ADDRESS
AT THE OPENING OF THE SESSION 1877-78,
NOVEMBER 2nd, 1877,
BY THE PRESIDENT,
PROF. J. MORRIS, F.G.S.

INTRODUCTION.

The opening of another Session of the Association recalls to our remembrance the admirable and suggestive addresses delivered from this chair by my predecessors—Mr. Carruthers and Mr. H. Woodward. This evening I will simply attempt to recapitulate some of those facts connected with Geological Science with which many of you are familiar. I therefore propose to offer some general remarks on the geographical distribution of the different geological formations in relation to the succession of life on the globe. In doing so, I shall avail myself of the results arrived at by those whose observations have so largely contributed to our knowledge of this special branch of Geology.

Most of you who are acquainted with the leading principles of geological investigation, are aware that the present faunas and floras which now occupy the surface of the globe have not been the same at all previous periods. We find from these enquiries that the forms of life in the deposits immediately anterior to the present period bear considerable resemblance, or are closely related, to those living in the same area at the present day, but that as we recede in time, a great difference is found to exist between the fauna and the flora of the present period and those of still earlier periods of the earth's history. The study of the fossil remains of former life may be considered under different heads. First,—the nature of those remains that are found fossilized, and the extent to which these remains are preserved in the various sedimentary strata of the earth dependent on the conditions in which they occur, for it must be remembered that only the more solid parts of animal structures are preserved, and as a certain number of forms now living consist of soft parts only,

it is almost impossible that their remains should be found,* whilst the existence of other forms may not readily be detected except as impressions.† Again some forms of life have not yet been observed, owing to their minuteness, yet from the known habits of other existing animals as to their food we may infer that such minute forms might have existed. Secondly,—the relations of the extinct forms to those that now live upon the globe, from which it appears that the present great divisions or types of the organic world include also all those that are found in a fossil state; so that, broadly speaking, the scheme of creation, past and present, becomes one uniform whole. Thirdly,—the deductions that may be drawn from the habits of existing forms as to the probable conditions under which former animals and plants lived, so that we may understand more clearly, and reason more safely, respecting the varied conditions by which the different sedimentary rocks containing their remains were accumulated.‡ Again, the study of these remains shows to some extent the order of succession of life upon the globe, and how far from past times to the present there has been any progression; thus enabling us to consider the relation of the animals and plants which now live upon the surface of the earth to those which have existed in former times.

GEOGRAPHICAL PROVINCES.

From the various admirable memoirs and papers which have of late years been published upon the geographical distribution of animals, we learn that the present surface of the globe has been divided into a series of Natural History Provinces based upon the principle that certain forms of animals and plants are peculiar to each of these provinces. According to the different views of the naturalists who have studied the subject, they have been divided

* Dr. S. Woodward states there are about 600 species of soft or naked Mollusca. "Manual of Mollusca, p. 348."

† M. D'Orbigny terms some of these, physiological impressions. "Cours Élémentaire de Paléontologie," p. 27.

‡ Not only do we find the Miocene beetles differentiated and adapted to all the habits of life which their Oolitic predecessors had already possessed, but for the first time we come across true *flower-haunting* beetles, belonging to groups actually specialized in our own day to particular genera of flowers. So striking is this that Professor Heer infers the existence of such flowers (*although they have not as yet been found*) during the Miocene epoch. J. E. Taylor, "Popular Science Review," Jan., 1878, p. 44.

into a greater or less number. Thus Professsr Huxley* makes four main divisional provinces—(1), Arctogæa, which includes a very considerable portion of the northern hemisphere, and three other divisions, North America, Africa, and India; (2), New Zealand; (3), Australasia, and (4), Austro-Columbia, including South America, and a portion of North America, North of Mexico. Mr. Wallace has divided them into six provinces, respectively named according to the regions so circumscribed by him—Palæarctic, Ethiopian, Oriental, Nearctic, Neotropical, Australian.† According to Dr. Selater, there are nine principal, zoo-geographical provinces (with minor sub-regions) dependent on his views of the restricted distribution of animals.‡ Mr. Griesbach§ divides the surface of the globe into 24 natural regions of vegetation, each of which is supposed to have been a centre of creation where the several characteristic floras took their origin.

Taking the distribution of Mollusca, we find that Dr. S. Woodward increases the number, making 27 land regions—that is to say, 27 regions based entirely upon the land and freshwater shells of those respective areas—and 18 marine provinces based upon the peculiar distribution of marine forms.||

DISTRIBUTION OF FOSSILS.

The present distribution of animals and plants upon the globe is one of extreme interest, both to the Biologist and to the Geologist, inasmuch as it bears upon the origin of the animals and plants of those divisional provinces, and the question is suggested why are they now so specially localised, and whether as we recede back in time there were equally good divisional provinces? It is to

* On the Alectoromorphæ, &c., Proc. Zool. Soc., 1868, p. 316. "Thus, if we consider the distribution of the Alectoromorphæ alone, the whole surface of the globe must be primarily sub-divided into two principal areas—a northern and a southern. And I think it is not difficult to show, from other considerations, that these are really the most important divisions which can be established for the geographical distribution of both Birds and Mammals." See also Ann. Address Geol. Soc., 1870.

† On the Comparative Antiquity of Continents, Proc. Roy. Geogr. Soc., Vol. 21, 1877.

‡ Palæarctic	} Arctogæa	Neotropical	} Dendrogæa
Ethiopian		Antillean	
Lemurian		Australian	} Antarctogæa
Indian		Pacific	
Nearctic			Ornithogæa

"British Assoc. Report," 1875; Sections p. 86.

§ Die Vegetation der Erde nach ihrer Climatischen Anordnung, 1872. Translated into French by M. Tchihatchef.

|| "Manual of Mollusca," pp. 349-381

assist us in replying to this enquiry that I wish to recall attention to the facts relating to the distribution of life upon the globe in past times. From the knowledge which has been derived by the researches of various geologists during many years past, we are conversant with the fact that in each of these so-called divisional provinces—each of these separate areas—there has been a succession more or less of distinct deposits, as well as of animal life, from the earliest times observed in each of them up to the present day.* The question naturally arises, what relation does this succession of life, and of formations found in these respective provinces bear to each other? Were they in former times as dissimilar as they are at the present day, or were they more or less uniform? This can only be successfully answered by a careful study of the nature of the different rocks and of the organic remains of these respective areas, from which it appears that there is not only an apparent similarity of succession (that is probably not quite synchronous but homotaxial), but that a great number of forms are to some extent representative, and in some cases identical.† Did these similar forms, occurring in the same apparent relative position, originate in those respective areas, or did they not? Mr. Wallace, in speaking of land-areas, says—“As the theory of evolution does not admit the independent development of the same group in two disconnected regions to be possible, we are forced to conclude that these animals have migrated from one continent to another.”‡

* Conybeare remarked in 1822, “It is to be regretted that we have as yet no means of ascertaining whether a similar succession of Secondary beds takes place in very distant countries (America for instance), and whether these are characterized by similar families of organic remains. As the recent animals of these countries are widely different, one would naturally suppose the fossils would be different also; yet in some instances we have reason to believe that this, in the earlier Secondary strata at least, is not the case,” &c. “*Outlines of Geology, Introduction*,” p. xiii. Note.

† Scarcely any palæontological discovery is more striking than the fact that the forms of life change almost simultaneously throughout the world. Thus our European Chalk formation can be recognised in many distant parts of the world, under the most different climates, where not a fragment of the mineral chalk itself can be found; namely, in North America, in equatorial South America, in Tierra del Fuego, at the Cape of Good Hope, and in the Peninsula of India. C. Darwin “*On the Origin of Species*,” p. 349.

‡ On the Comparative Antiquity of Continents, *Proc. Roy. Geogr. Soc.*, Vol., 21. “Thus cats, deer, mastodons, true horses, porcupines, and beavers existed in Europe long before they appeared in America. Camels and, perhaps, ancestral horses, on the other hand, were more abundant and more ancient in America, and may have migrated thence into Northern Asia.” See also Professor Marsh, “*Succession of Vertebrate Life in America*,” p. 50.

With regard to the distribution of similar fossils over wide and at present disconnected regions of the globe, a few facts may be stated.

M. Barrande and other European and American palæontologists show that many species of Crustacea and Mollusca are common to the Silurian rocks of Europe and America.*

Professor McCoy states that certain species of Graptolites, found in the Lower Silurian rocks in the Victoria district of Australia, occur in strata of presumed similar age in Sweden, Bohemia, United States, Quebec, and in North Wales, and that the other conditions are somewhat similar, for these graptolites occur in slaty rocks in Australia and Wales, and in both cases these rocks are traversed by quartz veins containing gold.†

Mr. Lapworth has arrived at similar conclusions with regard to the range of the Graptolites: "The Graptolithina of the Lower or Glenkiln division are those of the highest Llandeilo Flags of Wales, the corresponding Middle *Dicranograptus*-schists of Sweden, and the Norman's Kiln shales that *underlie* the Trenton (Bala) Limestone of New York. The Hartfell species occur in the Bala beds of Conway, &c., the higher *Dicranograptus*-schists of Sweden, and the Utica and Lorraine shales that *overlie* the Trenton Limestone. Those of the Birkhill shales agree almost species for species with the fossils of the Coniston Mudstone of Cumberland, the Kiesel Schiefer of Thuringia, and the Lobiferous beds of Sweden, which lie at the summit of the Lower Silurians of their respective countries."‡

In the Upper Silurian, Devonian, and the Carboniferous rocks the same fossils are found in widely disconnected areas.

In the higher Silurian rocks of Australia, supposed to represent the Ludlow and Llandovery deposits, there are many species, according to Professor De Koninck, common to the European Silurian—Corals, 18; Brachiopods, 14; Lamellibranchs, 1; Ptero-

* Bigsby, "Thesaurus Siluricus," p. 29. D. Sharpe, Quart. Journ. Geol. Soc., Vol. 6. Miller, "American Palæozoic Fossils," 1877.

† Professor McCoy says—"Having, shortly before coming to Victoria, knocked out with my hammer, from the slate rocks of the Welsh old Roman gold mines, at Gogofau, near Llanpump-saint, exactly the same species of Graptolites which I found to be the most common in our gold-field slates in this colony; showing that the Romans had obtained their gold from quartz veins in slates in Wales of exactly the same geological age as our Australian formations." "Palæontology of Victoria," 1874, Decade 1, p. 5.

‡ Proc. Geol. Soc., No. 341, Nov., 1877.

pod, 2; Crustacea, 8; and in higher beds referred to the Devonian are species found in the Devonian and Carboniferous of Europe—Corals, 14; Brachiopods, 2; Lamellibranchs, 2; Gasteropoda, 6. Of the 249 species from the Carboniferous rocks of New South Wales, 81 are considered to be identical with those from the same formation in Europe; of these, 22 are common to all three divisions of the Carboniferous Limestone, and 36 belong exclusively to the upper division, from which M. de Koninck infers that it is the upper series which is mostly represented in New South Wales.*

From the Carboniferous Limestone of Bolivia, Franz Joulia mentions some species of Brachiopoda characteristic of the same formation in Europe, as *Spir. striata*, *Spir. octoplicata*, *Rhynchonella pleurodon*, *Orthis resupinata*, *Productus cora*, and *Prod. semireticulatus*. The latter form, with other European Carboniferous species, have been described by Professor Beyrich as occurring in the Island of Timor.

