

MACMILLAN'S MAGAZINE.

DECEMBER, 1860.

A POPULAR EXPOSITION OF MR. DARWIN ON THE ORIGIN OF SPECIES.

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No scientific work that has been published within this century has excited so much general curiosity as the treatise of Mr. Darwin. It has for a time divided the scientific world into two great contending sections. A Darwinite and an anti-Darwinite are now the badges of opposed scientific parties. Each side is ably represented. In the foremost ranks of the opposition against Darwin have already appeared Professor Owen, Mr. Hopkins, Sir B. Brodie, and Professor Sedgwick; whilst Professor Huxley, Professor Henslowe, Dr. Hooker, and Sir Charles Lyell, have given the new theory a support more or less decided. We shall endeavour most carefully to avoid the partiality of partisanship; and, as our object is neither to attack nor to defend, but simply to expound, we shall have no necessity to assume the tone of ungenerous hostility exhibited in the *Edinburgh Review*, or to summon from theology the asperities contained in the *Quarterly*. Such may be appropriate to controversy, but can give those who are unacquainted with Mr. Darwin's work no idea of his theory; which, all must agree, has been stated with the most perfect impartiality, and is the result of a life of most careful scientific study.

It will be, in the first place, advisable to enunciate, as clearly as possible, the problem which the treatise on the Origin

of Species suggests for solution. And this cannot be done unless we possess a distinct conception of the words we employ. Let us therefore inquire, what is the meaning of the word species? The necessity of classifying the various objects in the animal and vegetable kingdoms was fully recognised by Socrates when he applied his dialectical mode of investigation to test the meaning of general terms. The object of classification was to carve out the organic world into distinct groups, each of which possessed some common property. "Family" was the most comprehensive, then "Genus," then "Species," and then "Variety." A Family would thus include many Genera, a Genus many Species, and a Species many Varieties. These divisions are to some extent arbitrary and artificial; for in nature many of the distinctions, which in certain cases seem most marked and decided, are not universally preserved, but fade gradually away. Thus no distinction might appear to be more easily recognisable than that which exists between animals and vegetables; but, as we descend to the less highly-organised forms of creation, the most distinctive characteristics of animals and vegetables become fainter, and at length we meet with organisms with regard to which even the highest scientific acumen finds it difficult to decide whether they

are vegetables or animals. And, similarly, it is impossible accurately to define the exact amount or the exact kind of difference which is sufficient to place two organisms in two distinct Families or two distinct Genera. This difficulty and doubt increases as we descend to the lower classificatory divisions, and it is admitted that it is impossible to frame any exact definition of a specific difference. This difficulty is strikingly exhibited in botany. A most eminent botanist, Mr. Bentham, maintains that there are only one thousand two hundred species of English plants. An equally high botanical authority, Mr. Babington, affirms that there are two thousand species. A similar difference of opinion exists amongst naturalists. For instance, it was long a disputed point whether or not the dog and wolf were varieties of one species.

The following definition of a species is sometimes given: that two animals or vegetables belong to different species when they are infertile with each other. This hardly deserves the name of a definition. It is enunciated in deference to pre-conceived notions, and assumes the incorrectness of the theory which it is afterwards used to disprove. This definition can manifestly have little influence in diminishing that difficulty, which has been above alluded to, of deciding what is a specific difference; for it requires a test which can rarely be applied to the existing organic world, and is entirely inapplicable to those numerous species which have passed away. Thus it would be almost impossible to ascertain whether different molluscs, or insects, or testacea, are fertile with each other; and, manifestly, such an imperfect experiment in breeding cannot be made upon those animals and plants of which we have solely a geological record. Therefore it would seem that the classification of species must remain so arbitrary, that equally high scientific authorities may continue to dispute whether the plants of a limited area like England should be held to constitute two thousand or one thousand two hundred species. The question of species may thus, at the first

sight, appear to be a dispute about an arbitrary classification, and it may naturally be asked, Why, therefore, does the problem of the Origin of Species assume an aspect of supreme scientific interest?

