ON THE PROGRESS OF PALÆONTOLOGY

ANNIVERSARY ADDRESS DELIVERED BEFORE THE GEOLOGICAL SOCIETY

IT is now eight years since, in the absence of the late Mr. Leonard Horner, who then presided over us, it fell to my lot, as one of the secretaries of this society, to draw up the customary Annual Address. I availed myself of the opportunity to endeavour to "take stock" of that portion of the science of biology which is commonly called "palæontology," as it then existed; and discussing one after another the doctrines held by palæontologists, I put before you the results of my attempts to sift the well-established from the hypothetical or the doubtful. Permit me briefly to recall to your minds what those results were.

1. The living population of all parts of the earth's surface which have yet been examined, has undergone a succession of changes which, upon the whole, have been of a slow and gradual character.

2. When the fossil remains which are the evidences of these successive changes, as they have occurred in any two more or less distant parts of the surface of the earth, are compared, they exhibit a certain broad and general parallelism. In other words, certain forms of life in one locality occur in the same general order of succession as, or are *homotaxial* with, similar forms in the other locality.

3. Homotaxis is not to be held identical with synchronism without independent evidence. It is possible that similar, or even identical, faunæ and floræ in two different localities may be of extremely different ages, if the term "age" is used in its proper chronological sense. I stated that "geographical provinces or zones may have been as distinctly marked in the Palæozic epoch as at present; and those seemingly sudden appearances of new genera and species, which we ascribe to new creation, may be simple results of migration."

4. The opinion that the oldest known fossils are the earliest forms of life, has no solid foundation.

5. If we confine ourselves to positively ascertained facts, the total amount of change in the forms of animal and vegetable life since the existence of such forms is recorded, is small. When compared with the lapse of time since the first appearance of these forms, the amount of change is wonderfully small. Moreover, in each great group of the animal and vegetable kingdoms, there are certain forms which I termed PERSISTENT TYPES, which have remained, with but very little apparent change, from their first appearance to the present time.

7. In answer to the question "What then does an impartial survey of the positively ascertained truths of palæontology testify, in relation to the common doctrines of progressive modification, which suppose that modification to have taken place by a necessary progress from more to less embryonic forms, from more to less generalised types, within the limits of the period represented by the fossiliferous rocks?" I reply, "It negatives these doctrines, for it either shows us no evidence of such modification, or demonstrates such modification as has occurred to have been very slight; and, as to the nature of that modification, it yields no evidence whatsoever that the earlier members of any long continued group were more generalised in structure than the later ones."

I think I cannot employ my last opportunity of addressing you, officially, more properly—I may say more dutifully—than in revising these old judgments with such help as further knowledge and reflection, and an extreme desire to get at the truth, may afford me.

1. With respect to the first proposition, I may remark that whatever may be the case among physical geologists, catastrophic palæontologists are practically extinct. It is now no part of recognised geological doctrine that the species of one formation all died out and were replaced by a bran-new set in the next formation. On the contrary, it is generally, if not universally, agreed that the succession of life has been the result of a slow and gradual replacement of species by species; and that all appearances of abruptness of change are due to breaks in the series of deposits, or other changes in physical conditions. The continuity of living forms has been unbroken from the earliest times to the present day.

2, 3. The use of the word "homotaxis" instead of "synchronism" has not, so far as I know, found much favour in the eyes of geologists. I hope, therefore, that it is a love for scientific caution, and not mere personal affection for a bantling of my own, which leads me still to think that the change of phrase is of importance; and, that the sooner it is made, the sooner shall we get rid of a number of pitfalls which beset the reasoner upon the facts and theories of geology.

One of the latest pieces of foreign intelligence which has reached us is the information that the Austrian geologists have, at last, succumbed to the weighty evidence which M. Barrande has accumulated, and have admitted the doctrine of colonies. But the admission of the doctrine of colonies implies the further admission that even identity of organic remains is no proof of the synchronism of the deposits which contain them.

4. The discussions touching the *Eozoon* which commenced in 1864, have abundantly justified the fourth proposition. In 1862, the oldest record of life was in the Cambrian Rocks; but if the *Eozoon* be, as Principal Dawson and Dr. Carpenter have shown so much reason for believing, the remains of a living being, the discovery of its true nature carried life back to a period which, as Sir William Logan has observed, is as remote from that during which the Cambrian Rocks were deposited, as the Cambrian epoch itself is from the tertiaries. In other words, the ascertained duration of life upon the globe was nearly doubled, at a stroke.

5. The significance of persistent types, and of the small amount of change which has taken place even in those forms which can be shown to have been modified, becomes greater and greater in my eyes, the longer I occupy myself with the biology of the past.

Consider how long a time has elapsed since the Miocene epoch. Yet, at that time, there is reason to believe that every important group in every order of the *Mammalia* was represented. Even the comparatively scanty Eocene fauna yields examples of the orders *Cheiroptera*, *Insectivora*, *Rodentia*, and *Perissodactyla*; of *Artiodactyla* under both the Ruminant and the Porcine modifications; of *Carnivora*, *Cetacea*, and *Marsupialia*.

Or, if we go back to the older half of the Mesozoic epoch, how truly surprising it is to find every order of the *Reptilia*, except the *Ophidia*, represented; while some groups, such as the *Ornithoscelida* and the *Pterosauria*, more specialised than any which now exist, abounded.

There is one division of the *Amphibia* which offers especially important evidence upon this point, inasmuch as it bridges over the gap between the Mesozoic and the Palæozoic formations, often supposed to be of such prodigious magnitude, extending, as it does, from the bottom of the Carboniferous series to the top of the Trias, if not into the Lias. I refer to the Labyrinthodonts. As the address of 1862 was passing through the press, I was able to mention, in a note, the discovery of a large Labyrinthodont, with well-ossified vertebræ, from the Edinburgh coal-field. Since that time eight or ten distinct genera of Labyrinthodonts have been discovered in the carboniferous rocks of England, Scotland, and Ireland, not to mention the American forms described by Principal Dawson and Professor Cope. So that, at the present time, the Labyrinthodont Fauna of the Carboniferous rocks is more extensive and diversified than that of the Trias, while its chief types, so far as osteology enables us to judge, are quite as highly organised. Thus it is certain tha ta comparatively highly organised vertebrate type, such as that of the Labyrinthodonts, is capable of persisting, with no considerable change, through the period represented by the vast deposits which constitute the Carboniferous, the Permian, and the Triassic formations.

The very remarkable results which have been brought to light by the sounding and dredging operations, which have been carried on with such remarkable success by the expeditions sent out by our own, the American, and the Swedish Governments, under the supervision of able naturalists, have a bearing in the same direction. These investigations have demonstrated the existence, at great depths in the ocean, of living animals in some cases identical with, in others very similar to, those which are found fossilised in the white chalk. The *Globigerinæ*, Coccoliths, Coccospheres, Discoliths, in the one are absolutely identical with those in the other; there are identical, or closely analogous, species of Sponges, Echinoderms, and Brachiopods. Off the coast of Portugal, there now lives a species of *Beryx*, which, doubtless, leaves its bones and scales here and there in the Atlantic ooze, as its predecessor left its spoils in the mud of the sea of the Cretaceous epoch.