In other and newer formations similar facts as to the wide distribution of species have been noticed, as in the Triassic, Jurassic, Cretaceous and Tertiary deposits of widely separated areas.

Thus fossils characteristic of the Trias of Hallstadt, in Europe, have been observed by Dr. Hector in beds of similar position in New Zealand, as *Monotis salinaria*, *Halobia Lommelli*. These and other Triassic forms, showing their wide distribution, have been noticed in Nevada, California, Arabia, New Caledonia, Siberia, Thibet, and Timor. (Marcou, p. 126.)

Professor Duncan says—"The Upper Trias in the Himalayas has a very European facies of the St. Cassian type, and contains *Halobia Lommelli*, *Ammonites floridus*, and *Orthoceras latiseptum*,† and four European Brachiopods."

The Middle and Upper Liassic and Oolitic faunas of distant localities are foreshadowed in the Upper Rhætics of the Himalaya, but the Jurassic formations of India also contain European species.‡ Mr. C. Moore§ has pointed out the identity of some Australian

* "Recherches sur les Fossiles Paléozoïques de la Nouvelle—Galles du Sud." Bruxelles, 1876—77.

† Annual Address, Geological Society, Feb., 1877, containing some suggestive remarks on the distribution of fossils and the bearings of Palæontology on evolution.

‡ Duncan, Presidential Address, Geol. Soc., Feb. 1877, p. 50; also "Abstract of the Geology of India," p. 41.

§ Quart. Journ. Geol. Soc., Vol. 26, p. 231.

species with those from the English and European Lias and Inferior Oolite.*

Don A. R. de Corbineau, in his "Palæontology of Chili" (Santiago, 1867), cites sundry species of Ammonites and of Brachiopoda from strata in the valley of Copiapo and adjoining districts, as identical with those occurring in the Jurassic rocks of Europe.

In the province of Coquimbo there are some fossils characteristic of European Cretaceous strata, and the Cretaceous rocks of India contain species identical with those from the White Chalk and Upper Greensand of Europe.†

The Coal Measures of America have many plants in common with those of Europe—some species occurring also in Eastern Siberia, Arctic Greenland Lat. 77°, also in the Brazilian and Australian coal fields. The striking resemblance of the Mesozoic coal floras with those of Europe, India and America has been long noticed, as well as the marked similarity of character of the flora of the Miocene period over a wide area, as in Greenland, North America, and Europe.

The *Producta semireticulata* is found in the Carboniferous rocks of Europe, America, Brazil, Bolivia, India, China and Australia. This wide distribution of the same species in the old Palæozoic seas is represented at the present time by another brachiopod, having a wide range, the *Crania ringens*, which, according to Mr. Davidson, is now living in the Mediterranean and in the seas of

* Vouloir qu'on ait les mêmes formes d'êtres en Australie et en Europe à chaque époque géologique, est évidemment aller contre tous les principes de géographie physique et naturelle et contre tous les résultats acquis actuellement en géologie et en géographie. Sans doute, on cite quelques Brachiopodes et autres animaux inférieurs comme identiques en Europe et en Australie, mais leur contemporanéité ne s'ensuit nullement. Certaines formes d'êtres ont la vie extrêmement dure et robuste; rien ne peut anéantir, presque même en employant d'actifs moyens de destruction. Marcou, "Explication de la Carte Géologique de la Terre," p. 205.

† Professor E. Forbes remarked on the collection of fossils from Southern India, with regard to the distribution of animal life during the Cretaceous era—"It shows that during two successive stages of that era the climatal influence, as affecting marine animals, did not vary in intensity in the Indian, European and American regions, whilst the later of the two (Trinconopoly and Verdachellum stage) had specific relations with the seas of Europe, which are absent from the earlier (Pondicherry stage). The cause of this remarkable fact is not to be sought for in a more general distribution of animal life at one time than at another, but rather in some great change in the distribution of land and sea, and in a greater connection of the Indian and European seas during the epoch of the deposition of the Upper Greensand than during that of the Lower," Trans. Geol. Soc., Vol. 7. See also M. d'Archiac, Bull. Geol. Soc., France, Vol. 11, p. 202, &c.

Australia. The *Spirifera lineata* has also a wide distribution, but varies in size according to the localities (due to former conditions) where it is found.

CONTEMPORARY FAUNAS AND STRATA.

In the early history of Geology, Dr. W. Smith enunciated the law that strata were to be identified by their organic remains, and that strata containing similar fossils were of the same age. The later investigations of naturalists and geologists* seem to have considerably modified this doctrine, and if the law previously mentioned (p. 194) be true, then the strata in distant areas containing similar remains could not have been contemporaneous, while strata with dissimilar fossils may have been so.

De la Beche remarked that in the present comparatively advanced state of Geology, it behoves us carefully to weigh the conditions under which animal and vegetable life now exists, before we assume that a given deposit can or cannot be determined by its organic contents.†

As bearing on contemporaneous strata one or two facts respecting modern distribution may be noticed. M. D'Orbigny states that the east and west coasts of South America have a different molluscan fauna, with a very few similar species, and the genera are not equally distributed; of the 110 genera of Mollusca, 55 are common to both sides, the other 55 are differently distributed, 34 genera are peculiar to the Patagonian and Chilian coasts, and 21 to the Atlantic coast. The character of this fauna is further modified by the varying conditions to which it is subjected, such as depth, temperature, and currents, accounting for unequal distribution, and influencing the forms of life over the area; the cold currents from the south that are partially divided under Cape Horn (a portion passing through the Straits of Magellan), proceed upwards on the Pacific side to a far greater distance before they diverge than those which traverse the eastern side. Currents, therefore, are one means of distributing certain forms along coast lines; but there are other conditions in the nature of the old sea-beds. The genera which live upon the eastern coast of America are those which usually are to be found on sandy and muddy shores, that being for the most part the character of the Atlantic coast, while on the

* De la Beche, Woodward, Forbes, Huxley, Wallace.

† "Theoretical Researches," 1835, p. 224.

more rocky coast and the deeper seas of the western shore other genera are found which are adapted to that kind of habitat.*

The elevation of these contemporaneous sea-beds would show deposits with two distinct faunas having scarcely any species in common. Similar facts may be observed on the coasts of France, where the distribution of the genera of Mollusca are to some extent dependent on the physical surroundings, as in the Celtic, Lusitanian, and Mediterranean regions.†

Again deposits may be taking place on two distant shores, as those now occurring on the coast of North America and our own country. Dr. S. Woodward‡ states there are 70 species of Mollusca found on the coast of Massachusetts north of Cape Cod, and common to Northern Europe. If those shores were elevated, the examination of the two faunas might lead to the inference that the deposits had taken place, not only at the same time, but that they were probably also once continuous.§ As at present, so in past times, therefore, a series of forms might be living in two different areas contemporaneous with each other without being part of a continuous deposit, or, as suggested by De la Beche, equal circumstances existing in two different localities, the eggs of marine animals being transported from one to the other, by natural causes, deposits in the progress of formation in such localities may, though not continuous, contain somewhat similar organic remains.|| On the other hand this coincidence may arise from some former coast-line now lost, which joined the two areas. A different amount of elevation of the two coast-lines (*i.e.*, America and England), producing an extinction of more species on one coast than on the other, might modify the comparison.

* D'Orbigny, "Cours Élémentaire," tome 1, p. 98; Woodward, "Manual of Mollusca," pp. 373, 4.

† D'Orbigny, "Cours Élémentaire," &c., p. 100; Delesse, "Lithologie du Fond des Mers," chap. 13. Lyell, "Elements of Geology," p. 104.

‡ "Manual of Mollusca," p. 358. Gould, "Invertebrata of Massachusetts," 1841.

§ With regard to a mixture of organic remains in contemporaneous deposits, Prof. E. Forbes shows that while vegetables of a sub-tropical character may be borne down by the Nile into the Mediterranean on one side, accompanying the remains of crocodiles and ichneumons, the Danube may transport parts of the vegetation of the Austrian Alps, with the relics of marmots and mountain salamanders, the marine remains mingled with these contemporaneous deposits retaining a common character. De la Beche, "Geological Observer," p. 146. Forbes, Rep. Brit. Assoc., Vol. xiii, 1843, p. 154.

|| De la Beche "Theoretical Researches," p. 259.

With regard to deposits containing similar organic remains being contemporaneous, Sir H. De la Beche many years since* suggested that formations containing similar fossils were not necessarily of the same age, by showing that, presuming there is a coast-line with different zones of depth (1, 2, 3) extending seawards, each tenanted by slightly different living groups, there would occur three series of forms living in the same area, differing from each other; and, presuming that if this area was either depressed or elevated, two sets of conditions would arise. If the area were depressed gradually then, it will be perceived, the animal life living in zone No. 2 would creep over zone No. 1, while the animal life living in zone No. 1 would spread itself on the former sea shore; and as the depression went on, so in proportion would the animal life and deposits of No. 3 cover No. 2. On the other hand, if elevation took place the reverse of these conditions would arise, No. 1 overlying No. 2, and 2 over 3, and so on; and if the changes were comparatively gradual, there would be zones of life at different horizons containing similar forms, which would be deposited, not at the same time, but at different times.†

RECURRENCE OF SPECIES AND DOCTRINE OF COLONIES.

In some districts are found a recurrence of similar species of fossils at two different horizons, separated by a great thickness of intervening strata, in which no trace of them occur; but these strata frequently contain a distinct assemblage of forms, thus indicating long periods of time, showing the caution to be exercised with regard to fossils as true chronological evidence.

In Bohemia, M. Barrande, describing his "Colonies," has shown that a series of Upper Silurian fossils occur intercalated in strata of Lower Silurian age, and which limited fauna does not appear again until after a long interval in the same area.‡ M. Barrande§ suggests that while the Lower Silurian fauna prevailed

* De la Beche "Theoretical Researches," p. 253.

† De la Beche, "Theoretical Researches," 1834, p. 253.

‡ M. D'Orbigny doubts the theory of Colonies: "Puisque les colonies sont inconnues actuellement; mais qu'elle est un effet des oscillations du sol, qui a placé deux dépôts côtiers, séparés par un dépôt sous-marin, à la suite d'affaissements et de sur-élévations alternatifs du sol." "Cours Élémentaire," tome 2., p. 309.

§ As bearing on the subject of Barrande's Colonies, Mr. C. Lapworth has sent the following extract from Dr. Linnarsson's paper, "On the Graptolite Schist of Kongslena, in Westrogothia":—"It has long been the general opinion that the Graptolites which characterise Barrande's Colonies and his Etage Fe. 1 had originally their home in the North of Europe, and that from

in Bohemia,* an Upper Silurian fauna already flourished, or co-existed, in some other more or less remote area, from which they either migrated or were drifted by currents into the then Lower Silurian sea, which they occupied for a certain time; but the conditions becoming unfavourable for their continued existence they did not return again into the same region until Upper Silurian times,† when they became the predominant fauna and were continuous in the two regions.

