

adjoin the counter septum,—either on the convex or concave side, and whether it be long or short.

We thus arrive at a more complete *definition of the primary counter septum*: it is that (1) *in relation to which the contiguous septa are arranged in a parallel direction*, and (2) *which has adjoining primary interseptal chambers, containing no secondary principal septa*.

Duerden is not correct in stating that the main septum and the counter septum lie respectively on the convex and on the concave side of the coral independently of the arrangement of the contiguous septa. This very arrangement has been regarded by palæontologists as characteristic of the primary septa, and, as will be seen from the above, it is more permanent than has hitherto been known.

XIII.—*On the Distribution of Marine Animals* *.

By Prof. M'INTOSH, M.D., LL.D., F.R.S., &c.

THE distribution of land-animals is a subject which has always been fraught with deep interest to naturalists—more especially as certain regions are characterized by the forms inhabiting them. Thus it would be anomalous to find, for instance, a marsupial in Africa, an armadillo or a sloth (*Bradypus*) in Asia, or a stag in Australia. The chief barriers, moreover, to the general distribution of such forms have been mountain-chains, deep tracts of the sea, barren regions such as the great deserts, and the vicissitudes of temperature. Yet certain aerial forms, such as the bats, are more or less cosmopolitan, and the shrews, the pigs, and the mice are almost so. In weighing the statement, however, that the distribution of certain of these forms, such as the pigs, has been extended by their swimming powers across arms of the sea, it has to be borne in mind that even marine animals do not always avail themselves of the lines of migration at their disposal.

As three fourths of the surface of the globe are composed of water—for the most part continuous throughout—a vast field exists for the distribution, under natural conditions, of its inhabitants, from mammals to Protozoa. Pelagic types may thus range from pole to pole and from the eastern shore of the Isthmus of Panama round the world to the western.

* Notes of an Introductory Lecture, 16th October, 1903.

Attempts have been made to divide this vast area into regions characterized by special features. For instance, Prof. Forchhammer, of the Chair of Mineralogy in the University of Copenhagen, in 1862 described no less than eleven regions distinguished by the mean quantity of solid matter in the water, the tropical regions containing the greatest amount.

For facility in describing the collections made by the 'Challenger,' seven regions of the ocean were made, viz. the North Atlantic, the South Atlantic, the South Indian or Kerguelen, the Australian, the Philippine or Japanese, the North Pacific, and the South Pacific. Taking the seals, sirenians, and whales as a basis, Dr. Sclater has comparatively recently (1899) made six regions, viz. North Atlantic, mid-Atlantic, Indian, North Pacific, mid-Pacific, and Antarctic. This classification is useful in emphasizing, amongst other things, the fact that even with the continuous medium, which permits migration in various directions, certain forms cling to special areas. It lacks, however, corroboration from the other divisions of marine animals, and embraces so wide a subject that further consideration of all the facts is desirable.

In passing therefore the distribution of the chief groups of marine forms under review, the first amongst the marine mammals are the sea-otters (*Enhydris*), which often swim 10 to 15 miles from land, and are confined to the area of the North Pacific. They do not appear to be spreading, but, as Beddard says, persecution by man has made them more purely oceanic.

The eared seals are chiefly confined to the south Polar ocean. Three species are found all over the North Pacific area, whilst two frequent the west coast of South America (Sclater). The walruses are Arctic, the same species probably occurring in the North Atlantic and the North Pacific, though the latter by some is considered distinct. The seals (*Phocidæ*) are most numerous in the Arctic and Antarctic seas and in certain intermediate areas. In the North Pacific three out of four seals are identical with those in the North Atlantic. The true seals of the Antarctic Ocean are all distinct from those of the Arctic seas (Sclater). Thus the seals, as a whole, do not support the theory of the bipolarity of marine forms.

The peculiar range of the living Sirenians and their structural features would seem to point to an inaptitude for migration, especially in the case of the manatees, yet the dugong and Steller's sea-cow might have passed from islet to coast-line and spread over a greater area, unless temperature or other circumstance (*e. g.* food) had proved inimical.