The common assumption that species are infertile with each other, and that the descendants of any particular species always belong to that species, at once suggests this difficulty:—How can a new species be introduced into the world? There is abundant evidence that new species have been introduced. If we go back to a comparatively modern geological epoch, it will be found that all the fossil animals belong to undoubtedly distinct species from any which exist at the present time. This is admitted by every naturalist and geologist, whatever may be his opinion on the origin of species. The geological record shows us that past species have died out, and that existing species have been gradually introduced. What is the cause which has produced this extinction of species? What is the agency by which the new species have been placed upon the earth? These are the questions to which Mr. Darwin has sought to give an answer. The same question has been asked again and again, and it admits only two kinds of answers. If the ordinary assumption is admitted that no two members of different species can be the progenitors of a mixed race, and if it is also supposed that the descendants of any varieties of a particular species must always be considered as belonging to this species, and that, however much in succeeding ages such descendants may differ from the parent stock, this difference can never entitle them to be ranked as distinct species—if these propositions are admitted, it then becomes quite manifest that the statement that a new species has appeared is tantamount to the assertion that a living form has been introduced upon the earth which cannot have been generated from anything previously living. It therefore becomes necessary to suppose that the same effort of Creative Will, which originally placed life upon this planet, is repeated at the introduction of every

new species; and thus a new species has to be regarded as the offspring of a miraculous birth. We are as powerless to explain by physical causes this miracle as we are any other. To hope for an explanation would be as vain as for the human mind to expect to discover by philosophy the agency by which Joshua made the sun and moon stand still. Our ignorance, therefore, of the origin of species is absolute and complete, if every new species is supposed to require a distinct and independent act of the will of an Omnipotent Creator. When it was supposed that every heavenly body had its path guided by a direct omnipotent control, all are now ready to admit that the cause of the motion of these bodies was unknown, and that this want of knowledge was not the less complete because it was disguised under such expressions as the harmonies of the universe. Those, therefore, who attempt to render unnecessary the belief in these continuously-repeated creative fiats, seek to explain hitherto unexplained phenomena of the highest order of interest and importance in natural history. Whenever this explanation shall have been given, a similar service will have been done to this science, as was performed by Newton for astronomy, when he enunciated his law of gravitation. Newton's discovery is now found in numerous religious works as a favourite illustration of the wisdom of the Creator; and it is now considered that a hymn of praise is sung to God when we expound the simplicity of the Newtonian laws. The day will doubtless come when he who shall unfold, in all their full simplicity, the laws which regulate the organic world, will be held, as Newton is now, in grateful remembrance for the service he has done not only to science, but also to religion.

Aptly, indeed, has the origin of species been described as the mystery of mysteries; for, as long as a phenomenon is accounted for by creative fiats, it is enshrouded in a mystery which the human mind is powerless to penetrate. Mr. Darwin has endeavoured to bring this subject within the cognisance of

man's investigations, by supposing that every species has been produced by ordinary generation from the species which previously existed. Such a supposition is the only alternative for those who reject the doctrine of creative fiats.

We shall now proceed to expound the agency by which Mr. Darwin conceives that this development of new species from previous ones has taken place. We think our exposition will indicate the great difference between the speculations of Mr. Darwin and those of other theorists upon the transmutation of species, such as Lamarck and the author of the "Vestiges of Creation." But it may perhaps conduce to clearness to remark beforehand upon a very unfair and very erroneous test which has been applied to Mr. Darwin's work. Every hostile criticism repudiates the theory, because, as it is asserted, it is not based upon a rigorous induction. There is much philosophic cant about this rigorous induction. An individual who is supremely ignorant of science finds no difficulty in uttering some such salvo as, "This is not the true Baconian method." Such expressions, which too frequently are mere meaningless phrases, were repeated *ad nauseam* at the British Association. They are revived in an article on Mr. Darwin in the *Quarterly Review*. There we find it reiterated, "This is not a true Baconian induction." In reply to all this, it should at once be distinctly stated that Mr. Darwin does not pretend that his work contains a proved theory, but merely an extremely probable hypothesis. The history of science abundantly illustrates that through such a stage of hypothesis all those theories have passed which are now considered most securely to rest on strict inductive principle. Dr. Whewell has remarked, "that a tentative process has been the first step towards the establishment of scientific truths." Some association perchance, as the falling apple, first aroused in Newton's mind a suspicion of the existence of universal gravitation. He then had no proof of the particular law of this gravitating force; he made several

