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PHASES OF ANIMAL LIFE.

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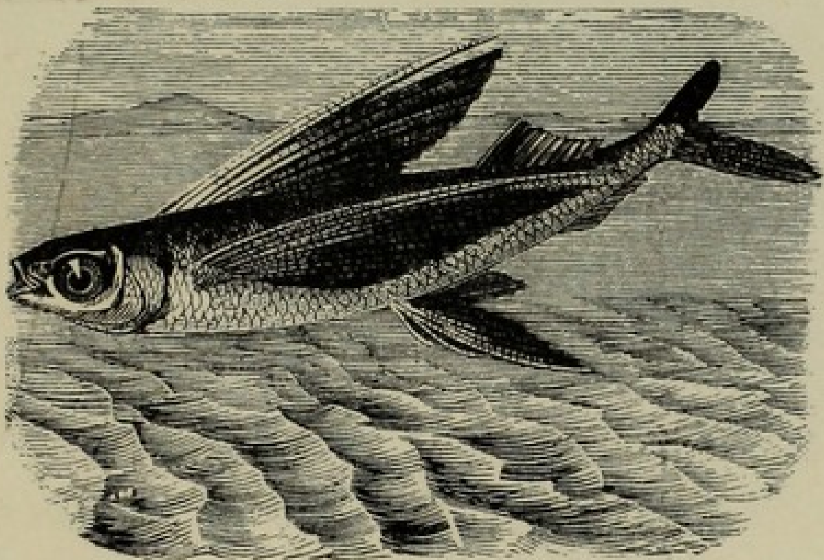
PHASES OF ANIMAL LIFE

PAST AND PRESENT.

By R. LYDEKKER, B.A. (Cantab.)



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PREFACE.

THE following Essays are, by the kind permission of the Editor, reproduced from KNOWLEDGE, with some emendations, and a few additional illustrations.

They are intended to illustrate in a popular manner a few of the various modes in which animals—especially vertebrates—are adapted to similar conditions of existence; and also to demonstrate some of the more remarkable types of structure obtaining among the higher vertebrates. It will be found that while some of the Essays form a continuous series, others are totally unconnected with those to which they stand in juxtaposition. While living forms are by no means neglected, especial attention is concentrated on the less known, strange, and often gigantic creatures which have now passed away for ever, and are revealed to us—it may be but obscurely—only by their dry bones.

The series has, the author flatters himself, met with a favourable reception in its original form; and he trusts that it may obtain at least equal approval in its present guise.

CONTENTS.

PHASES OF ANIMAL LIFE, PAST AND PRESENT.

CHAPTER I.

MAIL-CLAD ANIMALS.

AMONG civilised nations throughout the world the practice of protecting their fighting-men by coats of mail, which prevailed so extensively during the middle ages, has been entirely abandoned; the cuirass of the English Household Cavalry and of the French Cuirassiers being a survival, or, as naturalists would say, a rudiment, of the complete coat-of-mail, which is retained more on account of the smartness which it adds to the equipment than for any practical use as a protection. The use of armour as a protection has, indeed, been transferred from men's bodies to the sides of ships of battle; and even there it appears problematical whether the ever-increasing weight of the armour which is necessary to keep pace with the development in the size and speed of the missiles employed against it will not eventually become so burdensome as to lead to its abandonment.

In the case of the coats-of-mail of the mediæval warriors a gradual process of evolution had, indeed, brought them to a marvellous pitch of perfection at the time when they were once for all abandoned; and the beauty of the suits of chain- and plate-armour, both as works of art and as admirable adaptations for their particular purpose, must at once strike all who visit a gallery of ancient armour.

If we now direct our attention to the animal, as distinct from the human, world, and confine our survey to that portion of it which includes the back-boned, or, as naturalists term them, the vertebrate animals, we shall find in the early periods of the earth's history a great tendency in many groups to the development of a coat-of-mail, fully as beautiful, and frequently much more efficient than that of the knights of old. We shall find, moreover, that, on the whole vertebrate animals have, so to speak, come to the conclusion that a coat-of-mail is not altogether an advantage, more especially among the higher forms, in the struggle for existence; and that a better protection is to be found in the swiftness of limbs for flight, or in the length of tusks and talons for attack. Still, however, there are certain groups of animals which have preserved the old-fashioned plan of living and fighting the battle of life in armour, although even some of these seem to be in two minds as to whether, after all, the plan of facing the world with unprotected bodies is not really the best.