Professor Hughes applies the doctrine of "Colonies" in explanation of certain points observed in the Lake district. In the Winder Grit band, belonging to the Coniston Grits of Wenlock age, he describes a group of fossils having an "exclusively Ludlow facies," an entirely different fauna from that which usually occurs in the other fossiliferous portions of the Coniston Grits, both above and below. This band is separated by 7,000 feet of strata (with a totally different group of fossils) from the formation where the fossils which characterise it become the prevalent forms.‡

thence they made excursions into the Bohemian basin. In their earlier migrations they could not find complete footing there, and consequently formed a colony, which soon died out. Later—viz., at the time of the formation of Barrande's Etage Fe. 1—they established themselves in permanent occupation of the Bohemian basin. Formerly, when it was thought that the graptolites of the Upper Graptolite Schist of Sweden were co-existent with the trilobites of the subjacent Trinucleus Schist, and that their equivalent English Graptolite-bearing beds belonged to Llandeilo and Caradoc, such a view was very natural. Now, however, the better insight we have attained of the English and Swedish succession has robbed it of all its weight in this direction. There is no reason whatever for believing that the Graptolites which inhabited Barrande's Colonies emigrated from the Ocean of the N.W. Where they actually came from is, at least for the present, impossible to determine; but probably the Bohemian Colonies are *older* than all the Swedish and English beds in which the same fauna is found. Instead, therefore, of the emigration having taken place as believed hitherto (from Britain and Scandinavia to Bohemia), if we may judge from the facts now obtained, it ought rather to have taken place in the opposite direction."

* Barrande, "Defense des Colonies." Bull. Soc. Geol. de France, tomes xvii and xx. Murchison, "Siluria," 1867, pp. 375, 379.

† Prof. Bronn, after noticing the recurrence of Inferior Oolite species of Mollusca in the Great Oolite and Cornbrash of Gloucestershire, as bearing on the Colonies of Barrande, says: "Ainsi il n'y a pas de doute que le retour de conditions de vie identiques a par faire apparaitre une seconde fois dans certaines limites de temps des groupes ou colonies d'espèces animales, qui dans des circonstances moins favorables avaient émigré en d'autres endroits, étaient devenus rares et avaient passé presque à l'état de pygmées ou avaient été peut-être entièrement anéanties pendant quelques temps, et tout cela non par suite d'un changement de climat, mais d'une altération du sol, du fond de la mer, de la station où ces êtres devaient demeurer. Bronn, "Suppl. Comptes Rendus," t. 2, p. 724.

‡ Explanation of Quarter-Sheet, 98 N.E., p. 10.

Nearly every fossil of the Winder Grit band occurs, however, in the Wenlock rocks of Siluria.

The study of the American Silurians affords another example of recurring forms. Dr. Nicholson has shown that certain species which occur in the Lower Silurian of the Hudson River group, recur in the Clinton beds, which form the base of the Upper Silurian, without being found in the intermediate strata ; but that in the district far away, in the Anticosti group of Canada, the same species are found which occur in the upper and lower beds of the former district.*

As partly bearing on "Colonies," allusion may be made to the observations of Dr. Dawson in his very interesting address to the Natural History Society of Montreal, in 1874, which show that along the Nova Scotia coast there has been in comparatively modern times a series of changes which have affected not only the seas but the land of that area. He states that around some parts of the Bay of Fundy and the Acadian Bay, there are depressed peat bogs with pine stems, varying from 30 to 60 feet in depth, showing the depression which that area has undergone within comparatively modern times ; but he has pointed out, from his own observations, and those of Mr. Verrill, that in some parts of that area there are still a few lingering species of Mollusca which are known to be inhabitants of New England to the south, associated now with a more or less Arctic fauna. Dr. Dawson suggests that these pine forests show that the land must have stood at a higher elevation when they lived and thrived upon the shore of the then Bay of Fundy, and that they had been subsequently depressed ; that during the time when they stood at a higher elevation the climatic conditions were different to what they are at present ; that the colder seas would be thrown further out, and that the warmer seas would bathe the shore, so that the species now living in the more southerly area migrated northwards, over a larger space than they now occupy ; that with the depression of the land and the submergence of these forests the climatic changes were partly reversed—colder conditions arose and the Arctic seas returned, bringing with them the Mollusca and associated fauna which previously existed in that area ; thus partly representing the "Colonies" of Barrande, in that remnants of the southern are mixed with the

* Transactions Edinburgh Geological Society, Vol. 3, p. 3.

Arctic fauna, and then unfavourable conditions arising for the continuation of the southern forms, they would gradually die out and be replaced by Arctic ones.

These are a few of the general facts showing the caution which should be exercised with regard to the study of the conditions under which apparently similar deposits either in very closely connected or widely separated areas have taken place.

SUCCESSION OF LIFE.

I will now offer a few remarks on the question, how far a study of the series of animal forms found fossil in the various strata of different geographical provinces assists us in tracing the past history of the life of the earth.

The evidence derived from a general study of the terrestrial forms in the present divisional provinces, points to the fact that there is *not only* a similarity between existing forms and those whose remains are found fossil in the deposits which immediately preceded the present period in each separate province, but a great successive resemblance in the still older faunas,* when each province is compared with the others.

The animal kingdom is divided into six great types or Sub-Kingdoms—Protozoa, Cœlenterata, Annuloida, Annulosa, Mollusca, and Vertebrata—to which groups all the fossil remains belong, so that there is no new type in the broadest signification of the word, and no lost type. There are, however, many extinct families, genera and species, but Nature has retained the same type. In the language of the Poet—

“So careful of the type she seems,
So careless of a single life.”

In studying the conditions of life, past and present, it will be observed that (1) the lower forms of Invertebrata are more widely distributed than the higher forms of Vertebrata, and that (2) the larger the division a Sub-kingdom or Class, the wider is its distribution in space and the longer is its range in time; and the smaller the group as the genus, and still more the species, the more restricted is its vertical and horizontal distribution. So that there are localized species at the present day in certain areas, and special or characteristic species in the different formations.

* Darwin, “Origin of Species,” p. 349.

THE PROTOZOA.—The Foraminifera are widely distributed in time and space. They are found in all seas, and constitute in some places a considerable portion of the ooze of the Atlantic. They range through all the geological series, being present in some band or other of each formation, and even constitute the mass of some limestones, as *Fusulina* in the Carboniferous of Russia, of Tyrol and Ohio. The Chalk, the Nummulitic Limestone of Egypt, the Alps and Spain, the Miliolitic Limestone of Paris, the *Alveolina* Limestone of Bracklesham, and the *Amphistegina* Limestone of New South Wales, are foraminiferal deposits.

Unlike the higher forms of Invertebrata, both genera and species of Foraminifera have a long range in time. Some genera are widely represented in the same geological horizon, as *Fusulina* in the Carboniferous of Russia, North and South America, Sumatra, Tyrol, the Arctic Regions, California, and Armenia. This genus is also found in the Permian Limestones of New Mexico and Texas.*

So also *Nummulina*, which occurs in the Carboniferous and in the present seas, had a wide distribution in the Eocene period, ranging from Bracklesham and Spain to China and Sumatra.†

As Mr. H. B. Brady has lately shown, some of the earliest Foraminifera (Carboniferous) have the highest organization of their group, and indeed we may quote Carpenter, Dawson, and Jones for Laurentian Eozoon having the same standing. Contemporary with these high class Foraminifera, Mr. Brady shows that some forms, like *Nodosaria*, have structureless shells, and others, quite similar in appearance, put on a hyaline character, and that indeed this double habit may represent the original and passage condition of these simple forms, which are now differentiated into long *Lituolæ* on one hand, and the neat compact *Nodosaria* on the other.

Prof. Rupert Jones remarks that *Miliola* among the "Porcellaneous," *Trochammina* and *Lituola* among the "Arenaceous," *Textilaria*, *Nodosarina*, *Globigerina*, *Pulvinulina* and *Planorbulina* among the "Hyaline" Foraminifera, are the chief of the genera of

* Brady, "Geological Magazine," Vol. xii, p. 538.

† Few of the Nummulites have a wider distribution than *N. Ramondi*—from the south-west of France, eastwards through Central Europe, North Africa and Asia; indeed almost everywhere wherever the early Tertiary Nummulitic strata appear. H. B. Brady, Geol. Mag., Vol. xii, p. 534.

longest (known) existence, that is beginning before the Cretaceous period, and living now.*

He has further indicated that nearly fifty of the so-called species or "notable varieties" of the Foraminifera, are common to the Cretaceous rocks, and the present seas.† The general distribution of the Foraminifera in time may be given as follows, the

Perforate and Hyaline Foraminifera—Laurentian to Recent.

Imperforate { Porcellaneous—Lias to Recent.
Arenaceous—Carboniferous to Recent.

The Orders belonging to the other division, Spongida of the Protozoa, as the Hexactellenida, Lithistida and Calcispongia are considered to be more or less represented in the geological series, the spicula of siliceous sponges sometimes constituting beds of chert and flint in the Cretaceous rocks, where also the Hexactenellid genus, *Ventriculites*, is a characteristic form.‡

CœLENTERATA.—The Sub-Kingdom, Cœlenterata, is widely distributed in space, but the two Classes—Hydrozoa and Actinozoa are equally distributed in time; the latter, from the stony nature of the skeleton, is well represented through all the geological periods, and constitutes in some formations extensive coral reefs.§

The Oldhamiæ and Graptolitidæ have been referred to the Hydrozoa; both are extinct forms, and the Graptolites, under many

* T. R. Jones, "On the Range of the Foraminifera in Time," Proc. Geol. Assoc., Vol. 2, p. 180.

† See Prestwich, Ann. Address, Geol. Soc. 1871, p. li.; also Morris, "Geology of Croydon," p. 7, where a list of the forms is given; and "Cretaceous Rotalina," Jones and Parker, Quart. Jour. Geol. Soc. May, 1875.

‡ The genera at present known in the Silurian (*Eospongia*, *Archæocyathus*, &c.) differ in essential characters from the later Hexactellenida, and possibly required other conditions of life than their successors. In the Devonian and Carboniferous Limestone, and in the Dyas, the Order is as yet represented by only insufficiently investigated genera, [referred to as] *Acanthospongia*, Carb., and *Bothroconus*, Dyas. In the Trias and Lias no Hexactellenida are at present known, and in the Lower Oolites they are very scarce. The Upper Jura exhibits a rich development of the Order and also of Lithistida, but only where it occurs in the form of limestone. In the lower and middle stages of the Cretaceous formation (except where they present a deep-sea facies) the Hexactellenida occur but sparingly. The greatest variety of fossil Hexactellenida and Lithistida is furnished by the Upper Cretaceous division, but only by such deposits as the White Chalk of deep-sea origin. Although they are scarce in the Eocene deposits, M. Pomel has discovered numerous Miocene sponges in the province of Oram. In formations which are at present known under a littoral facies, there are no Hexactellenida, and thus the different sponge horizons are in part separated by enormous intervals of time. Zittel, Ann. Nat. Hist., Ser. 4, Vol. xx., p. 421.