It might be supposed, again, that species so active and so powerful as the whales would range over the whole ocean, from the Arctic to the Antarctic seas. Yet in viewing their distribution it appears that, with the whole stretch of the ocean at their command, they, with the exception of the dolphins, frequent special areas. Thus the right- or whalebone-whales are confined to the temperate and cold regions of both hemispheres. The Arctic right-whale haunts the neighbourhood of ice, under which it frequently takes refuge. Temperature may thus have an important bearing on its distribution; but, granting this, it has also to be remembered that nowhere but in such waters could it find a pelagic fauna so rich in large *Cliones* and other Pteropods and of large Copepods intermingled with Medusæ, on which it delights to feed. Moreover, nowhere could it, one of the most timorous mammals, find such vast solitudes, where it can roam without molestation. The same causes probably affect the distribution of the southern right-whale, and it is at least known that its active pursuit led to its rarity in European waters, for it is less rigidly confined to the Antarctic seas than the northern species to the Arctic. Another species of small size (*Neobalæna*) is confined to the seas of Australia and New Zealand. Food, environment, and temperature may have an important bearing on limitation in this case.

Of the toothed whales the sperm-whales and the Ziphioids have an extensive range, being, as Beddard says, "equally at home in the calm seas of the tropics and in the stormy waters of the Antarctic ocean," as well as in the North Atlantic. The former, as a rule, is an inhabitant of the deeper waters far from land, probably because the cuttlefishes, which form a favourite article of diet, are most plentiful there, yet it also feeds on fishes, even, like the porbeagle shark, stripping the fishermen's lines, and occasionally swallowing a shark or a seal. This varied dietary is consistent with its wide range in the ocean.

In the family of the Dolphins, *Beluga* is for the most part Arctic, only rarely being seen on European shores; but it ascends rivers, *e. g.* the St. Lawrence, as Prof. Prince, the Dominion Commissioner of Fisheries, tells me, for 150 miles, apparently after salmon. The narwhal frequents the same oceanic region. The common porpoise is Northern Atlantic and Pacific; another occurs off South America and in the Pacific; whilst *Neomeris* is found in the seas of India, the Cape, and Japan. The dolphins frequent all the oceans, seas, and great rivers of the world, and they are capable of adapting

themselves to every vicissitude of climate. Nor do their layers of fat seem to present notable differences in the several regions. As they are piscivorous, their food is obtained without difficulty in every ocean and river. The killer (*Orca*) is likewise cosmopolitan, its chief food consisting of seals and porpoises. *Globicephalus melas* has also a wide range—from the northern seas to the Cape and New Zealand—and *Tursiops* is nearly as extensively distributed.

On the other hand, most of the species of *Sotalia* are fluviatile, occurring in China and with *Inia* and *Pontoporia* in the Amazons and other rivers of South America, whilst one species (a vegetable feeder) frequents the Cameroon River.

With a distribution so complex, in an element which offers no obstacle (except temperature, safe surroundings, and food) to a cosmopolitan range for every species of marine cetacean, the question as to the explanation of these diversities presents itself. Why does *Beluga* not frequent European seas, or *Berardius* of New Zealand stretch far northwards into the Pacific? Beyond the answer that each finds in its special area suitable environment and the food best fitted for it, no answer is at present available. Hereditary tendencies, peculiarities of structure, and habit are, perhaps, responsible for the pertinacity with which the anomalous dolphins, like *Platanista*, cling to fresh water, though it is true one genus (*Sotalia*) is found equally in the Amazon and the sea. Nor does the distribution of the whales throw much light on their origin. So far as facts warrant, it would appear that the toothed whales are the primary forms from which those with whalebone have been evolved, but whether from a marine or a freshwater form cannot yet be answered with certainty, though the number of oceanic species shows that the sea at least proved a congenial area. The enormous lapse of time necessary for the development of the various groups further indicates that the ocean-basins are of great antiquity, though they may not always have had the same conformation.

The distribution of certain birds (which pass most of their time at sea), such as penguins, auks, grebes, divers, and guillemots—all, with the exception of the first, possessing the power of flight,—is limited to the colder areas; yet there is no serious impediment to their ranging over a much larger field except the difficulty of a secure breeding-place and the question of temperature. Food is everywhere abundant. In all probability it is the safety and convenience of their "rookeries" which keep the penguins to the southern seas.

A few Batrachians, Mr. Boulenger tells me, live in brackish or salt water, such as *Rana limnocharis*, *Bufo halophilus*, and to a certain extent the European *Bufo viridis* and *Bufo calamita*; but as their eggs only develop in fresh water, their opportunities for oceanic distribution are limited and need not at present be further dealt with.

