

rally into three subdivisions, which may be generally indicated as Guiana, Brazil, and the Eastern Andes, each of which is characterized by a great number of peculiar generic types. These three areas are considered by Professor Newton (in his article BIRDS in this work) to be sub-regions, each equivalent to the whole of south temperate America, and to the tropical part of North America, which may be termed the Mexican sub-region. But each of these latter may be also divided. South temperate America consists of a western and an eastern division, each with many distinct groups, while the southern parts of Central America differ greatly from the northern; and all these subdivisions may be considered as provinces of their respective sub-regions. It seems better, therefore, for the purposes of such a general sketch as the present, to consider the tropical parts of South America, as above limited, to be one great sub-region, characterized by possessing a large proportion of the animal forms of the whole region. It will therefore only be necessary to indicate in what way the other sub-regions differ from this.

The Chilean sub-region, or temperate South America as above defined, is well characterized by its exclusive possession of the family of the *Chinchillidae* (comprising three genera) and the genus *Auchenia* (the llamas and alpacas), the only representatives of the *Camelidae* in the New World. It also has a peculiar form of bear, several peculiar genera of rodents, and two peculiar forms of armadillos. Among birds it has the curious plant-cutters (*Phyllostomidae*), a peculiar family of waders (*Thinocoridae*), about 26 peculiar genera of passerine birds—1 of parrots, 2 of pigeons, and 2 of tinamous. It also possesses the American ostriches (*Rhea*), and 3 peculiar genera of plovers. The reptiles are usually of tropical genera, but a few are peculiar. Many of the fresh-water fishes are of peculiar genera, but there are some Australian forms, and even one species (*Galeus allenudus*) is common to New Zealand, Tasmania, and Patagonia.

Among insects alone we meet with indications of a decided affinity for forms of the north temperate zone. There are several butterflies allied to *Erebia*, an Arctic genus, and others belonging to the northern genera *Hipparchia*, *Argynnis*, and *Colias*. The mass of the butterflies, however, are purely Neotropical. Of the beetles some are Australian, but the majority are allied to Neotropical forms; yet among the *Carabidae*, or carnivorous ground-beetles, there are many truly northern genera, such as *Carabus*, *Anchomenus*, *Trechus*, &c., whose presence supports the theory of a migration along the Andes from the northern hemisphere. (See Wallace's *Geographical Distribution of Animals*, vol. ii. pp. 44-48.)

In tropical North America, or the Mexican sub-region, we find far less peculiarity. The southern portion from Panama to Nicaragua can hardly be separated zoologically from the adjacent parts of South America, while further north the chief difference consists in the absence of many typical Neotropical groups, and the appearance of a few which more especially characterize the Nearctic region. A peculiar form of tapir (*Elasmognathus*) inhabits Central America, with one or two peculiar genera of rodents; while such northern forms as *Sorex*, *Vulpes*, *Lepus*, and *Pteromys* range as far south as Guatemala. Birds are more especially characteristic, since the sub-region possesses no less than 37 peculiar genera of land birds; but many Neotropical groups are absent. The most important of these deficiencies are the *Pteroptochidae*, and the sub-families *Furnariinae*, *Conopaginae*, and *Rupicolinae*, as well as most of the peculiar groups of waders. In place of these are found tits (*Paridae*), creepers (*Certhiidae*), waxwings (*Amphispidae*), and turkeys (*Phasianidae*) from the north. The fresh-water fishes as well as the insects are almost wholly Neotropical in character, but exhibit a considerable amount of speciality.

There remains the West Indian Islands or the Antillean sub-region, which in the amount of isolation and speciality it exhibits is better marked than any other part of the region. The Mammalia are few but very interesting, as is usually the case in islands separated from continents by very deep sea. There are no monkeys, Carnivora, Ungulates, or Edentata, the only orders represented being the Insectivora and the Rodentia. The former, which is unknown in South America, is here represented by a peculiar genus, *Solenodon*, belonging to a family, *Contelidae*, only found elsewhere in Madagascar. The Rodents consist of two very peculiar genera—*Cappromys* and *Plagiodontia* belonging to a family which is especially South American, with a peculiar mouse, and an agouti (*Dasyprocta*) in the lesser Antilles. The birds are far more abundant, about 200 resident species being known, besides a large number of migrants from the United States. These belong to 95 genera, of which about one-third are peculiar. The only entirely peculiar family group is that of the todies (*Todidae*), small and elegant birds whose nearest allies are the South American motmots and jacamars.

The reptiles are not very well known, but they seem tolerably numerous, and mostly allied to South American groups; and the same remark applies to the fresh-water fishes. Insects are not very abundant, and beetles seem especially scarce considering the luxuriant vegetation of most of the islands. In land-shells, however, the very reverse is the case, the Antilles being more productive than

any other part of the world. The number of species of West Indian land-shells is equal to that of the entire continent of America, while the number of genera is greater. No less than 11 of the genera are peculiar, a very unusual degree of speciality considering the extensive range of most of the genera of land-mollusca.

VI. *The Nearctic Region.*—This comprises all temperate North America; and its peculiar fauna is best represented in the United States, and especially in that portion extending from the Mississippi valley to the Atlantic. It is allied both to the Neotropical and the Palearctic regions, but it also possesses a considerable number of peculiar or characteristic forms. Among Mammalia it possesses 3 peculiar genera of moles, 2 of weasels, 2 of hollow-horned ruminants—*Antilocapra* (the prong-buck) and *Aplocerus* (the mountain goat or antelope)—and a number of Rodents, among which the most peculiar are the *Sacomys* or pouched rats. Of those groups which are more peculiarly Neotropical it has skunks (*Mephitis*), racoons (*Procyon*), and opossums (*Didelphys*). The number of Palearctic groups is greater, the more important being lynxes, wolves, martens, bears, elks, bisons, sheep, flying-squirrels, and marmots.

Of birds there are between forty and fifty genera which are peculiar or highly characteristic. Most of them belong to the passerine families, the wood-warblers (*Mniotiltidae*) and the finches (*Fringillidae*) being especially rich in peculiar groups; and there are also a few among the thrushes, wrens, crows, hang-nests, woodpeckers, grouse, and some other families. Among the larger birds the turkeys (*Meleagris*), the ruffed grouse (*Cupidonia*, &c.), and the crested partridges (*Oreortyx*, &c.) are the most remarkable.