In drawing a parallel between human and animal armour we must, however, always recollect that the animal has this inestimable advantage over man, that his armour is grown upon his own body, and is in fact part and parcel of himself, instead of having to be put on and off. Again, whereas the chief types of human armour may be summarised under the three forms of chain- scale- and plate-armour, we find a much greater variety prevailing in the coats-of-mail of animals. And here we would impress upon the reader how much knowledge he would gain of these wonderful, and frequently very beautiful, structures if he were to visit the Natural History Museum at South Kensington, and inspect the admirable collection of different types of these and other marvellous animal structures arranged in the cases placed in the bays on the left side of the great central hall.

Our brief survey of some of the more important types of animal armour will be best understood if we take the various groups in their natural sequence of rank and their succession in geological time, commencing with the lower and earlier forms. Our first glance will then be directed towards the great class of fishes, of which some of the earliest examples occur in the Old Red Sandstone rocks of Scotland, laid down in lakes and rivers ages before those forests flourished, the wood and foliage of which we now burn in our fires as coal. Strange and uncouth indeed must have been many of these old fishes, whose bodies were encased in a complete coat of plate-armour unlike that found in any living forms, and consisting of larger or smaller shield-like bones closely united together at their edges. The head, too, in some of these fishes (Fig. 1) was most remarkable, and looked something like a flattened and expanded ploughshare. It has, indeed, been suggested that the reason why these earliest fishes possessed such an extraordinary strong coat-of-mail is that the waters of the primeval epochs were hot from contact with the still heated globe, and were also impregnated with strong acids or salts; but against this it may be urged that it does not appear that it would be any advantage to be par-boiled in a coat-of-mail rather than in an ordinary

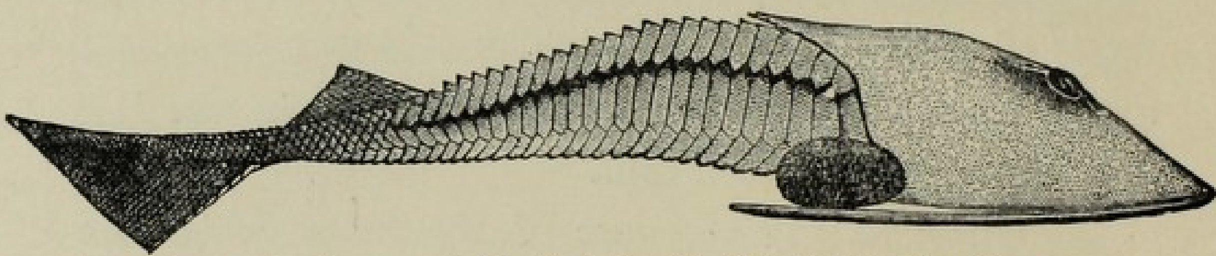


FIG. 1.—An Armoured Fish (*Cephalaspis*) of the Old Red Sandstone.

skin. Somewhat later in the world's history, that is to say, at and about the period when our coal was formed, fishes with an armour of a different type were very abundant; many of the same groups also occurring in the Old Red Sandstone. In these Ganoid fishes, as they are scientifically termed, the body (Fig. 2) was often covered with a coat of lozenge-shaped scales, formed of solid bone, and faced with a hard coating of shining and polished enamel. These scales did not, as in most fishes of the present day, overlap one another like the slates on a roof, but were joined together at their edges,—frequently with the aid of a peg from one scale received into a socket in the adjacent one. Fishes with this form of plate-armour flourished not only in the Coal period, but were also abundant at that later date when the blue Lias clays and limestones now forming the cliffs of Whitby and Lyme-Regis were laid down on the old sea-bottom. After that, however, this type of armour seems to have gradually gone out of fashion, and the only fish in which it now remains is the Gar-pike of the American rivers, which may thus be regarded as a kind of mediæval knight. The Sturgeons, known to many of us chiefly or entirely through that Epicurean luxury *caviare,* present us with another type of armour, which is probably also a survival from long past days. In these gigantic fresh-water fishes the body is protected by several longitudinal rows of large diamond-shaped bony plates, which are not connected with one another. Whether, however, this modification of plate-armour is derived from a complete suit, and is thus somewhat analogous to the Life-Guardsman's cuirass,