In addition to the semimarine Iguanids—*Amblyrhynchus*, which enters the sea (by diving) to feed on seaweeds, *Tropidurus*, and the various turtles,—marine reptiles are only found amongst the snakes, if the estuarine crocodiles and Trionychoids, which occasionally wander some miles seawards, are passed by. As Mr. Boulenger* observes, “no better instance of gradual modification from terrestrial into marine forms could be found than in the snakes living at the present day, amongst which are also to be found the only recent reptilian types that, being viviparous, never leave the water.” These are the Hydrophids or sea-snakes, the largest of which is about 12 feet long. They are, as described by the author just mentioned, found in the Indian and western South Pacific Oceans, ranging from the Persian Gulf to North Australia, one species (*Hydrus bicolor*) stretching throughout the Indian and tropical Pacific Oceans, the extreme points being the Cape of Good Hope and Guayaquil.

As snakes are most abundant in tropical and subtropical regions, it would appear that certain land-snakes in these parts had gradually adapted themselves, probably in connexion with food, to marine life—so much so that some are never known to leave the water. Yet their distribution has been limited, perhaps partly by temperature, though they probably have extended considerably from their original centre. It may be also that they are kept in check by the large predatory forms, such as Elasmobranchs and Cetaceans.

The marine fishes are, perhaps, more actively and characteristically pelagic than any other group. As already shown, the obstacles which oppose the distribution of land-animals are absent—food and temperature chiefly requiring consideration, though the abundance of the former in every sea almost removes it from such a category. Another factor, it is true, is the pelagic or demersal condition of the eggs, since the latter habit might be supposed to have the effect of making the proximity of the shores, or at least of the bottom, a necessity at certain seasons. Yet one of the best known and most widely distributed amongst pelagic fishes, the herring, has demersal eggs.

* Nat. Science, vol. i. p. 45 (1892).

Mr. Wallace thinks that temperature and the depth of the water are of primary importance in the distribution of the marine fishes, for many species are adapted for shores and shallows. Yet it is difficult to see how either acts; for example, some shore-fishes, like the five-bearded rockling, have pelagic eggs and still more actively pelagic young, so that the question is complex. It must be admitted, however, that many peculiar fishes frequent the great abysses (the temperature of which does not vary much).

Is temperature sufficient to explain the varied distribution of the vast variety of fishes? Does it make impassable barriers, for instance, between the temperate and the tropical and subtropical regions? Such can hardly be the rule in every case, since, as Mr. Boulenger has pointed out*, the grey mullet (*Mugil capito*) ranges from Scandinavia to the Cape, and is as much at home at the mouth of the Congo as off the shores of Northern Europe. Yet some, such as the cod, prefer the colder northern waters, and range from the shores of Norway to those of North America; whilst others, like *Chaetodon* and the Sphyrænidæ, choose the warmer waters of tropical and subtropical regions. The variations in temperature which a fish is capable of enduring are not, perhaps, sufficiently known, but the northern plaice survives in the warmer waters of Australia after a protracted journey of thousands of miles. Prof. Prince†, moreover, in an interesting article on "Adaptation in Fishes," mentions that Prof. Jordan found in the volcanic geyser area of the Yellowstone Park suckers and chubs in water of 85°-88° F., and young trout in a temperature about 75° F. It is long since the eggs of the flounder were heated in a test-tube at St. Andrews, and yet they survived and healthy larvæ were hatched from them.

Moreover, in roughly grouping the fishes under Dr. Sclater's six oceanic regions the families seem to be inextricably interwoven throughout, some occurring in every area or ranging from the North Atlantic to the Indian Ocean, and thence to the Pacific. A few features given by Mr. Wallace from Dr. Günther's work are noteworthy. Thus six families out of about eighty are confined to the northern seas, and amongst them are the suckers and the sturgeons. One family (one genus and one species) is restricted to New Zealand waters. Four inhabiting the depths of the ocean are only found in the Atlantic, whilst thirteen families occur only in

* Poiss Ben. Congo, p. 355.