Reptiles seem to be more numerous than in the Palearctic region. About a dozen genera of snakes are peculiar or characteristic, the most remarkable being the well-known rattle-snakes (*Crotalus*). Among lizards the so-called "glass-snake" (*Ophisaurus*) is a peculiar form analogous to our slow-worm; while the horned-lizards (*Phrynosoma*) and many other genera of Iguanidae are peculiar. Fresh-water fishes are exceedingly numerous and highly peculiar, there being no less than five (or, according to recent authors, eight) peculiar families, and a large number of peculiar genera. The perches and their allies (*Percidae*, *Ichthyidae*, *Labracidae*, and *Etheostomidae*), the carps (*Cyprinidae*), the suckers (*Catostomidae*), and the catfish (*Siluridae*) are the most abundant groups.

In insects the Nearctic region is not remarkably rich or very peculiar. Its butterflies, though tolerably abundant, belong for the most part to well-known European groups with a small infusion of Neotropical forms in the Southern States. The same may be said of its Coleoptera. Land-shells are tolerably plentiful but not strikingly peculiar; the Alleghany district being the most productive, and possessing a large number of peculiar species. In fresh-water shells North America surpasses every other part of the globe, considerably over a thousand species, most of them *Unionidae* or fresh-water mussels, having been described.

Subdivisions of the Nearctic Region.—Owing to the researches of American zoologists these have been ascertained with tolerable accuracy, and may be termed respectively the Californian, the Rocky Mountain, the Alleghany, and the Canadian sub-regions.

The western or Californian sub-region comprises the narrow tract between the Sierra Nevada and the Pacific, not including Lower California, but extending northward into British Columbia to about 53° N. lat. It is characterized by a few very peculiar forms, and by a greater infusion of South American types than are found in similar latitudes on the east coast. Among Mammals *Macrotus*, a genus of vampire bats; among birds a cuckoo of the genus *Coccyz*, and 2 genera of humming-birds (*Selasphorus* and *Aithya*); and among reptiles *Lichanotus*, a snake allied to the boas, are Neotropical forms. California has also five or six peculiar genera of mammalia.—*Urotrichus*, one of the moles, and *Haplodon*, forming a distinct family of Rodents, being the most remarkable; while

Chamaea, forming a distinct family allied to the wrens, is the most interesting and peculiar bird.

The central or Rocky Mountain sub-region extends eastward from the Sierra Nevada across the Rocky Mountains to a line a little eastward of the 100th meridian, where a marked change in the climate, vegetation, and animal life is found to occur. To the north it is bounded by the great Canadian forest-zone on the upper Saskatchewan, while southwards it extends into Texas and Lower California and along the line of highlands to beyond the city of Mexico. This sub-region is characterized by many peculiar animals, some of which are closely allied to Palearctic types—as the so-called buffalo (*Bison americanus*), the big-horned sheep (*Ovis montana*), the glutton (*Gulo arcticus*), and the pika (*Lagomys princeps*); while others are altogether distinct forms, as the prong-horn (*Antilocapra*) and the antelope or mountain goat (*Aplocerus*). Of Palearctic forms of birds it has two peculiar genera of grouse (*Centrocercus* and *Pedioetes*), and the Arctic wood-pecker and ptarmigan. More especially Nearctic are a genus of wrens (*Salpinctes*) and some peculiar genera of finches and crows. The Nearctic pouched-rats (*Sacomys*) are abundant.

The eastern or Alleghany sub-region comprises the country to the east of the last, and as far north as Wisconsin and the southern parts of Canada. It contains examples of all that is most characteristic in Nearctic zoology, and has besides a few peculiar groups. Of these the most noteworthy is the star-nosed mole (*Condylura*), and among birds the passenger-pigeon (*Ectopistes*) and a few groups of wood-warblers and finches. The reptiles are more peculiar, as there are several genera of snakes, including two of *Hemalopside* and two of rattle-snakes, which hardly extend beyond it. Among lizards the glass-snake (*Ophisaurus*) is peculiar, and no less than four genera of tortoises are almost or quite confined to the sub-region. Here, too, are found the peculiar Amphibia for which North America is so remarkable, such as the two genera of the Sirenidae (*Siren* and *Pseudobranchius*), *Menobranchius* allied to the *Proteus* of Europe, *Amphiuma*, an eel-like creature with four rudimentary feet constituting a distinct family, and three peculiar genera of salamanders (*Salamandridae*). Fishes, too, are very abundant, and several of the peculiar North American forms are confined to this sub-region; such are the pirate-perch (*Aphredoderus*), the cave-fishes (*Amblyopsidae*), the trout-perches (*Percopsidae*), several genera of sun-fishes (*Ichthyidae*), and many others.

The sub-Arctic or Canadian sub-region has very few distinctive features, but it serves at once to connect and separate the other three regions which almost merge into it. The musk-sheep (*Ovibos*) is almost the only form peculiar to it, though this is more properly Arctic. Many of the most characteristic Nearctic animals, such as *Condylura* and *Mephitis*, only just enter its southern borders, while most of the Arctic forms are more abundant here than further south. Great numbers of birds migrate here in summer from the Southern States and Mexico; while a few especially Palearctic groups (as *Budytes*, *Phylloscopus*, and *Pyrrhula*), which do not occur elsewhere in North America, have been found in Alaska. The scanty fauna of Greenland shows that it forms a part of this sub-region.

DISTRIBUTION OF THE HIGHER ANIMALS DURING THE TERTIARY PERIOD.

Before we proceed to other divisions of our subject, we shall find it useful to consider briefly the geographical relations of the Tertiary and post-Tertiary faunas to that which now exists, as we shall thereby arrive at a better comprehension of the true nature of zoological regions, and the meaning of the diverse and complex relations that exist between them.

Post-Tertiary Faunas.—Researches in alluvial clays and gravels, cave-earths, and other superficial deposits have made known to us very completely the character of the fauna which immediately preceded that now existing, and which lived at the close of the glacial period and in the era of prehistoric man. We find, as might be expected, that a considerable number of the Mammalia were identical with living species, but along with these we almost always find a number of extinct forms, some closely related to living species in the same district, while others seem to indicate migration and a change of climate, by their resemblance to species which now only live further north or south. More extraordinary is the fact, that many of these recently extinct forms were of huge size as compared to any now living, often reminding us of the bulkiest inhabitants of the tropics or of those huge animals which we

associate with an earlier condition of the earth's surface. Thus, in Europe during the post-Tertiary period, the reindeer, the glutton, and the Tartarian antelope inhabited France, along with powerful felines allied to the existing lion. At the same time elephants and rhinoceroses of several species roamed all over Europe; and at one period hippopotami ranged as far north as the Thames, while the European beaver was replaced by a much larger species. In North America about the same time we find extinct lions, horses, tapirs, and camels, with bisons and musk sheep, as well as elephants and mastodons; and along with these, three genera of gigantic sloths as large as rhinoceroses and elephants,—forming an assemblage of large Mammalia wonderfully different from that which now exists in the same country. In South America we find that there were larger monkeys than any now living, together with lions, bears, horses, tapirs, and antelopes, as well as mastodons, and a tree-porcupine as large as a peccary. Here also were armadillos as large as a rhinoceros, and huge sloths as in North America but of more varied kinds. Even in Australia very similar phenomena occur. Extinct wombats as large as tapirs, kangaroos the size of elephants, and a phalanger nearly as large as a lion have been found in cave-deposits, along with a number of other forms more nearly like those now living. But in this case all are Marsupials or Monotremes, and there is no sign of any migration from other lands, which indeed, owing to the insular nature of the country, we could hardly expect. Again, in New Zealand and Madagascar we have a similar phenomenon presented to us by the great extinct terrestrial birds—the "moas," the "dodos," and the *Epyornis*, which, from the conditions under which their remains are found, have evidently not long ceased to exist.