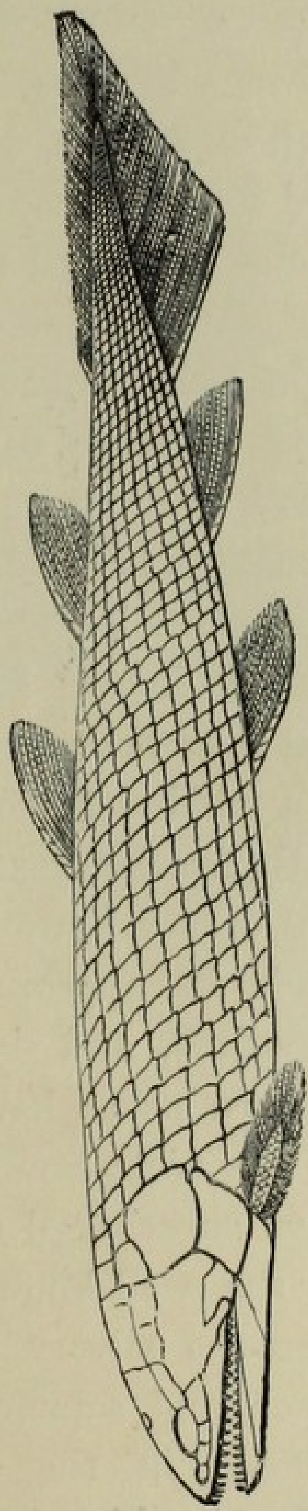


FIG. 2.—A Ganoid Fish (*Osteolepis*) of the Old Red Sandstone.

or whether it was always of the same type as at present, is one of those questions which does not yet admit of a decisive answer. In contrast to the Ganoid fishes, where we see a gradual dying out of the old mail-clad types, we may notice the case of the Sharks and Rays. These fishes seem to have taken a moderate course in regard to armour, avoiding on the one hand the plate-armour of the Ganoids, and on the other the light scale-armour of the fishes of the present day. In most of these fishes the skin is studded with very small bony granules, and thus has a rough file-like structure, being commonly known under the name of shagreen. These fishes, be it noted, while among the earliest known forms, are still extremely abundant, and thus present a striking instance of the advantage of a middle course in the struggle for existence.

By far the great majority of the fishes of the present day belong, however, to a group which seems to have made its appearance shortly before our Chalk was deposited, and is now the dominant one. These modern fishes have succeeded in entirely getting rid of the plate-armour of the Ganoids, for which they have substituted a much lighter scale-armour formed of the well-known overlapping horny scales which give the silvery lustre we admire so much in the roach and salmon. The same type of armour also obtains in the curious Baramunda of Queensland (Fig. 3), which belongs to an older group. Whereas, however, the majority of the fishes of the present day have adopted this light scale-armour in place of the old-fashioned plate-armour, a few have struck out a new line in the development of a different type of bony coat-of-mail. Thus the Coffer- and File-fishes of the tropical seas have a protective coat of bony plate-armour with a sculptured outer surface, so locked together as to form a box-like structure investing the entire body. Again, among the fresh-water Cat-fishes there is one genus in which the body is covered with a cuirass of overlapping plates formed of solid bone. Perhaps, however, the most peculiar kind of armour in