Many years ago* I ventured to speak of the Atlantic mud as "modern chalk," and I know of no fact inconsistent with the view which Professor Wyville Thomson has advocated, that the modern chalk is not only the lineal descendant of the ancient

* *Saturday Review*, 1858, "Chalk, Ancient and Modern."

chalk, but that it remains, so to speak, in the possession of the ancestral estate; and that from the cretaceous period (if not much earlier) to the present day, the deep sea has covered a large part of what is now the area of the Atlantic. But if *Globigerina*, and *Terebratula caput-serpentis* and *Beryx*, not to mention other forms of animals and of plants, thus bridge over the interval between the present and the Mesozoic periods, is it possible that the majority of other living things underwent a "sea change into something new and strange" all at once?

7. Thus far I have endeavoured to expand, and to enforce by fresh arguments, but not to modify in any important respect, the ideas submitted to you on a former occasion. But when I come to the propositions touching progressive modification, it appears to me, with the help of the new light which has broken from various quarters, that there is much ground for softening the somewhat Brutus-like severity with which I have dealt with a doctrine, for the truth of which I should have been glad enough to be able to find a good foundation, in 1862. So far indeed as the *Invertebrata* and the lower *Vertebrata* are concerned, the facts and the conclusions which are to be drawn from them appear to me to remain what they were. For anything that, as yet, appears to the contrary, the earliest known Marsupials may have been as highly organised as their living congeners; the Permian lizards show no signs of inferiority to those of the present day; the Labyrinthodonts cannot be be placed below the living Salamander and Triton; the Devonian Ganoids are closely related to *Polypterus* and to *Lepidosiren*.

But when we turn to the higher *Vertebrata*, the results of recent investigations, however we may sift and criticise them, seem to me to leave a clear balance in favour of the doctrine of the evolution of living forms one from another. In discussing this question, however, it is very necessary to discriminate carefully between the different kinds of evidence from fossil remains, which are brought forward in favour of evolution.

Every such fossil which takes an intermediate place between forms of life already known, may be said, so far as it is intermediate, to be evidence in favour of evolution, inasmuch as it shows a possible road by which evolution may have taken place. But the mere discovery of such a form does not, in itself, prove that evolution took place by and through it, nor does it constitute more than presumptive evidence in favour of evolution in general. Suppose A, B, C to be three forms, of which B is intermediate in structure between A and C. Then the doctrine of evolution offers four possible alternatives. A may have become C by way of B; or C may have become A by way of B; or A and C may be independent modifications of B; or A, B, and C may be independent modifications of some unknown D. Take the case of the Pigs, the *Anoplotheridæ* and the Ruminants. The *Anoplotheridæ* are intermediate between the first and the last; but this does not tell us whether Ruminants have come from the pigs, or pigs from Ruminants, or both from *Anoplotheridæ*, or whether pigs, Ruminants, and *Anoplotheridæ* alike may not have diverged from some common stock.

But, if it can be shown that A, B, and C exhibit successive stages in the degree of modification, or specialisation, of the same type; and if, further, it can be proved that they occur in successively newer deposits, A being in the oldest, and C in the newest, then the intermediate character of B has quite another importance, and I should accept it without hesitation as a link in the genealogy of C. I should consider the burden of proof to be thrown upon any one who denied C to have been derived from A by way of B; or in some closely analogous fashion. For it is always probable that one may not hit upon the exact line of filiation, and, in dealing with fossils, may mistake uncles and nephews for fathers and sons.

I think it necessary to distinguish between the former and the latter classes of intermediate forms, as *intercalary types* and *linear types*. When I apply the former term I merely mean to say, that as a matter of fact, the form B, so named, is intermediate between the others, in the sense in which the *Anoplotherium* is intermediate between the Pigs and the Ruminants—without either affirming, or denying, any direct genetic relation between the three forms involved. When I apply the latter term, on the other hand, I mean to express the opinion that the forms A, B, and C constitute a line of descent, and that B is thus part of the lineage of C.

From the time when Cuvier's wonderful researches upon the extinct Mammals of the Paris gypsum first made intercalary types known, and caused them to be recognised as such, the number of such forms has steadily increased among the higher Mammalia. Not only do we now know numerous intercalary forms of *Ungulata*, but M. Gaudry's great monograph upon the fossils of Pikermi (which strikes me as one of the most perfect pieces of palæontological work I have seen for a long time) shows us, among the *Primates*, *Mesopithecus* as an intercalary form between the *Semnopitheci* and the *Macaci;* and among the *Carnivora*, *Hyænictis*, and *Ictitherium* as intercalary, or, perhaps, linear, types between the *Viverridæ* and the *Hyænidæ*.

Hardly any order of the higher Mammalia stands so apparently separate and isolated from the rest as that of the *Cetacea*, though a careful consideration of the structure of the fissipede *Carnivora*, or seals, shows in them many an approximation towards the still more completely marine mammals. The extinct *Zeuglodon*, however, presents us with an intercalary form between the type of the seals and that of the whales.

The skull of this great Eocene sea monster, in fact, shows, by the narrow and prolonged interorbital region; the extensive union of the parietal bones in a sagittal suture; the well-developed nasal bones; the distinct and large incisors implanted in premaxillary bones, which take a full share in bounding the fore part of the gape; the two-fanged molar teeth with triangular and serrated crowns, not exceeding five on each side in each jaw; and the existence of a deciduous dentition—its close relation with the seals. While, on the other hand, the produced, rostral form of the snout, the long symphysis and the low coronary process of the mandible, are approximations to the cetacean form of those parts.

The scapula resembles that of the cetacean *Hyperoodon*, but the supra-spinous fossa is larger and more seal-like; as is the humerus, which differs from that of the *Cetacea* in presenting true articular surfaces for the free jointing of the bones of the fore-arm. In the apparently complete absence of hinder limbs, and in the characters of the vertebral column, the *Zeuglodon* lies on the cetacean side of the boundary line; so that, upon the whole, the Zeuglodonts, transitional as they are, are conveniently retained in the cetacean order. And the publication, in 1864, of M. Van Beneden's memoir on the miocene and pliocene *Squalodon*, furnished much better means than anatomists previously possessed, of fitting in another link of the chain which connects the existing *Cetacea* with *Zeuglodon*. The teeth are much more numerous, although the molars exhibit the zeuglodont double fang; the nasal bones are very short, and the upper surface of the rostrum presents the groove, filled up during life by the prolongation of the ethmoidal cartilage, which is so characteristic of the majority of the *Cetacea*.