guesses. The inverse square was the only one which caused calculation to agree with observation; the inverse square was therefore assumed to be the true law. The most complicated calculations were based upon this assumption; they have been carefully corroborated by observation, and in this manner the law of gravitation has been proved true beyond all dispute. Those who attack the philosophic method of Mr. Darwin ought explicitly to state how they would proceed to establish a theory on the origin of species by what they term a rigorous induction. Is such an example to be found in the doctrine of creative fiat? The greatest of logicians has remarked,¹ "The mode of investigation which, from the proved inapplicability of direct methods of observation and experiment, remains to us as the main source of the knowledge we possess, or can acquire, respecting the conditions and laws of recurrence of the more complex phenomena, is called in its most general expression the deductive method, and consists of three operations—the first, one of direct induction; the second, of ratiocination; and the third, of verification." The method here indicated Mr. Darwin has most rigorously observed. A life devoted to the most careful scientific observations and experiments, and to the accumulation of a most comprehensive knowledge of the details of natural history, has suggested to Mr. Darwin's mind a certain hypothesis with regard to the origin of species. The results which have been deduced from this hypothesis he has endeavoured to verify by a comparison with observed phenomena. Mr. Darwin has been himself most careful to point out that this verification is not yet complete. Until it becomes so, Mr. Darwin's theory must be ranked as an hypothesis. The eminently high authorities who have already welcomed Mr. Darwin's theory as a probable hypothesis, should induce the general public to welcome it as a legitimate step towards a great scientific discovery; and those who cannot take any

special part in the controversy will render science a great service if they resent bigoted prejudice, and earnestly seek to give both parties in the dispute a fair hearing.

It has been previously remarked that every species is composed of individuals, which are grouped into varieties, these varieties being distinguished from each other by a varying amount of difference. For instance, all the breeds of dogs are varieties of the same species. The characteristic points of these breeds strike the most casual observer. There is the utmost diversity in size; the heads vary in form, the coats in colour and texture, the legs in length; and animals varying in these respects inherit also different constitutions and different capabilities. But all these breeds are considered to belong to the same species, because each variety of dog is perfectly fertile with every other. Now that it is found that a fertile cross can be with facility obtained between the wolf and the dog, these animals are classed in the same species. A less difference may very reasonably be thought to exist between the horse and the ass than between the poodle and the mastiff; but the mule, which is the offspring of the horse and the ass, is sterile, and therefore these animals are regarded as distinct species. The various breeds of dogs have been produced by a method with which, as applied to the varieties of other species, every agriculturist and gardener is perfectly familiar. Mr. Darwin supposes that a similar method is at work throughout the whole range of animated nature. He has himself for years made most careful experiments upon the breeding of pigeons, and the art may be thus explained:—Suppose a breeder is anxious to produce pigeons with some particular characteristic, for instance, a short beak. It is a law which is always in operation, but which, at the same time, cannot be explained, that the offspring of the same parents possess some individual differences. The most casual observer must have remarked the many points of difference which the same litter of pups presents. Similarly, when a number of

¹ Mill's Logic, vol. i. book iii. chap. xi. p. 491.

pigeons, the offspring of the same parents, are minutely examined, it will be invariably found that there are already existing some slight points of diversity in the particular organ which it is sought still further to modify. If the object, therefore, is to produce short beaks, those young pigeons must be selected which have the shortest beaks. Another universal but still inexplicable law can be enunciated, that individual peculiarities are inheritable, and thus the young pigeons, which are bred from those which have been previously selected for their short beaks, will, on the average, possess shorter beaks than those which have been bred from unselected parents. A second selection is now made. The shortest-beaked birds are again reserved; and thus at last, by continuing the process, these small differences will be constantly accumulated, until at length the shortened beak becomes a decided characteristic, and a new breed or variety will have been thus established. In this manner all our breeds of domestic animals and all our varieties of plants and flowers might have been produced. Thus a gardener may have raised a plot of seedling geraniums from seed all taken from the same plant. The flowers and leaves of these seedling geraniums will in all probability present some points of difference in colour and size. It may be the gardener's object to produce a flower of some particular colour. Amongst his seedlings he selects those which approach most nearly to this colour. Very possibly out of many hundreds he may find very few which offer a sufficient approximation. Let us suppose that he has selected two. As plants are more prolific when not fertilized with their own pollen, he fertilizes one of these geraniums with the pollen of the other. Amongst the geraniums which are raised from this seed, only a few will probably possess any tendency towards the colour which it is sought to produce. Those which exhibit the strongest tendency towards this colour are again preserved; the process is again repeated, until at length the skill of the gardener is rewarded, the new colour is obtained, and a new

variety of geranium is the result. Then there will be no difficulty in perpetuating this variety by means of cuttings, which always produce plants true to the one from which they have been taken. And thus the horticulturists and the breeders of animals avail themselves of two universal laws of nature, which are—

1st. The constant tendency towards individual variations.

2dly. The constant tendency to inherit individual peculiarities.

