PALÆONTOLOGY.

ABOUT two centuries ago a great controversy raged in Italy as to whether certain stones imitative of organic shapes were produced by a peculiar fatty matter, *materia pinguis*, set into fermentation by heat, or were porous bodies (originally real bones and shells), converted into stone by the action of a "lapidifying juice;" or whether possibly they may not have been mere stones and earthy concretions—*lusi naturæ*—sports of nature, thrown off in moments of leisure as a relaxation from the heavy labour of carrying on the everyday affairs of life.

The stony representatives of animals and plants thus existing beneath the soil, in sand, gravel, limestone, and other substances, were, at the time alluded to, described in general language, with all other mineral substances, as *fossils*, or things dug up. Curious people collected them and put them into museums, with pieces of broken pottery, flints supposed to represent human features, the cast carapace of a rare crab, the extracted rattle of a rattle-snake, and similar remarkable objects, natural and artificial, while many learned individuals, despising all grovelling propensities, occupied themselves in writing exceedingly indifferent verses, or very dull prose, endeavouring to make their neighbours appear ridiculous and contemptible, for following such useless pursuits.

By degrees these imitative organic shapes were found in so many places, and in such great abundance—they simulated so exactly the remains of animals and vegetables—they presented for investigation so many remarkable varieties of structure, and seemed to indicate so clearly, that they had once belonged to real living organic beings, that the study of "*fossils*" (this term in time becoming limited in its meaning to fossil organic remains), ceased to be the pursuit of curiosity-hunters, and the source of bad rhymes to small poets, and it was admitted that the object in question must have been the remains of the former inhabitants of the world, buried during the lapse of ages in those various deposits of mineral matter of which the earth's crust is chiefly composed.

Thus arose a department of zoology and botany, which in its turn influenced the study of general natural history. For it was found, as natural history assumed the form of a science, that a certain order of arrangement or grouping, or in other words, a certain distribution of animals and vegetables could be traced over the earth, different countries, or districts having peculiar climates, and often various distant places having similar climates, and that each place served as a centre, where numerous specially adapted species lived as in a proper home, and whence they diverged gradually, in diverging becoming less abundant, or losing some of their characteristic peculiarities.

Thus, for example, Africa—an almost isolated tract of land chiefly in tropical and sub-tropical climates—abounds with elephants, rhinoceroses, hippopotamuses, and antelopes among herbivorous animals, and with lions and hyenas among the carnivora. Asia, in similar latitudes, has also its elephants, rhinoceroses, and antelopes, and lions, tigers, and other flesh-feeding tribes; but the African and Asiatic species, of all these animals, are entirely distinct. No one has ever seen the African elephant out of Africa; nor the Bengal tiger on the western side of Arabia, except when they have been removed by man for his pleasure or convenience. In tropical and South America the lion is replaced by the puma, and the tiger by the jaguar—while instead of the elephant and rhinoceros, we have only the tapir. In all these cases the climate is equally favourable in the different countries; but the species, although they range widely, do not

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Palæontology, or a Systematic Summary of Extinct Animals and their Geological Relations. By Richard Owen, F.R.S., &c. Edinburgh: A. & C. Black. 1860.

On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life. By Charles Darwin, M.A., F.R.S., &c. London: J. Murray. 1860.

willingly go out of certain bounds, within which they seem to be naturally limited.

Were it necessary to illustrate this further, we might remind the reader of the vegetation of South Africa, comparing it with what is known of the native plants in New Zealand, Australia, and South America, in the southern, or with Asia and America, in the northern hemisphere. Where the climates are similar, the vegetation becomes also similar; but the approximation, however close, never produces identical species. We can introduce the heaths and other plants of South Africa, into our part of the world, and they will sometimes live and flourish; we can adopt the potato plant, and we can grow excellent tobacco; but the heaths of the Cape, the potato and the tobacco plant of America were never seen in Europe till conveyed thither by human agency. The breed of horses ranging over boundless plains in South America, was introduced by the Spaniards, and is now wild; but no horses lived in South America when the Spaniards first visited the country. The European dog will drive out the native dog in Australia, and the whole tribe of marsupials—originally the exclusive four-footed tenants of the soil—will very probably become rare or altogether lost in the settled parts of that remarkable country, while the domesticated races, ill-adapted as they seem to be at present to battle with the peculiarities of climate, will before long adapt themselves and occupy the country.