It appears to me that, just as among the existing *Carnivora*, the walruses and the eared seals are intercalary forms between the fissipede *Carnivora* and the ordinary seals; so the Zeuglodons are intercalary between the *Carnivora*, as a whole, and the *Cetacea*. Whether the Zeuglodonts are also linear types in their relation to these two groups cannot be ascertained, until we have more definite knowledge than we possess at present, respecting the relations in time of the *Carnivora* and the *Cetacea*.

Thus far, we have been concerned with the intercalary types which occupy the intervals between families, or orders, of the same class. But the investigations which have been carried on by Prof. Gegenbaur, Prof. Cope, and myself, into the structure and relations of the extinct reptilian forms of *Dinosauria* and *Compsognatha*, have brought to light the existence of intercalary forms between what have hitherto been always regarded as very distinct classes of the vertebrate sub-kingdom, namely, *Reptilia* and *Aves*. Whatever inferences may, or may not, be drawn from the fact, it is now an established truth that, in many of these *Ornithoscelida*, the hind limbs and the pelvis are much more similar to those of birds than they are to those of reptiles, and that these Bird-reptiles, or Reptile-birds, were more or less completely bipedal.

When I addressed you in 1862, I should have been bold indeed had I suggested that palæontology would before long show us the possibility of a direct transition from the type of the lizard to that of the ostrich. At the present moment we have, in the *Ornithoscelida*, the intercalary type, which proves that transition to be something more than a possibility. But it is very doubtful whether any of the genera of *Ornithoscelida* with which we are at present acquainted are the actual linear types by which the transition from the lizard to the bird was effected. These are, very probably, still hidden from us in the older formations.

Let us now endeavour to find some cases of true linear types, or forms which are intermediate between others because they stand in a direct genetic relation to them. It is no easy matter to find clear and unmistakeable evidence of filiation among fossil

animals. For, in order that such evidence should be quite satisfactory, it is necessary that we should be acquainted with all the most important features of the organization of the animals which are supposed to be thus related; and not merely with the fragments upon which the genera and species of the palæontologist are so often based. M. Gaudry has arranged the species of *Hyænidæ*, *Proboscidea*, *Rhinocerotidæ*, and *Equidæ* in their order of filiation from their earliest appearance in the Miocene epoch to the present time, and Professor Rütimeyer has drawn up similar schemes for the Oxen—with what I am disposed to think is a fair and probable approximation to the order of Nature. But as no one is better aware than these two learned, acute, and philosophical biologists, all such arrangements must be regarded as provisional, except in those cases in which, by a fortunate accident, large series of remains are obtainable from a thick and wide-spread series of deposits. It is easy to accumulate probabilities—hard to make out some particular case in such a way that it will stand rigorous criticism.

After much search, however, I think that such a case is to be made out in favour of the pedigree of the Horses.

The genus *Equus* is represented as far back as the latter part of the Miocene epoch; but, in deposits belonging to the middle of that epoch, its place is taken by two other genera, *Hipparion* and *Hipparitherium* (or *Anchitherium*); and, in the lowest Miocene and upper Eocene only the last genus occurs. A species of *Hipparitherium* was referred by Cuvier to the *Palæotheria* under the name of *P. Aurelianense*. The grinding teeth are in fact very similar in shape and in pattern, and in the absence of cement, to those of some species of *Palæotherium*, especially Cuvier's, *Palæotherium minus*, which has been formed into a separate genus, *Plagiolophus*, by Pomel.

But in the fact that there are six full-sized grinders, the first premolar being very small; that the anterior grinders are as large as, or rather larger than, the posterior ones; that the second premolar has an anterior prolongation; and that the posterior molar of the lower jaw has, as Cuvier pointed out, a posterior lobe of much smaller size and different form, the dentition of *Hipparitherium* departs from the type of the *Palæotherium*, and approaches that of the horse.

Again, the skeleton of *Hipparitherium* is extremely equine. M. Christol, who founded the genus, goes so far as to say that the descriptions of the bones of the horse, or the ass, current in veterinary works, would fit those of *Hipparitherium*. And, in a general way, this may be true enough, but there are some most important differences, which, indeed, are justly indicated by the same careful observer. Thus the ulna is complete throughout, and its shaft is not a mere rudiment, fused into one bone with the radius. There are three toes, one large in the middle, and one small on each side. The femur is quite like that of a horse, and has the characteristic fossa above the external condyle. In the British Museum, there is a most instructive specimen of the leg bones, showing that the fibula was represented by the external malleolus and by a flat tongue of bone, which extends up from it on the outer side of the tibia, and is closely ankylosed with the latter bone. The hind toes are three, like those of the fore leg; and the middle metatarsal bone is much less compressed from side to side than in the horse.

In the *Hipparion* the teeth nearly resemble those of the Horses, though the crowns of the grinders are not so long; like those of the Horses they are abundantly coated with cement. The shaft of the ulna is reduced to a mere style ankylosed throughout nearly its whole length with the radius, and appearing to be little more than a ridge on the surface of the latter bone until it is carefully examined. The front toes are still three, but the outer ones are more slender than in *Hipparitherium*, and their hoofs smaller in proportion to that of the middle toe. In the leg, the distal end of the fibula is so completely united with the tibia that it appears to be a mere process of the latter bone, as in the Horses.

In the Horses, finally, the crowns of the grinding teeth become longer, and their patterns are slightly modified; the middle of the shaft of the ulna vanishes, and its proximal and distal ends ankylose with the radius. The phalanges of the two outer toes in each foot disappear, their metacarpal and metatarsal bones being left as the "splints."

The *Hipparion* has large depressions on the face in front of the orbits, like those for the "larmiers" of many ruminants; but traces of these are to be seen in some of the fossil horses from the Sewalik Hills.

When we consider these facts, and the further circumstance that the Hipparions, the remains of which have been collected in immense numbers, were subject, as M. Gaudry and others have pointed out, to a great range of variation, it appears to me impossible to resist the conclusion that the types of the *Hipparitherium*, of the *Hipparion*, and of the ancient Horses constitute the lineage of the modern Horses, the *Hipparion* being the intermediate stage between the other two, and answering to B in my former illustration.

The nature of the process by which the *Hipparitherium* has been converted into the horse is one of specialisation or of more and more complete deviation from what might be called the average form of an ungulate mammal. In the Horses, the reduction of some parts of the limbs, together with the special modification of those which are left, is carried to a greater extent than in any other hoofed mammals. The reduction is less, and the specialisation is less in the *Hipparion*, and still less in the *Hipparitherium*; but yet as compared with other mammals, the reduction and specialisation of parts in the *Hipparitherium* remains great.

Is it not probable, then, that, just as in the Miocene epoch we find an ancestral equine form less modified than the horse, so, if we go back to the Eocene epoch we shall find some quadruped related to the *Hipparitherium*, as *Hipparion* is related to *Equus*, and consequently departing less from the average form?

