a far-fetched sense be said to struggle with these trees, for, if too many of these parasites grow on the same tree, it languishes and dies. But several seedling mistletoes, growing close together on the same branch, may more truly be said to struggle with each other. As the mistletoe is disseminated by birds, its existence depends on them; and it may metaphorically be said to struggle with other fruit-bearing plants, in tempting the birds to devour and thus disseminate its seeds.'

(3) The third proposition of the theory of natural selection is that all living beings are subject to variation. As has been previously seen, the individuals which compose any and every 'species' of animals and plants are not *precisely* alike. They invariably differ from one another in more or less numerous points, some of the differences being extremely minute, while others may be very conspicuous. We do not know whether variation is indefinite, and affects *every* part of the organism, or whether it is definite and is confined within certain limits. Nor has it been clearly proved whether variation is fortuitous, or whether it takes place in obedience to some determinate law, which governs the direction which it follows. It is, however, certain that 'variation,' to a greater or less extent, is of universal occurrence among all living beings.

(4) Some of the variations which occur in the individuals composing any species, are favourable to the species; some are unfavourable. That is to say, some variations will either help the individual to obtain more food, or to keep himself warm, or render him less liable to fall a prey to his natural enemies, or will otherwise help him in the struggle for existence. On the other hand, some variations will keep the individual back in the race for life, and will increase the difficulty which *all* individuals have in maintaining their existence. It follows from this, that in any given species of animals or plants those individuals which are born into the world in the possession of any favourable variations are, *cæteris paribus*, likely to be preserved; while those having unfavourable variations are likely to go to the wall and to be stamped out.

This law is what Mr Herbert Spencer has called the law of the 'Survival of the Fittest,' or what Mr Darwin has called 'Natural Selection.' This last name is in allusion to the fact that the action of 'Nature'—that is, the aggregate of natural forces—is to insure the 'selection,' out of the young of any species, of all those individuals which are 'fittest' for their surroundings. These young are preserved, while those not possessing any such favourable variations, and therefore not so well fitted for their surroundings, are weeded out and perish. The operation of the law may be illustrated by the imaginary example of the Giraffe, which Mr Darwin has himself used as illustrating the action of natural selection, and which was previously taken as illustrating Lamarck's view as to the action of external conditions upon the structure of animals. If we suppose, namely, that the giraffe, to begin with, possessed a neck of no more than normal length, and lived principally upon the ordinary terrestrial herbage; and if we further suppose a severe and protracted drought to occur in the region inhabited by the giraffes, we may assume that many individuals would perish for want of food, but that some would manage to survive. In all such cases there must be some general reason to account for the survival of the few who did survive, in preference to the many who perished. In this particular instance we may suppose that the individuals who survived were those who possessed necks of a slightly greater length than the average, and who, therefore, were better fitted for browsing upon shrubs or trees, after the herbage had been destroyed by the drought, than were the more normal individuals. This imaginary example, then, will show how the possession of a favourable variation tends to preserve certain individuals, in preference to those which are without the variation.

(5) But, the young of all animals and plants tend to *inherit* the peculiarities of their parents. Hence, favourable variations or peculiarities which preserve alive certain individuals of each species, will tend to be handed down to their offspring. On the other hand, individuals not possessing these favourable variations, or possessing unfavourable variations, are killed off, and do not have the opportunity of transmitting *their* peculiarities to offspring. The general action of the law of the 'Survival of the Fittest,' or of 'Natural Selection,' is, thus, *to preserve all favourable variations* which may occur among the indi-

viduals composing any species, and *to destroy all unfavourable variations amongst the same.*

To use once more the imaginary illustration above employed, the longer necks which enabled certain individual giraffes to survive a drought, would be handed down by inheritance to their young. On the other hand, the comparatively short-necked individuals would not have the chance of leaving offspring because, by the hypothesis, they would be killed off.

Moreover, in the course of this transmission, the favourable variation (whatever it may be) will tend to become *intensified* in each succeeding generation, so long as the conditions which render the variation favourable to the life of the individual remain in existence. So long as this continues, the same process of 'selection' will go on in each succeeding generation; and the varying character will become in each generation successively stronger and stronger. Thus, in our illustration, so long as the region tenanted by the giraffe continued subject to periodic droughts, and so long as it was, therefore, good for the individual giraffe to have a long neck, the individuals in each generation which had the longest necks would have the best chance of survival. The best chance of survival, however, implies the best chance of leaving offspring, and in this way the neck of the giraffe might go on getting in each generation longer and longer, by the preservation of the individuals which possessed this variation to the greatest extent, and the elimination of those with shorter necks.