This existence of limited districts in different parts of the world, in which groups of animals and plants, having certain things in common, would seem to have originated, and from which they have migrated, is a fact only observed and recorded within a very recent period, or at least if known, was not till lately followed to its legitimate consequences. Like all other great results of observation, it involves a principle, and in this case it is a principle of no small magnitude and importance. Running parallel with the fact just alluded to, is another which is not dissimilar, concerning the distribution of existing animals and vegetables in zones of elevation. It is found that the zone or belt nearest the sea, in a mountain district, is not only the warmest, and therefore contains forms of life belonging to its peculiar temperature, but differs from the zones above not more in climate than in the character of the types of vegetable and animal life, the higher zones resembling but not being identical in their fauna and flora, with countries at a distance, having corresponding ranges of temperature and similar rain-fall.

The principle involved in these well known, but extremely interesting facts, seems to be the following:—that the method of nature in providing animal or vegetable inhabitants for a district, involves, in some way or other, a special adaptation to all the peculiar conditions of the district, especially its climate, rain-fall, and soil; and that even when there is a resemblance amply sufficient in all these respects, there is no repetition of form, but merely a strong resemblance, which is shown occasionally in external characters, and not unfrequently in minute details of structure. This, in a few words, is the method of nature in the distribution of organic beings, in horizontal and vertical space on land.

A precisely similar method or law was enunciated some years ago by the late Professor Edward Forbes, as affecting the distribution of marine animals. He found regions of depth to correspond with zones of elevation, the inhabitants being affected by the rock bottom just as on land the development of life is affected by the soil. So clearly defined were these regions, that as many as eight were made out in the waters of the Eastern Mediterranean, distinguished from each other by the associations of the species they severally include. The language used by Professor Forbes in his report on the Ægean Invertebrata* is equally significant and explanatory in reference to sea and land, and well describes all that is yet known with certainty on this subject. "Certain species in each are found in no other, several are found in one region which do not range into the next above, whilst they extend to that below, or *vice versâ*. Certain species have their maximum of development in each zone, being most prolific in individuals

* Report of British Association Meeting for 1843, p. 155.

in that zone in which is their maximum, and of which they may be regarded as especially characteristic. Mingled with the true natives of every zone are stragglers, owing their presence to the action of the secondary influences which modify distribution. Each zone is capable of subdivision into smaller belts, distinguished for the most part by negative characters, derived from the cessation of species."

The discovery and careful examination of large groups of the shells of marine animals in various deposits of sand and limestone, led, before long, to the important conclusion, that species are distributed *in time* according to the same general method or law as that above explained as referring to horizontal and vertical space on land and at sea. This conclusion marked an important era in the history of fossils, and introduced the necessity of much minute investigation, not only of the remains themselves, but of all such natural objects —the product of living animals or plants—as could in any way be preserved in a fossil state. Hence originated that department of general natural history which has been called *Palæontology*—*παλαιός, ancient, ὄντα, beings, λόγος, a discourse*—a discourse concerning ancient beings—the investigation of all that can be known of the plants and animals of the ancient world. Laying aside all speculative or theoretical views of geologists thus much is certain. The earth, as far as we can examine it, consists of various mineral substances, an exceedingly large proportion of which can be described as sandstones, limestones, and clays, arranged in beds, strata, or layers, in pretty regular order, lying one over another, and often tilted up, so that by the mere travelling across them in a certain direction we find one after another at the surface. If we travel on them, beginning with the uppermost or last deposited, we may cross by degrees all the others, originally below, but now successively intersected at the horizontal surface, until at last we come to the lowest bed which the tilting has brought to the level of the ground we travel over. Each one of these beds we may regard as being remarkable for some group or other of organic remains (*fossils*), and such fossils afford the only means we have of learning the conditions under which that particular bed was deposited, and the representative forms of that portion of geological time.