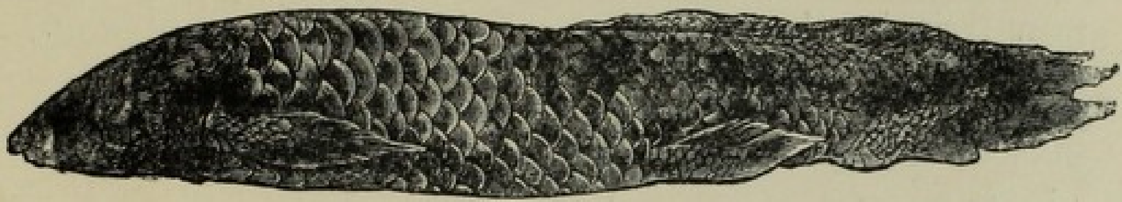


FIG. 3.—The Baramunda of Queensland, showing overlapping scale-armour.

the entire class is found among some of the well-known Globe-fishes, which are likewise so remarkable for their habit of inflating their bodies into a balloon-like shape. In these fishes, as is shown by a preparation in one of the cases already alluded to in the Natural History Museum, the body is protected by a coating of long spines, each of which may be as much as two inches in length, and is inserted in the skin by a flat and expanded plate of bone.

As a whole, then, in spite of the exceptions last mentioned, which according to the time-honoured phrase only serve to prove the rule, fishes appear to have come to the same conclusion as the more advanced divisions of the human race, that a massive armour for the protection of the body is an encumbrance rather than an advantage as a means of protection against attack.

The same story is told still more clearly in that group of animals now represented by the frogs, newts, and their allies, which are popularly reckoned among Reptiles, but which naturalists, with that tendency to multiply terms for which they are so celebrated, distinguish as Amphibians. Thus during, and for some time after, that distant epoch to which we have already referred, when the coal-forests waved over what is now Britain, there lived a number of salamander-like creatures, termed, from the complicated internal foldings found in the teeth of many of them, Labyrinthodonts.* In these creatures the under surface of the chest was protected by three large bony plates; while in some cases an armour of scale-like bones covered the rest of the body. All the existing frogs, salamanders, and such-like creatures have, however, totally dispensed with the panoply of their forefathers; and have, as we all know, a soft and naked skin.

The true Reptiles, in which the naturalist includes crocodiles, lizards, snakes, tortoises, and turtles, as well as a host of extinct forms, appear, speaking metaphorically, to have held divided opinions as to whether a bony coat-of-mail was or was not a thing to be retained as a permanency; since, while some extinct and early groups never had any armour at all, others have

* See Chapter IV.

continued this protective covering in great perfection to the present day. Reptiles are, moreover, remarkable for the great variety of the kinds of armour which they have displayed in the course of a long career.

The Crocodiles offer the best living examples of reptiles with a plate-armour, recalling that of some fishes. In these fierce creatures, the back and upper surface of the tail are covered with a number of oblong bony plates buried in the skin and covered by horny shields. In the true crocodiles (which in India so many people will insist on misnaming alligators), this armour is confined to the upper surface of the body; but in some, although not in all, alligators, there was also a similar armour upon the lower surface. Since, moreover, most of the earlier fossil types had an armour upon both aspects of the body, it seems that crocodiles have, on the whole, found it advantageous to get rid of the lower buckler, so that to a certain extent they seem to have followed the general rule. It is, however, very curious to find that there were some fossil crocodiles which had totally discarded their armour; and since these have altogether disappeared, it would seem that this radical change did not answer in this particular instance.

As first cousins of the crocodiles, we may briefly note those fossil reptiles to which, from the gigantic size of some of them, the name of Dinosaurs,* has been applied. Some of these huge creatures, which far exceeded the elephant in bulk, had a bony armour which

* See Chapter VIII.

formed a solid cuirass over part of the back and loins; while in many cases the bony plates which covered the body were developed into huge spines of more than a foot in length; and in others the back and tail were armed with a row of large plates set edge-ways along the back-bone, and extending from the head to the tip of the tail, as shown in Fig. 39.

The Lizards and Snakes, which we may regard as advanced and highly specialised reptiles, having but little kinship with the old-fashioned Crocodiles and Dinosaurs, have, as a rule, discarded the plate-armour of the latter, and acquired instead a light scale-armour of overlapping horny scales, which in many of them are beautifully marked. The snakes, indeed, never have any trace of the bony plate-armour, which would, of course, interfere with their lithe motions; but in some lizards, small rudimentary bony plates are found in the skin underlying the scales, to tell the tale of their old alliance.