By means of this process of 'natural selection,' it is easy to comprehend how 'varieties' might be produced.

Nor can it be reasonably doubted that in the case of animals this *is* the process by which varieties are originated and established. But it has been previously seen that 'species' and 'varieties' pass into one another by imperceptible gradations. It is, in fact, impossible to lay down any fixed rule for the determination of where a 'variety' ends, and where a 'species' begins. If, therefore, it be admitted that 'varieties' are produced by 'natural selection,' it is not possible to deny that the same cause must have given rise to at any rate *some* of those groups of individuals which naturalists call 'species.' If this be conceded, it is an inevitable logical conclusion that *all* species have been thus produced by 'natural selection.' At any rate, the admission that *any* species have been produced by the operation of 'natural selection,' throws upon those who deny the universal operation of the law, the burden of proof that any particular species has *not* been produced by the action of the same law.

The above may be taken as a brief statement of the principal propositions upon which Darwin based his celebrated theory of the Origin of Species by means of Natural Selection. This statement would, however, be incomplete without a short additional exposition of what Mr Darwin has called 'artificial selection.' In the case, then, of our domestic animals and their innumerable varieties, there is the obvious fact that the law of 'natural' selection is prevented from operating in its entirety owing to the action of man. Man, in the case of his domestic animals, steps in as a *deus ex machinâ*, and more or less efficiently interferes with the law of natural selection by protecting certain individuals of a species in the struggle for existence, and affording them assistance which they could not have had in a wild state. The individuals of the Wild Boar, for example, have to face the rigid and merciless operation of the law of natural selection, and the weakest therefore go to the wall. The individuals of the Domestic Pig—the same animal really as the wild boar—are so far relieved from the action of the law of natural selection, that man feeds them when they are hungry, protects them from the cold artificially, and, so far as he can, cures them when they are ill. Man does of course the same thing to the weaker individuals of his own species, and all such things as poor-laws and the like are, in the Darwinian sense, attempts on the part of man to defeat or neutralise the operation of 'natural selection.' In the case of many varieties of our domestic animals, it is certain that man's interference has gone so far as to render them wholly incapable of facing the law of natural selection in its untempered severity. In other words, there are many of our domesticated breeds of animals which would infallibly become exterminated if they were turned loose to make their own living, and if the protecting hand of man were wholly withdrawn from them.

Man, however, not only protects domestic animals in this way from the direct action of surrounding conditions, but at the same time exercises, on his own behalf, a sort of 'selection,' analogous to 'natural selection,' but necessarily operating within much narrower limits, and also exercised in a much more arbitrary fashion. Darwin has given a masterly exposition of the whole of this subject under the head of what he has called 'artificial selection;' and a few words may be said here as to what he understands by this name. Our domesticated animals, as is well known, have in all cases originated from wild species, which have gradually been brought under the influence and dominion of man. The same is true of all our domesticated, or rather cultivated, plants. In certain cases—as that of the pig above referred to—we not only have the domesticated breed or breeds, but we are also acquainted with the wild species from which the domestic form was derived. In other cases, the domesticated animals have undergone changes so great that we can no longer point with certainty to the wild forms in which they originated. In some cases, it may be, the wild form is no longer in existence. In all cases, however, our domestic animals show, more or less conspicuously, two remarkable characteristics or tendencies. One of these is that they exhibit more numerous and more marked 'varieties' than is the case, as a rule, with wild species. They have a more pronounced *tendency* to variation than wild animals have, and their variations also extend through a wider range. The other is, that the peculiarities which are distinctive of our domestic animals as compared with their wild forms, are not of such a nature as to fit the animal better for its natural wild life, but, as specially insisted on by Mr Darwin, are adaptations to the taste, or fancy, or requirements of man. Thus, any modifications produced by natural selection in the wild boar would be in the direction of making it stronger, or enabling it better to resist cold, or rendering it fitter to cope with its natural foes, or the like. Man, however, does not desire any improvements of this kind in the domestic pig. He does not, for example, wish to increase its muscular power and consequent activity; because he wants it to fatten readily, and vigorous exercise tends to keep an animal lean. What is true of the pig is true of all our domestic animals, though it is more evident in some than in others. The variations, for instance, which separate the different breeds of the dog from one another are exceedingly well marked, and they are all variations which adapt particular breeds for the special purposes for which man wants them. On the other hand, the different breeds of the Goose differ little from one another, or from their wild form (the Grey Lag Goose), because man's demands from the goose are few and simple, and are quite well answered by the ordinary form of the species.