These resources are supplied to man in the original constitution of organic life, and enable varieties to be produced when the selection is directed by man's intelligence. In nature, a selection cannot be thus directed. Is there, therefore, in nature any such selection regulated by fixed laws? Mr. Darwin maintains that this power of selection is supplied by the struggle for life; and the main fundamental object of his theory is, to show that this struggle for existence is ever at work, constantly tending to produce and to perpetuate, by definite laws, varieties of organisms no less distinct and decided than those which man creates amongst domesticated animals and cultivated plants.

There are those who dispute whether the struggle for existence is capable of effecting all that Mr. Darwin attributes to it; but the reality of this struggle for existence throughout the whole of nature is a demonstrated truth. Mr. Darwin remarks: "This struggle for existence inevitably follows from the high geometrical ratio of the increase of all organic beings throughout the world." This is the doctrine of Malthus applied to the whole animal and vegetable kingdoms. The mention of Mr. Malthus will, we fear, not induce conviction; for our leading public journal, no doubt very accurately, re-echoed the popular ignorance and prejudice with regard to Mr. Malthus, when he was lately described as that "morose, hard-hearted old man, whose theories now are entirely exploded." But the intensity of the struggle for existence, necessitated by the laws of propagation which regulate the increase of animals

and plants, can be abundantly illustrated by a few facts. "There is no exception to the rule, that every organic being naturally increases at so high a rate, that, if not destroyed, the earth would soon be covered by the progeny of a single pair. Even races of slow-breeding men have been doubled in twenty-five years; and at this rate, in a few thousand years, there would be literally not standing-room for his progeny. Linnæus has calculated that, if an annual plant produced only two seeds—and there is no plant so unproductive as this—and their seedlings next year produced two, and so on, then in twenty years there would be a million plants. The elephant is reckoned the slowest breeder of all known animals, and I have taken some pains to estimate its probable minimum rate of natural increase. It will be under the mark to assume that it breeds when thirty years old, and goes on breeding until ninety years old, bringing forth three pairs of young in this interval. If this be so, at the end of the fifth century there would be alive fifteen million elephants descended from the first pair."

Therefore, as long as the earth is peopled with a multitudinous variety of living creatures, and as long as its surface is adorned with a highly-variegated vegetation, an exterminating war throughout the whole of nature must ceaselessly be waged. Who are the victims in this conflict? Shall we say that everything is determined by inexplicable chance, and that we have no further insight into the laws which regulate those who are slain than we have in a battle waged by the passions of man? The conflict is so severe, and so equally balanced, that the slightest advantage in structure will tell unerringly in the result. Mr. Darwin supposes that, in consequence of the universal tendency towards individual variations—a law upon which we have already remarked—relative advantages and disadvantages will always exist. An animal may require a particular weapon against its most powerful foe. There will be individual variations

in this weapon; and those who possess it in its most effective state will prevail against the dangers with which they are surrounded, and will be preserved when their less fortunate companions are sacrificed. The laws of nature, in fact, select a portion to live, because a particular individual variation is possessed. Man, we have seen, is enabled to make a similar selection; but his choice is not unfrequently directed by caprice. Nature's choice is, however, regulated by undeviating laws, which never cease to act, but which depend on complicated conditions beyond our powers to analyze. And, when this force of selection existing throughout nature is distinctly perceived, there can be no difficulty in understanding that an analogous process to that which is adopted by man in the breeding of animals and in horticulture, can secure the perpetuation in nature of varieties of animals and plants. Thus the struggle for life selects a certain number of individuals out of every species to live, because they possess some individual variation. In deference to that second universal law of organic life which has been enunciated, the offspring of those which are thus selected will show a tendency to inherit those modifications of structure which have previously determined the selection. Those who inherit these modifications of structure with the greatest intensity will be again selected in the struggle for existence; the process will be continuously repeated; and, as long as this struggle for life is carried on under the same surrounding physical conditions, the conflict will require similar weapons of defence and offence, and the modifications will constantly accumulate in the same direction. Few can deny the reality of this struggle for existence, and few can dispute the method of its action and the tendency of its results. The main ground of controversy is, Will this constant accumulation of inherited variations ever constitute a specific difference? The most hostile critics of Mr. Darwin acknowledge the value of his theory so far as it accounts for the origin of varieties, but maintain that he

has failed to prove that the accumulated inheritance of these small variations, singled out by a process of natural selection, will ever constitute a specific difference, or, in other words, would produce in any organism a variation so great as to cause it to be infertile with the stock from which it originated. As we have before remarked, Mr. Darwin's theory cannot pretend to be completely proved; we are therefore bound not to apply to it those tests supplied by logic to which every proof ought to be submitted. It is a question of probability; and, as long as it remains so, everything which can be either said in support or contradiction ought to be fairly stated and maturely weighed. We will therefore endeavour to give a correct statement of the leading arguments on both sides.