I think that this desideratum is very nearly, if not quite, supplied by *Plagiolophus*, remains of which occur abundantly in some parts of the upper and middle Eocene formations. The patterns of the grinding teeth of *Plagiolophus* are similar to those of *Hipparitherium*, and they are similarly deficient in cement; but the grinders diminish in size forwards, and the last lower molar has a large hind lobe, convex outwards and concave inwards, as in *Palæotherium*. The ulna is complete and much larger than in any of the *Equidæ*, while it is more slender than in most of the *Palæotheria*. It is fixedly united, but not ankylosed with the radius. There are three toes in the fore-limb, the outer ones being slender, but less attenuated than in the *Equidæ*. The femur is more like that of the *Palæotheria* than that of the horse, and has only a small depression above its outer condyle in the place of the great fossa which is so obvious in the *Equidæ*. The fibula is distinct, but very slender, and its distal end is ankylosed with the tibia. There are three toes on the hind-foot having similar proportions to those on the fore-foot. The principal metacarpal and metatarsal bones are flatter than they are in any of the *Equidæ*.

In its general form, *Plagiolophus* resembles a very small and slender horse, and totally unlike the reluctant, pig-like creature depicted in Cuvier's restoration of his *Palæotherium minus* in the Ossemeus Fossiles.

It would be hazardous to say that *Plagiolophus* is the exact radical form of the Equine quadrupeds; but I do not think there can be any reasonable doubt the latter animals have resulted from the modification of some quadruped similar to *Plagiolophus*.

We have thus arrived at the Middle Eocene formation, and yet have traced back the Horses only to a three-toed stock. But these three-toed forms, no less than the Equine quadrupeds themselves, present rudiments of the two other toes which apperfain to what I have termed the "average" quadruped. If the expectation raised by the splints of the horse that, in some ancestor of the horse, these splints would be found to be complete digits, has been verified, we are furnished with very strong reasons for looking for a no less complete verification of the expectation that the three-toed *Plagiolophus*-like "avus" of the horse must have had a five-toed "atavus" at some earlier period.

No such five-toed "atavus," however, has yet made its appearance among the few middle and older Eocene Mammalia which are known.

Another series of closely-affiliated forms, though the evidence they afford is perhaps less complete than that of the Equine series, is presented to us by the *Dichobune* of the Eocene epoch, the *Cainotherium* of the Miocene, and the *Tragulidæ*, or so-called "Muskdeer" of the present day.

The *Tragulidæ* have no incisors in the upper jaw, and only six grinding teeth on each side of each jaw, while the canine is moved up to the outer incisor, and there is a diastema in the lower jaw. There are four complete toes on the hind-foot, but the middle metatarsals usually become, sooner or later, ankylosed into a cannon bone. The navicular and the cuboid unite, and the distal end of the fibula is ankylosed with the tibia.

In *Cainotherium* and *Dichibune* the upper incisors are fully developed. There are seven grinders; the teeth form a continuous series without diastema. The metatarsals, the navi-

cular and cuboid, and the distal end of the fibula, remain free. The *Cainotherium*, also the second metacarpal, is developed, but is much shorter than the third, while the fifth is absent or rudimentary. In this respect it resembles *Anoplotherium secundarium*. This circumstance, and the peculiar pattern of the upper molars in *Cainotherium*, lead me to hesitate in considering it as the actual ancestor of the modern *Tragulidæ*. If *Dichobune* has a four-toed front foot (though I am inclined to suspect it resembles *Cainotherium*) it will be a better representative of the oldest form of the Traguline series. But *Dichobune* occurs in the middle Eocene, and is, in fact, the oldest known artiodactyle mammal. Where, then, must we look for its five-toed ancestor?

If we follow down other lines of recent and tertiary *Ungulata*, the same question presents itself. The pigs are traceable back through the Miocene epoch to the upper Eocene, where they appear in the two well-marked forms of *Hyopotamus* and *Chœropotamus*. But *Hyopotamus* appears to have had only two toes.

Again, all the great groups of the Ruminants, the *Bovidæ*, *Antelopidæ*, *Cameleopardalidæ*, and *Cervidæ*, are represented in the Miocene epoch, and so are the camels. The upper Eocene *Anoplotherium*, which is intercalary between the pigs and the *Tragulidæ*, has only two or, at most, three toes. Among the scanty mammals of the lower Eocene formation we have the perissodactyle *Ungulata* represented by *Coryphodon*, *Hyracotherium*, and *Pliolophus*. Suppose for a moment, for the sake of following out the argument, that *Pliolophus* represents the primary stock of the perissodactyles, and *Dichobune* that of the Artiodactyles (though I am far from saying that such is the case) then, we find in the earliest fauna of the Eocene epoch, to which our investigations carry us, the two divisions of the *Ungulata* completely differentiated, and no trace of any common stock of both or five-toed predecessors to either. With the case of the horse before us, justifying a belief in the production of new animal forms by modification of old ones, I see no escape from the necessity of seeking for these ancestors of the *Ungulata* beyond the limits of the tertiary formations.

I could as soon admit special creation, at once, as suppose that the perissodactyles and artiodactyles had no five-toed ancestors. And when we consider how large a portion of the tertiary period elapsed before *Hipparitherium* was converted into *Equus*, it is difficult to escape the conclusion that a large proportion of time anterior to the tertiary must have been expended in converting the common stock of the *Ungulata* into perissodactyles and artiodactyles.

The same moral is inculcated by the study of every other order of tertiary monodelphius *Mammalia*. Each of these orders is represented in the Miocene epoch:—the Eocene formation, as I have already said, contains *Cheiroptera*, *Insectivora*, *Rodentia*, *Ungulata*, *Carnivora*, and *Cetacea*. But the *Cheiroptera* are extreme modifications of the *Insectivora*; just as the *Cetacea* are extreme modifications of the Carnivorous type; and therefore it is to my mind incredible that monodelphous *Insectivora* and *Carnivora* should not have been abundantly developed along with *Ungulata* in the Mesozoic epoch. But, if this be the case, how much farther back must we go to find the common stock of the monodelphous *Mammalia*? As to the *Didelphia*, if we may trust the evidence which seems to be afforded by their very scanty remains, that a Hypsiprymnoid form existed at the epoch of the Trias, side by side with a carnivorous form. At the epoch of the Trias, therefore, the *Marsupialia* must have already existed long enough to have become differentiated into carnivorous and herbivorous forms. But the *Monotremata* are lower forms than the *Didelphiæ*, which last are intercalary between the *Ornithodelphia* and the *Monodelphia*. To what point of the palæozoic epoch then must we, upon any rational estimate, relegate the origin of the *Monotremata*?