If this supposed law of distribution of species in time were not a law of nature, we should soon discover it by finding identical species in beds of the same mineral character and at various depths without such species occurring in the intermediate deposits. In other language, and remembering what has been said of representative forms, we should expect to find identical species in beds above and below those which contain representative species. This has never yet been done, and as many thousand species have been examined and carefully described from a vast number of distinct beds, the law may be regarded as established.

But if this is so—if Palæontology is in a state to command attention as a science dealing with admitted facts and established laws, and may thus take rank as a distinct and complete department of general natural history, there result some inferences and consequences equally startling and suggestive.

Thus it would seem that by the aid of Palæontology all the gaps and deficiencies that occur in the grouping and classification of animals ought to be filled up. Palæontology and general natural history (zoology and botany) together, ought to supply every link, and either form a perfect chain or prove that there is no such thing in nature.

So, again, it might be expected that we should be enabled to determine the peculiarities of climate that prevailed on the earth during the existence of certain groups of animals and plants in any district.

While the climate of the earth and the broken links in creation thus seem likely to be made out by the pursuit of Palæontology, a knowledge of the depth and temperature of the ocean, and some idea of the nature of its bottom during the deposit of any particular stratum, may also be looked for. In a word, a real and unbroken history of nature in her operations through the organic and inorganic world would seem the only limit to this comprehensive branch of science.

Perhaps at some future day, when observations shall have multiplied and generalizations have kept pace with their increase—when the vast tracts of land now unexamined geologically shall have been ransacked for fossils, and all the accumulations of evidence have been weighed and distributed, each having been allowed its fair value in the discovery of truth, something of this kind may occur. Meanwhile it must be admitted that the evidence, perfectly to be depended on as far as it goes, is yet very limited in its range—the blanks and intervals between strata and species are far greater and more frequent than might have been hoped, while the continuity of the so-called chain is by no means proved.

It will be clear that there are two aspects in which we may regard this new science of Palæontology. On the one hand, collecting and arranging the varieties of specific character presented by the fossil and generally extinct races, we may construct, as well as circumstances admit, a series of groups of species, each corresponding to a presumed period of the earth's history, regarding each of these periods as we do a country in which characteristic species seem to have originated. Such a country is, in technical natural history language, a *specific centre*, or a point from which species have diverged. The whole earth is considered, according to this view, to be parcelled out at present into a number of districts, each of which is a *specific centre*, and each such district must be supposed to have commenced its biological history by having no species except those created expressly for it, or, in other words, all the prevailing types must have been introduced by an express act of creation.

Admirable instances of natural provinces are given in a little work recently published on the Natural History of the European Seas, originally planned and partly executed by that most philosophical of naturalists, the late Edward Forbes. Six such provinces are there described as belonging to the European seas only, and "a province," to use the words of Professor Forbes, "is an area within which there is evidence of the special manifestations of the creative power," that is to say, within which there have been called into being the originals or protoplasts of animals and plants. In the course of diffusion, and through the lapse of time, the species may become extinguished in its original centre and exist only in some one or several portions of the area over which it became diffused; and as groups of individuals of a single species may thus become isolated, they may present the fallacious aspect of two or more centres for the same species. To get at the causes of such phenomena we must trace the history of the species backwards in time, and inquire into its connexion with the history of geological change.

Provinces, also, like species, must be traced back to their history and origin in past time, and palæontological research exhibits the phenomenon of provinces in time as well as in space. Such is one of the aspects under which Palæontology may be regarded.

But this is not the only view. As the study of natural history and of species in distant countries with similar climates, or in shores immediately adjacent but separated by an impassable barrier, shows distinct groups of so-called species in these different localities, not less does the comparison of typical and common forms under such circumstances show a marvellous relation of analogy, if not of affinity. A common bond of brotherhood appears to unite the various families of one province, however distinct they may seem; but a bond of cousinship only—a mutual relationship to the same distant ancestor—is the link that unites races separated by impassable barriers. Looking back far into time we find that the same rule holds good. The resemblance is of one kind when the succession is made out in any given spot by the comparison of species in beds successively deposited; but of another kind when we examine contemporaneous groups separated by wide intervals of horizontal or vertical space.