Many common animals are sculptured upon ancient Egyptian tombs; many have also been preserved as mummies; and, when it is found that, during the three thousand years which have elapsed, the ibis, for instance, has remained unchanged, it is maintained that the process of development supposed by Mr. Darwin's theory cannot have occurred.

An individual would excite a smile of ridicule who, having discovered that Mont Blanc three thousand years ago was of the same altitude as it is at the present time, should consider that he had refuted those theories of modern geology which suppose that the stupendous peaks of Switzerland were lifted from off their ocean bed, and that every physical change in this earth's appearance has been produced by the indefinitely prolonged operation of the same physical causes which on every side around us continue in ceaseless activity. The extinction of species and the introduction of new ones are associated with periods which can only be described as geological epochs; and the time which has elapsed since the occurrence of the most remote recorded historical event is but an instant compared with the period which is indicated by the deposition of one of the strata which tell the history of this planet's structure.

The three thousand years which have elapsed since the animals were sculptured upon the Egyptian tombs have not sufficed to produce any change in the physical geography of the valley of the Nile. We have no reason to suppose but that the soil was then of the same fertility as it is now, the temperature of the same warmth, the air of the same moisture, and that the mighty river itself rolled down the same volume of water and sedimentary matter to the sea. The struggle for existence was carried on then under precisely the same conditions as it is now; particular animals and plants possessed then as now the same relative advantages and disadvantages in their structure; and the causes which determine success in this struggle for life have remained absolutely unaltered. But let us look forward to the geological epoch. Egypt may not be then what she is now; the land may be upheaved; the Nile may have changed its course; and many animals and plants which flourish there now will be unsuited to these changed physical circumstances; they will then probably not prevail in the struggle for existence, but will pass away as extinct species, and their place will be occupied by other organisms which are adapted to the changed conditions of life. The fossils in every stratum unmistakably indicate such successive revolutions in the animal and vegetable world. No one will dispute that old forms of life are thus succeeded by new ones. The question to be determined is, Must we continue to confess complete ignorance of the laws which regulate the introduction of these new forms of life? A confession of this ignorance is made whenever we resort to the doctrine of creative fiat.

Those who, like Mr. Darwin, endeavour to explain the laws which regulate the succession of life, do not seek to detract one iota from the attributes of a Supreme Intelligence. Religious veneration will not be diminished, if, after life has been once placed upon this planet by the will of the Creator, finite man is able to discover laws so simple that we can understand the agency by which all

that lives around us has been generated from those forms in which life first dawned upon this globe.

The distinctness of the groups of the fossil animals which compose the geological records supplies the most formidable argument against Mr. Darwin's theory; and, unless the difficulty thus suggested can be explained away, the main support of the theory is gone. We cordially rejoice that this theory is ultimately to be refuted or established by the principles of geology. We were therefore not a little astonished, that in the discussions upon Mr. Darwin at the British Association at Oxford geology was not even alluded to. It was sad, indeed, to think that the opponents of the theory sought to supply this omission by summoning to their aid a species of oratory which could deem it an argument to ask a professor if he should object to discover that he had been developed out of an ape. The professor aptly replied to his assailant by remarking, that man's remote descent from an ape was not so degrading to his dignity as the employment of oratorical powers to misguide the multitude by throwing ridicule upon a scientific discussion. The retort was so justly deserved, and so inimitable in its manner, that no one who was present can ever forget the impression it made. Happy are we to be able to escape from such recriminations, for there is some chance of a satisfactory solution when we can appeal to physical principles.

The argument to which allusion has just been made shall be stated in Mr. Darwin's own words; for, so singular is his impartiality, and so sincere his love of truth, that he has himself advanced, in their utmost force, all the most important arguments which can be opposed to his theory. "The number of intermediate varieties which have formerly existed on the earth must be truly enormous. Why, then, is not every geological formation, and every stratum, full of such intermediate links? Geology assuredly does not reveal any such finely graduated organic chain; and this, perhaps, is the most obvious

"and gravest objection to my theory. The explanation lies, as I believe, in the extreme imperfection of the geological record."

