remarkable for the exceedingly small size of the brain cavity, compared with the arches and ridges of the skull developed for muscular attachments. This character has been supposed to indicate marsupial affinities, but the rest of the osteology, as far as known, does not favour this view. The lower jaw has not been found, but the cranium shows the full complement of teeth so frequent in Eocene mammals. There are three broad tubercular molars behind the trihedral sectorial, which indicate that the animal was rather omnivorous than truly carnivorous in its habits. Another genus which includes many species of various size, and having a wide geographical range, being found in late Eocene and early Miocene deposits in France, Germany, England, and North America, is called *Hyænodon*. It also has been by many naturalists placed among the marsupials on account of the peculiarities of its dentition, which is certainly without parallel among placental Carnivores. It possesses the primitive or typical dental formula of the Eocene mammals, and the incisors, canines, and premolars, are not unlike those of a dog, but the three true molars, both above and below, are shaped like the sectorial teeth of a cat or hyæna, and increase in size from the first to the last, and thus there are no teeth formed like the "tuberculars" of ordinary Carnivores. This repetition of the sectorial character in the true molars occurs in the carnivorous marsupials, though the general structure of the skull, and limb bones as far as they are known, including the position of the lachrymal canal within the orbit, will not permit our placing *Hyænodon* in that group. Many of the lately discovered American Eocene carnivores presented the same peculiarity of several successive molars having sectorial characters. One of these from Wyoming, apparently allied to Hyænodon, has been described by Cope, under the name of *Mesonyx*, and another still more aberrant form, as *Synoplotherium*. The inferior canines project forwards, and are closely approximated, the incisors (at all events in the aged specimen on which the genus was founded) being absent. The molar teeth were so much worn that their characters cannot be satisfactorily made out. The most interesting features of these animals are in the structure of the feet, the ungual phalanges being flatter and broader than in any existing Carnivora, and grooved above, and the scaphoid and lunar bones of the carpus not being united as in all existing Carnivores.

These naturally lead to the consideration of some animals, the remains of which have been discovered in the same locality and formation, of such anomalous construction, that they cannot be placed in any of the known groups, and for which Prof. Marsh has constituted the order *Tillodontia*. The type of the order *Tillotherium*, Marsh, is described as having a skull with the same general shape as in the bears, but in its structure resembling that of Ungulates. The molar teeth are of the Ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and growing from persistent pulps, as in Rodents. The adult dentition is $i\,\frac{2}{2}\;c\,\frac{1}{1}\;p\,\frac{3}{2}\;m\,\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The brain was small and somewhat convoluted. The skeleton most resembles that of Carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The radius and ulna, and the tibia and fibula, are distinct. The feet are plantigrade, and each had five digits, all terminated by long, compressed and pointed ungual phalanges, somewhat similar to those in the bears. Judging from the figures and description, this animal is the same as that of which a lower jaw was previously described by Leidy as *Trogosus castoridens*, and which is perhaps identical with *Anchippodus riparius*, described by the same naturalist at a still earlier date, from a single tooth from New Jersey. If this identity can be satisfactorily established, the latter name must be adopted, but as the lower molars of so many very different animals bear a close resemblance to each other, it is not very easy to do so, and the whole history is a good illustration of the inconvenience that often arises from the practice of giving names to minute and isolated fragments.

In some of its dental and osteological characters, *Tillotherium* or *Anchippodus* bears some resemblance to the *Rodentia*, but the definition of that order would have to be widened considerably before it could be admitted within its bounds. *Mesotherium*, spoken of in the third lecture, has better claims to be considered a Rodent, though certainly a very aberrant one. Leaving this animal aside, palæontology tells us nothing of connecting, or even of more greatly generalised forms of Rodents, or affords any better indications of the affinities of the order than can be derived from the study of its living members. Nearly all the existing families have been well represented throughout the Pliocene and Miocene epochs, and the earliest known Rodents, those of the Upper Eocene, do not appear to have been more generalised than the existing species.

Numerous species of extinct *Insectivora* have been described from various formations from the Upper Eocene to the present time, both in Europe and America, but their characters and affinities have not been thoroughly worked. The European species mostly belong or are allied to genera now existing. It has been suggested that some of the generalised Amerian Eocene Carnivores may possibly be gigantic *Insectivora*, though in the actual fauna of the world there are no connecting links between these orders. It is also not certain whether some of the mammals of the Mesozoic strata may not be placental *Insectivores*.