It appears then that in all parts of the world where we have been able to obtain the requisite information, the period which immediately preceded that in which we live was characterized by great movements or migrations of the higher animals where that was possible; and everywhere, by the extinction of a variety of huge animals belonging to almost every order of Mammalia and to several orders of birds, many of which are now totally unrepresented on the globe.

Tertiary Faunas, and their Geographical Relations with those of the six Zoological Regions.—When we go back to the late and middle Tertiary deposits, we find a series of remains of the higher animals which exhibit yet more remarkable changes of distribution. Various parts of central and southern Europe, for example, were then inhabited by animals which now form the most characteristic features of Ethiopian and Oriental zoology—such as apes and monkeys, lions and hyenas, horses, tapirs, elephants, rhinoceroses, giraffes, and various antelopes; and along with these a number of extinct ancestral forms of many of the same groups. Among birds, too, we find the eastern jungle-fowl, the edible-nest swift, and the trogon, along with African parrots and plantain-eaters. In the Miocene beds of Northern India are found such typical African groups as the hippopotamus and giraffe.

Now geology teaches us, that in the Eocene, or earliest portion of the Tertiary epoch, a continuous arm of the sea extended from the Bay of Bengal to the Atlantic Ocean, cutting off the peninsula of India and Central Africa from the Palearctic region; and it is therefore highly probable that, when this sea-bed became dry land, the various large Mammalia now so characteristic of Africa entered it for the

¹ See Mr Searles V. Wood, jun., "On the Form and Distribution of the Land Tracts during the Secondary and Tertiary Periods respectively, and on the effect upon Animal Life which great changes in Geographical Configuration have probably produced" (*Philosophical Magazine*, 1862).

first time from the north. This will explain many of the peculiarities of the Palearctic, Oriental, and Ethiopian regions, and of their several sub-regions, and especially the persistence of low types in those districts which were wholly or partially protected from the competition of more highly organized animals.

The Tertiary fauna of North America compared with that of Europe exhibits proofs of a former communication between the two northern continents both in the North Atlantic and North Pacific, but always, probably, in rather high latitudes. This is indicated both by the groups which appear to have originated in one continent and then to have passed across to the other, and also by the entire absence from America of many important groups which abounded in Europe (and *vice versa*), indicating that the communication between the two hemispheres was always imperfect and of limited duration.

The past zoological history of North and South America exhibits a somewhat analogous series of phenomena. Their productions were generally very dissimilar. North America, in closer connection with the great northern continent, made an almost equal advance in the development of the more highly-organized animals; while South America, for the most part isolated and thus prevented from receiving a constant supply of immigrants from the larger land-areas, developed a series of lowly-organized creatures, the smaller forms of which still constitute its chief zoological feature.

The knowledge we possess of Tertiary and post-Tertiary Mammalia thus gives us an important clue to the successive migrations of the various groups of animals from one region to another, and to the geographical changes which rendered such migrations possible. The general result arrived at is, that the great northern continents represent the original seat of mammalian life, and the region of its highest development; while the southern continents—Australia, South America, and Africa—have been isolated for varying periods, and, after receiving an immigration of lowly forms, have developed and preserved these to a greater or less extent, according as they were more or less completely protected from the irruption and competition of higher types. Australia, during the Secondary period, received from the northern continent a stock of Marsupials and perhaps some still lower forms, and, having been since completely isolated, has developed these groups alone into its existing fauna. South America, at a somewhat later period, obtained the ancestors of its Edentata and Rodents; and though at various times some higher forms entered it from the north, these never seem to have been sufficiently numerous to overcome its indigenous fauna. In Africa the case was different. For a long time its Mammalia were probably analogous to those of South America; but when the great irruption of higher animals took place in the latter part of the Tertiary period, most of these were destroyed, and a few only remain—such as the *Orycteropus*, the Lemurs, and the peculiar Rodents—as indications of the character of the primeval fauna. In the peninsula of India a very similar course of events occurred, and the fauna of both these countries now consists mainly of comparatively recent immigrants. (For a fuller discussion of this subject see Wallace's *Geographical Distribution of Animals*, chapters vi. to xv.)

The Birth-place and Migrations of some mammalian Families and Genera.—From the knowledge we now possess of the extinct fauna of most of the great continents, it is possible to determine approximately the original birth-place of some now widely distributed groups. The true bears, for example, date back in Europe to the older Pliocene, while in North America they occur only in post-Pliocene deposits. We may conclude, therefore, that they originated in the Old World and are comparatively recent

immigrants in America. True horses of the genus *Equus* are also of older Pliocene date in Europe and of the post-Pliocene, or perhaps newer Pliocene, in America, and are therefore also recent immigrants into the latter country. But it is a curious fact that the most perfect series of ancestral forms of horses occur in the Miocene and Eocene deposits of North America; whence it would seem probable that the earlier stages of the development of this wonderfully specialized animal were effected in America, whence they passed to the eastern hemisphere, and there attained to the full development of the equine type, again, perhaps, to be transferred to America,—to be largely developed there (for remains of eight or ten distinct species have been discovered), and finally to become wholly extinct, while continuing to exist in the Old World, whence the most perfect form has been again introduced, and seems quite capable of maintaining itself in a wild state. Tapirs, though now more abundant in America than in Asia, are an Old World group, going back to the Lower Miocene in Europe, but only appearing in America in the post-Pliocene epoch. The peccaries (*Dicotyles*), now almost wholly Neotropical, are really a North American group, and probably only entered South America in later Pliocene times. Camels, though now confined to Asia and South America, are really a North American form, having been largely developed during the Miocene period, whence the true camels appear to have passed into Asia and the llamas into South America. True deer are European from Miocene times, but only appear in America in the later Pliocene and post-Pliocene epochs. Elephants are an Old World type, abounding from the Miocene period in Europe and Asia, but only appearing in America in the later Pliocene and post-Pliocene times. It is possible, however, that the Eocene *Dinocerata* of North America may be ancestral forms of *Proboscidea*, and that, as in the case of the horses, the development of elephants may have begun in America to be subsequently perfected in the larger area of the eastern hemisphere. As a last and curious example we may refer to the marsupial opossums, now exclusively American, but which are certainly recent immigrants from Europe or Asia. No trace of them occurs in American deposits before the post-Pliocene period, while they existed in Europe both in Eocene and Miocene times.