† 'The Ottawa Naturalist,' vol. xiv. no. 11, p. 216.

the Pacific. Two families (Lycodidæ and Gadidæ) inhabit the Arctic and Antarctic seas only, though one species of the latter (Gadidæ) exists in the Indian Ocean. One extensive genus (*Diagramma*, family Pristipomatidæ) is confined to the Pacific, with the exception of a single species in the Mediterranean. One family (Notacanthi) has representatives in Greenland, the Mediterranean, and West Australia. Lastly, the single representative of the family Lophotidæ is found only in Japan and the Mediterranean. Similar results follow in considering the classification of Prof. Palacky, of Prag*. Further and more minute investigation of the several areas may reduce the number of these anomalies; but it is difficult to unravel the tangled web of the distribution of fishes.

In glancing at the families most widely distributed it is found that a considerable proportion of them have pelagic eggs, but others, such as the blennies, gobies, and pipe-fishes, have demersal eggs, and the fishes themselves are not noted for swift progression or nomad habits. From the fact that some cosmopolitan forms, such as the Clupeoids, have both pelagic and demersal eggs within the limits of the family, this condition would not seem to be the chief factor associated with their distribution. Some families have representatives on the shores of Britain, Chili, and Kamschatka, whilst others frequent the open sea in all parts of the world. Fishes, like the wrasses, which occur on the European and American shores and extend to Japan and New Zealand, increase the complexity of the problem. The facts of distribution, indeed, may be associated with the origin of the fishes from pre-existing forms, for the families could scarcely have arisen as the result of variation since the land and water had their present conformation. Again, the occurrence of isolated species or genera at points widely distant from other members of the family indicates, amongst other things, that the production of species by variation is in some cases very slow.

The comparatively recent origin of the Teleosteans has made no noteworthy limitation in the distribution of the families, in contrast with the much older group—Mollusca—some of which are found in the Lower Silurian, though the latter comprises forms less actively pelagic. Mr. Wallace thinks fishes less cosmopolitan than mollusks, a feature he attributes to the antiquity of the shell-fishes; but it may be due to other causes, such as food and temperature, which keep

* 'Die Verbreitung der Fische' (Prag, 1895).

fishes to certain areas, for their powers of progression in a continuous element are great.

The pelagic Tunicates, such as *Salpa*, *Doliolum*, *Pyrosoma*, and the Appendicularians, are practically cosmopolitan, ranging from the northern seas to the Antarctic. Thus Prof. Herdman found *Salpa runcinata fusiformis* in water at a temperature of 80° in the Gulf of Manaar, and the same species occurs in the Antarctic seas. He has noticed that some fixed forms, like *Styela plicata*, are also cosmopolitan or range from the seas of Europe to those of Australia. He has also drawn special attention to the large size and the abundance of the Tunicates in the Antarctic regions. Simple Ascidians, again, are perhaps more common in shallow than in deep water, and few extend to the abyssal zone. Compound forms appear to attain their greatest development in the south temperate zone. Botryllidæ are partial (if not confined) to the northern hemisphere. Distomidæ are found in the northern and southern hemispheres, whilst Polyclinidæ are southern (Herdman, 'Challenger').

In the present state of our knowledge it can scarcely be said that the sea can be mapped into regions by the distribution of the Ascidians, or that there is any clue to their origin from pre-existing forms by their occurrence in modern seas. Temperature has little influence on the distribution of the simple forms, for they range from nearly freezing-point upwards (Herdman), though, as pointed out in a former Introductory Lecture, they are more conspicuous on the seaweeds of the west than the east coast of Scotland.

Out of fifty-eight families of marine mollusks forty-eight are cosmopolitan, but the limitation of a whole family to an area occurs very seldom. For example, while most of the cones are tropical, Wallace points out that *Pleurotoma* is cosmopolitan. In the same way the volutes are tropical, but *Mitra* occurs in Greenland. The cowries are also characteristic of warm regions, yet one species is found in Britain and one in Greenland. Of the cuttlefishes some, like the argonaut and pearly nautilus, are characteristic of warm seas, whilst the majority are cosmopolitan, their enormous numbers in the great oceans being only occasionally in evidence by their destruction of fishes on the lines, by the occurrence of their beaks in the stomachs of numerous fishes (from the cod and *Lampris* to sharks), and by their forming the chief article of diet for the sperm-whales.