The mode therefore is plainly indicated by which the incorrectness of Mr. Darwin's speculations can be completely established. If the physical philosopher can demonstrate that the geological record has not this character of extreme imperfection, Mr. Darwin will doubtless be amongst the first to admit that his theory can then be no longer maintained. Mr. Hopkins¹ of Cambridge, than whom no one can be better qualified, has commenced this mode of attack; and such is the spirit with which Mr. Darwin receives a fair and generous antagonist, that we believe he was amongst the first to welcome and acknowledge the hostile criticism of Mr. Hopkins.

Mr. Darwin attributes imperfection to the geological record upon two different grounds:—

First.—An extremely incomplete examination has yet been made of any existing strata, and the animals and plants which are preserved in any strata can only form a very small portion of those which were living when the strata were deposited.

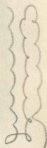
Secondly.—The strata which now exist form but a small proportion of those which have been deposited. Between the strata now remaining numerous intermediate ones have been completely removed by denudation.

The first of these propositions rests upon the following considerations:—Strata have only been examined with a scientific purpose for the last few years. The geology of many countries is as yet unknown; only those portions which now happen to be dry land are exposed to view. Certain conditions are requisite for the preservation of an animal or plant in a fossil state. For instance, when a dead body sinks to the bottom of the sea it will decay, unless there is a sufficiently rapid deposition of sediment to surround and inclose the animal before decay commences. In every case,

¹ See *Fraser* of June and July, 1860.

also, the soft tegumentary portions of an organism must perish. The late Professor Forbes has remarked, "Numbers of our fossil species are known and named from single and broken specimens, or from a few specimens collected on some one spot." These considerations are important, and would suffice to account for the non-appearance of complete series of transitional forms. But Mr. Darwin frankly admits that the explanation of the almost entire absence of transitional forms must be mainly based upon those other causes which, according to his explanation, have made the geological record so extremely imperfect. The efficiency of denudation in completely removing every trace of a stratum, impressed itself upon Mr. Darwin's mind when, in the *Beagle*, he examined the western coast of South America. This coast along many hundred miles of its length is, by subterraneous agency, gradually rising with a uniform velocity of about three feet in a century. Suppose this upheaval has been continuous, the time will then have been comparatively recent since many portions of this shore which are now dry land were undoubtedly covered with the ocean. Along this coast the rocks are being ceaselessly worn by the action of the waves, and rivers are constantly bearing to the sea sedimentary matter. It will therefore inevitably follow that upon the bed of the ocean strata are being continuously accumulated. Similar strata must have been formed upon the adjacent dry land before it was upheaved from the ocean; therefore it might be expected that here would be found a considerable accumulation of tertiary strata. Such, however, is not the case; the tertiary strata are so poorly developed, that they will be inevitably removed by rain and other atmospheric agencies before the expiration of a comparatively brief geological epoch. What, then, has become of those considerable strata which were undoubtedly accumulated upon this land when it formed the bed of the ocean? There is one way, and only one, by which we can account

for this removal of strata. As the bed of the ocean became gradually upheaved, different portions of the land, before emerging from the ocean, became subject to the action of coast-waves. Denudation consequently occurred; and the power and extent of this denudation is recorded by the fact, that of these stratified deposits the remains are too small to enable any permanent record of their former existence to be long preserved. Such considerations, Mr. Darwin maintains, may be extended to the whole world; for modern geology requires us to suppose that in every portion of this globe there have been alternate periods of depression and upheaval. There is reason to suppose that life can rarely be maintained beneath water of a certain depth. It has, for instance, been clearly demonstrated that those minute animals which build up our coral reefs require a certain amount of light, and that therefore they must work at a fixed distance beneath the surface of the ocean. Coral reefs exist on the coast of Australia many hundreds of feet in perpendicular height. The bed of the ocean, therefore, must have subsided with exactly the same rapidity as the walls of these coral reefs have risen in perpendicular height. In a similar manner, a deposit of great thickness filled with the same kind of fossil shells probably indicates that during the formation of this deposit the ocean remained of a uniform depth; or, in other words, the subsidence kept pace with the deposition of sedimentary matter. When this subsidence ceased, and an upheaval commenced, the rate of this upward movement may perhaps have been uniform with the former downward motion. The strata would then, as they approach the surface of the ocean, be subjected to a denudation by the coast-waves during a period equal to that which sufficed for their deposition. By this denudation Mr. Darwin maintains that we have every reason to suppose that a series of strata might be completely removed in a similar manner to those tertiary strata which, as we have before remarked, have been washed from off the rising coast of South



America. Against this theory of denudation, Mr. Hopkins has advanced an argument which is well worthy of serious consideration. In order that it may be stated in its full force, Mr. Hopkins's own words shall be used :—