Perhaps, however, the most original idea in the way of a coat-of-mail is found in the Tortoises and Turtles.* In these reptiles, the ribs and back-bone of the skeleton have taken part with bony plates, analogous to those of the crocodiles, to form a solid armour which in the land-tortoises (Fig. 4) is welded together into a complete box, from which the creature can only protrude its head, tail, and limbs. This remarkable and unique arrangement has entailed the further curious modification that the shoulder-blade and haunch-bones are

* See Chapter VII.

placed inside the ribs, instead of externally to them, as in all other living animals. This type of armour, which we may term box-armour, seems to have been a success, since tortoises and turtles are, in certain parts of the

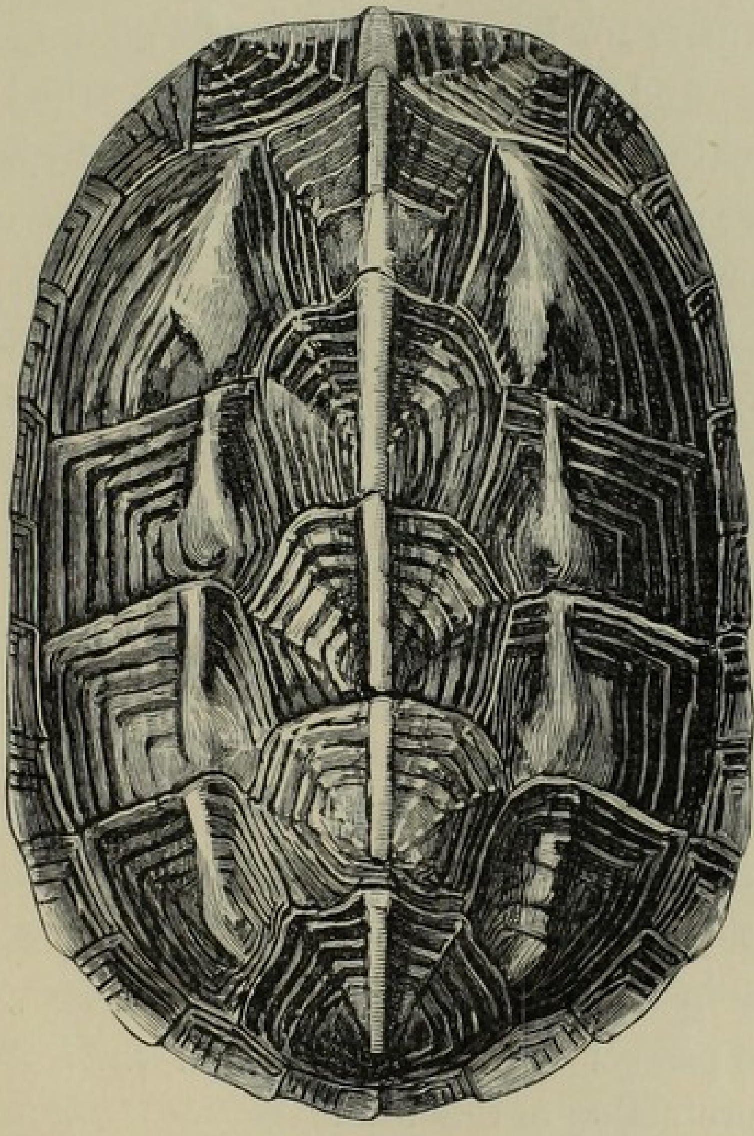


FIG. 4.—Upper surface of the carapace of a Tortoise.

world, among the commonest of reptiles. In some of those types which are dwellers in water, such as the well-known soft tortoises, or mud terrapins, so abundant in the Nile and other tropical and subtropical rivers, the breast-plate and the back-plate of the armour are, however, quite separate from one another, this arrangement being probably more conducive to freedom of action in swimming.