Let us illustrate this by a few examples. No two marine faunas are more distinct—there is hardly a fish, shell, or crab in common—than those of the eastern and western shores of South and Central America; yet these great faunas are separated only by the narrow but impassable Isthmus of Panama. Further west in the eastern islands of the Pacific, separated by a wide, open ocean, is another and totally distinct fauna. All these are in the same latitude and under corresponding climates, but they are totally distinct. Similar illustrations might readily be given in abundance, but one is sufficient.

Just so it is in tracing back the history of organic beings in time. By the study of Palæontology "the law of geographical distribution as deduced from existing species is shown to have been in force during periods of time long antecedent to human history or to any evidence of human existence; and yet in relation to the whole known period of life-phenomena upon this planet, to have been a comparatively recent result of geological forces determining the present configuration and position of continents.

"Hereby Palæontology throws light upon a most interesting branch of geographical science—that, namely, which relates to former configurations of the earth's surface, and to other dispositions of land and sea than prevail at the present day.

"Finally, Palæontology has yielded the most important facts to the highest range of knowledge to which the human intellect aspires. It teaches that the globe allotted to man has revolved in its orbit through a period of time so vast that the mind in attempting to realize it is strained by an effect like that by which it strives to conceive the space dividing the solar system from the most distant nebulæ.

"Palæontology has shown that, from the inconceivably remote period of the deposition of the Cambrian rocks, the earth has been vivified by the sun's light and heat, has been fertilized by refreshing showers, and washed by tidal waves; that the ocean not only moved in orderly oscillations, regulated as now by sun and moon, but was rippled and agitated by winds and storms; that the atmosphere, besides these movements, was healthily influenced by clouds and vapours rising, condensing, and falling in ceaseless circulation. With these conditions of life Palæontology demonstrates that life has been enjoyed during the same countless thousands of years, and that with life from the beginning there has been death. The earliest testimony of the living thing, whether coral, crust, or shell, in the oldest fossiliferous rock, is, at the same time, proof that it died. At no period does it appear that the gift of life has been monopolized by contemporary individuals through a stagnant sameness of untold time; but it has been handed down from generation to generation, and successively enjoyed by the countless thousands that constitute the species. Palæontology further teaches, that not only the individual, but the species, perishes; that as death is balanced by generation, so extinction has been concomitant with the creative power, which has continued to provide a succession of species; and furthermore, that as regards the various forms of life which this planet has supported, there has been an advance and progress in the man."*

But Palæontology has not taught, and cannot teach, the law, according to which species have been successively introduced, and as the operation of the introduction of new species is veiled from our eye, except, indeed, it can be traced in the gradual departure of varieties from the type of the species, it is difficult to imagine in what way this mystery will be penetrated.

We owe to Mr. Darwin, in his work recently published "On the Origin of Species," an admirable and philosophical essay, full of careful and honest induction in reference to this subject. Without accepting all the conclusions of the author, and without entering upon those questions that have been and will continue to be disputed, there is abundance of matter in this volume which all naturalists must value, and which even for the general reader is as interesting as it is novel. Mr. Darwin, having observed the extreme variability of certain species of domesticated animals and cultivated plants, has ingeniously connected these facts with the great struggle for existence, which results from the command of nature to increase and multiply. The only check on an increase so large and so rapid that any one would speedily occupy the space provided for all, is a mutual destruction of the weakest and least vigorous individuals.

It is not difficult to follow out this train of thought. A species of animal

* "Owen's Palæontology," pp. 2, 3.

or plant abundant in any particular locality is so because circumstances are favourable for its development, and are not so favourable for others at hand that would replace it if they could. There is, however, no permanence in existing things, for no two seasons are exactly alike, cold and heat, wet and dry, shelter and exposure, all vary from year to year, while a slight change in almost any of these may, in a thousand indirect ways, affect any species. Every species, therefore, must be subject to occasional crowding out, producing starvation, if it be not to some extent capable of adapting itself to changing circumstances. If it should not be thus far capable of change, either in itself, or in some of its offspring, it can only be abundant for a short time, and will then be lost altogether. If it be changeable in any important respect, or if, of the rising generation of plants or animals of any species, some individuals are more readily altered, or are naturally more modified in a favourable direction than the rest, then there will be the commencement of a variety formed by the accidental peculiarity of some one member of a group. Owing to the well-known law of resemblance of the offspring to the parent, there will probably be some of the next succession who possess this peculiarity of the parents, whatever it may be. Out of the whole number then, those which are strongest and best able to fight their way must succeed, and the rest fail and die, being beaten in the battle. If, therefore, the peculiarity is advantageous, it will be perpetuated; if unfavourable, it will be lost.