The *Chiroptera*, or bats, differ strikingly from all other mammals in the adaptation of the fore-limbs as organs of true flight. Their origin is an extremely interesting question to the evolutionist. No existing forms throw any light upon it, and what little is known of the past history of the order shows that its general characters and geographical distribution have not changed materially during the Tertiary period. All the bats found fossil in the Brazilian caves resemble those now inhabiting the same country, though it is true these only go back as far as Pleistocene ages. In France, however, remains of bats have been found in the Miocene and Upper Eocene (Paris gypsum), but all belonging to the *Vespertilionidæ* and *Rhinolophidæ*, families now existing in Europe, and in the earliest known forms no signs of generalisation have been detected, nor have any of the intermediate stages between the ordinary mammal and the bat, if they ever existed, yet been discovered. No fossil remains of the large fruit-eating bats, or *Pteropi* have been found.

(*To be continued.*)

PROF. HUXLEY'S LECTURES ON THE EVIDENCE AS TO THE ORIGIN OF EXISTING VERTEBRATE ANIMALS[1]

V.

WE saw in the last lecture that the differences between birds and reptiles were very great; nevertheless, many of them tend to disappear on a closer examination. For instance, the extremely avian character of the absence of teeth, and the presence of a horny beak, is found in turtles and tortoises; that of the penetration of the bones by air cavities exists in the skull of crocodiles; and, although no existing reptile possesses the power of flight, or a fore-limb in any way approaching in structure to a bird's wing, yet, in the crocodiles, the fourth and fifth digits—those we found to be wholly absent in the bird—are much smaller than the others, and have no claws.

[1] A course of six lectures to working men, delivered in the theatre of the Royal School of Mines. Lecture V., March 27. Continued from p. 469.

On passing to the internal organs, and the mode of development, we find far greater points of resemblance; as to the latter, in fact, the correspondence is wonderful, the account given of the development of a reptile (NATURE, vol. xiii., p. 429), applying in every respect to that of a bird.

On the whole it is certain, from anatomical characters alone, that birds are modificatons of the same type as that on which reptiles are formed, and if this similarity of structure is the result of community of descent, we should expect to find, in the older formations, birds more like reptiles than any existing bird, and reptiles more like birds than any existing reptile. If the Geological record were sufficiently extensive, and the conditions of preservation favourable, we ought to find an exact series of links, but this, of course, is hardly to be expected, and it will be a great step if we can show that certain forms tend to bridge over the gulf between the two groups.

Let us see, then, what the facts of Palæontology tell us in this matter: and first, as to birds.

It is a curious fact that, just as in the case of Crocodiles, all the birds found in the Tertiary deposits differ in no essential respects from those of the present day. Great numbers of remains have been found in beds of Miocene age—beds found at the bottoms of great lakes—and the very perfectly preserved specimens show, beyond any doubt, that the Miocene birds are referable to precisely the same groups as those of our own time. Our knowledge of the Eocene forms is less perfect, but enough is known to show that the same fact held good at the commencement of the Tertiary epoch.

Throughout the secondary period remains of birds are very rare; until lately, in fact, there were none at all. But within the last ten or fifteen years some remarkable discoveries have been made—one or two in Europe, and a whole series in America, which give us some very precise information as to the nature of the Mesozoic birds.

Two of the most interesting of these—the genera *Hesperornis* and *Ichthyornis*—occur in certain beds in the United States, corresponding in age to our later Cretaceous. Hesperornis is stated, by its describer, to have had nearly the organisation of our Northern Diver (*Colymbus*); it was five or six feet in length, of swimming habits, had small wings, like those of the Penguin or Auk, and a long beak like the Diver. But—and this is the interesting feature in its organisation—both jaws were beset with teeth: not mere serrations of the jaw, such as many existing birds have, but true teeth like those of a reptile. Here then we have the appearance of a true reptilian character.

Ichthyornis was, in some respects, even more curious. It was about as large as a good-sized pigeon, had large wings adapted for powerful flight, and teeth in both jaws, like Hesperornis. In another character it showed a still greater approximation to the lower reptilian type: the bodies of its vertebræ, instead of having the cylindroidal or saddle-shaped form so characteristic of nearly all birds,[1] were bi-concave. Thus, in tracing birds back in time, we find a parallel series of modifications to those described in the Crocodilia.

Beyond this point, the history of birds is almost a blank, the only other remains being—curiously enough—one or two feathers, and the *Archæopteryx* of the Solenhofen slates, a formation which has been of great service in the preservation of organic remains, the same qualities which make it so useful for purposes of lithography having fitted it for the preservation of even such perishable structures as jelly-fish.

Archæopteryx, known only by a single specimen now in the British Museum, was a bird about the size of a crow. Its head is unfortunately wanting; its tail is quite unlike that of any existing bird, being long, composed of a great number of vertebræ, and having two rows of feathers attached, one to each side of it. The leg is quite like that of any ordinary perching bird. Unluckily, the bones of the wing are detached, so that the exact structure of the manus is not known, but it is quite certain that the metacarpal bones were not united together, but were separate and terminated by distinct claws; there was thus an approximation in structure to a true fore-paw. Long quills were attached to the wings, and both they and the tail-feathers are in an exquisite state of preservation.