That the mollusks have had ample time to spread them-

selves over the great oceans is proved by their antiquity, many, like both groups of truly pelagic forms (the Heteropods and Pteropods), ranging back to the Silurian period.

Their complex distribution is not easily explained. Was the *Pleurotoma* of Greenland evolved from the same stock as the cones of the tropics, or did each arise from pre-existing forms in the special areas? Why are the pearl-oysters (*Aviculidæ*) tropical or subtropical, like the giant-clam (*Tridacna*)? Why should the conditions accompanying the formation of pearls in the former be limited to special regions, even though the presence of certain fishes be necessary?

The marine Insecta are comparatively few, and it will suffice to take the two genera described by Dr. Buchanan White * from the collection of the 'Challenger.' Thus five species of *Halobates* occur in the Atlantic, but only one is restricted to it. Six species are found in the Indian Ocean west of long. 100° E., whilst (chiefly) in the West Pacific eight species are met with, of which four are restricted to that region. The metropolis of the genus appears to be the Indian Ocean and West Pacific, for nine out of the eleven known species occur there, and White thinks even originated there, and that currents have carried them eastward. The other genus (*Halobatodes*) is represented only in the Indian Ocean and the China Sea. The Halobatidæ are therefore chiefly inhabitants of the warmer seas, and though they have not spread over the whole ocean, they are widely distributed.

In the class Crustacea the distribution of marine forms is remarkably wide, just as the number of some of the smaller forms like the Copepods swarm in every sea, from pole to pole. Thus a species of the Amphipod *Podocerus* extends, Mr. Stebbing informs me, from the waters of New Zealand to 77° 7' N., and another from Tahiti to the Faroës. The higher Crustacea are sensitive to temperature, as is evident from the behaviour of such forms as the shore-crab in summer and winter, and, as Mr. Stebbing observes, by the paucity of species in Arctic, Antarctic, and very deep waters. Yet, as this experienced author states, there are Amphipods and Isopods which abound most and attain their greatest size in Arctic waters. The comparison of the Copepods (*Calani* &c.) from the feeding-grounds of the right-whale with those in European waters is equally pronounced, the size of the Arctic forms being much greater. Mr. Stebbing mentions that every fresh expedition tends to show the intimate relationship

* 'Challenger,' vol. vii. pp. 77 & 78.

of the marine Crustaceans from north to south and east to west. "Land-crabs and river-crabs are chiefly confined to warm climates. Again, very few crabs occur at either end of the globe, but that does not prevent the discovery of many crabs living in deep and therefore very cold water in the intermediate zones. There is, besides, a sort of zonal facies, which an expert in each group would probably recognize. There are circumpolar Amphipods, Isopods, and Sympods (Cumacea), which one would regard with great suspicion if it was said they had been collected at the tropics. But, nevertheless, the deep-water communication accounts for the closest family connection between members of the Lithodidæ found far north and far south." (*Stebbing*.) The same author is of opinion that in some cases there may be isolation and restricted distribution, these seldom going beyond specific distinction. Yet as regards the Crustacea it is difficult to make regional areas of demarcation in the ocean. It would also be difficult to say that any family of marine crustaceans is exclusively tropical and another as exclusively Arctic, and though certain forms are found in deep water (*e.g.* the Japanese *Thaumatocheles*), yet representatives of the same family may occur in shallow water.

In dealing with the families of the marine Polychæta it is also impracticable to map out the ocean in regions to suit their distribution, for almost every family has representatives in diverse regions; and although of some it may be said that they are more prominent in tropical or subtropical waters, yet other representatives range to the poles.

As examples of families usually considered characteristic of the warmer parts of the sea are the Euphrosynidæ and Amphinomidæ, yet examples of both occur in Norway and of the former in Greenland; indeed their range is almost cosmopolitan. The Eunicidæ likewise are often conspicuous in tropical and subtropical seas, yet the abundance and size of some from the shores of Norway and from the North Atlantic show the cosmopolitan distribution of the group. With our present knowledge it can hardly be said of any family that it is, on the one hand, a purely northern or a purely southern, or, on the other hand, a purely temperate or a purely tropical one. Some Annelids range from Greenland to Japan, from Norway to the Cape and New Zealand, and many are cosmopolitan.