“ We believe the entire destruction of
 “ any sedimentary bed of considerable
 “ horizontal extent to have been of rare
 “ occurrence. All the more important
 “ denudations of which we have any
 “ evidence have been preceded by large
 “ upheavals, by which the strata have
 “ been tilted; and thus, while those
 “ portions of each stratum which have
 “ been most elevated may have been ex-
 “ posed to enormous denudation, those
 “ portions which have been least elevated
 “ or perhaps depressed, have been thus
 “ kept out of the reach of the denuding
 “ agencies. The entire obliteration of a
 “ stratum would require in general that
 “ it should be upheaved in such a man-
 “ ner as never to deviate sensibly from
 “ a horizontal position. In fact, this
 “ approximation to horizontality must
 “ be closer than it frequently may be
 “ during the time of deposition, for the
 “ smallest dip in an extensive stratum
 “ would place it in a condition as to
 “ denudation similar to that above
 “ described as due to large upheavals.
 “ The higher portions might be denuded,
 “ while the lower remain untouched.
 “ The Weald affords one of the best
 “ elucidations of denudation accom-
 “ panied only by the partial destruction
 “ of strata. We have no reason to
 “ suppose that a single stratum has been
 “ obliterated by this denudation, which,
 “ while it has left scarcely a remnant of
 “ the removed beds in the central por-
 “ tion of the district, has left portions
 “ of them untouched on its borders,
 “ where they dip beneath the existing
 “ surface.”

We cannot here enter more fully into this deeply interesting question. Our object has been to indicate as much of the character of the argument on both sides as would convince the reader that the solution of the problem which is here suggested involves many of the most complicated and profound princi-

ples of physical geology. And yet Mr. Darwin admits that with the solution of this question his whole theory must either stand or fall. Why, then, have his speculations in some quarters been received in so unscientific a spirit, when he maintains that they are based upon scientific principles, and boldly challenges these same principles to prove their incorrectness?

It might appear according to the geological record that whole groups of allied species have suddenly come upon the earth. This suggests another difficulty, which deserves careful consideration. Low down in the chalk, groups of teleostean fishes are found in great numbers, and it has been supposed that before them no traces are preserved of any species allied to these teleostean fishes. Yet such allied forms must undoubtedly have existed, if this new species has been introduced by a process of gradual development. The whole question, therefore, turns upon the degree of perfection which is to be attributed to the geological record. Mr. Darwin's position upon this subject has been most powerfully strengthened by a recent discovery in paleontology. Sessile cirripedes are found largely distributed over all tertiary strata, and they are of the most ubiquitous families of testacea existing at the present time. Until within a very few years not the slightest trace of a sessile cirripede had been found in any secondary strata, and the sessile cirripedes might have been quoted against Mr. Darwin with even more effect than the teleostean fishes. It was, in fact, repeatedly said, “ Here are a group of animals so easily preserved that they are fossilized in great numbers in all tertiary strata. They cannot be found in any secondary strata. Is it not therefore evident that they could not have been gradually developed, but that they were suddenly created at the commencement of the tertiary period?”

Mr. Darwin would then, as he does now, have in vain besought his opponents not to place too implicit confidence in the perfection of the geological record.

But within the last few months a skilful paleontologist, M. Bosquet, has sent Mr. Darwin a drawing of a perfect specimen of an unmistakable sessile cirripede, which he had himself extracted from the chalk of Belgium. And, as if to make the case as striking as possible, this sessile cirripede was a *Chthamalus*, a very large and ubiquitous genus, of which not one specimen has as yet been found, even in any tertiary stratum. Hence we now positively know that sessile cirripedes existed during the secondary period; and these cirripedes might have been the progenitors of our many tertiary and existing species.

Since, before this discovery, nothing appeared more improbable than that sessile cirripedes were to be found in the secondary period, ought we to regard the difficulty suggested by the teleostean fishes as insuperable? For who can say that in a similar manner advancing knowledge may not some day remove it? Already M. Pictet has carried the existence of the teleostean fishes one stage beyond the period when it has been supposed they were suddenly created. Other eminent paleontologists incline to the belief "that some much older fishes, whose affinities are as yet imperfectly known, are really teleostean."

Mr. Darwin appears desirous to maintain, as a probable inference from his theory, that every past and present organism has descended from four original forms. Such an inference is at once met by a very obvious objection; for it requires us to suppose that life existed upon this planet long previous to the deposition of those Silurian rocks which afford us the first traces of fossil remains. Mr. Darwin is consequently compelled to assert that fossil-bearing rocks of a date long anterior to the Silurian period were once deposited, but have been either removed or transformed.