§ Duncan, Quart. Journ. Geol. Soc., Vol. 26, p. 51.

genera, are especially characteristic of the Silurian period.* *Palæocoryne* is found in the Carboniferous rocks, but indications of the other Orders were considered obscure. *Millepora* and its allies, formerly classed with the Tabulata, are now shown to belong to the Hydrozoa.† The Rugosa, Favositidæ, and Thecidæ are characteristic Palæozoic forms; the former is almost extinct, having but one genus, *Holocystis* in the Cretaceous, one in the Tertiary of Australia, *Conosmilia*, and two living genera, *Haplophyllia* and *Guynia*.‡ The Favositidæ diminish in numbers through the Mesozoic and Tertiary to the present time. One Palæozoic genus, *Chatetes*, occurs in the Trias. The Tubulosa are Palæozoic. The Aporosa (for *Palæocyclus* belongs to the Rugosa) commence in, and is the chief order of Jurassic§ corals, associated with some of the Perforata; both of these Orders occur somewhat abundantly in the Cretaceous and Tertiary rocks, and comprise most of the reef-building and deep-sea corals of the present seas. The Alcyonaria are found in the Palæozoic (*Protovirgularia*), Cretaceous and Tertiary, and the researches of Mr. Moseley have shown that *Heliolites* and other Silurian genera (*Propora*, *Plasmopora*, &c.),|| closely related to *Heliopora*, do not belong to the Tabulata, but to the Alcyonaria, thus adding more of this group to the Palæozoic period, while *Millepora*, formerly classed with the Tabulata, should be referred to the Hydrozoa.¶

The Sclerobasic corals first appear in the Tertiary strata.**

* Lapworth and Hopkinson, Quart. Journ. Geol. Soc., Vol. 31, p. 634. Nicholson, Ann. Nat. Hist., Nov., 1868. Hopkinson, Journ. Quek. Mic. Club, Vol. I.

† Moseley, "Philosophical Transactions," Vol. 166, p. 91.

‡ Prof. Duncan states: "There can be no doubt about the persistence of the rugose type of Palæozoic Madreporaria through the Neozoic formations to the present time, and that the species with hexamerous and decamerous septal arrangements descended from rugose types, and the latter especially from those with an indefinite septal number." On the Structure of *Guynia*, Phil. Trans. 1872. See also Trans. Zool. Soc., Vol. 8, p. 335.

§ According to Verrill the *Z. perforata* were represented in the Silurian seas. "American Journal," p. 194, 1872.

|| Dolfuss classes the *Héliolites* with the modern *Milléporiens*. "Comptes Rendus," Tome 80, p. 681, 1857.

¶ Moseley, "Philosophical Transactions," Vol. 166, p. 91.

The group of the Tabulata ceases to exist, and its members must be grouped either with the Hexacoralla, the Octocoralla, or the Hydrozoa. Huxley, "Manual of Invertebrata," p. 166. See also Duncan, Brit. Assoc. Report, 1871.

** For the distribution and characters of the Coelenterata, see the valuable Manual by J. R. Greene. London, 1861, from which the Table is compiled.

RANGE OF CŒLENTERATA.

	PALÆOZOIC.				MESOZOIC.				TERTIARY.			
	S	D	CB	P	TR	J	CR	EO	MI	P	PL	R
ACTINOZOA.												
Zoantharia ...	...											
Malacodermata ...	...											
Sclerodermata ...	...											
Aporosa ...	...											
Turbinolidæ ...	...	...	...	...	...	*	*	*	...	...	...	*
Desmidæ ...	...	...	...	...	...	*	...	*	...	...	...	*
Oculinidæ ...	...	...	...	...	...	*	*	*	...	...	...	*
Stylophoridæ ...	...	...	...	...	...	...	...	...	*	...	...	*
Astreidæ ...	...	...	...	...	...	*	*	*	*	...	...	*
Fungidæ ...	...	...	...	...	...	*	*	*	...	...	...	*
Perforata ...	...	...	...	...	...	*	*	*	...	...	...	*
Madreporidæ ...	...	...	...	...	...	...	*	...	*	...	...	*
Poritidæ ...	...	*	*	...	...	*	...	...	*	...	...	*
Tubulosa ...	...											
Auloporidæ ...	...	*	*	*								
† Tabulata ...	...											
Thecidæ ...	...	*							...	...	...	*
Favositidæ ...	...	*	*	*	*	*	*	...	...	...	...	*
Sclerobasica ...	...	...	...	...	...	...	...	...	*	...	...	*
Rugosa ...	...	*	*	*	*	...	*	...	*	...	...	*
Alcyonaria ...	...											
Pennatulidæ ...	...	*	...	...	...	...	*	*	...	...	...	*
Gorgonidæ ...	...	...	...	...	...	...	*	...	...	...	...	*
Heliclitidæ ...	...	*	*	*								*
HYDROZOA.												
Seriatoporidæ ...	...	...	*	*	...	...	...	...	...	...	...	*
Milleporidæ ...	...	*	*	*	...	*	*	...	*	...	*	*
Sertularidæ... ..	...	*										*
Graptolitidæ ...	...	*										*

ANNULOIDA.—Of this Sub-Kingdom, the Echinodermata, under various modified forms, has a long range in time, from the Cambrian upwards, and presents the same succession in distant areas as that in Britain.

Of the eight Orders (see Table) composing this Class, three, Cystidea, Blastoidea and Edrioasteridæ, are extinct, and characteristic of the Palæozoic period; the Crinoidea, very abundant in the same period, gradually diminishes as an Order in Jurassic and succeeding periods, and is but feebly represented at the present day; two of the families are, however, somewhat persistent—the Pentacrinidæ and Apiocrinidæ, which extend from the Lias and Oolite through the Cretaceous to the present time, where the *Pentacrinus* and *Rhizocrinus* are the respective living forms.

Pentacrinidæ—*Pentacrinus*, Lias, Oolite, Cret, Tert, Recent.

Apiocrinidæ—*Apiocrinus* and *Millericrinus*, Oolite; *Bourguetiercinus*, Cretaceous; *Bathyerinus* and *Rhizocrinus*,* Recent.

The free Crinoids are but few, the *Marsupites* and *Glenotremites* of the English Chalk, and the *Uintacrinus* of the American Cretaceous are now represented by the genus *Comatula*, or *Antedon*.

The orders Asteroidea and Ophiuroidea, commencing in the Cambrian, are fairly abundant in the Silurian rocks, and are well represented in the succeeding formations to the present time.

The true Echinoidea, under various forms, range from the Silurian upwards. In the Palæozoic rocks they are represented by a peculiar and characteristic family, the Palæchinidæ or Perischoechinidæ, which differs from the Neoechinidæ in having more than two rows of interambulacral and sometimes of ambulacral plates, and a greater number of genital and ovarial pores.† Some of the forms closely resemble the living genera, *Phormosoma* and *Calveria*, in the flexible nature of the testaceous covering and overlapping plates, to which the Cretaceous genus, *Echinothuria*, seems also allied.‡

The Neozoic and recent Echini are divisible into two sections, the regular and irregular echinoids or Endocyclica and Exocyclica, according as the vent is within or without the ambulacral areas. The former or less organized forms (*Cidaridæ*, &c.), commence earlier in time than the latter (*Spatangidæ*, &c.).

The genus *Cidaris* ranges from the Trias, and the family *Salenidiæ* from the Oolites, and has a living representative.

RANGE OF ECHINODERMATA.

	Cambrian.	L. Silurian.	U Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Holothuroidea							~							*
Asteroidea														
Ophiuroidea														
Echinoidea														
Crinoidea														
Blastoidea														
Cystoidea														
Edrioasteroidea														

* Thomson, "Depths of the Sea," figs. 72, 73.

† Keeping, "Palæozoic Echini," Quart. Journ. Geol. Soc., Vol. 32, p. 35.

‡ Woodward, "The Geologist," Sept., 1863. Thomson, "Depths of the Sea," p. 156.

RANGE OF THE ECHINOIDEA IN TIME.

[illegible]

ANNULOSA.—The next Sub-Kingdom, the Annulosa, contains a number of Orders of great interest to the Palæontologist, but whose distribution is not uniform, as seen from the following table, which is partly compiled from the elaborate catalogue of fossil Crustacea, prepared by Mr. H. Woodward.*

RANGE OF CRUSTACEA AND ANNELIDA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
CRUSTACEA.														
Brachyura	...	...	...	...	...	...	...	*	...	...	...	...	...	...
Anomura	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Macrura	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Stomapoda	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Isopoda	...	...	...	*	*	...	...	*	*	*	...	...	...	...
Trilobita	*	*	*	*	*	...	...	...	...	...	...	...	...	...
Amphipoda	...	...	...	...	*	*	...	*	...	...	...	...	...	...
Xiphosura	...	...	*	...	*	...	...	*	...	...	...	...	...	...
Euryptera	...	...	...	*	*	...	...	...	...	...	...	...	...	...
Phyllopoda	*	*	*	*	*	*	...	*	*	...	...	...	...	...
Ostracoda	...	*	...	*	*	*	...	*	*	*	*	...	...	...
Balanidae	...	...	...	...	...	...	...	...	...	...	*	...	...	...
Lepadidae	...	...	*	...	...	...	...	*	*	...	...	...	...	...
Myriapoda	...	...	...	...	*	...	...	...	...	...	...	...	...	...
ANNELIDA	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tubicolæ	...	...	*	...	...	...	...	*	...	...	...	...	...	...
Errantia	*	*	...	...	...	...	...	*	*	*	...	...	...	...

* "A Catalogue of British Fossil Crustacea, with their synonyms, and the range in time of each genus and order," by H. Woodward, F.R.S. London: Printed by order of the Trustees, 1877.

From this table it is seen that the two Orders which are extinct, are also characteristic of the Palæozoic period, the Eurypterida and Trilobita, and that the lower organized forms, the Ostracoda and Phyllopoda range throughout all geological formations, while the higher forms of Crustacea, as the Macrura and Brachyura, do not appear until a later period of the earth's progress; and of these again, the less centralized Macrura appear earlier than the Brachyura: so, in the Merostomata, the more segmented Eurypterida become extinct in the Palæozoic period, while the higher Xiphosura are continued to the present time. Among the Crustacea, the genus *Estheria* is the most persistent form, as it ranges from the Old Red Sandstone, and is now living in the freshwaters of Brazil and Natal.

The two orders of Annelida are represented throughout all the geological periods; the shelly coverings of the Tubicola being preserved in most of the successive formations, from the Silurian upwards; the genera *Serpula* and *Spirobis*, from their range may be considered as persistent types, while the Errantia "are abundantly represented by their trails upon old sea-bottoms, or their burrows in sand and mud; remains of which occur in all formations, almost from the Lower Cambrian up to the present day."*

The Insecta, Arachnida and Myriopoda commence in the Palæozoic period, the last two in the Carboniferous, and the former in the Devonian of Canada.