The causes of the above-mentioned peculiarities of domesticated animals, as compared with wild ones, have been fully expounded by Mr Darwin, and are readily intelligible. As regards the first of them—namely, the tendency to excessive variation shown by domestic animals —the cause is to be found in the varied character and artificial nature of the conditions under which they live. Wild animals are exposed, as regards each species, to an approximately uniform and unvarying set of conditions, and the conditions are alike for all the individuals of the species. Variation does not become excessive, because the tendency of natural selection is to destroy all variations which are not good for the *individual* itself in its natural condition. On the other hand, domestic animals are kept by their masters under very different sets of conditions, as regards different individuals of the species, and man at the same time prevents the law of natural selection from rigidly exterminating those individuals which happen to be born with variations which would be hurtful to the species in a wild state. The fact that domesticated animals exhibit peculiarities which are in no way adaptations to their natural surroundings, but which are mere adaptations to man's wants or tastes, is explained by 'artificial selection.' Man, namely, has as regards each domestic animal an ideal of what he wants. It may be that he has no consciousness of having any such ideal before him, but it may be taken as certain that he possesses it nevertheless. 'Artificial selection' consists essentially in the choice which man exercises as to the young of his domestic animals, in respect to which he will allow to live, and which he will destroy. In the case of the young of each of his domesticated animals, a man sees some individuals having peculiarities which he thinks will be useful to him, or which come nearest to the ideal which he has formed of the animal, or of what the animal *ought* to be. Such individuals he keeps, and permits to have offspring; so that the peculiarities which induced him to keep these individuals are perpetuated and handed down to future generations, becoming in the process intensified. On the contrary, all those individuals amongst the young, which do not conform to man's ideal standard of perfection, are either killed off on the spot, or are, at any rate, prevented from leaving offspring behind them. In this way, by a long-continued process of *selecting* the particular individuals which he will allow to live and to breed, man has succeeded in producing the numerous domesticated varieties of animals. In the case of savage tribes of men, this selection is no doubt carried on unconsciously, but among the breeders of cattle, or among pigeon-fanciers, it is a strictly scientific process, carried on consciously and deliberately, and according to rules, which are none the less fixed that they are largely 'rules of thumb.'

Those who wish to understand this most interesting subject in all its bearings must turn to the pages of the 'Origin of Species,' where it is fully treated by the hand of the master. All that need be done here is to say one word as to the relation between the known facts of 'artificial selection' on the one hand and the theory of the origin of wild species by 'natural selection' on the other hand. If it be admitted, namely, that our numerous varieties of domesticated animals owe their peculiarities to the 'selection' exercised by man during the comparatively brief period during which he has existed upon the earth, it is not unreasonable to suppose that 'natural selection,' operating through an infinitely longer period, and by methods much more subtle and far-reaching, has produced the different wild 'species' of animals by modifications of one or more aboriginal types. The unquestionable facts, therefore, as to the production of our domesticated breeds of animals from wild species by means of 'artificial selection,' afford a strong presumption in favour of the theory that our existing wild species have been produced by the modification of pre-existing wild species through the operation of 'natural selection.'

THE THEORY OF NATURAL SELECTION
(CONTINUED).

HAVING now given the briefest possible sketch of the Theory of Natural Selection, as expounded by Mr Darwin, it may be well to notice, with equal brevity, the leading objections which have been urged against this theory by various naturalists, and notably by Mr Mivart.* It may also be as well to enumerate shortly the chief *general* grounds upon which naturalists base the now generally accepted belief that species have been produced from pre-existing species by the action of *some* law of evolution, apart from the question of the method or methods in which this law operates.