The cases now adduced are sufficient to show how much interest attaches to the distribution of the ancestral forms of our existing animals; but we wait for fuller knowledge of the Tertiary deposits of Asia, Africa, and South America in order to complete the history of these migrations, and to gain some knowledge as to many other groups whose origin is now involved in obscurity (*Geog. Dist. of Animals*, vol. i. p. 153.)

DISTRIBUTION OF MARINE ANIMALS.

The zoological regions which serve to represent the main facts of the distribution of land animals are evidently inapplicable to those inhabiting the ocean, except in a few cases where the group is confined to shallow waters or to estuaries. It is true that, as the great continents are separated by the oceans, so the oceans are to some extent separated by the continents, but owing to the superior area of water the separation is far less complete and effective. In the southern hemisphere the Pacific, Atlantic, and Indian oceans freely communicate, and for truly oceanic animals there would seem to be hardly any obstacle against universal distribution. Yet even in this case physical conditions, especially depth and temperature, are found to be effective barriers. The fact that the deep waters even of the tropical seas are cold, renders it indeed possible for some temperate or Arctic forms to cross the equator if they can travel at great depths; but for sur-

face-dwellers the broad expanse of warm water between the tropics, with its hosts of specially adapted organisms, forms an absolute barrier. In like manner the inhabitants of the tropical shallow waters are limited, and it is only by temporary subsidences of land or elevations of the sea-bottom to near the surface, allowing of a passage east or west, that they can migrate into remote areas. We have good reason to believe, however, that subsidences have often occurred between North and South America, allowing of a free interchange of aquatic animals between the Atlantic and Pacific oceans; while in Eocene times a strait is supposed to have connected the Atlantic and Indian oceans, and more recently the Red Sea and Mediterranean have almost certainly been united. We cannot, therefore, expect to find any such strongly-marked zoological regions among aquatic as among terrestrial animals, and the facts at our command entirely confirm this view. For many groups the warm and the cold, or the northern, tropical, and southern seas, are the only well-marked divisions; while for others the North Atlantic, the North Pacific, and the Indian Ocean form additional regions of a more or less defined character. For special studies of the more highly-organized marine groups—as the Mollusca or Crustacea—a host of provinces and sub-provinces have been formed, each important sea or coast presenting some peculiar features; but as these divisions mostly depend on specific rather than generic distribution, they need hardly be noticed here.

Owing to the absence of any well-marked regions, and the general imperfection of our knowledge of the distribution of marine animals, we must follow a different plan in our sketch of this subject from that adopted for the terrestrial fauna. We propose, then, to notice successively the more important classes of marine animals, and to state briefly what general facts are established as to their distribution.

Foraminifera.—These exceedingly low organisms are important, because their shells or tests are found extensively in various geological formations, and often form a considerable part of the constituents of rocks. They are found in all seas, and the species have often an enormous range. The surface swimmers are almost universally distributed, while the bottom-livers—as the writer is informed by Mr H. B. Brady—appear to be distributed according to depth and latitude rather than to follow any circumscribed areas. This gentleman is now engaged in working out the "Challenger" collections, and already sees reason to think that there may be found some differences between Atlantic and Pacific, and also between North Atlantic and South Atlantic forms. These organisms have been found living in the surface waters and down to a depth of 2000 fathoms, but only their dead remains are brought up from the floor of the deep ocean.

Spongia.—Sponges form another extensive group, often preserved as fossils, of which our knowledge of the recent forms is rapidly increasing. There seems, however, to be little geographical limitation of groups. The freshwater *Spongillidae* are found in all regions. The horny and calcareous sponges are widely distributed, but are much more abundant in warm and tropical seas. The beautiful siliceous sponges—of which the glass-robe (*Hyalonema*) and Venus's flower-basket (*Euplectella*) are conspicuous examples—are found scattered throughout all warm seas, and have recently been found in abundance in many of the great ocean depths,—in the Atlantic at 2650 fathoms, and in the Pacific at 3000 fathoms,—so that they probably exist wherever the nature of the bottom is favourable. (Sir Wyville Thomson, *Depths of the Sea*; "Reports from the 'Challenger,'" *Proc. Roy. Soc.*, vol. xxiv.; Bowerbank's "Papers on Sponges" in *Proceedings of Zoological Society*, 1869-1874.)

Actinozoa.—The coral-bearing groups of these animals are the more important, because of the abundance of fossil forms of every geological age. By far the greater number of these are found exclusively in tropical seas. Many of the *Alcyonaria* are temperate and even Arctic, while among the *Zoantharia* the *Caryophyllidae* alone are well represented beyond the tropics. The distribution of corals is in great part determined by the physical conditions of the sea-bottom. An influx of fresh water or of mud brought down by rivers is fatal to them, and volcanic deposits seem to be almost equally prejudicial. A high temperature is also necessary for most of the groups. Coral reefs are therefore restricted to certain seas and coasts within or near the tropics. They abound in and near the West Indies, on the east coast of Africa, in the Indian Ocean, in the Malay and Pacific archipelagoes, and on the coast of Australia; while they are absent from the whole of the west coasts of South America and of Africa, from the Indian peninsula, and from much of the east coast of South America. The coral-reefs of the Bermudas, in 33° N. lat., are the farthest from the equator; in the Red Sea they reach 30° N., in the Pacific 27° N., while they nowhere extend to more than 29° S. of the equator. Besides the corals actually forming the reefs, the same localities abound in what are termed deep-sea corals, and thus the general distribution of the group is determined by similar conditions. The coral regions are therefore somewhat peculiar, and differ considerably from those which best exhibit the distribution of other marine animals. The regions adopted by Mr Dana are three,—the first comprising the Red Sea and Indian Ocean; the second, the whole of the Pacific islands and the adjacent coasts of Australia; and the third the West Indies. This last region is the most isolated in position, and it is not surprising that it should contain the largest proportion of peculiar forms. The corals of the Central Pacific are also very peculiar, as are those of the Red and Indian seas. Considering the great similarity of the molluscan fauna of the Pacific and Indian oceans, it is remarkable that the corals should be so different as Mr Dana's tables show them to be. Although some corals exist at great depths in the ocean, they diminish rapidly when we pass the moderate depth of 200 fathoms. The "Challenger" expedition obtained 27 genera at a greater depth than 250 fathoms, but only 3 of these extended below 1500 fathoms. Count Pourtales on the American coast found them at 400 fathoms; the "Porcupine" expedition first found them at a greater depth than 1000 fathoms in the North Atlantic; while in the Pacific a single species has been found at the enormous depth of 2900 fathoms. The following genera were obtained by the "Challenger" dredgings at a greater depth than 1000 fathoms:—*Caryophyllia*, *Deltocyathus*, *Ceratotrochus*, *Flabellum*, *Amphelia*, *Cryptohelia*, and *Fungia*. Some of these were of brilliant colours—pink, madder-red, white, and emerald green. A large proportion of fossil genera of corals survive in the deep seas, no less than seven genera, before only known in the fossil state, having been added by the explorations of the "Challenger"; seven of these are found at or below 1000 fathoms. It is curious, however, that the deepest by far of all corals, *Fungia*, is not known to be fossil, nor is any member of the family *Stylasteridae*, six genera of which are deep-sea corals; so that too much importance must not be attached to the fact of genera hitherto only known as fossils having been found living at great depths in the ocean. (Dana's "Zoophytes" in *U.S. Exploring Expedition*, vol. vii.; "Report on Corals Dredged by the 'Challenger,'" by H. N. Moseley, *Proc. Roy. Soc.*, vol. xxiv. p. 544.)