The remains of insects are found in most of the geological formations, from the Devonian to the present time, as shown in the table.

RANGE OF INSECTA.

INSECTA.	PALÆOZOIC.				MESOZOIC.				TERTIARY.			
	S.	D.	C.	P.	TR.	J.	CR.	E.	MI.	P.	PB.	R.
...	...	*	*	...	*	*	*	*	*	*	...	*
Lepidoptera ...	...	...	...	...	...	?	...	*	*	...	...	*
Diptera ...	...	...	...	...	...	*	...	*	*	...	...	*
Hymenoptera ...	...	...	...	...	...	*	...	*	*	...	...	*
Hemiptera ...	...	...	*	...	*	*	...	*	*	...	...	*
Coleoptera ...	...	...	*	...	*	*	...	*	*	...	*	*
Orthoptera ...	...	...	*	...	*	*	...	*	*	...	*	*
Neuroptera ...	...	...	*	...	*	*	...	*	*	...	*	*
Palæodictyoptera ...	...	...	?	...	...	*	...	*	*	...	...	*
ARACHNIDA ...	...	...	*	...	...	...	...	*	*	...	...	*

With regard to their first occurrence, as far as present

* Nicholson, "Manual of Palæontology," p. 141.

researches show,* the Orthoptera and Neuroptera appear in the Devonian, Coleoptera, and Hemiptera in the Carboniferous, Hymenoptera and Diptera in the Jurassic, and probably also the Lepidoptera represented by the *Palæontina oolitica*, the affinity of which is doubted by some entomologists; however in Tertiary strata Lepidoptera undoubtedly occur.†

In the Miocene strata of Switzerland no fewer than nine hundred species of insects have been noticed by Prof. Heer, belonging to all the Orders, of which the Coleoptera number more than five hundred, and associated with them are about seven hundred species of phanerogamous plants.

Mr. Herbert Goss, F.L.S., who has paid great attention to the subject, informs me that:—"The Neuroptera is certainly the oldest Order, as the only six specimens of insects as yet discovered in Devonian strata have all been referred to it; but as three or four of these Devonian insects exhibit characters common both to the Neuroptera and Orthoptera, Dr. Goldenberg had placed them in an extinct Order, which he has called Palæodictyoptera. Several species referable to this extinct Order, as well as a number of true Neuroptera, have also been discovered in the Coal Measures.

"The next Order to appear was the Orthoptera, which is better represented than any other Order in the Carboniferous period, no less than 51 species from the Coal Measures having, up to the present time, been named and described.

"The Coleoptera and Hemiptera are also represented in the Coal Measures, but as yet only two specimens of the former and three of the latter have been detected therein. A few specimens of the Coleoptera have been found in the Trias, but in no rocks of older date than the Lias have specimens of either that Order or the Hemiptera been obtained in any numbers. From the Lias of the Swiss Alps no less than 116 species of Coleoptera have been discovered, and some 29 species have been determined from British strata of that period. The Hemiptera are also tolerably well represented both in the British and Foreign Lias.

"The Orders next to appear on the Geological horizon seem to have been the Hymenoptera and Diptera, but the exact date of the first appearance of either of them is uncertain. A few doubtful

* Lubbock, "Origin and Metamorphoses of Insects."

† Taylor, "Popular Science Review," Jan. 1878, p. 41. "Facts and Arguments for Darwin," Translated by W. S. Dallas, 1869, p. 119.

fragments of the Hymenoptera have been recorded from the Swiss Lias and the Solenhofen Slate, and in this country a few specimens have been obtained from the Purbecks. A few remains of Diptera have been recorded from the Solenhofen Slate, and several from the English Purbecks; but neither specimens of this Order nor of the Hymenoptera are found in any numbers in any strata below the Tertiaries.

"The most recent Order is undoubtedly the Lepidoptera, as with the exception of a few specimens from the Jurassic rocks, most of which are very doubtful, the specimens recorded are all from Tertiary strata.

"You will observe that the Orders comprising the flower-feeding species have been the last to appear, and these species have not been found in any numbers prior to the period at which the dicotyledonous plants attained their highest state of development."

MOLLUSCA.—The Molluscs, so important to the Palæontologist, from their abundance, present some points of interest and significance with regard to their distribution, which seem to involve more than the law of succession, and partly suggests another enquiry—how far function was one of the plans of creative intelligence in maintaining the balance of power in the past economy of Nature?

Among the different Classes of Mollusca, as well as their subdivisions, there is a certain unequal and peculiar distribution. The highest and the lowest Classes, Cephalopoda and Brachiopoda have a long range in time; they were largely developed in the Palæozoic period, when many genera became extinct.

The Cephalopoda, which present various modifications in their generic forms, are divided into two Orders—the Dibranchiata and Tetrabranchiata, which, however, commenced at distinct periods of time. The Dibranchiate group, considered to represent the higher forms, make their first appearance, so far as the present evidence goes,* only in the Mesozoic rocks, and gradually increase to the present time, whereas the other division, Tetrabranchiata, swarmed in the seas of the Palæozoic period with genera of the families Nautilidæ and Orthoceratidæ, and in the Mesozoic, with the Ammonitidæ, while in the Tertiary are a few species of *Nautilus*,

* Prof. Williamson says, in the Silurian age these cuttle fishes were represented by the Orthoceras. "Manchester Science Lecture," 1877, see p. 11 and p. 32.

which persistent genus is the only representative of the Order at the present time.*

The fossil Pteropods and Heteropods are almost wholly Palæozoic forms, so that their succession cannot easily be traced, for in the Mesozoic, except *Bellerophina* (Gault) and a few in the Tertiary, their remains are wanting.

RANGE OF CEPHALOPODA, PTEROPODA, AND HETEROPODA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
CEPHALOPODA														
DIBRANCHIATA.														
<i>A. Octopoda</i>														
Argonautidæ ...	...	...	...	...	...	...	...	...	...	...	...	*	...	*
Oetopodidæ ...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
<i>B. Decapoda</i>														
Teuthidæ ...	...	...	...	...	...	...	...	*	...	*	...	...	...	*
Sepiadæ ...	...	...	...	...	...	...	...	*	...	*	...	...	...	*
Belemnitidæ ...	...	...	...	...	...	...	...	*	*	...	...	...	...	*
Spirulidæ ...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
TETRABRANCHIATA.														
Nautilidæ ...	...	...	...	*	*	*	...	*	*	*	*	...	...	*
Orthoceratidæ ...	...	*	*	*	*	...	*	*	*	*	*	...	...	*
Ammonitidæ ...	...	...	...	*	*	...	*	*	*	...	...	...	...	*
PTEROPODA.														
Gymnosomata ...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Thecosomata ...	...	*	*	*	*	...	...	...	...	*	*	*	...	*
HETEROPODA.														
Firolidæ ...	...	...	...	...	...	...	...	...	...	...	*	...	...	*
Atlantidæ ...	...	...	*	*	*	...	*	...	*	...	...	...	...	*

M. Barrande describes nearly 90 species of *Theca*, more than 80 species of *Conularia*, and about 50 species of *Tentaculites* from the Palæozoic rocks.

The Gasteropoda present some interesting facts in their distribution. There are two chief divisions—one in which the shell has an entire aperture, and the other which has the aperture more or less notched or prolonged into a canal. These two divisions, as far as our knowledge of the habits of the recent animals

* M. Barrande enumerates 26 genera, and subgenera of Cephalopods, containing 2,312 species in the Palæozoic rocks. The persistent genus, *Nautilus*, has 119 Palæozoic, 157 Mesozoic, 19 Tertiary, and three recent species.

extends, are thus differentiated: the Holostomata are chiefly herbivorous, although some of them, as the Naticidæ, are animal feeders, while the Siphonostomata include those families which are mostly flesh-eaters or zoophagous.

The distribution in time of these two divisions is shown in the table. It will be seen that the Holostomata were abundant in the Palæozoic seas, while there is scarcely any trace of the Siphonostomous Molluscs during the same period, from which the inference arises that co-existent with these Holostomata there must have been some vegetable matter, though apparently all traces of it are nearly lost in the Lower Palæozoic rocks.*

The Holostomata, comparatively abundant in the Palæozoic period, were equally or even more abundant in the Mesozoic, and also in the Tertiary period, but the Siphonostomata, entirely wanting in the Palæozoic period, commence in the Mesozoic, and become far more largely developed in the Tertiary than in any preceding period.†

The great abundance of the Cephalopoda in the Lower Palæozoic, and of carnivorous fish in the Upper Palæozoic, may have partly represented and compensated for the absence of the Siphonostomata in modifying the increase of the herbivorous and other Mollusca of those periods.

The Pulmonifera are not only widely distributed at present, but range far back in time, *Pupa* and *Helix* (Zonites) being found in the Carboniferous rocks of Nova Scotia; *Physa*, *Planorbis*, *Valvata*, and *Limnea* (?) occur in the Purbeck beds and succeeding Tertiary freshwater strata, although absent in the Wealden, where they are replaced by the branchiferous genus, *Paludina*.

Among the freshwater bivalves two or three genera may be considered persistent forms; thus the genus *Anodon* is found in the Old Red Sandstone, and although not yet noticed in the Mesozoic rocks, is continued through the Tertiary period. *Cyrena* ranges from the Lower Oolites upwards, and is now restricted to the freshwaters of Africa and Asia. *Unio* and *Cyclas* are widely distributed, the former ranging from the Lower Oolite and the latter from the Tertiary strata.

* Anthracitic and carbonaceous shales and Fucoidal schists have been noticed in the Lower Silurian.

† A set of extensive tables prepared by Mr. J. Logan Lobley some years ago were exhibited at the meeting, which showed in a novel manner the distribution of the families, genera, and the numerical proportion of the species in the various formations, and thus rendered the subject very intelligible.

RANGE OF GASTEROPODA.