It is, of course, a most important inquiry how far this production of a variety can go, and what it leads to. As far as man is concerned, he can only take advantage of what he sees, and his selection of peculiarities, from which a permanent variety can be secured, is confined to a few external characters. His object, also, being generally to produce modifications, which the animal in a state of nature would not be able to sustain, it cannot be regarded as rendering the employments of the method of selection by nature less probable, that known varieties, produced by domestication and cultivation, have a tendency to die out, or even to fall back towards the original type. There is, indeed, no proof that the actual original would, in such cases, be obtained; but the natural varieties of domesticated animals run wild are, as might have been expected, such as point to the peculiarities of structure adapted to freedom and not restraint, and are apt to imitate very closely the peculiarities of structure of the original wild parent.

The principle suggested by Mr. Darwin as the one adopted by nature to produce, first, permanent useful varieties; then, species; and afterwards, perhaps, wider divergencies, is then that of *selection*. This word is meant to express the method according to which, in the great battle of life and struggle for existence and supremacy, a balance is always and everywhere struck, and that never-ceasing natural variety is preserved, which is one of the most striking illustrations of the infinite power and wisdom of the Original Designer. It cannot be said that the enunciation of this law is to be regarded as a great discovery in natural history; but it seems to us that, in applying it to solve the great mystery of the gradual modification of old and the production of new species, Mr. Darwin deserves all the credit that belongs to one who has thoughtfully, and with great labour, investigated a large group of facts, and indicated their meaning. In connecting these facts he has, we think, been the first to see and proclaim the inevitable result; and he has been honest and bold enough to state, prominently and distinctly, all the difficulties and objections, without pretending to explain them away.*

* In the *Gardener's Chronicle* for 7th February, 1860, is a long communication from Mr. Patrick Matthew, of Gourlie, N.B., the author of a treatise "On Naval Timber and Architecture," in 1831, in which a claim is made by the author to have been the originator of Mr. Darwin's theory of natural selection. In a letter to the editor of this journal, Mr. Matthew has repeated the claim, and considers himself wronged by the remarks in our journal of February (*vide* p. 235). We cannot, however, perceive, either in the extracts from his work, or in his remarks, any thing more than a repetition of a fact long familiarly known, namely, that many species pass into each other by insensible gradations—a fact acknowledged by all

Whatever may be said, however, as to the theory, it is beyond all doubt a result of the incessant struggles taking place, that there is so much order and system in nature, and that every race is continued by those individuals who are best adapted to the circumstances of the day, whatever they may be. And it is in this way that we find preserved in harmony the grand scheme of creation according to which life is everywhere present, and is always tending to higher forms of development where circumstances are favourable. There is nothing in this view of the method of creation that can be regarded as derogatory to the power and dignity of the Great Creator; for, the gradual derivation of species from varieties, under the action of a law imposed on organization, is as great an exhibition of power as the occasional infraction of a law, or the constant recurrence of special acts of creation.

Following the plan of Professor Owen in his "Palæontology," already quoted, let us now rapidly glance at the succession of organic beings on the earth, so far as is made known by the remains that have been handed down for our examination.

In the language of natural history there is a large and by no means unimportant group of animals called *Protozoa*. These are simple in structure, consisting of a repetition of similar cells, often secreting carbonate of lime or silica from water, and not unfrequently superadding a horny integument. The common sponge of commerce is not a bad illustration of the kind of skeleton such animals possess; but it is only one of many forms by no means all alike. Of the sponges, those secreting limestone abound in the rocks of the secondary period, especially the oolites and chalks, while those living now are chiefly horny. As, however, the horny sponges secrete silica, and the horny parts would readily decompose, while the siliceous spicules are very minute and easily injured, this may involve a false conclusion. The sponges belong to a group called *Amorphozoa*, from their being without regular form, and are known to be much more widely distributed in a fossil state than they were at one time supposed to be. The celebrated fossil locality of Blackdown, the beds at Warminster, the Kentish rag, and the greensand of Farringdon, are all rich in these remains; and some of gigantic size are occasionally found with chalk flints in the upper members of the chalk formation.