Polyzoa.—The coral-like Mollusca forming the extensive group of marine polyzoa, have been carefully studied,

but they are so widely distributed as to offer few special features of distribution. One or two families—as the *Selenariadae*—are almost exclusively tropical; others—as the *Catenicellidae* and *Vinculariadae*—are confined to the southern hemisphere. The *Diastoporidae* are mostly northern, while the *Celleporidae* are found in both north and south temperate seas. But the great mass of the families are either universally distributed or widely scattered over the globe. They range to high northern latitudes, having been found abundantly by the Swedish expedition on the shores of Nova Zembla in 70° N. lat. They inhabit the profound depths of the ocean, having been dredged from near 2000 fathoms in the North Atlantic, 2500 fathoms in the Pacific, and 2650 fathoms in the Southern Ocean during the voyage of the "Challenger." (Busk's *Brit. Mus. Catalogue of Marine Polyzoa*; "Challenger" Reports, *Proc. Roy. Society*, vol. xxiv. pp. 466, 468, 572, 635.)

Echinodermata.—The best-known groups—the starfishes and sea-urchins—occur abundantly as fossils, but their existing distribution does not offer many features of special interest. The *Asteroidea*, or star-fishes, are most abundant in the Indian and Pacific oceans, while the *Ophiuroidea* (brittle stars) are better represented in the European and African seas. A few genera are exclusively American, but on the whole star-fishes are far less abundant in the western than in the eastern hemisphere. Although most abundant in shallow seas, they also inhabit the floors of the deepest oceans, some having been obtained by the "Challenger" expedition from a depth of 2700 fathoms in the Pacific. They abound even in the Arctic seas, "hundreds of seastars" having been obtained by a single haul of the swab at 76° N. lat. in Novaya Zembla by the Swedish exploring ship "Proven" in 1875. The *Echinoidea* (sea-urchins) are also very abundant in Eastern seas, while they are comparatively scarce in America. Although much larger and more varied in the tropics, they are tolerably abundant in temperate and cold seas; and they probably reach the greatest depths in the ocean, since some have been obtained by the "Challenger" from a depth of nearly 3000 fathoms in the North Pacific. (*Nature*, vol. xii. p. 556; Van der Hoeven, *Handbook of Zoology*.)

Crustacea.—The distribution of the higher Crustacea has been discussed in detail by Mr James Dana in the *Zoology of the United States Exploring Expedition*; and, considering that most of the species are shore-dwellers, the facts are very interesting and often quite unexpected. We will, therefore, give an abstract of the conclusions of this writer.

The marine regions which best represent the distribution of these animals are three in number, termed by Mr Dana the Occidental, the Africo-European, and the Oriental. The first comprises both coasts of the American continent; the second, the eastern shores of the Atlantic both African and European; and the third comprehends the vast area from the east coast of Africa to the Central Pacific. Each of these is of course subdivided into climatal and local provinces, but the primary divisions alone are those which we have now to consider. The facts adduced in support of this scheme of distribution are very interesting. No less than 47 genera are exclusively American, and 15 are common to both the east and west coasts; but as 26 genera are said to be confined to the west coast, and 6 to the east, it will be seen that these two provinces are really very distinct, even if they do not form primary regions. The Africo-European region has 19 peculiar genera, and only 8 in common with the American region; so that the eastern and western shores of the Atlantic are decidedly more distinct than the eastern and western coasts of America. The extensive Oriental region is by far the richest, containing

no less than 115 peculiar genera, and only 19 in common with the Africo-European region. About 40 genera are said to be found in all three regions.

The distribution of Crustacea in relation to temperature also presents some peculiar features. The species are almost equally divided between the tropical and the extra-tropical regions. The highest form of Crustacea—the Brachyura—are most abundant in the tropics, while the less developed Amphipoda and Isopoda are more numerous in temperate and frigid zones. This may, however, in part depend on these groups having been less assiduously collected in the tropics. More interesting, and less open to doubt, is the fact that among the four chief types of Crustacea—Brachyura, Macroura, Isopoda, and Amphipoda—the most highly developed species are extra-tropical. The largest species of the Macroura are found in temperate seas, and though the largest Brachyura are tropical, yet the Maioids—the highest group of Brachyura and of all Crustaceans—reach their largest dimensions in the temperate zone. Mr Spence Bate adduces the curious fact that in the cosmopolite sub-family *Lysianassina*, the largest species are found in Arctic and Antarctic latitudes, while a species from the Straits of Magellan so closely resembles one from Spitzbergen that they may even be identical; and in the family *Caprellidae* the same species often occurs in both the northern and southern hemispheres. Mr Dana lays great stress on similar cases of wide and discontinuous distribution, which (he considers) necessitate the adoption of the theory of special creations. Thus, two species (*Kraussia rugulosa* and *Galene natalensis*) are found at the Hawaiian islands and Natal, but in no intermediate localities. Other identical species occur in the Japan seas and Natal. The same species (*Plagusia tomentosa*) occurs in South Africa, New Zealand, and Valparaiso; and another (*Cancer Edwardsii*) at New Zealand and Valparaiso. The same species and several identical genera (*Latreillia*, *Epygra*, *Sicyonia*) are found in the Mediterranean Sea and Japan, but in no intermediate districts. Closely allied species (of the genera *Amphiroidea* and *Ozius*) are found in Australia and Chili; but perhaps the most singular fact is the occurrence of closely allied or perhaps identical species of *Palamon* in New Zealand and the British Seas, and also of certain British or American genera (as *Portunus* and *Cancer*) in New Zealand. Many of these cases, and more especially the last, undoubtedly offer great difficulties on the theory of transmission and specific modification. There are, however, some considerations which afford hints for a possible solution of the difficulty. We now know many cases in which the distribution of an animal or a group of animals has been rendered discontinuous by its recent extinction in intermediate localities. The tapirs, for example, exist only in tropical America and the Malay islands, and it might well be argued that no passage from one of these localities to the other is conceivable for such an animal. But we now know that the South American tapir lived in North America down to post-Pliocene times, that in Europe there were tapirs in the later Pliocene period, while in the Pliocene or Miocene periods allied species inhabited North India and some parts of China. The present remotely isolated forms are therefore seen to be the remnants of a genus which once ranged over almost the whole northern hemisphere. Perhaps more to the point is the case of the genus *Panopæa*, adduced by Mr Woodward in his *Manual of the Mollusca*. There are only 11 living species, which occur widely scattered in the northern seas, the Cape of Good Hope, Australia, New Zealand, and Patagonia. But of this same genus nearly 150 fossil species are known, distributed over many intermediate localities, so that the existing species are seen to be but relics of an ancient form of life lingering at various points on the outskirts of the