	Cambrian.	Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
I. PROSOBRANCHIATA.													
<i>Siphonostomata.</i>													
Strombidæ ...	...	...	...	...	...	...	*	*	*	*	*	*	*
Muricidæ ...	...	...	...	...	...	...	...	*	*	*	*	*	*
Buccinidæ ...	...	...	...	...	...	...	*	...	*	*	*	*	*
Conidæ ...	...	...	...	...	...	...	...	...	*	*	*	*	*
Volutidæ ...	...	...	...	...	...	...	...	*	*	*	*	*	*
Cypræidæ ...	...	...	...	...	...	...	...	...	*	*	*	*	*
<i>Holostomata.</i>													
Naticidæ ...	...	...	...	*	*	...	...	*	*	*	*	*	*
Pyramidellidæ ...	...	...	*	*	*	...	*	*	*	*	*	*	*
Cerithiadæ ...	...	...	...	...	...	*	*	*	*	*	*	*	*
Melaniadæ ...	...	...	...	...	...	...	*	*	*	*	*	*	*
Turritellidæ ...	...	...	*	*	*	...	...	*	*	*	*	*	*
Litorinidæ ...	...	...	...	...	*	...	...	*	*	*	*	*	*
Paludinidæ ...	...	...	...	...	...	...	*	*	*	*	*	*	*
Neritidæ ...	...	...	*	*	*	...	*	...	*	...	...	*	*
Turbinidæ ...	...	...	*	*	...	*	*	...	*	*	*	...	*
Haliotidæ ...	...	...	*	*	...	*	*	...	*	...	...	...	*
Fissurellidæ ...	...	...	...	...	...	*	*	*	*	...	*	*	*
Calyptræidæ ...	...	...	...	*	...	...	...	*	*	...	...	*	*
Patellidæ ...	...	...	...	*	...	...	*	...	*	*	*	*	*
Dentalidæ ...	...	...	...	*	...	...	*	*	*	*	...	*	*
Chitonidæ ...	...	...	*	...	...	...	...	...	...	...	...	...	*
II. OPISTHO-BRANCHIATA.													
Tornatellidæ ...	...	...	...	*	...	...	*	*	*	...	*	...	*
Bullidæ ...	...	...	...	...	...	...	*	...	*	*	*	...	*
III. PULMONIFERA.													
Inoperculata ...	...	...	...	*	...	...	*	...	*	*	*	*	*
Operculata ...	...	...	...	...	...	...	...	...	*	...	*	*	*

Of the Holostomatous forms referred to, the following living genera have been noticed in the Palæozoic rocks :—*Capulus*, *Chiton*, *Chemnitzia*, *Dentalium*, *Turbo*, *Turritella*, and *Pleurotomaria*; the latter, abounding in the Secondary rocks, is scarcely represented in the Tertiary, and has one living species. On the other hand, the Siphonostomous families Conidæ, Volutidæ, and Cypræidæ are nearly restricted to and characteristic of the Tertiary rocks.

The Lamellibranchiata, or bivalve Molluscs, are divided into Asiphonida and Siphonida, according as they are without or provided with siphonal tubes.

The greater number of the Palæozoic bivalves belong to the

Asiphonida, as the Aviculidæ, Arcadæ, Mytilidæ,* with some Siphonida as Cardiadæ and Cyprinidæ; on the other hand, the sinupalleal Siphonida are feebly represented in the Palæozoic rocks, but most of the families commence in the Mesozoic period, and attain their maximum of species in the Tertiary, while the greatest development of the Asiphonida is in the Jurassic strata.†

The Siphonida are further arranged in two divisions—Integropalleal and Sinupalleal—dependent on the palleal line being entire or more or less broken by a deep inflexion or sinus. These two divisions present somewhat different structures, and have different habits; those with a sinus have more or less elongated tubes for the purpose of aeration, and mostly burrow in the sand, mud, or rock; those with the palleal line entire have no tubes, or very short ones.

RANGE OF LAMELLIBRANCHIATA.

	Cambrian.	Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
I. ASIPHONIDÆ—													
Ostreidæ	...	...	...	...	...	*	*	*	*	*	*	*	*
Aviculidæ	...	*	*	*	...	*	*	*	*	...	...	...	*
Mytilidæ	*	*	*	*	*	*	*	...	*	*	*	*	*
Arcadæ	*	*	*	*	...	*	*	*	*	*	*	...	*
Trigonidæ	...	*	*	*	*	*	*	*	...	...	...	...	*
Unionidæ	...	...	*	...	...	...	...	*	*	*	*	*	*
II. SIPHONIDÆ—													
A. Integropalliala.....													
Chamidæ	...	...	...	...	...	...	*	*	*	...	...	...	*
Hippuritidæ	...	...	...	...	...	...	...	*	...	...	...	...	*
Tridacnidæ	...	...	...	...	...	...	...	...	...	*	...	...	*
Cardiadæ	...	*	...	*	...	*	*	*	*	*	...	...	*
Lucinidæ	...	?	...	...	...	...	*	...	*	*	*	...	*
Cycladidæ	...	...	...	...	...	...	*	*	*	...	...	*	*
Cyprinidæ	...	?	*	*	*	*	*	*	*	*	*	*	*
B. Sinupalliala													
Veneridæ	...	...	...	...	...	...	*	*	*	*	*	...	*
Mactridæ	...	...	...	...	...	...	?	...	*	*	*	...	*
Tellinidæ	...	...	...	...	...	...	*	*	*	*	*	...	*
Solenidæ	...	...	...	...	...	...	...	*	*	*	*	...	*
Myacidæ	...	...	...	...	...	...	*	*	*	*	*	...	*
Anatinidæ	...	*	...	*	*	...	*	*	*	*	...	...	*
Gastrochaenidæ	...	...	...	...	...	...	*	...	...	*	*	...	*
Pholadidæ	...	...	...	...	...	...	*	*	*	*	*	*	*

* Phillips' "Memoirs of the Geological Survey," Vol. 2, p. 264.

† Lohley, "Distribution of British Fossil Lamellibranchiata," Quart. Journ. Geol. Soc., 1871, p. 411.

The Hippuritidæ, so characteristic of the Cretaceous rocks of the South of Europe, is the only extinct family of Lamelli-branchiata. The more persistent forms of this class are—*Avicula*, *Modiola*, *Nucula*, *Pinna*, *Solen*.

RANGE OF THE BRACHIOPODA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
INARTICULATA—														
Lingulidæ	*	*	*	*	*	*	...	*	*	*	...	...	...	*
Discinidæ	*	*	*	...	*	*	...	*	*	...	...	*	...	*
Craniadæ	...	*	*	*	*	...	...	*	*	...	...	...	...	*
Trimerellidæ	...	*												
ARTICULATA—														
Terebratulidæ	...	...	...	*	*	*	*	*	*	*	...	*	*	*
Rhynchonellidæ	...	*	*	*	*	*	...	*	*	...	...	*	*	*
Spiriferidæ	...	*	*	*	*	*	*	*	*	...	...	*	*	*
Orthidæ	*	*	*	*	*	*	*	*	*					
Productidæ	...	...	...	*	*	*	*	*	*					
Thecididæ	...	...	...	...	...	...	*	*	*	*	...	...	...	*

The class Brachiopoda is divided into the Inarticulata or Treten-terata and the Articulata or Clistenterata.

The Inarticulata have, with the exception of *Trimerella*, a long range in time, and thus *Lingula*, *Discina*, and *Crania* may be considered persistent types differing little from their first appearance.

Rhynchonella and *Terebratula* of the Articulata extend from the Palæozoic rocks to the present time, others range only from the Palæozoic to the Secondary, as *Spirifera* and *Strophalosia*; other genera are restricted to special formations, as *Stringocephalus* and *Davidsonia* to the Devonian, and *Koninckia* to the Trias.*

* Of the 122 genera noticed by Mr. Davidson, 82 are confined to the Palæozoic rocks, nine are peculiar to the Secondary period, and nine are found living only. Again, 9 genera appear for the first time in the Cambrian, 53 Silurian, 21 Devonian, 7 Carboniferous, 2 Permian, 2 Trias, 10 Jurassic, 5 Cretaceous, 2 Tertiary, and 9 in the recent period.—“Qu'est ce qu'un Brachiopode,” par Th. Davidson, Traduit par Th. Lefèvre, Ann. Soc. Malac. de Belgique, tome x.; and Geol. Mag., 1877. See also Lobley, “Distribution of British Fossil Brachiopoda,” Geol. Mag., Nov., 1868, and Proc. Geol. Assoc., Vol. 2.

The Bryozoa or Polyzoa* occur from the Cambrian rocks upwards, mostly in calcareous deposits, and are represented by many forms chiefly belonging to the Cyclostomata and Cheilostomata. In the Palæozoic rocks all the genera are extinct, and do not range into the Mesozoic, and chiefly belong to the family Fenestrellidæ. In the Jurassic and Cretaceous rocks the Polyzoa are numerous, especially in the latter. In the Tertiary they are also abundant in some deposits, as the Suffolk Crag, where the still living genera, which first appear in the Jurassic strata, increase in numbers.

VERTEBRATA.—Having given, generally, the geological distribution of the Invertebrata, I shall attempt to state briefly some leading facts connected with the range in time of the Vertebrata.

The great groups or types of the Invertebrata and Vertebrata have not a parallel distribution in time.

The five types of the Invertebrata occur together in the Lower Palæozoic rocks, *i.e.*, Lower Silurian, or, perhaps, the Cambrian, while the five types of the Vertebrata appear nearly in the order of their relative organisation, *viz.*, Pisces, Amphibia, Reptilia, Aves and Mammalia.

The Class Pisces, or the fishes, first appear in the Upper Silurian, for thousands of feet of sedimentary strata were accumulated, through long periods of time, during which the Palæozoic sea was only tenanted by the Invertebrata, not only in Europe, but in America. They are represented in the Upper Silurian of Europe (with the doubtful exception of the Conodonts) by a few remains of the genera *Pteraspis* and *Onchus*.

In the Silurians of America no fishes occur; for there they first appear in the Devonian, and among them are some gigantic forms of Placoderms as *Dinichthys* and its allies.

The student of biology and the laws of evolution may pause here and reflect on the fact, that from the geological horizon of *Eozoon Canadense*, we have passed through nearly 18 miles in thickness of oceanic deposits, representing many ages for their deposition, while the changes in the forms of life have been numerous and wonderful, and the development into higher forms constant

* Mr. Pascoe, in his "Zoological Classification," classes the Polyzoa with the Vermes, p. 36.

throughout the whole period. Yet that life had found its complete development in the lowly organised articulate animal—the somewhat awkwardly constructed, loosely thrown together, flimsy *Eurypterus*.*

The Elasmobranchs and Ganoids, which are especially characteristic of the Palæozoic age, also occur in America, but are not so numerous as in the Old Red Sandstone of Europe, where they present remarkable and interesting forms, some of them being allied to the *Polypterus*, and others to the Dipnoid fishes.

The same Orders extend, with different generic forms, through the Carboniferous and Permian strata, and thus these Orders are characteristic of the Palæozoic period.

The Elasmobranchs and Ganoids—the latter with homocercal tails and mostly related to *Lepidosteus*—continue through the Mesozoic period, but are peculiar only to the lower part, the Triassic and Jurassic, for in the Upper Cretaceous the Cestracionts and Chimæroids are associated with the first incoming of the Teleostean fishes, which increase in number in the Tertiary period and constitute the dominant Order in the present seas. The two other Orders are represented in the Tertiary period and at the present time, but considerably diminished in numbers, especially the Ganoids.

Mr. Carruthers,† in his suggestive Address, pointed out that, through long ages of the earth's history, the land plants consisted chiefly of Cryptogams, Gymnogens, and some Endogens, but it was only in the Cretaceous period that Dicotyledonous plants first appeared, showing a somewhat marked relation between the incoming of certain animals and certain plants; at any rate the appearance of Teleostean fish, contemporary with the first known appearance of Dicotyledonous plants, is a singular coincidence.‡

Among the more persistent genera of fish is the *Ceratodus* which occurs in the Trias, Lower and Upper Oolite, and although absent

* Miller, "The American Palæozoic Fossils," Cincinnati, Ohio, 1877.