With Archæopteryx we come to the end of all precise information as to the history of birds, and the only possible trace of the group in earlier formations are certain footprints found in the Trias of Connecticut, and referred to the genus *Brontozoum*. These were prints of some gigantic three-toed animal, which certainly walked on its hind legs, and was always supposed to be an ostrich-like bird until some recent discoveries, presently to be mentioned, have shown that Brontozoum may have been a reptile.

It would at first seem easy to show an equally striking approximation of reptiles to birds, for we have, throughout the greater part of the secondary rocks, and notably in the Solenhofen slates, remains of a group of reptiles known as *Pterodactyles*. These remarkable creatures had teeth set in distinct sockets, sometimes extending to the end of the long snout, sometimes stopping short, and having their place taken by a horny beak. The neck was long; the sacrum consisted of from three to six vertebræ; the tail was short in some, long in other genera. The breast-bone had a great keel, like that of a bird, the shoulder-girdle was also quite birdlike, as also were the humerus and the bones of the fore-arm. The manus, on the other hand, was quite different to anything found in birds; the first, second, and third digits were of the usual reptilian character and bore claws, but the fourth was immensely prolonged, produced downwards, and clawless. The pelvis was, in some respects, birdlike, in others quite peculiar: the hind-limb was reptilian.

It is certain that the Pterodactyles were animals of flight, and that there was a membrane, like a bat's wing, stretched between the fourth finger and the sides of the body; it is also certain that it was unable to walk, though it may have used its hind-limbs, as bats do, for hanging itself head downwards from branches.

Although these creatures are, in many respects, very birdlike, yet it can hardly be said that they give us any direct help, or that they connect reptiles and birds any more than bats connect birds and mammals. Their avian characters seem to have been purely adaptive, or produced in relation to their peculiar mode of life, and we must therefore try some other line of reptiles for the origin of birds.

In the rocks from the Trias to the later Cretaceous there are, in many places, abundant remains of a group of wholly extinct terrestrial reptiles known as *Dinosauria*. Most of these are of great size, the genus *Iguanodon*, for instance, must have attained a length of fully thirty feet. Our knowledge of most of them is imperfect, but many points of the greatest possible interest are perfectly well known.

Some genera have the snout turned downwards like a turtle's beak, and both it and the large lower jaw were ensheathed in horn. In some the vertebræ are slightly excavated on both faces, and are penetrated with air cavities. The shoulder-girdle consists of a long blade-bone and a short coracoid like that of many lizards. Of the fore-limb nothing is known for certain in the larger species. The sacrum is composed of as many as six vertebræ, which often take on a remarkably birdlike character. More curious still, the ilium has a great forward process,

[1] In this peculiarly avian form of vertebra, the front face of the centrum is convex from above downwards, and concave from side to side, the hinder face being concave from above downwards, and convex from side to side. The Penguins have the dorsal vertebræ opisthocœlous, *i.e.*, with a ball in front and a cup behind.

and the ischium and pubis are both turned backwards, parallel with one another, so as to have almost exactly the same position as in birds. There can be no doubt about this most remarkable point now, as the parts have been found in place in the genus *Hypsilophodon*. The femur was evidently brought parallel to the long axis of the body, and it has the characteristic ridge between the places of articulation of the tibia and fibula. The tibia has a great crest on its front surface, the fibula is quite small, and the flattened end of the tibia fits on to a pulley-shaped bone exactly like the ankylosed astragalus of a bird. The middle or third toe is the largest, and the outer and inner toes small; the metatarsals, although separate from one another, have their faces so modelled that they must have been quite incapable of movement. Substitute ankylosis for ligamentous union, and a bird's metatarsus is produced; in fact the whole structure of the Dinosaurian hind-limb is exactly that of an embryonic bird.

In the very remarkable genus *Compsognathus* of the Solenhofen slates, which is nearly allied to the Dinosauria, and included, with them, in the order *Ornithoscelida*, the head is small, the neck extremely long, and the peculiarities of the hind-limb are entirely bird-like; it also seems that the tibia and astragalus were actually united. The fore-limb, moreover, was very small, and it is certain that Compsognathus must have walked on its hind-legs.

The question, then, naturally arises, did the gigantic Dinosauria, such as Iguandon and Megalosaurus, have the same mode of progression? This seems, at first sight, hard to believe, but there is considerable reason for thinking that it may have been the case, for, in the case mentioned above of the great three-toed footprints of the Connecticut valley and others found in the Wealden formation, no impression of a fore-foot has ever been found; so that, even if we suppose that the impressions of the fore-feet were entirely obliterated, as the animal walked, by those of the hind-feet, the former must, at any rate, have been very small.