vast area it once occupied. Such cases as these occur in all classes of animals where our knowledge of the extinct fauna is sufficiently extensive, and we are therefore justified in believing that a large proportion of the existing instances of anomalous and discontinuous distribution are to be explained in a similar way. In the case of the Crustacea we must also take into account our comparative ignorance of many parts of the globe, and especially our ignorance of the powers of dispersal of the ova, and of the young animals during their earlier larval condition. This dispersal may systematically occur to a far greater extent than we are yet aware of; though only in rare and exceptional instances may a species succeed in maintaining itself beyond the normal limits of its race. The certainty we are now acquiring of the long duration and wide-spread influence of the glacial period must also materially affect such questions as these; for although the equatorial lowlands may never have suffered from its influence, it is highly probable that during the period of greatest cold the temperature of the entire ocean may have been lowered, while in certain directions cold currents may have afforded a passage for temperate forms of marine animals from the northern to the southern hemisphere. While admitting, therefore, that the distribution of Crustacea presents to us some problems of extreme difficulty, we must deny that they are such as to justify us in resorting to a solution such as "special creation," which is negatived by the evidence afforded by almost every other class of animals.

The reports of the "Challenger" expedition already published afford valuable information on the distribution of Crustacea in the oceanic depths. The higher forms (Decapoda) have been found living at a depth of 1875 fathoms in the North Pacific, 2600 fathoms under the equator, and 2385 fathoms in the South Pacific. In the North Atlantic, at a depth of 1900 fathoms, was found a cray-fish allied to the *Astacida*, but deprived of even the rudiments of eyes, while others equally blind (from both the Atlantic and Pacific) are believed to have their nearest allies among the extinct *Eryonitides* of the Jurassic period. The higher Crustacea, which are most abundant at great depths, and which have afforded the greatest variety of new and interesting forms, belong to the Schizopoda. They have been found at depths of more than 2000 fathoms in the Pacific, and down to 2550 fathoms in the Atlantic Ocean. Some of them are blind, but a more remarkable fact is, that many of them are brightly coloured, though living in absolute and perpetual darkness. Among the Edriopthalmata (sessile-eyed Crustacea) examples of the remarkable blind family *Munopsida* have been found at a depth of 2175 fathoms in the Atlantic, and at nearly 2000 fathoms in the Southern Ocean. Other forms usually found in shallow water (*Serolis*) also occurred at great depths—more than 2000 fathoms in the Pacific; and one of these, obtained near the southern ice-barrier at a depth of over 1900 fathoms, was of "a fine blue colour with a red spot over the middle of the body." Entomostraca also occur at great depths, the most remarkable being a gigantic Ostracod found at 1600 fathoms in the Southern Ocean. At 1375 fathoms, near the Crozets, a Pycnogonoid (sea-spider) was obtained, measuring 2 feet across the legs. But besides these bottom-dwellers, the trawl nets at different depths showed that the ocean is inhabited by peculiar tribes of free-swimmers—principally Copepoda, Amphipoda, and Cypridinae, often of a bright orange colour. These occurred in all parts of the Pacific to a depth of 2000 fathoms, but they were never found in the surface nets. (*United States Exploring Expedition*, vols. xiii. and xiv.; Spence Bate on "Geographical Distribution," in Spence Bate and Westwood's *British Sessile-Eyed Crustacea*; Dr Rudolf von Willemoes-Sulm's "Report on the

Crustacea of the 'Challenger,'" *Proc. of the Royal Society*, vol. xxiv. p. 585.)

Cirrhipedia.—The barnacles are a tolerably extensive group of anomalous Crustacea, whose distribution differs somewhat from that of the more typical portion of the class. The genera are almost all widely or universally distributed, from 74° 18' N. lat. to Cape Horn, and some of the species have an equally wide range. No genus having more than a single species is confined to the torrid zones, and only two genera are limited to the southern hemisphere. Although the temperate zones have a smaller area than the torrid, they possess rather more species of Cirrhipeds, which Mr Darwin imputes to the fact of these zones being two, while the torrid is but one. As in some groups of the higher Crustacea, large species are most abundant in the temperate zones. Owing to the wide range of the genera the Cirrhipedal regions can only be determined by the distribution of species. These, according to Mr Darwin, are as follows:—1. The North Atlantic, comprising North America and Europe down to N. lat 30°; 2. The West American, from Behring Straits to Tierra-del-Fuego; 3. The Malayan, from India to New Guinea; 4. The Australian, comprising Australia and New Zealand. The Malayan and Australian regions are the richest in Cirrhipeds. During the voyage of the "Challenger" these animals were found to inhabit the deep seas, the most remarkable being a gigantic *Scalpellum* from a depth of 2850 fathoms in the North Atlantic, while other forms occurred at almost the same depth in the Pacific. (Darwin's "Monograph of Cirrhipedia," *Roy. Society*, 1854.)

Mollusca.—The marine Mollusca, from their great abundance in all seas, the ardour with which they have been collected and studied, and the frequency of their occurrence as fossils, offer an extensive field for the study of distribution. But many causes have combined to render the results yet arrived at unsatisfactory. Their classification has been for some time undergoing a progressive change, owing to the greater attention paid to the organization and development of the animals, but there is still much uncertainty as to the limits of genera and sub-genera. Owing to their being in many cases articles of commerce, either on account of their uses or their beauty, the place where they were originally obtained has often been confused with the place from which they were exported. Their numbers, too, have so rapidly increased that few persons have been found to devote themselves to the great labour of geographical tabulation. And, lastly, the genera are so often of great extent and world-wide distribution that the range of species alone has generally been attended to.