Numerous difficulties admittedly have to be met, if we attempt to apply the theory of natural selection (even when combined with what Darwin has called 'sexual selection') as the sole principle involved in the production of 'species.' Many of these difficulties are of a special nature, affecting special cases only, and they need no discussion here. It is possible that many of these special

* *The Genesis of Species*, by St George Mivart, 1871.

difficulties may disappear in the light of wider knowledge. There are, however, certain general difficulties which demand a moment's consideration, as indicating that though we admit the action of 'natural selection' to the full, we must nevertheless look beyond and outside this for the *complete* explanation of the existence and origin of species. The general difficulties in question were perfectly recognised by Mr Darwin, and have been met by him, as far as it is at present possible to meet them. The principal are the following: *

(1) One of the most general, and certainly one of the most serious of the difficulties in the way of the theory of natural selection is 'the uselessness of many organs in their incipient stage.' Hosts of structures (such as the milk-glands of the Quadrupeds, or the whalebone plates in the mouth of the Whalebone Whales) are exceedingly useful to the animal when perfectly developed; but it is inconceivable that they could have benefited the animal when first they began to be developed. According to the theory of the evolution of species in general, and the theory of natural selection in particular, milk-glands did not exist in the animal forms out of which the class of the Mammals was evolved, nor did baleen-plates exist in the ancestors of the Whalebone Whales. There must, therefore, have been a time when milk-glands and baleen-plates respectively first came into existence, and it is impossible to suppose that they were suddenly produced in complete structural and functional perfection as we now see them. On the contrary, they must, to begin with, have been mere

* An excellent résumé of these objections is given by Mr Pascoe in his *Notes on Natural Selection and the Origin of Species*, 1884.

rudimentary structures, functionally useless, and it can only have been in the course of development during many successive generations, that they assumed their present perfection. Now there is absolutely no evidence to show that the fine beginnings of structures can be useful or profitable to the animal possessing them. They may be harmless, but that is all that can be said. It is, however, the very essence of the theory of natural selection, that the law of the struggle for existence is powerless to preserve or intensify any structures except such as are *useful to the individual*. The fact that a structure may be useful to the *race* is not enough, as final causes or ends are wholly excluded from the theory of natural selection. Upon the whole, the difficulty of accounting for the preservation of incipient organs and structures by the action of natural selection appears to constitute the most formidable of the arguments which have been urged against Mr Darwin's views; since it is a general difficulty, and strikes at the very root of the theory of natural selection.

(2) A second general objection of great weight is that unless 'many individuals should be similarly and simultaneously modified,' there would be little chance of any useful variation which might have appeared in a species being ultimately preserved and handed down. Any new structure or organ, or any alteration in a pre-existing structure, must be slowly produced, and pass through an incipient stage. If, however, such a new structure, or alteration in an old structure, appeared, to begin with, in only one or two individuals of a species, it could hardly be preserved, as it would be 'lost by subsequent intercrossing with ordinary individuals.' But it is hardly

probable that any variation would simultaneously appear in many individuals of a species; and we have at any rate no evidence to show that this ever occurs.

(3) The theory of the origin of species by means of natural selection, in the third place, implies that the production of any given species from any pre-existing species can only be effected by gradual modification, and therefore through the intervention of a long series of intermediate or transitional forms. Moreover, the transitional forms by which we should pass from a given species to the pre-existing species from which it was developed, must, on the theory of natural selection, be so closely related to one another as to render it difficult to distinguish them. In other words, if we had before us all the forms by which one species had been gradually converted into another, we should not have the slightest difficulty in recognising the distinctness of the individuals forming the extreme terms of the series; but the individuals standing between the extremes would pass into one another by such fine gradations as to render their separation almost or quite impossible. It seems also clear that, in the modification of any one species into any other, the total number of the individuals of intermediate or transitional form must greatly exceed the total number of individuals contained in the original species and the new species put together. Now, if all species of animals, living and extinct, have been produced by gradual modification from pre-existing species, we ought to find abundant evidence of the existence of the infinite number of transitional forms postulated by the theory of natural selection. In fact, as these transitional