Those remarkable shells, long known as *Foraminifera*, consisting of numerous cells coated with carbonate of lime, and communicating apparently by small orifices, are infinitely abundant in some deposits. They are also found in deep sea mud. It is impossible to exaggerate the variety of form presented by these little shells, most of which are microscopic. Large beds, covering thousands of square miles, are made up of single groups of species, and they range from the carboniferous limestone to the existing period. The limestone of which much of Paris is built, is a mass of these remains; the Pyramids of Egypt are built of them; and they are found in the West Indies. The mud of the Atlantic bottom, at a depth of two miles and upwards, over a space measuring 1,000 miles in longitude by 600 in latitude, consists of nine-tenths, by weight, of similar remains; and in the Pacific and Antarctic Oceans, an almost equal proportion of the mud seems to consist of flinty carapaces of animals, very closely allied. Dr. Hooker mentions a deposit of this latter kind 400 miles long by 120 broad, and of great and rapidly increasing thickness. Siliceous remains of the simplest form of plant-life are also exceedingly abundant, and form beds of sensible magnitude, although it requires a good microscope to be

naturalists, and to account for which, Lamarque's theory of the modification of specific characters was not the first invented. A statement that individuals and varieties were often involved in a struggle for existence, in which the strongest and the best adapted to the circumstances of the moment would prevail—a knowledge of the existence of sporting varieties in many well-known species, and the possibility of certain modifications introduced into species in consequence, do not interfere with Mr. Darwin's claim to be regarded as the first who has put forward the principle of natural selection as the method adopted by nature to insure a succession of varieties resulting in species, adapted to continue, throughout all time and in absolute perfection, the chain of created beings.

able to distinguish the smallest trace of organization, on account of their exceedingly minute proportions.

Many hundreds of species of each of these different kinds have been named; but it may be hoped that some day or other the law of their variations may be detected, and we may reduce to a small group the actual named species.

It is the universal opinion of the best microscopists that one species of these plants and animals ranges through a long series of deposits, and also through wide space in a living form. It may be assumed that the power that admits of one, may also account for the other extension.

Of the invertebrate animals of more complex structure, a very large proportion are represented in the various deposits, and, indeed, there are none possessed of any hard skeleton or covering that are not paralleled in many geological periods. There are, indeed, some so uniformly soft and decomposing with such extreme rapidity, that we cannot hope to see them preserved. Of this kind are the so-called sea-anemones, and some of the true Polyps, of the latter of which the specimens can only be made to retain their characteristic appearance for a very short time; so that we can only guess at the possible originals of the fossil species.

The *Graptolites* (among the earliest fossils known) are of this kind, and are now represented by the sea-pens. They are abundant in the oldest rocks, not only throughout the British Islands, but wherever such rocks recur.

With the Graptolites, and in all, or almost all the rocks of all ages, are found stony corals. Of these, some are large, and construct gigantic reefs, others are minute and gradually fill up pools surrounded by the more hardy individuals. There is a marked difference between the stony corals of the different periods. Upwards of a thousand extinct species have been described, and more are being added every day.

The *Bryozoa*, a class of animals intermediate in some respects between the Polyps, constructing ordinary coral, and the mollusca, who, for the most part, construct shells, are as widely distributed as either. They are compound animals, constructing singular and complicated habitations, often of extreme beauty, and generally of small size. The number of extinct species is even greater than that of the true corals.

Star fishes, sea urchins, brittle stars, encrinites, and other singularly formed animals, are referred to the class of *Radiata*. The "stone lilies," occasionally met with on our coast, formed an important group in ancient times. The *Briaræus*, a species of the genus *Pentacrinites*, named from its hundred arms thrown out to collect food, is found in the middle and west of England, and in Yorkshire, and numerous species of other generic forms abound in the carboniferous limestone, and the oolites. Star fishes, though less common, have still a wide range, and a few sea-urchins are distributed at distant intervals.