The investigation of the occurrence of the classes and of the orders of the *Sauropsida* in time, points in exactly the same direction. If, as there is great reason to believe, true Birds existed in the Triassic epoch, the ornithoscelidous forms by which Reptiles passed into Birds must have preceded them. In fact, there is even, at present, considerable ground for suspecting the existence of *Dinosauria* in the Permian formations. But in that case Lizards must be of still earlier date. And if the very small differences which are observable between the *Crocodilia* of the older mesozoic formations and those of the present day, furnish any sort of approximation towards an estimate of the average rate of change among the *Sauropsida*; it is almost appalling to reflect how far back in palæozoic times we must go, before we can hope to arrive at that common stock from which the *Crocodilia*, *Lacertilia*, *Ornithoscelida*, and *Plesiosania*, which had attained so great a development in the Triassic epoch must have been derived.

The *Amphibia* and *Pisces* tell the same story. There is not a single class of vertebrated animals, which, when it first appears, is represented by analogues of the lowest known members of the same class. Therefore, if there is any truth in the doctrine of evolution, every class must be vastly older than the first record of its appearance upon the surface of the globe. But if considerations of this kind compel us to place the origin of vertebrated animals at a period sufficiently distant from the upper Silurian, in which the first Elasmobranchs and Ganoids occur, to allow of the evolution of such fishes as these from a Vertebrate as simple as the *Amphioxus*; I can only repeat that it is appalling to speculate upon the extent to which that origin must have preceded the epoch of the first recorded appearance of vertebrate life.

Such is the further commentary which I have to offer upon the statement of the chief results of palæontology, which I formerly ventured to lay before you.

But the growth of knowledge in the interval makes me conscious of an omission of considerable moment in that statement, inasmuch as it contains no reference to the bearings of palæontology upon the theory of the distribution of life; or takes note of the remarkable manner in which the facts of distribution, in present and past times, accord with the doctrine of evolution—especially in regard to land animals.

That connection between palæontology and geology on the one hand, and the present distribution of terrestrial animals, which so strikingly impressed Mr. Darwin thirty years ago, as to lead him to speak of a "law of succession of types"; and of the wonderful relationship on the same continent between the dead and the living, has recently received much elucidation from the researches of Gaudry, of Rütimeyer, of Leidig, and of Alphonse Milne-Edwards, taken in connection with the earlier labours of our lamented colleague Falconer. And it has been instructively discussed in the thoughtful and ingenious work of Mr. Andrew Murray "On the geographical distribution of mammals."

I propose to lay before you, as briefly as I can, the ideas to which a long consideration of the subject has given rise in my own mind.

If the doctrine of evolution is sound, one of its immediate consequences clearly is, that the present distribution of life upon the globe is the product of two factors: the one being the distribution which obtained in the immediately preceding epoch; and the other, the character and the extent of the changes which have taken place in physical geography between the one epoch and the other. Or, to put the matter in another way—the Fauna and Flora of any given area, in any given epoch, can consist only of such forms of life as are directly descended from those which constituted the Fauna and Flora of the same area, in the immediately preceding epoch; unless the physical geography (under which I include climatal conditions) of the area has been so altered as to give rise to immigration of living forms from some other area.

The evolutionist therefore is bound to grapple with the following problem whenever it is clearly put before him:—Here are the Faunæ of the same area during successive epochs. Show good cause for believing, either that these Faunæ have been derived from one another by gradual modification, or that the Faunæ have reached the area in question by migration from some area in which they have undergone their development.

I propose to attempt to deal with this problem so far as it is exemplified by the distribution of the terrestrial Vertebrata, and I shall endeavour to show you that it is capable of solution in a sense entirely favourable to the doctrine of evolution.

I have, elsewhere,* stated, at length, the reasons which lead me to recognise four primary distributional provinces for the terrestrial Vertebrata in the present world; namely, firstly, the *Novozelanian*, or New Zealand province: secondly, the *Australian* province, including Australia, Tasmania, and the Negrito Islands: thirdly, *Austro-Columbia*, or South America plus North America as far as Mexico; and fourthly, the rest of the world or *Arctogæa*, in which province America, north of Mexico, constitutes one sub-province; Africa, south of the Sahara, a second; Hindostan a third; and the remainder of the old world a fourth.

* "On the classification and distribution of the Alectoromorphæ." Proceedings of the Zoological Society, 1868.

Now the truth which Mr. Darwin perceived and promulgated as "the law of the succession of types" is, that in all these provinces the animals found in Pliocene or Pleistocene deposits are closely affined to those which now inhabit the same provinces, and that conversely, the forms characteristic of other provinces are absent. North and South America, perhaps, present one or two exceptions to the last rule, but they are readily susceptible of explanation. Thus, in Australia, the later tertiary Mammals are Marsupials (possibly with exception of the Dog and a Rodent or two, as at present). In Austro-Columbia the later tertiary Fauna exhibits numerous and varied forms of Platyrhine apes, Rodents, Cats, Dogs, Stags, *Edentata*, and Opossums; but, as at present, no Catarhine apes, no Lemurs, no *Insectivora*, Oxen, Antelopes, Rhinoceroses or *Didelphia* other than opossums. And, in the widespread Arctogæal province, the Pliocene and Pleistocene Mammals belong to the same groups as those which now exist in the province. The law of succession of types, therefore, holds good for the present epoch as compared with its predecessor. Does it equally well apply to the Pliocene Fauna when we compare it with that of the Miocene epoch? By great good fortune an extensive Mammalian Fauna of this epoch has now become known, in four very distant portions of the Arctogæal province which do not differ greatly in latitude. Thus Falconer and Cautley have made known the Fauna of the sub-Himalayas and the Perim Islands; Gaudry that of Attica; many observers that of Central Europe and France; Leidig, that of Nebraska on the eastern flank of the Rocky Mountains. The results are very striking. The total Miocene Fauna comprises many genera and species of Catarhine apes, of Bats, of *Insectivora*, of Arctogæal types of *Rodentia*, of *Proboscidea*, of Equine Rhinocenti, and Tapirine quadrupeds; of cameline, bovine, antelopine, cervine, and traguline Ruminants; of Pigs and Hippopotamuses; of *Viverridæ* and *Hyænidæ* among other *Carnivora*; with *Edentata* allied to the Arctogæal *Orycteropus* and *Manis*, and not to the Austro-Columbian Edentates. The only type present in the Miocene, but absent in the existing, Fauna of Eastern Arctogæa is that of the *Didelphidæ*, which, however, remains in North America.

But it is very remarkable, that while the Miocene Fauna of the Arctogæal Province, as a whole, is of the same character as the existing Fauna of the same province as a whole, the component elements of the Fauna were differently associated. In the Miocene epoch, North America possessed Elephants, Horses, Rhinoceroses, and a great number and variety of Ruminants and Pigs which are absent in the present indigenous Fauna. Europe had its Apes, Elephants, Rhinoceroses, Tapirs, Musk-deer, Giraffes, Hyenas, great Cats, Edentates, and opossum-like Marsupials, which have equally vanished from its present Fauna. And in Northern India, the African types of Hippopotamuses, Giraffes, and Elephants were mixed up with what are now the Asiatic types of the latter and with Camels, Semnopithecine and Pithecine apes of no less distinctly Asiatic forms.