forms must have greatly exceeded in total number the combined number of individuals which are clearly recognisable as distinct species, we ought to find *more* abundant evidence of their existence than of the existence of the separate species. As a matter of fact, however, the study of extinct animals does not afford more than very incomplete evidence as to the existence of the numerous and closely graduated transitional forms required by the theory of natural selection. It is true that palæontology has brought to light many forms of animals which are distinctly intermediate in their characters between groups which would otherwise stand far apart. Thus, we have numerous extinct types which bridge over the gap between the reptiles and the birds; and others which stand intermediate between the existing horses and their original five-toed ancestors. So far, then, palæontology unquestionably lends support to the general theory of the evolution of species from pre-existing species. The theory of natural selection requires, however, more than this. It requires that there should be a *series* of intermediate types graduating into one another by slight and hardly perceptible differences. In some cases, as regards allied species of animals, such a continuously graduated series can be shown to exist (in some extinct Shell-fish, for example). In most cases, however, it must be admitted that palæontology has so far failed to demonstrate the past existence of the numerous and finely-graduated series of transitional forms between different species absolutely demanded by the theory of natural selection. Such transitional forms as are known for the most part stand quite sharply distinguished from one another and from the types which they connect. Mr Darwin has met this difficulty by pointing to the great 'imperfection of the palæontological record,' the fossil forms known to us doubtless forming only an insignificant fraction of those which once existed. This argument is entitled to receive great weight; but it does not sufficiently account for the *general* absence of graduated intermediate forms. This, however, is a point which cannot be further discussed here, and upon which each investigator will decide, in one sense or the other, according to the particular direction in which he may be led by his studies.

(4) It is, again, assumed upon the theory of natural selection, that 'variation' among the individuals of a species is *indefinite*, both in amount and direction. It would appear that the theory of the origin of species by means of natural selection requires a belief in the 'omnifarious' nature of individual variation. The action of 'Natural Selection' would, of course, still go on, even supposing variation to be strictly limited in amount; but in this case it is hardly conceivable that our existing species should owe their origin to natural selection, as the principal or sole factor in their production. On the contrary, it seems necessary to suppose that variation affects, or may affect, all parts of the organism, and that there are no limits to the extent of its operation, though the single steps of the process are small in amount. We have, however, no positive evidence which would enable us to assert, as a scientific fact, that variation is thus omnifarious and indefinite. The evidence actually in our possession is admittedly small, because it only

extends back to the beginning of the human period; but, so far as it goes, it would rather support the view that variation is limited and definite both in amount and direction. The 'artificial selection,' for example, which man has exercised in the case of his domestic animals for some thousands of years, has not, so far, resulted in the production of a single new 'species.' New 'varieties' have been produced, but that is all; and we know that these *may* appear suddenly (as in the instance of the Black-shouldered Peacock), without the direct or indirect action of man at all. Besides, if variation be indefinite, it is difficult to account for the constantly-recurring phenomenon of the extinction of species—a phenomenon which is, on any hypothesis, very difficult to satisfactorily explain. So far as wild animals are concerned there is no direct evidence to show that a single 'species' has come into existence since the beginning of the historical period; nor is there any evidence to show that during the same period a single wild species has become extinct, except only where its extinction has been the result of the interposition of man.

The points above enumerated are sufficient to show that there are great difficulties in the way of accepting 'Natural Selection' as the *sole* agent in the production of species. That it is *one* agent, and an important one, is a matter that does not admit of doubt. Under any circumstances, however highly we may rate 'natural selection' as an agent in the production of species, it remains certain that we are still almost entirely ignorant of the causes of the two fundamental laws which have to do with the production of species—namely, the law of variation and the law of inheritance. Our ignorance as to both of these is freely and fully admitted by Mr Darwin. The theory of natural selection does not profess to explain *why* variations occur; it only explains how those variations which are useful to the individual are preserved, and how those which are injurious are 'rigidly destroyed.' Like all other hypotheses as to the origin of species, it leaves us entirely in the dark as to the *causes* of variability. The law of variation is therefore an unknown law, lying behind the law of evolution, and possibly beyond the limits of scientific investigation. Similarly, the laws of inheritance are almost wholly unknown. 'No one can say why the same peculiarity in different individuals of the same species, or in different species, is sometimes inherited and sometimes not so; why the child often reverts in certain characters to its grandfather or grandmother or more remote ancestors; why a peculiarity is often transmitted from one sex to both sexes, or to one sex alone, more commonly but not exclusively to the like sex' ('Origin of Species,' page 10).