Many of those who may be inclined to agree with Mr. Darwin that all organisms have descended from a few original forms will, perhaps, think that it is unfortunate to lay stress upon such

a supposition. It is not involved in the theory, nor is it a necessary inference from it; it cannot, therefore, be advisable to allow speculative difficulties to add to the obstacles against which the theory has to contend. There is a great problem to be solved, and its *enunciation* may involve nothing which can even be disputed; for it is a demonstrated truth, that those organisms of which we have the first record were succeeded by new and distinct species, and that the same process has been again and again repeated. What has been the agency to affect this succession of life? All must admit that such a problem really presents itself for solution. Why, then, attempt to make the solution likewise indicate the form in which life was first introduced upon this earth? Transmutationists and non-transmutationists must agree that life was originally introduced by an act of Creative Will, and a transmutationist need not necessarily concern himself with the number of forms which were thus first spontaneously created.

In an earlier part of this paper we have endeavoured to point out the analogy between the process of natural selection and the method which is pursued by the horticulturist and the breeder of animals. The question will very probably arise, What has the horticulturist and the breeder of animals effected towards the creation of a new species? It is important to consider this question, because it will lead to the perception of that imperfection in the common definition of species which we have already alluded to. Breeds of pigeons which have undoubtedly descended from the same original stock have been made by the pigeon-fancier, so different in their structure that, if they were found as fossils, they would be undoubtedly classed as distinct species. But they are not regarded as distinct species, because they are fertile with each other. Man has never yet made two varieties from the same stock to differ so much from each other as to possess the great characteristic of distinct species, namely, infertility. If this is ever effected, it will be the greatest ex-

perimental corroboration of Mr. Darwin's theory. Man, therefore, has already produced what may be termed a morphological species, but he has not produced a physiological species. This is a distinction which ought to be kept carefully in view; for there is not any amount of structural difference which would enable us *a priori* to predict whether two animals were infertile with each other—this being the only reliable test of physiological species. Thus the horse differs from the ass in only two particulars. The horse has a bushy tail; the ass a tufted tail. The horse has callosities on the inner side of both the fore and hind legs; the ass has callosities only on the inner side of the fore legs.¹ No trace of these characteristic differences could be found in fossil specimens of the horse and ass. If, therefore, found fossil, they could but be classed as belonging to the same species; but, when the physiological test is applied, they are at once ranked as distinct species, because the offspring of the horse and the ass are infertile. And, therefore, with reference to the classification of species, we often argue in a vicious circle. Thus, formerly, every botanist considered the cowslip and the primrose as belonging to two distinct species; but within the last few years horticulturists have unmistakably produced the cowslip from the primrose; and, therefore, it would appear that they might claim to have produced a species by the accumulation of the differences presented by varieties. Thus one species would have been generated from another species; and the great species question could be regarded as solved. But then

¹ * Further information upon this subject will be found in a most able Essay on Mr. Darwin, in the *Westminster Review* for April, 1860.

it is at once rejoined, "This has not, by an ocular demonstration of the efficiency of development, been done. Our original classification was wrong. It is true we should not have discovered its error unless you had made your experiment, because, without such an experiment, we must have continued to believe that the cowslip and the primrose were specifically distinct."

We have now exhausted all the space we can claim; we trust we have devoted it to a candid exposition of the leading points of Mr. Darwin's theory, and that we have fairly stated the most important arguments on the other side. Our object will be fully attained if we induce those who do not know the work itself to peruse it with an unprejudiced mind. It is not for us to hazard a prediction as to the ultimate fate of the theory itself. Dr. Hooker, a man of the highest scientific reputation, when closing a most remarkable discussion at the late meeting of the British Association, used emphatic words to the following effect:—"I knew of this theory fifteen years ago; I was then entirely opposed to it; I argued against it again and again; but since then I have devoted myself unremittingly to natural history; in its pursuit I have travelled round the world. Facts in this science which before were inexplicable to me became one by one explained by this theory, and conviction has been thus gradually forced upon an unwilling convert." Other minds may perhaps pass through similar stages of primary doubt and ultimate belief; but, be that as it may, if Mr. Darwin's theory were disproved to-morrow, the volume in which it has been expounded would still remain one of our most interesting, most valuable, and most accurate treatises on natural history.



No. 14.]

[One Shilling.

MACMILLAN'S MAGAZINE

EDITED BY DAVID MASSON.

DECEMBER, 1860.

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LONDON: B. CLAY, PRINTER.]



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