When we consider what a very strong piece of evidence this is, we are forced to the conclusion that the evolution of birds from reptiles, by some such process as these facts indicate, is by no means such a wild speculation as it might, from *à priori* considerations, have been supposed to be.

(*To be continued.*)

THE UNEQUAL DISTRIBUTION OF RARE PLANTS IN THE ALPS[1]

M. DE CANDOLLE has recently distributed copies of a paper communicated by him to the Botanical Congress held at Florence in 1874, in which he explains in a very convincing manner a fact which all botanists have noticed in Switzerland, but the causes of which have not hitherto been properly understood. No one is better acquainted with the plants of the Alps than Mr. Ball, and M. De Candolle prints as a text to his paper a remark made by the well-known author of the Alpine Guide, that it is matter of curious inquiry to ascertain why the vegetation of certain districts of the Alps is more varied than that of others.

Two instances to illustrate this will be sufficient. The mountain chain situated between Italy and the Valais is rich in rare and local plants, while that between the Valais and Canton Bern is very poor; again, after tabulating the species found in Switzerland in single cantons only, while sixty-three are peculiar to the Valais, the Canton Bern has but one.

The explanations which have been given hitherto have mainly rested on existing physical causes. Wahlenberg, at the beginning of the century, insisted upon the action of soil and climate. Perrier and Songeon have endeavoured to correlate the distribution of plants with that of different geological formations. Grisebach, more recently, cuts the knot by supposing that the Alps have been a centre of vegetation, and that their present distribution is an ultimate fact.

De Candolle has sought the true reason in the circumstances which accompanied the retirement of the glaciers at the close of the glacial period. "The valleys and groups of mountains which have at present a maximum of rare species and the most varied flora, belong to districts in which the glaciers disappeared soonest. On the other hand, where the duration of snows and glaciers has been most prolonged, the existing flora is poor."

The objection which may be made that a cause so remote can hardly influence the present distribution, is met by pointing out the extreme slowness with which a vegetation establishes itself, and the persistence with which it maintains its *status quo* when so established. Thus the rare plants for which the botanists of the sixteenth century were accustomed to visit particular localities may still be gathered there. Again, the Rhone valley is intersected by numerous moraines; the lower and more ancient are covered with chestnuts, while the higher are more and more barren and still covered only with pines.

From a variety of causes which De Candolle enumerates, it seems probable that the southern and eastern glaciers of the Alps were of smaller extent than the northern, and would consequently be the soonest to retreat. They also probably furnished a refuge amongst their ramifications on smaller mountains which even in the Glacial period would be without snow in the summer, to some of the ancient Alpine and sub-alpine plants which were driven southwards as the glaciers increased.

We have therefore the curious fact that some of the most ancient fragments of the Alpine flora are now only to be found on the *southern* slopes of the Alps. This is the case with species of *Primula*, *Pedicularis*, and *Oxytropis*, which exist neither in the interior of Switzerland nor in the north of Europe. But it is easy to see that, like the other members of this flora, they were driven south during the Glacial period, returning as the mountains reappeared from underneath their snowy covering; while on the northern side they were in great measure exterminated. De Candolle points out as a fact in further confirmation that the Alpine species of *Campanula*, peculiar to Mont Cenis and the Simplon and neighbouring valleys, are not related to the Arctic species, but find their nearest allies in Greece, Asia Minor, and the Himalaya.

The Valais was freed from glaciers while the Mont Blanc district and the interior of Switzerland was still in the condition of Greenland. It was gradually stocked by means of species which arrived from France. The first plants to arrive must have been those which are found at the present time on the Jura and the mountains between Geneva and Chamouni. Established at first in the lower part of the valley, they would ascend as the snow diminished. The remarkable plants of the Grande Chartreuse and of Mounts Vergy and Brezon in Savoy, of the higher parts of the Western Jura, and even of the neighbourhood of Bex in Switzerland, probably belong to this period. When the perpetual snow and glaciers had disappeared from these mountains, the neighbourhood of the Lake of Geneva, the base of the Jura, and even the commencement of the Valais were more favourably circumstanced. Plants of still more southern origin could then arrive from France. This is probably the date at which the box and many *Cistineæ* and *Labiatæ*, characteristic of dry southern districts, established themselves at the foot of the Jura. Seeds carried from Italy by winds or birds introduced some of the rare

[1] Sur les Causes de l'Inégale Distribution des Plantes rares dans la Chaîne des Alpes, par Alphonse De Candolle. (Florence, 1875