That 'species' have originated by modifications through descent may now be taken as an accepted doctrine in modern zoology. It is Mr Darwin's supreme merit to have brought about this radical change in the views of naturalists by the establishment of the law of 'natural selection,' which for the first time rendered possible an explanation of the method in which the modifications of specific forms are caused. Whether or not natural selection has been 'the exclusive means of modification' is a point upon which different naturalists hold different opinions. Mr Darwin himself believed that it was at any rate 'the most important' means. Whatever may be the view ultimately adopted as regards this point, there is overwhelming evidence in favour of the belief in *some* general law of evolution, by which all animal and vegetable species have been produced. The evidence in favour of this may be briefly stated as follows:

(1) All the animals belonging to each great primary division of the Animal Kingdom are constructed upon one fundamental plan, which is capable of endless modifications, but is never lost. Thus, to give one example, the fishes, amphibians, reptiles, birds, and quadrupeds, which together constitute the 'sub-kingdom' of the Vertebrate Animals, are all built according to one common plan. However unlike they may be to one another in the details of their organisation, 'homologous' structures can be traced throughout the ground-plan of them all. This unity of plan in the types of life which compose each sub-kingdom is, however, inexplicable upon any other view than that it is the result of blood-relationship, and depends upon descent from a common ancestor, which possessed the essential structural characters distinctive of Vertebrates as a whole.

(2) The animals composing each sub-kingdom are constructed upon the same plan, and the 'sub-kingdoms,' taken as whole, stand therefore separate and apart. But there exist transitional forms by which one sub-kingdom is linked with another. Thus the singular marine animals known as the Sea-squirts (*Tunicata*) form a link between the true Shell-fish (*Mollusca*) and the Vertebrate Animals. In certain points, namely, in their

organisation, they approach the ordinary Shell-fish, while in others they show a relationship with the lower Vertebrates.

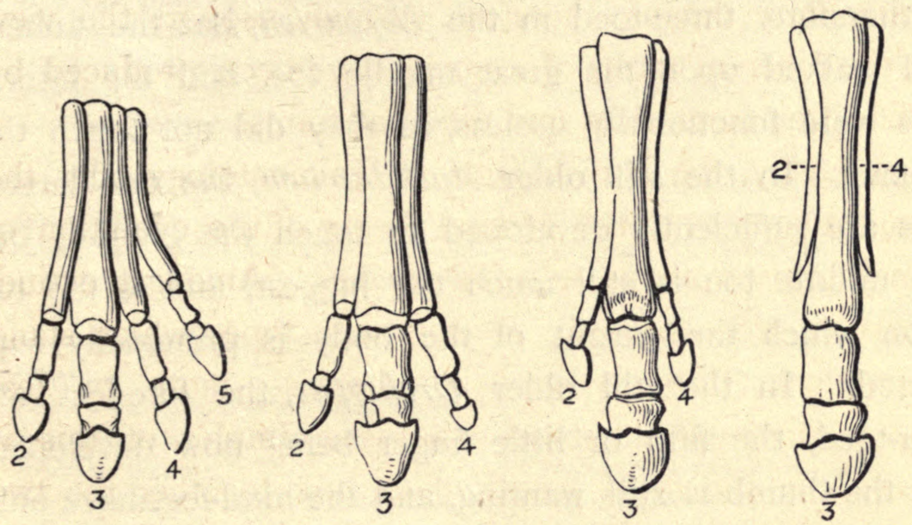
(3) It is a well-known embryological law that the young animal in the early stages of its development commonly possesses structures which it does not possess in its adult state. It is also a well-known law that structures which have only a temporary existence in the embryo of one animal, are often found existing throughout life in the adult of some other animal; and that when this occurs, the latter animal will occupy a lower position in the animal scale than the former. Thus, the embryo of the Quadrupeds possesses on each side of the neck a series of transverse slits or fissures (the so-called 'visceral clefts'), which lead down from the surface into the upper part of the gullet (the 'pharynx'). In the adult Quadruped no traces of these clefts are seen, only one of them remaining at all (the opening of the ear), and that only in a much modified form. On the other hand, the embryo of the Fishes not only possesses these clefts, but they are permanently retained, and are present therefore in the adult, in which they become connected with the gills. It seems, however, impossible to satisfactorily explain the possession of visceral clefts by the mammalian embryo, except upon the supposition that the Mammals and the Fishes alike have descended from a common ancestor in which these structures were present. The general fact, therefore, that the embryos of animals so often possess structures which are found in the adults of other animals, is strongly in favour of the belief in the production of animals by evolution from common ancestral types.