In fact, the Miocene Mammalian Fauna of Europe and the Himalayan regions contains associated together the types which are now separately located in the South African and Indian sub-provinces of Arctogæa. Now there is every reason to believe, on other grounds, that both Hindostan, south of the Ganges, and Africa, south of the Sahara, were separated by a wide sea from Europe and North Asia, during the middle and upper Eocene epochs. Hence it becomes highly probable that the well-known similarities and no less remarkable differences between the present Faunæ of India and South Africa have arisen in some such fashion as the following. Sometime during the Miocene epoch, possibly when the Himalayan chain was elevated, the bottom of the nummulitic sea was upheaved and converted into dry land, in the direction of a line extending from Abyssinia to the mouth of the Ganges. By this means, the Dekhan on the one hand, and South Africa on the other, became connected with the Miocene dry land and with one another. The Miocene Mammals spread gradually over this intermediate dry land, and if the condition of its eastern and western ends offered as wide contrasts as the valleys of the Ganges and Arabia do now, many forms which made their way into Africa must have been different from those which reached the Dekhan, while others might pass into both these sub-provinces.

That there was a continuity of dry land between Europe and North America during the Miocene epoch, appears to me to be a necessary consequence; the fact that many genera or terrestrial Mammals such as *Castor*, *Hystrix*, *Elephas*, *Mastodon*, *Equus*, *Hipparion*, *Hipparitherium*, *Rhinoceros*, *Cervus*, *Amphicyon*, *Hyænarctos*, and *Machairodus*, are common to the Miocene formations of the two areas, and have as yet been found (except perhaps *Hipparitherium*) in no deposit of earlier age. Whether this connection took place by the east, or by the west, or by both sides of the old world, there is at present no certain evidence, and the question is immaterial to the present argument; but, as there are good grounds for the belief that the Australian province and the Indian and South African sub-provinces were separated by sea from the rest of Arctogæa before the Miocene epoch, so it has been rendered no less probable by the investigations of Mr. Carrick Moore and Prof. Duncan that Austro-Columbia was separated by sea from North America, during a large part of the Miocene epoch.

It is unfortunate that we have no knowledge of the Miocene Mammalian Fauna of the Australian and Austro-Columbian provinces. But seeing that not a trace of a Platyrhine ape, of a Procyonine carnivore, of a characteristically South American Rodent, of a Sloth, an Armadillo, or an Ant-eater, has yet been found in Miocene deposits of Arctogæa, I cannot doubt that they already existed in the Miocene Austro-Columbian province.

Nor is it less probable that the characteristic types of Australian Mammalia were already developed in that region in Miocene. times.

But Austro-Columbia presents difficulties from which Australia is free—*Camelidæ* and *Tapiridæ* are now indigenous in South America as they are in Arctogæa, and among the Pliocene Austro-Columbian mammals, the Austro-Columbian genera *Equus*, *Mastodon*, and *Machairodus* are numbered. Are these, post-Miocene immigrants, or præ-Miocene natives?

Still more perplexing are the strange and interesting forms *Toxodon*, *Macrauchenia*, and *Typotherium*; and a new Anoplotheriod mammal (*Omalodotherium*) which Dr. Cunningham sent over to me some time ago from Patagonia. I confess I am strongly inclined to surmise that these last, at any rate, are remnants of the population of Austro-Columbia before the Miocene epoch, and were not derived from Arctogæa by way of the north and east.

The fact that this immense Fauna of Miocene Arctogæa is now fully and richly represented only in India and South Africa, while it is shrunk and depauperised in North Asia, Europe, and North America, becomes at once intelligible, if we suppose that India and South Africa had but a scanty mammalian population before the Miocene immigration, while the conditions were highly favourable to the new comers. It is to be supposed that these new regions offered themselves to the Miocene Ungulates as South America and Australia offered themselves to the cattle, sheep, and horses of modern colonists. But after these great areas were thus peopled came the Glacial epoch, during which the excessive cold, to say nothing of depression and ice-covering, must have almost depopulated all the northern parts of Arctogæa, destroying all the higher mammalian forms except those which, like the elephant and rhinoceros, could adjust their coats to the altered condition. Even these must have been driven away from the greater part of the area. Only those Miocene mammals which had passed into Hindostan and into South Africa would escape decimation by these changes in the physical geography of Arctogæa. And when the northern hemisphere passed into its present condition, these lost tribes of the Miocene Fauna were hemmed by the Himalayas, the Sahara, the Red Sea, and the Arabian deserts, within their present boundaries.

Now, on the hypothesis of evolution, there is no sort of difficulty in admitting that the differences between the Miocene forms of the Mammalian Fauna and those which exist now, are the results of gradual modification; and since such differences in distribution as obtain are readily explained by the changes which have taken place in the physical geography of the world since the Miocene epoch, it is clear that the result of the comparison of the Miocene and present Faunæ is distinctly in favour of evolution. Indeed, I may go further. I may say that the hypothesis of evolution explains the facts of Miocene, Pliocene, and Recent distribution; and that no other supposition even pretends to account for them. It is, indeed, a conceivable supposition that every species of Rhinoceros and every species of Hyæna, in the long succession of forms between the Miocene and the present species, was separately constructed out of dust, or out of nothing, by supernatural power. But until I receive distinct evidence of the fact, I refuse to run the risk of insulting

any sane man by supposing that he seriously holds such a notion.

Let us now take a step further back in time, and inquire into the relations between the Miocene Fauna and its predecessor of the upper Eocene formation.

Here it is to be regretted that our materials for forming a judgment are nothing to be compared in point of extent, or variety, with those which are yielded by the Miocene strata. However, what we do know of this upper Eocene Fauna of Europe, gives sufficient positive information to enable us to draw some tolerably safe inferences. It has yielded representatives of *Insectivora*, of *Cheiroptera*, of *Rodentia*, of *Carnivora*, of Artiodactyle, and Perissodactyle *Ungulata* and of opossum-like Marsupials. No Australian type of marsupial has been discovered in the upper Eocene, nor any Edentate mammal. The genera (except in the case perhaps of some of the *Insectivora*, *Cheiroptera*, and *Rodentia*) are different from those of the Miocene epoch, but present remarkable general similarity to the Miocene and recent genera. In several cases, as I have already shown, it has now been clearly made out that the relation between the Eocene and Miocene forms is such that the Eocene form is the least specialised; while its Miocene ally is more so, and the specialisation reaches its maximum in the recent forms of the same type.