The great class of Birds, which Professor Huxley calls only highly modified reptiles, are remarkable in that there is no trace of a coat-of-mail in any single species. And when we come to consider the life which these creatures lead, we at once see the absence of any need for such a protection. Thus it is quite clear that in ordinary birds, which are gifted with the power of flight, a bony armour would not only be perfectly unnecessary as a protection, but would also seriously impede, if indeed it did not totally prevent, their flight. On the other hand, in the flightless birds, like the ostriches and their allies, or the kiwis of New Zealand, sufficient protection is afforded either by their size and strength, or by their nocturnal habits. There are, indeed, certain flightless species, like the extinct dodo of Mauritius, which have neither strength nor speed, nor are of nocturnal habits. Their want of the power of flight is, however, an acquired loss, due to their dwelling in islands in which they are, or were, free from the persecution of enemies, and thus needing no special protection of any kind.

Leaving the birds, we have to complete our survey of the various types of armour obtaining among vertebrate animals by a glance at that class which includes the highest of all vertebrates, and indeed of all animals. Unfortunately we are still in want of a good popular name for this class, which includes man himself. In common parlance these animals are, indeed, very generally termed quadrupeds; but this name is objectionable, in that it is equally applicable to many reptiles, and also since it can scarcely be applied to whales, which, as is well known, belong to the same class as man. The term Mammals is, however, becoming somewhat popularised in the sense of the older term quadrupeds, and, since it is in every way an excellent one, we shall take leave to employ it. Now, with the exception of one peculiar group or order, all mammals agree with birds in being conspicuous for the absence of a bony bodily armour; and since they have not the peculiar means of protection possessed by so many of the latter class, they afford striking examples of our thesis that as animals have progressed in organisation they have discarded protection by plates of bone, to find a better one in the strength or speed of their limbs, or in the sharpness of their teeth and talons.

The solitary group of mammals which has sought protection in a coat-of-mail is the one which comprises the sloths, ant-eaters, and armadillos. Only a few, however, of these creatures have thus protected themselves; while some, like the sloths, have sought refuge in an arboreal life; and others again, like the ant-eaters, have found protection by burrowing in the ground. These mammals, which are scientifically known as the Edentates, are all of a very low type of organisation, and widely different from all other members of the class. It is, however, noteworthy that low as they undoubtedly are, yet that they exhibit no signs of relationship with the lowest of the mammal class, such as the Australian duck-mole.* Since, moreover, the duck-mole and its allies have no coat-of-mail, it is further evident that the Edentates have not inherited their armour from lower forms, but that they have evolved it themselves *de novo*.

The Edentates, which are chiefly characteristic of South America, having however, so to speak, once