Of each of the tribes of articulated animals, worms, barnacles, trilobites, crabs and lobsters, and insects, some examples are found fossil in various rocks. The worms indeed are known chiefly by their casts, though two or three species provided with a strong coat, are to be met with. The barnacles are widely spread, adhering to drift wood in a fossil state, and very frequently to bones and shells. The individuals of one group of these (*Lepadidæ*) were apparently at a maximum in the chalk seas. Thirty-two species of this group are described from cretaceous rocks, and only five are now known in the richest locality for animals of this kind.

A remarkable group of crustacean animals (the *Entomostraca*) pervades the rocks of the older or Palæozoic period. Some of the specimens found in the Old Red sandstone are supposed to have belonged to individuals who attained a length of seven feet, and some of the others were a yard long. They bear some slight resemblance to fishes, but are more like the king crab (Limulus) of the West Indies. Trilobites are not far removed from them in proportions, but though probably allied, they offer many difficulties in classification. These animals having very prominent eyes, with large lenses made up of numerous facets, long ago attracted attention, as proving that in the most ancient seas the adaptation of the eye to light resembled precisely that now adopted, and indicate that the relation of the sun to our earth and the state of our atmosphere in regard to light, cannot have greatly changed.

Whilst the marine crustaceans and allied animals have altered considerably, the insects, necessarily almost confined to land, seem very similar, when we compare those of the coal measures and the oolites with those of the present day. Beetles, locusts, dragon flies, scorpions, spiders, have been met with, and though not identical with known species, they are all constructed after the same general plan.

Remains of the shell-bearing molluscs have always been the most common of all fossils, and afford the most characteristic marks for the identification of strata. According to Professor Owen, "the duration of types and species as a general rule is universally proportional to rank and intelligence. The most highly organized fossils have the smallest range, and mark with greatest exactitude the age of the deposit from whence they have been derived. But the evidence afforded by shells, if less precise, is more easily and constantly obtained, and holds good over larger tracts of country."—(*Owen*, *anti cit*, p. 49.)

Of the various testacea, the lamp shells (*Brachiopoda*) are in old rocks, the most abundant and characteristic, and have suffered most from time. Of 1,300 known and described species, only 75 are now living. The extinct forms are grouped into several genera, some of which are chiefly developed in the oldest or Palæozoic strata, while others quite distinct are more modern. The living shells of this group mostly inhabit deep water, and rocky situations, not very accessible to the dredge, but they do not appear limited to climate, some inhabiting the sea adjacent to our own coasts, others still more Arctic waters, others, again, the seas of the warmer parts of the Atlantic, and the rest the Antarctic Ocean, and the shores of Australia and New Zealand. Although so widely distributed, however, there are only nine living species of the group now referred to, although more than sixty species are described from a single deposit of the older secondary period. One of the Terebratulæ from the chalk so closely resembles an existing species that it cannot fairly be separated from it.

It is singular that other groups of these remarkable animals are almost equally aberrant. Both recent and extinct forms of *Rhynchonella*, which have no minute piercing of the shell for the passage of tubular spines and no calcareous skeleton of spiral form to support their arms, have been found all over the world. One of these recent species is in the Arctic seas, another in New Zealand, and a third at the Feejee Islands, while of the 250 extinct species, it would be difficult to say where they may not be looked for. Other forms again, as *Orthis*, *Calceola*, and even *Producta*, though once extremely common and highly characteristic, are now and have long been lost. *Crania* and *Lingula*, met with in the oldest fossiliferous rocks, may be said to have remained almost unchanged in strata of every period, the most ancient fossil shells offering absolutely no important peculiarities, to distinguish them from their recent representatives.