So far as the Upper Eocene and the Miocene Mammalian Faunæ are comparable, their relations are such as in no way to oppose the hypothesis that the older are the progenitors of the more recent forms, while, in some cases, they distinctly favour that hypothesis. The period in time and the changes in physical geography, represented by the nummulitic deposits, are undoubtedly very great, while the remains of middle Eocene and older Eocene Mammals are comparatively few. The general facies of the middle Eocene Fauna, however, is quite that of the upper.

The older Eocene, pre-nummulitic mammalian Fauna, contains Bats, two genera of *Carnivora*, three genera of *Ungulata* (probably all perissodactyle), and a didelphid marsupial. All these forms, except perhaps the Bat and the Opossum, belong to genera which are not known to occur out of the lower Eocene. The *Coryphodon*, however, appears to have been allied to the Miocene and later Tapirs; while *Phiolophus*, in its skull and dentition, curiously partakes of both artiodactyle and perissodactyle characters. The third trochanter upon its femur, and its three-toed hind foot, however, appear definitely to fix its position in the latter division.

There is nothing, then, in what is known of the older Eocene mammals of the Arctogæal province to forbid the supposition that they stood in an ancestral relation to those of the Calcaire Grossier and the Gypsum of the Paris basin; and that our present fauna, therefore, is directly derived from that which already existed in Arctogæa at the commencement of the Tertiary period. But if we now cross the frontier between the Cainozoic and the Mesozoic Faunæ, as they are preserved within the Arctogæal area, we meet with an astounding change, and what appears to be a complete and unmistakeable break in the line of biological continuity.

Among the twelve or fourteen species of Mammalia which are said to have been found in the Purbecks, not one is a member of the orders *Cheiroptera*, *Rodentia*, *Ungulata*, or *Carnivora*, which are so well represented in the Tertiaries. No *Insectivora* are certainly known, nor any opossum-like Marsupials. Thus there is a vast negative difference between the Cainozoic and the Mesozoic mammalian Faunæ of Europe. But there is a still more important positive difference, inasmuch as all these Mammalia appear to be Marsupials belonging to Australian groups; and thus appertaining to a different distributional province from the Eocene and Miocene marsupials, which are Austro-Columbian. So far as the imperfect materials which exist enable a judgment to be formed, the same law appear to have held good for all the earlier mesozoic Mammalia. Of the Stonesfield slate mammals, one, *Amphitherium*, has a definitely Australian character; one, *Phaseolotherium*, may be either Dasyurid or Didelphine; of a third, *Stereognathus*, nothing can at present be said. The two mammals of the Trias, also, appear to belong to Australian groups.

Everyone is aware of the many curious points of resemblance between the marine Fauna of the European Mesozoic rocks and that which now exists in Australia. But if there was this Australian facies about both the terrestrial and the marine Faunæ of Mesozoic Europe, and if there is this unaccountable and immense break between the Fauna of Mesozoic and that of Tertiary Europe, is it not a very obvious suggestion that, in the Mesozoic epoch, the Australian province included Europe, and that the Arctogæal province was contained within other limits? The Arctogæal province is at present enormous, while the Australian is relatively small. Why should not these proportions have been different during the Mesozoic epoch?

Thus, I am led to think that by far the simplest and most rational mode of accounting for the great change which took place in the living inhabitants of the European area at the end of the Mesozoic epoch, is the supposition that it arose from a great change in the physical geography of the globe, whereby an area long tenanted by Cainozoic forms was brought into such relations with the European area, that migration from the one to the other became possible, and took place on a great scale.

This supposition relieves us, at once, from the difficulty in which we were left, some time ago, by the arguments which I used to demonstrate the necessity of the existence of all the great types of the Eocene epoch in some antecedent period.

It is this Mesozoic continent (which may well have lain in the neighbourhood of what are now the shores of the North Pacific Ocean), which I suppose to have been occupied by the Mesozoic *Monodelphia*; and it is in this region that I conceive they must have gone through the long series of changes by which they were specialised into the forms which we refer to different orders. I think it very probable that what is now South America may have received the characteristic elements of its Mammalian Fauna during the Mesozoic epoch; and there can be little doubt that the general nature of the change which took place at the end of the Mesozoic epoch in Europe, was the upheaval of the eastern and northern regions of the Mesozoic sea bottom into a westward extension of the Mesozoic continent, over which the Mammalian Fauna, by which it was already peopled, gradually spread. This invasion of the land was prefaced by a previous invasion of the Cretaceous sea by modern forms of mollusca and fish.

It is easy to imagine how an analogous change might come about in the existing world. There is, at present, a great difference between the Fauna of the Polynesian Islands and that of the west coast of America. The animals which are leaving their spoils in the deposits now forming in these localites are widely different. Hence, if a gradual shifting of the deep sea, which at present bars migration, between the easternmost of these islands and America took place to the westward, while the American side of the sea-bottom was gradually upheaved, the palæontologist of the future would find, over the Pacific area, exactly such a change as I am supposing to have occurred in the North Atlantic area at the close of the Mesozoic period. An Australian Fauna would be found underlying an American Fauna, and the transition from the one to the other would be as abrupt as that between the Chalk and lower Tertiaries. And as the drainage area of the newly-formed extension of the American continent gave rise to rivers and lakes, the mammals mired in their mud would differ from those of like deposits on the Australian side just as the Eocene mammals differ from those of the Purbecks.

How do similar reasonings apply to the other great change of life—that which took place at the end of the Palæozoic period?

In the Triassic epoch, the distribution of the dry land and of terrestrial vertebrate life appears to have been, generally, similar to that which existed in the Miocene epoch; so that the Triassic continents and their Faunæ seem to be related to the Mesozoic lands and their Faunæ, just as those of the Miocene epoch are related to those of the present day.

In fact, as I have recently endeavoured to prove to the Society, there was an Arctogæal continent and an Arctogæal province of distribution in Triassic times as there is now. And the *Sauropsida* and *Marsupialia* which constituted that fauna were, I doubt not, the progenitors of the *Sauropsida* and *Marsupialia* of the whole Mesozoic epoch.

Looking at the present terrestrial fauna of Australia, it appears to me to be very probable that it is essentially a remnant of the Fauna of the Triassic, or even of an earlier, age; in which case Australia must at that time have been in continuity with the Arctogæal continent.

But now comes the further inquiry, Where was the highly-differentiated Sauropsidan Fauna of the Trias in Palæozoic times? The supposition that the Dinosaurian, Crocodilian, Dicynodontian, and Plesiosaurian types were suddenly created at the end of the Permian epoch may be dismissed, without further consideration, as a monstrous and unwarranted assumption. The supposition that all the types were rapidly differentiated out of *Lacertilia*, in the time represented by the passage from the

Palæozoic to the Mesozoic formation, appears to me to be hardly more credible; to say nothing of the indications of the existence of Dinosaurian forms in the Permian rocks, which have already been obtained.

For my part I entertain no sort of doubt that the reptiles, birds, and mammals of the Trias are the direct descendants of reptiles, birds, and mammals which existed in the latter part of the Palæozoic epoch, but not in any area of the present dry land which has yet been explored by the geologist.