† Proc. Geol. Assoc., Vol. v., p. 1.

‡ See Plate, p. 220, which has been kindly lent by the Publishers of "Popular Science Review," having been used to illustrate a paper on the Cretaceous Flora, in that Journal, for Jan., 1876.

in the succeeding formations, is now living in the freshwaters of Queensland. The *Beryx* (Ctenoid) of the Chalk is a present Atlantic genus, and the *Lepidosteus* (Ganoid) of the Eocene is the modern gar-pike of the North American rivers, and was represented in the Wealden by *Lepidotus*, and probably in the Trias by *Ischypterus*.

AMPHIBIA first appear in the Carboniferous rocks, represented by the Labyrinthodontia, which extend through the Permian (except in America) into the Trias. No traces of Amphibia have been recorded from the Jurassic and Cretaceous strata of Europe and America. In the Tertiary period most of the forms were related to modern types.

RANGE OF PISCES, AMPHIBIA AND REPTILIA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Teleostei ...	...	...	...	...	...	...	...	...	*	*	*	*	*	*
Placodermi ...	...	...	...	*	*	...	*	*	*	*	*	*	*	*
Elasmobranchii ...	...	...	*	*	*	...	*	*	*	*	*	*	*	*
Holocephali ...	...	...	...	*	*	...	...	*	*	*	*	*	*	*
Ganoidei ...	...	...	...	*	*	*	*	*	*	*	*	*	*	*
Dipnoi ...	...	...	...	*	*	...	*	...	...	...	...	...	...	*
Ostracostei ...	...	...	*	*	*	...	...	...	...	...	...	...	...	*
AMPHIBIA.														
Urodela ...	...	...	...	...	...	*	*	...	...	...	...	...	...	*
Batrachia ...	...	...	...	...	...	*	*	...	...	...	*	...	...	*
Labyrinthodonta ...	...	...	...	...	*	*	*	...	...	...	*	...	...	*
Gymnophiona ...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
REPTILIA.														
Ophidia ...	...	...	...	...	...	...	...	...	...	*	*	*	...	*
Chelonina ...	...	...	...	...	...	P	...	*	*	*	*	...	...	*
Mososauria ...	...	...	...	...	...	...	...	*	*	*	*	...	...	*
Lacertilia ...	...	...	...	...	...	*	*	*	...	*	*	...	...	*
Crocodylia ...	...	...	...	...	...	*	*	*	*	*	*	*	...	*
Ichthyosauria ...	...	...	...	...	P	...	P	*	*	*	*	*	...	*
Sauropterygia ...	...	...	...	...	...	...	P	*	*	*	*	*	...	*
Anomodontia ...	...	...	...	...	...	...	*	*	*	*	*	*	...	*
Dinosauria ...	...	...	...	...	...	...	*	*	*	*	*	*	...	*
Pterosauria ...	...	...	...	...	...	...	*	*	*	*	*	*	...	*
Pteranodontia ...	...	...	...	...	...	...	...	*	*	*	*	*	...	*
Theriodontia ...	...	...	...	...	...	P	*	...	...	...	...	...	...	*

REPTILIA.—With the exception of some vertebræ referred to *Eosaurus* by Professor Marsh, from the Carboniferous rocks of America, reptiles first appear in Europe with the lizard-like form *Proterosaurus* in the Permian beds of England and Thuringia; in the same formation also occur some remains referred to the Theriodont reptiles, which, however, are more characteristic of the Trias of South Africa.* In the succeeding Triassic and Jurassic rocks most of the Orders of reptiles appear, so that the Mesozoic has been termed the Age of Reptiles from their abundance. During the Triassic period some genera were widely distributed;† among the more remarkable forms are the Deinosauria, which extend to the Cretaceous. The Pterodactyles are both Jurassic and Cretaceous, but on the American continent they are represented in the Chalk of Kansas by an allied Order, without teeth—the Pteranodontia. These toothless Pterodactyles of America are singularly enough associated in the same formation with the remarkable toothed birds, the Odontornithes hereafter noticed.

The Chelonia which commence in the Lower Oolites, except the foot-prints noticed in the Permian, belong to this Order.

Another order of Reptilia is essentially Cretaceous. The Mososauria,‡ although scantily represented in Europe, are the most characteristic reptiles of the American Cretaceous strata, and in the seas of that period “they ruled supreme, as their numbers, size, and carnivorous habits enabled them easily to vanquish all rivals.”§

From the table it will be seen that eight of the Orders became extinct during the Mesozoic age, three only, which commenced in that period, extend through the Tertiary to the present time; these

* Owen, “Fossil Reptilia of South Africa,” 1877. This order derives its name from the resemblance in the dentition to the class Mammalia.

† Huxley, on the Classification of the Dinosauria. Quart. Journ. Geol. Soc., Vol. 26, p. 32.

‡ Marsh, Address, p. 14.

§ Prof. Owen regards the Mososauria as a family of Lacertilia equivalent to the Iguanodontidæ and Megalosauridæ in the order Dinosauria. The order Lacertilia among Reptiles being equivalent to the order Carnivora or Fera among Mammals, the Mososaurians would be the equivalents of the Seals in the latter. Proc. Geol. Soc., No. 238, June, 1877.

three—the Chelonia, Crocodilia, and Lacertilia—are, however, associated in the Eocene strata with the Order Ophidia, which appears, for the first time in the Lower Tertiary beds both of Europe and America. In the latter country remains of snakes are abundant in the freshwater Eocene.

The Crocodilia, with their successive amphicoelian, opisthocœlian, and procœlian vertebræ, have a long range in time from the Trias upwards, the former two divisions occur in the Lower Mesozoic rocks; the procœlian, to which the modern forms belong, commence in the Cretaceous of America and in the Eocene of Europe, and extend through the Tertiary.

In the Eocene deposits of England, as shown by Professor Owen, the three existing types are found together—Crocodile, Alligator, and Gavial—but which are now widely separated.*

AVES.—The birds (as at present known) are more restricted in time than the three preceding classes of Fishes, Batrachia, Reptiles, and even than the Mammals, if the foot-prints (*Brontotherium*) on the Triassic sandstones of Connecticut river do not belong to birds, but to reptiles.†

In the succeeding Jurassic strata birds commence with the singular genus *Archæopteryx* (Saururæ); in the Cretaceous rocks of Europe‡ remains of birds are rare, but in similar strata in America they are more abundant, and associated with allied modern forms is a remarkable Order of toothed birds, the Odontornithes, which together with other structures (as the biconcave vertebræ in *Ichthyornis*) present reptilian characters. The struthious birds (Ratitæ), which at the present day are nearly restricted to the southern hemisphere, occur in the Eocene of Europe as *Gastornis* and *Dasornis*, and in the Post-Pliocene of New Zealand, where these are abundant, and of gigantic sizes as *Dimornis*, preceding the now small wingless *Apteryx*. This Order is widely distributed,

* The Alligator is found in the West Indies, the Crocodile in the Nile, and three species of Crocodile in the Ganges associated with the Gavial. Owen, Pal. Soc., 1850.

† The evidence of their presence in the Trias, based on footprints and other impressions, is at present, as we have seen, without value, although we may confidently await their discovery there, if not in older formations. Professor O. C. Marsh, "Address," p. 18.

‡ Seeley, Cretaceous Birds, Quart. Journ. Geol. Soc., Vol. xxxii., p. 496.

from which is inferred its great antiquity, and each genus is restricted to its special province.*

Most of the existing groups of the Carinatae, to which all the other modern birds belong, are found in the Eocene deposits (represented by extinct genera), and in the succeeding Miocene and later strata. During the Tertiary periods birds were numerous in America.

Mr. S. Wood† has attempted to show (inferring their existence in the Trias) that the modern Struthionidae exist only in lands which are remnants of Secondary continents; and that as regards all the other wingless birds, except the Struthionidae, *i.e.*, the birds of Madagascar, the Mauritius, and adjoining Islands, and of New Zealand, they exist only in *isolated* remnants of those continents; and not less significant is it, that these forms of Mammalia and of modern wingless birds are associated with vegetable forms having the nearest affinities to the vegetation of the Secondary and Carboniferous periods—as witness the tree ferns and Cycadeae of Madagascar, Australia, and New Zealand, and the Araucariae of various parts of the southern hemisphere; while in the *Cestracion* and *Trigonias* of the Australian shores are preserved the only living examples of those Secondary genera.

RANGE OF AVES.

						Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Odontornithes	...	...	...	...	...	...	...	*					
Saururæ	...	...	...	...	...	...	...	*					
Ratitæ ...	...	...	...	...	...	?	...	...	*			*	*
Carinatae	...	...	...	...	...	...	...	?	*	*	*	*	*

* The Struthionides or Ratitæ include the African Ostrich, the Rhea of South America, the Emu of Australia, the Apteryx of New Zealand, and the Cassowary of the Indian Archipelago.

† "On the Form and Distribution of the Land-tracts during the Secondary and Tertiary Periods," by S. Wood, jun. Lond. and Edinb. Phil. Mag., 1862, Vol. 23, which paper also contains some valuable and suggestive remarks on the effects upon animal life produced by great geographical changes.

With regard to the Mammalia I shall very briefly explain their distribution, as shown by the following table:—

RANGE OF MAMMALIA.

	Trias.	Jurassic.	Cretaceous.	Eocene.	L. Miocene.	U. Miocene.	Pliocene.	Pleistocene.	Recent.
Marsupialia	*	*	...	*	*	...	...	*	*
Edentata	...	...	...	...	...	*	*	...	*
Cetacea	...	...	...	...	...	*	*	...	*
Sirenia	...	...	...	*	...	*	*	...	*
Perissodactyla	...	...	...	*	*	*	*	*	*
Artiodactyla	...	...	...	*	*	*	*	*	*
Bunodontia	...	...	...	*	*	*	*	*	*
Selenodontia	...	...	...	*	...	*	*	*	*
Hollow-horned Ruminants	...	...	...	...	...	*	*	*	*
Oreodontida	...	...	...	...	*	*	*	*	*
Proboscidea	...	...	...	...	*	*	*	*	*
Dinocerata*	...	...	...	*	...	...	...	*	*
Toxodontia	...	...	...	...	...	...	...	*	*
Tillodontia†	...	...	...	*	...	...	...	*	*
Rodentia	...	...	...	...	*	*	*	*	*
Cheiroptera	...	...	...	*	...	...	...	*	*
Insectivora	...	...	...	*	*	*	*	*	*
Carnivora	...	...	...	*	*	*	*	*	*
Pinnipedia	...	...	...	...	...	...	...	*	*
Plantigrada	...	...	...	...	...	...	*	*	*
Digitigrada	...	...	...	*	*	*	*	*	*
Quadrumania	...	...	...	*	*	*	*	*	*
Bimana	...	...	...	...	...	...	*	*	*

In the Super-Cretaceous rocks first appears the great incoming of the Mammalian class—not represented by one form, but by many forms. Have we yet to discover any ancestral type, or are we to consider that in this sudden appearance of a rich fauna, certain new creative powers were exercised, by which groups of animals were then introduced upon the surface of the earth?†

* These animals appear to belong to the great Ungulated group, and to hold a position somewhat intermediate to the Perissodactyles and the Proboscidea. Professor Flower, "The Extinct Animals of North America," Proc. Roy. Inst., 1876.