The late Dr Woodward established a series of eighteen marine provinces, founded professedly on the fact of one-half of the species being peculiar. The distribution of the genera is only casually mentioned, and it is almost certain that a large number of these provinces have no claim to rank as primary regions as regards the distribution of the Molluscan fauna. Dr Woodward himself states that his Arctic province is comparatively small and exceptional, while the three southern faunas of America, Africa, and Australia differ extremely. All the warmer provinces may, he says, be naturally grouped into three great divisions—the Atlantic, the Indo-Pacific, and the West American; and these are perhaps the only true Molluscan regions. The Indo-Pacific extends from the Red Sea and east coast of Africa to the easternmost Pacific islands, and exactly corresponds to Mr Dana's Oriental region for Crustacea. About 100 species are said to range over nearly the whole of this vast area. The Atlantic region unites the fauna of the east coast of America with that of West Africa and South Europe, but it also has considerable affinity for that

of West America, since about 60 genera are common to both. Several important genera appear to be restricted to the north temperate zone, which should perhaps form a distinct region. About 30 important genera are confined to the Indo-Pacific region; and nearly 20 are peculiarly tropical. The Atlantic coasts have few peculiar genera of importance, and the west coast of America hardly any, its difference from the Atlantic fauna on the one side and the Pacific on the other being chiefly specific. There is said to be not a single species common to the east and west coasts of tropical South America; while the corresponding coasts of North America have more than 50 species in common, and many others so closely representative as to be almost equivalent to identical species.

The shells of the Mediterranean were once supposed to be very peculiar, but recent dredgings have proved that most of them exist also in the Atlantic, and it is now doubted if any are really confined to that sea. A small number (about 70 or 80 species) are identical with Red Sea shells. The marine-shells of Australia and New Zealand are exceedingly unlike those of Britain,—exactly the reverse of what obtains among the Crustacea.

The influence of temperature on the distribution of Mollusca is very marked, the warmer regions presenting a greater variety of forms, with a greater proportion of large and finely-coloured species. Yet in some cases the largest species are extra-tropical, a striking example being found among the volutes, which abound in tropical seas, yet attain their largest size in New Zealand. In temperate and even in Arctic seas Mollusca are perhaps as abundant individually as in the tropics, but the number of species and genera is far less, and they are generally dwarfed in size, and of obscure colours.

Till a comparatively recent period very few shells had been obtained at a greater depth than 200 fathoms. These were mostly of small size and obscure colours, belonging to groups of wide range and great geological antiquity. *Dentalium*, *Cryptodon*, *Leda*, and *Arca* were the most important, and it was generally believed that the zero of Molluscan, if not of all but the very lowest forms of life, would be found at a depth of 300 or 400 fathoms. The recent development of deep-sea dredging has, however, completely changed our ideas on this subject, and the Mollusca as well as most other groups of Invertebrata are found to be capable of existing in the profoundest depths of the ocean. Off the coast of Norway Professor Sars has obtained Mollusca from a depth of 450 fathoms; and near Florida, Agassiz found them at 500 fathoms. During the cruise of the "Porcupine" Professor Wyville Thomson obtained species of *Pleurotoma* and *Dentalium* from the enormous depth of 2500 fathoms in the Bay of Biscay. During the recent voyage of the "Challenger" many other groups have been discovered in the deepest seas. In the North Atlantic, 500 miles west of Tenerife, three small living Mollusca belonging to the genera *Arca*, *Limopsis*, and *Leda* were dredged from a depth of 2740 fathoms; while in the Central Pacific, from a depth of 2425 fathoms, species of *Arca*, *Neara*, *Pleuronectia*, *Trochus*, *Fusus*, *Dentalium*, and some others have been obtained. All are small obscurely-coloured forms, resembling Arctic rather than tropical shells, due no doubt to the fact that in these profound depths the water is permanently at a temperature very little differing from that of melting ice. Equally interesting is the fact ascertained by the naturalists of the "Challenger," that the waters of the ocean down to the enormous depth of 1500 fathoms abound with true pelagic Mollusca belonging to the orders Pteropoda, Heteropoda, and Gasteropoda, while below this limit they appear to be absent (Woodward's *Manual of the Mollusca*; "Challenger" Reports," *Proc. Royal Society*, vol. xxiv.

pp. 536, 578; Letters of Sir Wyville Thomson, in *Nature*, vols. 7-10.)

Fishes.—The distribution of marine fishes appears to agree generally with that of the Mollusca and Crustacea, their greater powers of locomotion, leading to a wider dispersal, being to some extent compensated by the more recent origin of most of the species, genera, and families. There are about 80 families of marine fishes, and no less than 50 of these are almost universally distributed. Several other families range over all tropical seas. About 5 families are found only in the Arctic and temperate seas of both hemispheres, while two (*Discoboli* and *Accipenseridae*) are found in the north temperate seas only. The best marked region is undoubtedly (as in the Mollusca and Crustacea) that which extends from the Red Sea and east coast of Africa to the Sandwich Islands and Australia. About ten families are confined to this region (which may be termed the Oriental or Indo-Pacific marine region); many genera of other families equally characterize it, while there are even a number of species which range over the greater part of its vast area. On the other hand, no family of importance seems to be confined to the Atlantic, or to the coasts of Eastern or Western America, the differences of these provinces, as of the European and American shores of the Atlantic, being confined to generic and still more largely to specific forms. Many species of fish have enormous ranges, extending from the North Atlantic to Australia, from the Red Sea to the Sandwich Islands, and from New Zealand to South America. Some species range over almost the whole Atlantic Ocean, and a considerable proportion of those inhabiting the Atlantic and Pacific coasts of Central America have been found by Dr Günther to be identical.

It has long been known that a considerable number of fishes inhabit very deep water, never coming to the surface when alive; but the researches of the "Challenger" expedition have added greatly to our knowledge of these curious forms. A large number of genera and species, many of them new, and belonging to ten distinct families, have been obtained in the nets and trawls from a depth of 200 to 2400 fathoms in all the great oceans. These often come up greatly inflated by the expansion of the internal gases; some were transparent, several were blind, and some had curious phosphorescent organs on the head. These deep-sea forms generally have a wide range. The greater number of the new and remarkable forms obtained during the voyage of the "Challenger" belong to the *Scopelidae*, a family known to inhabit the deep waters of all the warmer seas. The size attained by marine fishes appears to have no relation to latitude or temperature. (Günther's *British Museum Catalogue of Fishes*; Mr J. Murray's "Preliminary Report on Vertebrates collected by the 'Challenger,'" *Proc. Roy. Soc.*, vol. xxiv. p. 537.)