Of the bivalve shells, nearly six thousand extinct species are named and described; in addition to about half that number of recent species. These forms of existence, however, would seem to have been gradually increasing in relative importance, as the whole number of described species in all the silurian rocks is less than 100, while the chalk alone contains 500, and one part (the middle) of the tertiary series, 800. Of the genera again, some have become extinct, some have passed their maximum, and some are altogether modern, but certain amongst them are universal. Thus the oysters, left-handed animals—resting always on the left valve, the scallops (*Pecten*) resting on the right valve, and some curious modifications of both groups are infinitely common, both in a fossil and recent state, and the same may be said of the mussels and the large group of ark-shells which range through rocks of all ages. The fresh-water mussels (*Unionidæ*) are widely distributed in fresh-water formations, and can hardly be separated from existing genera.

A curious group of animals inhabiting very thick and massive shells, like the recent *chama*, seems to have been widely represented by numerous generic and specific forms in ancient seas, especially those of the lower chalk period (thence called "hippurite limestone.") These are among the most divergent structures, and admit of great modification of form in the same species.

The secondary rocks contain 500 species of Ammonites, some as large as the wheel of a carriage, and they range not only throughout Europe, but in many parts of Asia, Africa, and the two Americas.

Besides those provided with defensive armour, the naked and soft cuttle fish, poulpes, or calamaries seem to have been present in incredible abundance. Complete specimens have been found not rarely in some of the clays, while the curious pen, the ink-bag, the horny claws, the mandibles, the mantle, and in fact the complete mummy of the animal have been preserved and are occasionally found. Among the most common remains of these animals is the stony *Belemnite*, a well known cylindrical fossil, having one extremity pointed and slightly conical, and terminating upwards in an open funnel-shaped cavity. The whole of this fossil represents the white *cuttle-bone*, often picked up on our shores, which served as a skeleton for the attachment of the muscles of the cuttle fish.

Such, in a few words, are the fossils of the invertebrate classes as at present known. Those of the vertebrata we must postpone to a second article, concluding this brief outline concerning the animals of lower and less complex organization, with a significant remark by Professor Owen, that "*every type of invertebrated animal is represented in the stratified deposits called Cambrian and Lower Silurian*"*—in other words, in the oldest of all those rocks in which organic remains have hitherto been found.

It is not to be denied that this fact of the almost universal distribution of invertebrate types throughout the oldest rocks, and the absence of any fossils in the large group of little altered sedimentary deposits occasionally found beneath them, offers grave objections to the view advocated by Mr. Darwin in his "Origin of Species." He remarks—

"If my theory be true, it is indisputable that before the lowest Silurian stratum was deposited, long periods elapsed—as long as, or probably far longer than the whole period from the Silurian age to the present day; and that during these vast, yet quite unknown periods of time, the world swarmed with living creatures.

"To the question why we do not find records of these vast primordial periods I can give no satisfactory answer. . . The difficulty of understanding the absence of vast piles of fossiliferous strata which in my theory no doubt were somewhere accumulated before the Silurian epoch, is very great. If these most ancient beds had been wholly worn away by denudation, or obliterated by metamorphic action, we ought to find only small remnants of the formations next succeeding them in age, and these ought to be very generally in a metamorphosed condition. But the descriptions we now possess of the Silurian deposits over immense territories in Russia and in North America, do not support the view that the older a formation is, the more it has suffered the extremity of denudation and metamorphosis."

Mr. Darwin states his belief that, after all, the imperfection of the geologic record is the real cause of the existence of this apparently grave objection; he regards this record "as a history of the world imperfectly kept and written in a changing dialect; and of this history we possess the last volume only, relating to two or three countries. Of this volume but here and there a short chapter has been preserved; and of each page, only here and there a few lines. Each word of the slowly changing language in which the history is supposed to be written, being more or less different in the interrupted succession of chapters, may represent the apparently abruptly changed forms of life entombed in our consecutive but widely separated formations."

Truly this is a modest, if painfully unsatisfactory, illustration of the state of geological knowledge in the department of Palæontology; but we feel inclined to suggest that the well known remark of Newton, who considered his own magnificent discoveries like those of a child selecting the smoothest and prettiest pebbles on the shore of the ocean of truth, seems to promise as little, in comparison to what he satisfactorily made out concerning the laws of nature. We believe also that a fair and honest study of the language in the great stone-book will be rewarded in due time by the development of the real law of progress, whatever that law may be.

D. T. A.

* Owen's Palæontology, p. 20.

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