† Combine the characters of Carnivores, Ungulates and Rodents.

‡ Professor Marsh remarks—"If the history of American mammals seems as a whole incomplete and unsatisfactory, we must remember the genealogical tree of this class has its trunk and larger limbs concealed beneath the *débris* of Mesozoic time, while its roots doubtless strike so deeply into the Palæozoic that for the present they are lost. A decade or

This is still a broad and open question. From the table it will be seen that of all the groups represented in the Tertiary period, only one, as at present known, extends far back in time; that is the group of pouched animals or Marsupials.*

In the Triassic rocks of Europe and America, Marsupial mammals first occur; represented in the former country by the *Microlestes* and in America by the *Dromatherium*,† considered to be related to the living *Myrmecobius* of Australia. In the succeeding Oolitic strata other Marsupial genera are found, as *Amphitherium* and *Phascolotherium*, associated with a doubtful form of perhaps higher grade, the *Stereognathus*.

In the Purbeck beds are many forms referred to this Order,‡ and though not found in Cretaceous, they occur again in the Eocene. "The low, comparatively non-differentiated condition of the Mesozoic Marsupials of Europe have been succeeded and finally represented in Europe by differentiated carnivorous climbers (*Didelphidæ*); but on this continent they did not survive to enter the latter half of the Neozoic period. Our latest European fossil Marsupial is a Miocene Opossum."‡

In the still later Post-Tertiary deposits of South America, Marsupial remains are found nearly related to those now living, and the probably contemporaneous strata of Australia have yielded gigantic forms of Diprotodons, Kangaroos, and others, which foreshadowed the "great diversity and specialisation of structures" which are found in the present varied marsupial fauna so characteristic of the Australian province. Hence arises one of the broader questions which has to be considered with regard to present distribution, viz., under what conditions, or by what means, similar forms to those which lived in the older Mesozoic period are now restricted to the Australian continent?

Mr. Wallace, in alluding to the Marsupials in the Trias of Europe and North America, says, "We have, therefore, every reason

two hence we shall probably know something of the mammalian fauna of the Cretaceous, and the earlier lineage of our existing mammals can then be traced with more certainty." Address, Amer. Assoc. Science, 1877.

See also, Gaudry, "Les Enchainements de Monde Animal dans le temps géologiques," Paris, 1878.

* Owen, "Mesozoic Mammals," Pal. Soc.

† Emmons—"American Geology," part vi., 1857, p. 93.

‡ The "Fossil Mammalia of the Mesozoic Formations," by Prof. Owen F.R.S., Pal. Soc., 1871.

§ *Ibid*, p. 113.

to believe that it was at or near this remote epoch when Australia, or some land which has been since in connection with it, received a stock of mammalian immigrants from the great northern continent; since which time it has almost certainly remained completely isolated.”*

The Edentata do not occur in the Eocene; a few are found in the Miocene, including *Moropus*, but in the Pliocene and Post-Pliocene they are widely distributed, especially in the later deposits of North and South America, and are now the characteristic mammals of the latter country.

The Cetacea first appear in the Eocene both of Europe and America, and are well represented in the Miocene of the latter country by the *Dalphin* family, and are tolerably abundant in the Pliocene (*Crag*) deposits of England and Belgium.

The *Sirenia* occur in the Eocene of Europe, and also in the Miocene of Europe (the genus *Halitherium*), and of America and throughout the later Tertiary; being represented at the present day by the Dugong and Manatee, and until recently by the *Rhytina*, which has now become extinct on the north-west coast of America, where it was once abundant. “The separation of the existing species in distant localities suggests that they are the remnants of an extensive group, once widely distributed” (Marsh).

The odd-and-even toed Ungulates, or the Perissodactyle and Artiodactyle groups, were the most abundant mammals in the Tertiary period, and range through all its divisions. They include a variety of fossils and some living genera as the horse and tapir among the Perissodactyles, and the Suillines of the Artiodactyles, which are considered to be the present modified representatives of a series of forms which can be traced through various changes from the Eocene upwards.†

The Hollow-horned Ruminants appear to have commenced in the Miocene, but are more fully developed in the later periods, as the Bison and Urus. The Musk-sheep, restricted now to Arctic America, was widely distributed in Post-Pliocene times over a great part of Europe and in America.

* A. R. Wallace—“Comparative Antiquity of Continents,” Proc. Roy. Geogr. Soc., Vol. xxi., 1877.

† See the interesting and suggestive Address, by Prof. O. C. Marsh, “Introduction and Succession of Vertebrate Life in America,” Nashville, 1877.

The Proboscidea commence in the Miocene by *Deinotherium*, and the *Mastodon*, *Stegodon*, and *Elephas* (in the Sevaliks) which latter genus, however, is not found in the Miocene of Europe or America, but is continued in Pliocene and Post-Pliocene times by the sub-genera *Loxodon* and *Euelephas*, to which the living African and Asiatic elephants belong.*

The Toxodontia, related to the Rodentia, Edentata, and Ungulata, are peculiar genera, hitherto only found fossil in the Post-Tertiary deposits of South America.

The Rodentia commenced in the Eocene period, are fully represented in the Miocene and Pliocene strata of North America, and were as equally abundant in the Post-Tertiary of South America as they are at present.

Both Cheiroptera (as *Vespertilio*) and Insectivora occur in the Eocene, but they do not appear to be common to the later periods. Insect-eating Bats existed in the Miocene period, as also did Moles and Hedgehogs; and in the Post-Tertiary caves of Brazil many remains of Bats have been noticed belonging to living genera of Phyllostomidae—a family peculiar to South America.

The Carnivora range from the Eocene (as *Canis*), and the remains of numerous genera are found in the Miocene, Pliocene, and Post-Pliocene strata.

The Quadrumana are represented by several genera in the Eocene period related to the Lemurs, and their remains are found in the Miocene and later Tertiary. Remains of Monkeys are abundant in the Brazilian caves, and these belong to genera now living in South America. No remains of Old World Monkeys have been found in America.

* Prof. Marsh states with regard to the Equine sequence in the American Tertiaries, that the earliest representative of the horse is the small *Eohippus* of the Lower Eocene, which is succeeded in the Middle and Upper Eocene by *Orohippus*. In the Lower Miocene is *Mesohippus*, followed in the upper part by *Miohippus*, allied to the *Anchiterium* of Europe, and in the Lower Pliocene by the more equine *Protohippus*, which resembles the *Hipparion* of Europe, and the very equine *Pliohippus*. In the Upper Pliocene only, does the true *Equus* appear, which in the Post Tertiary roamed over the whole of North and South America, and soon after became extinct.—“Address,” p. 32.

Prof. Marsh remarks, “The Himalayan deposits called Upper Miocene, and so rich in Proboscideans, indicate in their entire fauna that they are more recent than our Neobrara river beds, which, for apparently good reasons, we regard as Lower Pliocene. The latter appear to be about the same horizon as the Pikermi deposits in Greece, also regarded as Miocene.” —“Address,” p. 51.

This brief review of the distribution of the Animal Kingdom in geological time shows that it was not only one of progress but of gradual differentiation, and also that by the various physical changes which the earth's surface has undergone, the faunas of the later Tertiary period have become more isolated, and have differentiated in the marked geographical provinces to which I have previously alluded, in each of which the present mammalian fauna is closely related to its antecedents in the Post-Pliocene period of the same area,* and in some cases their ancestral forms may be traced still farther back in the Tertiary period, thus showing the law of the geographical succession of types which Mr. Darwin has so clearly enunciated.†

In thus bringing before your notice some of the facts upon which our deductions must be based, I must beg you to remember that much more time than is at my disposal this evening would be required to treat of them thoroughly. Looking, however, generally at the higher forms of Vertebrata, it will be seen that most of the great Orders, with the exception of the Marsupials, commenced in the Eocene or Lower Tertiary period, in which nearly all the genera are extinct, and they have been more or less continued through various forms to the present day, where they culminate in the existing groups of mammals.

In comparing, therefore, the plant-life with that of the Invertebrata, foreshadowed slightly as each Kingdom was in the preceding period—the sudden incoming of Cryptogams and a few Gymnogens with the Palæichthic life of the Devonian and Carboniferous seas, --the marked appearance of Gymnogens (Cycads and Conifers) with the first great development of Reptile life, and the nearly contemporaneous appearance of the Dicotyledons with most of the Orders of Mammalia at the commencement of the Eocene period, is a singular and interesting fact in the succession of life on the globe. (See Plate, p. 220).

The study of the Earth's history reveals a succession of forms, whether the result of continuous evolution, of modification by

* Thus the present Marsupial fauna of Australia, the Edentate fauna of South America, were respectively represented by Marsupial and Edentate genera in the Post-Tertiary deposits of the same countries; so the wingless birds of New Zealand were preceded by gigantic forms of a similar order; and even in the Arctogæal province most of the mammalia were foreshadowed by extinct species of the same genera in the Post-Pliocene period.

† "Origin of Species," Fourth Edition, p. 406.

descent, whether by means of successive creations, or "by orderly succession and progression due to Natural Law or Secondary cause,"* or by the operation of some higher law of change and progress conjointly acting with other causes, by which the numerous forms now peopling the earth came into existence.

Whatever may be the law of that progress, there can be little doubt, when viewed rightly, that in all past times of the earth's history there has existed the same unity and order, the same balance of power, the same adaptation of organic life to the successive inorganic conditions, the same evidence of creative intelligence and design, as we see displayed throughout existing nature at the present period, and as will doubtless be continued in the future; or, as was once tersely said by Professor Phillips, "The present explains the past, and reveals the future."

ORDINARY MEETING, NOVEMBER 2ND, 1877.

Professor JOHN MORRIS, F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Lecture on the Antiquity of Man," by Prof. T. Rupert Jones, F.R.S., 1877; from the Author.

"On the Corallian Rocks of England," by the Rev. J. F. Blake, M.A., F.G.S., and W. H. Hudleston, M.A., F.G.S., 1877; from the Authors.

"Quarterly Journal of the Geological Society of London," August, 1877; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," No. 339; from that Society.

"Journal of the Quekett Microscopical Club," July, 1877; from the Club.

"Annual Report of the Committee of the Bath Royal Literary and Scientific Institution," for the year 1876; from that Institution.

"Annual Report of the Bristol Naturalists' Society," for 1876 and 1877; from that Society.

"Proceedings of the Berwickshire Naturalists' Club," Vol. viii., No. 1.

* Owen, "On the Nature of Limbs," 1849, p. 86.