Marine Turtles.—These reptiles, forming the family *Cheloniidae*, are too few in number and too widely distributed to afford any indications as to oceanic regions.

Cetacea.—The whales and dolphins form the only group of truly oceanic Mammalia. They are very widely distributed, but their classification is too unsettled, and their history too imperfectly known, to throw much light on the general question of oceanic distribution. Two of the families—*Balaenidae* and *Balaenopteridae*—seem to be confined to the cold and temperate seas of both hemispheres. The *Catodontidae* (comprising the sperm whales), on the other hand, are more especially tropical and sub-tropical. The *Hyperoodontidae*, or beaked-whales, are widely distributed in northern, southern, and tropical seas; while the largest family—the *Delphinidae*—are universally distributed. The largest whales inhabit the cold northern and southern seas. (Dr J. E. Gray's *British Museum Catalogue of*

Whales and Seals; Mr Andrew Murray's *Geographical Distribution of the Mammalia*.)

General Relations of Marine with Terrestrial Zoological Regions.—The general facts of distribution of marine animals now adduced accord very well with what we know of those terrestrial changes which have led to the actual distribution of land animals. The great Indo-Pacific region—so well marked in every important group of marine animals—probably owes its individuality to the fact that Australia has been isolated during the whole of the Tertiary, and probably during much of the Mesozoic epoch, while numerous islands in the Indian and Pacific oceans have always afforded an extensive shore-line favourable to the development of aquatic forms of life. The Atlantic has probably been for long periods even more inclosed than it is now, owing to the greater southward extension of South Africa and South America; while the profound depths of its central channel have served as a barrier between the inhabitants of the shallow waters of its eastern and western shores. In like manner the great trough of deep water which separates the most eastern groups of the Pacific islands from the west coast of America has necessarily led to the establishment of distinct oceanic faunas in these regions; while this very fact—the remarkable distinctness of the Pacific and West American faunas—tells us plainly that this barrier of deep ocean is one of the ancient features of the earth's surface.

We shall find, too, that many of the details, and not a few of the anomalies, of the distribution of marine animals become intelligible from our knowledge of past geographical changes. The considerable affinity between the Crustacea, Mollusca, and fishes of the eastern and western coasts of America exactly corresponds to the fact, clearly established by a consideration of the distribution of living and extinct land animals, that these oceans have been united, at several distinct periods, by two or more channels over what is now Central America, the final union of the two continents being comparatively recent. The fact that the uniting channels were always situated within the same limited area sufficiently explains the considerable amount of generic and specific difference of two faunas ranging over coast-lines running north and south for many thousand miles on the opposite sides of great continents. The curious fact (only recently established) that so deep and extensive an inland sea as the Mediterranean contains but few peculiar marine animals, becomes quite intelligible when we consider that till middle or late Tertiary times it consisted of two inland seas or lakes. Such inland seas are always very poor in animal life; and it is therefore not surprising that the Mediterranean should now contain hardly any forms but such as it has received from the Atlantic, or from the Red Sea during a submergence of the Isthmus of Suez. The numerous allied or even identical forms in the northern and southern oceans, which are not found in the intervening warm regions, are more difficult to explain. Mr Darwin believes that such facts are due to the action of the glacial period, which at its height may have cooled certain tracts of the tropical ocean sufficiently to allow temperate forms to cross from the northern to the southern hemisphere or the reverse. Perhaps, however, the agency of icebergs may have been sufficient without any permanent cooling of the equatorial ocean; for even now these huge floating glaciers often reach to 40° N. lat. and 35° S., and, Captain Maury assures us, sometimes even reach the tropics. We may therefore well suppose that during the height of the glacial period icebergs would not only regularly reach the tropics, but, carried on by currents in definite lines, might often pass across the equatorial zone, carrying with them a girdle of cold water in which many inhabitants of the Arctic or Antarctic seas might safely

make the passage to another hemisphere. The fact that many forms of plants peculiar to cold or temperate regions are found scattered on isolated mountain summits in the tropics is, as Mr Darwin has shown, to be explained only by the influence of an extreme glacial period, and this must have produced analogous effects on the inhabitants of the ocean. (*Origin of Species*, 6th ed. p. 330.)

DISTRIBUTION OF ANIMALS IN TIME.

This subject will necessarily be treated in some detail under the articles GEOLOGY and PALEONTOLOGY. Here we shall only sketch its outlines and general principles.

The past history of living things as revealed by geology is an ever-changing panorama. At each successive stage some forms disappear, while new ones take their place. The farther we go back the more unlike is the general assemblage of animals and plants to that which now exists. If we confine our attention to any one class or order of animals, we find that it makes its first appearance at some definite epoch, and, under successively changing forms, either continues till the present time, or reaches a maximum, diminishes, and finally disappears. Thus some groups are altogether modern, others extremely ancient; some have run through all their phases in a comparatively short period, others have lived from the earliest epochs of the earth's history of which we have any record and still survive. If we could be sure that the numerous fossils yet discovered gave us anything like an adequate idea of all the varied forms of life that had ever lived upon the globe, and the order in which they had appeared, we should be in a position to decide as to the truth and value of the development hypothesis. But the more we examine the question, the more certain it becomes that the "geological record," as it is termed, is extremely imperfect, and that the whole of the extinct animals which we have discovered do not form any fair representation of the entire series that have lived upon the earth. This is the case even with the more recent deposits and those which are richest in animal remains; but as we go back into the past the record becomes more and more imperfect, till in the Secondary, and still more in the Palaeozoic formations, we only have preserved to us a few scattered fragments, equivalent perhaps to a few pages with here and there a short chapter taken at random out of a voluminous history. The causes of this necessarily imperfect record of the past have been fully discussed by Sir Charles Lyell and Mr Darwin; we need only refer here to two general causes of such imperfection. The first is, that every aqueous deposit is formed by the wearing down of previous deposits, so that the records of one age are, to a large extent, necessarily destroyed to provide the records of the next, which in its turn is destroyed in a succeeding age. The other cause of imperfection is, that extensive areas are always sinking (to allow new deposits to be formed over them), and are being subjected to subterranean heat to such an extent as to change their texture and obliterate their fossils, when they become crystalline or metamorphic rocks. The more recent deposits so acted on will rarely have had time to have become raised above the sea-level, and subsequently exposed by denudation; yet certain Eocene strata in the Alps are stated by Sir C. Lyell to be truly metamorphic (*Students' Elements of Geology*, p. 600). The older a formation is, therefore, the more frequently will it have been exposed in one area or another to this metamorphic action; and it follows that, going backward in time, we shall at last come to a period, all the formations antecedent to which will have become metamorphosed, and their fossils, if any, obliterated. We appear to have almost reached such a state of things at the base of the Palaeozoic rocks; and there is good reason to believe