In considering how it has happened that the same form is found in Greenland, Europe, and Japan, some, like Sir John Murray, would suppose that such had been universally dis-

tributed in the ocean at a former period, but that physical changes had subsequently restricted the range. Others see in this condition proof of the enormous powers of dispersion at the disposal of marine organisms, and the origin, in the several areas, from a pre-existing form.

Moreover, whatever may be the conditions (and Sir J. Murray thinks the quantity of carbonate of lime secreted by marine organisms is determined by the temperature of the water and therefore chiefly chemical rather than physical) in regard to coral-reefs, northern Annelids (*e. g.* *Filigrana implexa* and other Serpulidæ) have no difficulty in forming considerable masses of calcareous tubes*. Temperature appears to have no appreciable influence on the abundance and size of these calcareous tubes in cosmopolitan species. Nor is there a distinction in regard to the calcareous secretions of the Polyzoa and Echinoderms of the extreme north from those in the tropical oceans.

The families of the Nemerteans have a range as wide as that of any previous group, and the type of structure varies little whether the form be arctic, tropical, or antarctic. Of no special region of the ocean can it be said that its Nemertean fauna is diagnostic, for with advancing knowledge (largely due to the labours of Mr. R. C. Punnett) the distribution of the types is always extending. There is no evidence, moreover, that the arctic and antarctic forms have other relationships than those which spring from a cosmopolitan distribution.

So far as can be ascertained, the families of the Echinoderms correspond with those of other groups in regard to distribution. Some range from the arctic to the antarctic seas, and, as Mr. Bather observes, from the eastern shores of America round the world to the western, the same species thus occurring on the opposite shores of the Isthmus of Panama. It has, however, to be remembered that a communication existed between the respective sides up to a recent period. Some, again, range to great depths as well as have a wide distribution.

As in other groups, some forms suggest a northern area and some a tropical, but on the whole it cannot be stated that there are special regions of the ocean characterized by special families of Echinoderms, though it is true that certain types, like the Pentacrini and Elasipoda, occur in deep water.

* Murray thinks that those forms secreting a large quantity of carbonate of lime would be killed by the lowering of temperature at the poles—like those with pelagic larvæ.

Further, the slightly pelagic *Ophiopteron* of Amboyna, one of the Moluccas, is not so widely distributed as some other types devoid of such an apparatus for progression.

The distribution of the Cœlenterates, such as zoophytes, jelly-fishes, sea-anemones, corals, and sea-fans, presents special features, for some are more purely tropical, others more characteristic of the colder areas, whilst not a few—like *Campanularia*, *Obelia*, and *Eudendrium*—are cosmopolitan. Thus the coral-reefs are tropical and subtropical, yet some stony corals, such as *Lophohelia* and *Caryophyllia*, occur in temperate seas. The jelly-fishes and sea-anemones are cosmopolitan, though some, like *Cestus*, are characteristic of the warmer seas. Alcyonarians range from tropical to cold regions, those in the former, however, according to Prof. Hickson, being distinguished by the abundance of their spicules or by massive skeletal structures.

Sponges are often widely distributed, some forms being common to the North Atlantic and the Cape, others to the latter and Australia; whilst European types range to South Africa and America.

The Foraminifera, Radiolarians, and other types of the Protozoa (e. g. *Noctiluca*) have an extensive distribution, the former ranging from the Arctic to the borders of the Antarctic Ocean, and forming vast deposits in many areas. The distribution of *Noctiluca* and the pelagic forms like *Ceratium* is equally wide; nor is there any hard-and-fast line separating the distribution of families or larger groups from each other.

In connexion with regional distribution in the ocean, it has been supposed by some that the fauna of the deep water (abyssal region) is peculiar, but many families found there have representatives in shallower water and even between tide-marks. Thus amongst the deep-water fishes the Murænidæ include the eels so common between tide-marks in the Channel Islands and elsewhere. The Clupeidæ comprise the herring, sprat, and anchovy—widely distributed pelagic fishes which come near the shore to spawn. The Ophidiidæ are almost universally spread from Greenland to New Zealand, and the family includes the sand-eel of our shores. In the same way the Pediculati, another family of deep-water fishes, has a representative, viz. the frog-fish, in shallow bays. A considerable number of Mollusca are also inhabitants of the depths of the sea, but representatives of the same families or even genera occur in shallow water; and

so with the marine Polychæta and other Invertebrates down to the Foraminifera—only arenaceous forms of the latter are more abundant in abyssal regions, and it is said that no Brachyurous crustacean has been met with below 1000 fathoms (*Canon Norman*).