(4) This view is further borne out by the common existence in adult animals of what are known as 'rudimentary organs,' or, in other words, imperfectly developed organs which are of no use to their possessor. Thus, ordinary Snakes do not possess either the fore or hind limbs; but the Boas and Pythons possess rudimentary hind-limbs in the form of a pair of horny spurs. Again, the Whalebone Whales have no teeth; but they exist nevertheless in the young animal, though they remain buried in the jaw and never cut the gum. The same is true of the upper front teeth in Ruminant animals, which also do not cut the gum, and are therefore of no use to the animal. Another instance may be taken from the whales, which show no signs of hind-limbs externally, but which for all that often have the rudiments of these limbs hidden internally. The only satisfactory explanation of the general nature of rudimentary structures which it seems possible to give, is that they are structures which existed in a fully-developed condition in the remote ancestors of an animal, but which have gradually dwindled down in size and have lost their function through long-continued disuse. Sometimes rudimentary organs may be 'nascent' structures—that is, structures which in course of time may become functionally useful to the animal; or sometimes they may merely represent the atrophied condition of structures which the embryo possessed; but this does not affect the above general explanation. Accepting this view, we should judge that the whalebone whales were descended from some type of Mammal which possessed teeth in its jaws, and which was at the same time provided

with the hind-limbs as well as the fore-limbs. Similarly it would be concluded that the ancestral type of the Ruminants possessed well-developed upper front teeth; and that the snakes, though now footless, were descended from some reptilian type in which the limbs were present. Rudimentary organs, therefore, strongly support the view that the different forms of animals have been produced by modification from older and different forms.

(5) Lastly, the known facts of Palæontology offer the strongest support to the general theory of the evolution of animal forms from pre-existing species. Amongst extinct species we are constantly meeting with types which stand intermediate between groups otherwise more or less remote. One of the most famous examples of this is afforded by the fossil forms which link together the two groups of the Reptiles and the Birds—two classes of animals now so little resembling each other, that no one save a naturalist would ever suspect a relationship between them. Thus the past has yielded up to us the remains of true reptiles (the Deinosaurs) which walked upon their hind-legs, like birds; other reptiles (the Pterodactyles) possessed the hollow bones and the power of genuine flight characteristic of the living birds; some genuine birds (the *Odontornithes*), finally, resembled the Crocodiles in having the jaws furnished with numerous pointed conical teeth. Another famous example of the intermediate forms which palæontology has brought to light is that afforded by the extinct horse-like Quadrupeds of the Tertiary period. It is well known that our present Horse is peculiar in having only a single fully-developed toe on each foot. This toe corresponds with the middle

toe (or third toe) of an ordinary quadruped. If the skeleton of the horse's foot be examined, it will be seen that lying by the side of the great middle toe are two little splint-like bones, one on each side, which are the



FEET OF FOSSIL EQUIDÆ.

'rudiments' of the index (or second) toe, and the ring toe (or fourth toe). The horse, therefore, possesses a foot with one complete toe and two incomplete ones; the outermost toe (the little or fifth toe), and the innermost toe (the thumb or great toe, or first toe) having no representatives at all. If, however, there be any truth in the general doctrine of evolution, it may be taken as certain that the horse has descended from a five-toed ancestor, since the typical Mammals possess five digits to the foot. Through the researches of Gaudry, Marsh, and others, it may now be confidently asserted that the horse *has* descended from a five-toed form. Thus, we meet with a number of horse-like animals, all now extinct, in which we find the foot, as we trace them backwards into the past, to become progressively nearer and nearer to the normal pentadactylous type. In comparatively modern strata, we find the *Hipparion*, in which the two little splint-bones of the living horses are so far developed that they project externally and carry little hoofs at their ends. The foot is, therefore, three-toed in the *Hipparion*, but the animal still walked upon the great middle toe, and the lateral toes were functionally useless, as they did not touch the ground. In the still older *Anchitherium*, the two lateral toes are sufficiently developed to touch the ground, but the middle toe is still much the biggest, and is the toe upon which the weight of the body is principally supported. In the still older *Orohippus*, the fore-feet are four-toed, the fifth or little finger being now developed, but the thumb is still wanting, and the hind-feet have only three toes. Finally, in the *Eohippus*, the oldest type of equine animal yet discovered, the fore-foot possesses four complete toes, with a rudimentary thumb (or first toe) in addition, thus becoming morphologically five-toed. The above gives, of course, an exceptionally striking instance of how palæontology enables us to trace the *line of descent* of some particular living animal; but there are innumerable instances in which fossil forms exhibit characters which more or less extensively bridge over the gaps separating groups apparently widely remote. Upon the whole, therefore, the evidence of palæontology, though lending but a partial support to the theory of the origin of species by means of natural selection alone, is overwhelmingly in favour of a general theory of the evolution of animals from other pre-existent types.