This may seem a bold assumption, but it will not appear unwarrantable to those who reflect upon the very small extent of the earth surface which has hitherto exhibited the remains of the great Mammalian Fauna of the Eocene times. In this respect the Permian land vertebrate Fauna appears to me to be related to the Triassic, much as the Eocene is to the Miocene. Terrestrial reptiles have been found in Permian rocks only in three localities: in some spots of France and recently of England, and over a more extensive area in Germany. Who can suppose that the few fossils yet found in these regions give any sufficient representation of the Permian Fauna?

It may be said that the Carboniferous formations demonstrate the existence of a vast extent of dry land in the present dry land area; and that the supposed terrestrial Palæozoic vertebrate Fauna ought to have left its remains in the coal measures, especially as there is now reason to believe that much of the coal was formed on dry land. But if we consider the matter more closely, I think that this apparent objection loses its force. It is clear that during the Carboniferous epoch, the vast area of land which is now covered by coal measures must have been undergoing a gradual depression. The dry land thus depressed must, therefore, have existed, as such, before the Carboniferous epoch—in other words, the Devonian times—and its terrestrial population may never have been other than such as existed during the Devonian, or some previous epoch, although much higher forms may have been developed elsewhere.

Again, let me say that I am making no gratuitous assumption of inconceivable changes. It is clear that the enormous area of Polynesia is, on the whole, an area over which depression has taken place to an immense extent. Consequently a great continent, or assemblage of sub-continental masses of land, must have existed at some former time, and that at a recent period, geologically speaking, in the area of the Pacific. But if that continent had contained mammals, some of them must have remained to tell the tale; and as it is well known that these islands have no indigenous *Mammalia*, it is safe to assume that none existed. Thus, midway between Australia and South America, each of which possesses an abundant and diversified Mammalian Fauna, a mass of land, which may have been as large as both put together, must have existed without a Mammalian inhabitant. Suppose that the shores of this great land were fringed, as those of tropical Australia are now, with belts of mangroves which would extend landwards on the one side, and be buried beneath littoral deposits on the other side, as depression went on; and great beds of mangrove lignite might accumulate over the sinking land. Let upheaval of the whole now take place, in such a manner as to bring the newly emerging land into continuity with the South American, or Australian, continent; and, in course of time, it would be peopled by an extension of the Fauna of one of these two regions—just as I imagine the European Permian dry land to have been peopled.

I see nothing whatever against the supposition that distributional provinces of terrestrial life existed in the Devonian epoch, inasmuch as M. Barrande has proved that they existed much earlier. I am aware of no reason for doubting that, as regards the grades of terrestrial life contained in them, one of these may have been related to another as New Zealand is to Australia, or as Australia is to India, at present. Analogy seems to me to be rather in favour of, than against, the supposition that while only Ganoid fishes inhabited the fresh waters of our Devonian land, *Amphibia* and *Reptilia*, or even higher forms, may have existed, though we have not yet found them. The earliest Carboniferous *Amphibia* now known, such as *Anthracosaurus*, are so highly specialised, that I can by no means conceive that they have been developed out of piscine forms in the interval between the Devonian and the Carboniferous periods, considerable as that is. And I take refuge in one of two alternatives. Either they existed in our own area during the Devonian epoch and we have simply not yet found them; or, they formed part of the population of some other distributional province of that day; and only entered our area by migration, at the end of the Devonian epoch. Whether *Reptilia* and *Mammalia* existed along with them is to me, at present, a perfectly open question, which is just as likely to receive an affirmative, as a negative, answer from future inquirers.

Let me now gather together the threads of my argumentation into the form of a connected hypothetical view of the manner in which the distribution of living and extinct animals has been brought about.

I conceive that distinct provinces of the distribution of terrestrial life have existed since the earliest period at which that life is recorded, and, possibly, much earlier; and I suppose, with Mr. Darwin, that the progress of modification of terrestrial forms is more rapid in areas of elevation than in areas of depression. I take it to be certain that Labyrinthodont *Amphibia* existed in the distributional province which included the dry land depressed during the Carboniferous epoch: and I conceive that, in some other distributional provinces of that day, which remained in the condition of stationary, or of increasing dry land, the various types of the terrestrial *Sauropsida* and of the *Mammalia* were gradually developing.

The Permian epoch marks the commencement of a new movement of upheaval in our area, which attained its maximum in the Triassic epoch when dry land existed in North America, Europe, Asia, and Africa as it does now. Into this great new continental area the mammals, birds, and reptiles, developed during the Palæozoic epoch, spread, and formed the great Triassic Arctogæal province. But, at the end of the Triassic period, the movement of depression recommenced in our area, though it was doubtless balanced by elevation elsewhere; modification and development, checked in the one province, went on in that elsewhere; and the chief forms of mammals, birds, and reptiles, as we now know them, were evolved, and peopled the Mesozoic continent, from which I conceive Australia to have become separated as early as the end of the Triassic epoch, or not much later. This Mesozoic continent must, I conceive, have lain to the east, about the shores of the North Pacific and Indian Oceans; and I am inclined to believe that it continued along the eastern side of the Pacific area to what is now the province of Austro-Columbia, the characteristic Fauna of which is probably a remnant of the population of the latter part of this period.

Towards the latter part of the Mesozoic period, the movement of upheaval around the shores of the Atlantic once more recommenced, and was very probably accompanied by a depression around those of the Pacific. The Vertebrate Fauna elaborated in the Mesozoic continent, moved westward and took possession of the new lands which gradually increased in extent up to, and in some directions after, the Miocene epoch.

It is in favour of this hypothesis, I think, that it is consistent with the persistence of a general uniformity of the directions of the great masses of land and water. From the Devonian period, or earlier, to the present day, the four great oceans, Atlantic, Pacific, Arctic, and Antarctic, may have occupied their present positions, and only their coasts and channels of communication have undergone an incessant alteration. And, finally, the hypothesis I have put before you requires no supposition that the rate of change in organic life has been either greater, or less, in ancient times than it is now; nor any assumption, either physical or biological, which has not its justification in analogous phenomena of existing nature.

I have now only to discharge the last duty of my office, which is to thank you, not only for the patient attention with which you have listened to me so long to-day; but also for the uniform kindness with which, for the past two years, you have rendered my endeavours to perform the important, and often laborious, functions of your President, a pleasure, instead of a burden.

T. H. HUXLEY

SOCIETIES AND ACADEMIES

LONDON

Royal Society, Feb. 17.—The following papers were read: "Account of the Great Melbourne Telescope from April 1868, to its commencement of operations in Australia in 1869." By Albert le Sueur. The author stated that the building in which the telescope is placed is rectangular, 80 feet long meridionally by 25 wide, with walls 11 feet high. Of the meridional length, the telescope-room occupies the north 40 feet; the next 12 feet