Sir John Murray thinks that migration into the deep sea took place from the mud-line (viz. about 100 fathoms), and that there is little evidence, from the observations made in the 'Challenger,' to show that the deep sea has been peopled since the earliest geological times. The uncertainty on this head, however, is apparent by the statement of Prof. James Geikie that it was the absence of these abysses in early times (Palæozoic) which enabled many forms to become cosmopolitan. Murray, again, considers that the fauna of the deep water is less ancient than that of many shores (*Lingula* and *Heliopora*) and freshwaters (*Ceratodus*). In considering the deep-water fauna, however, it is well to bear in mind the difficulty of bringing the animals up for investigation.

A brief glance may now be taken at the bipolarity of marine animals as promulgated by Pfeffer and Murray. The latter, especially from his experiences in the 'Challenger' expedition, has put forward a strong claim on this head. He is of opinion that there are a large number of identical and closely allied species in the extra-tropical regions of the northern and southern hemispheres, which, so far as known, are not represented in the intervening tropics—even though the climatic conditions as regards temperature are the same. He thinks that the identical species now living towards both poles, or their immediate ancestors, had a world-wide distribution, which involves a nearly uniform temperature throughout the whole body of the ocean (probably in Middle Mesozoic times), and that as the poles cooled these animals were drawn towards the equator. As we go back to the Palæozoic period, he affirms, the tropical zone of temperature slowly widens. Murray further supports his theory by pointing out that pelagic larvæ are absent in the cold waters of the arctic and antarctic regions; yet this may have been accidental, and due to the depth at which the tow-nets were used. Certainly the Sponges, Cœlenterates (Zoophytes), Echinoderms, Annelids, and Molluscs of these regions have ciliated pelagic larvæ. This bipolar theory has been opposed by Ludwig for the Sea-Cucumbers, Ortmann for the Crustaceans, and D'Arcy Thompson generally, whilst many of the appearances may be explained by the cosmopolitan distribution of the various types.

In summing up, therefore, it would appear that the distribution of marine animals is bipolar.

bution of marine animals has features which diverge from those which characterize the distribution of land-animals—according to the views now prevalent; and, further, that the absence of impassable barriers does not, of necessity, lead to a cosmopolitan habit in those which can avail themselves of the opportunity. In the case of land-animals much weight has been placed on this check to migration, so that it is a prominent feature in the literature of the subject. Further, the conditions in the ocean tend to the permanence of the various types, which, with their wide distribution, varied sites, and uniform medium, have much to favour them in the struggle for existence. The vast or cosmopolitan distribution of many forms is thus conspicuous.

Again, in the present state of knowledge, the division of the ocean into regions characterized by special faunistic features can with difficulty, to say the least, meet with support from all the groups of marine animals.

This preliminary survey of the subject, moreover, is interesting insofar as it discloses no serious obstacle to the introduction of European food-fishes, shell-fishes, crabs, and other forms to various parts of the world—especially those of primary importance to man. If, for instance, the same or a closely allied shell-fish or annelid can live and flourish equally in the waters of Britain and those of the Cape, there is probably no insuperable barrier to the transference of a valuable food-fish from the one to the other. The recent transmission of adult plaice from Scotland to Australia has already met with success, and the same experiment may soon be carried out at the Cape.

Though at present, broadly speaking, no definite plan of distribution amongst the families of oceanic forms is discernible—very few families being monopolized by one region to the exclusion of the others,—future investigators may enable such a plan to be outlined; yet the number of cosmopolitan forms, and of others which range almost as widely, will always give a tone to the picture of the sea in contrast with that of the land.

XIV.—*Descriptions of new Frogs and Snakes from Yunnan.* By G. A. BOULENGER, F.R.S.

IN a recent number of these 'Annals' * I described a new gecko, *Gehyra yunnanensis*, obtained at Yunnan Fu (altitude

* Vol. xii. 1903, p. 429.



M'Intosh, William Carmichael. 1904. "XIII.—On the distribution of marine animals." *The Annals and magazine of natural history; zoology, botany, and geology* 13, 117–130. <https://doi.org/10.1080/00222930408562446>.

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