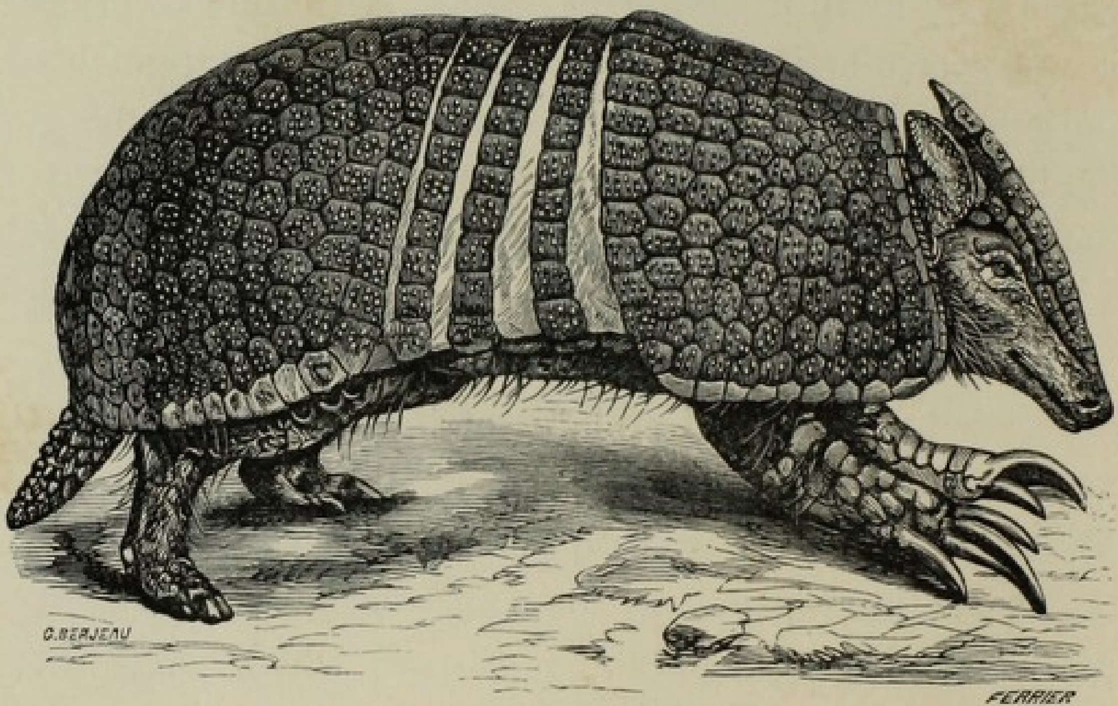


FIG. 5.—The three-banded Armadillo.

made up their minds that armour is the right thing, have gone in for it with a will, with the result that they show some of the finest specimens of plate-armour to be found in the whole animal kingdom. In the comparatively small Armadillos (Fig. 5), which are the best known examples of the armoured Edentates, the whole of the body, with the exception of the under

* See Chapter XI.

surface, is protected by a very strong bony armour, which is often elegantly sculptured. Thus their shoulders are encased in one solid shield, and their loins in another, the two shields being connected by a larger or smaller series of movable transverse bands, which permits the creature to roll itself up into a ball after the manner of a hedgehog, and thus present a

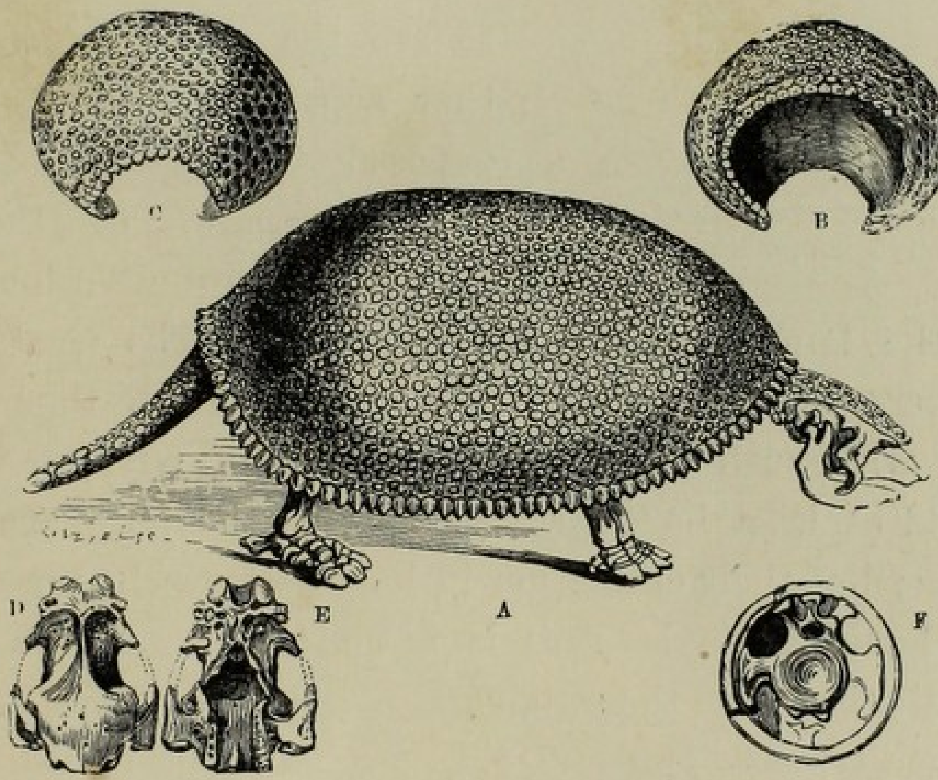


FIG. 6.—A Glyptodont, showing the carapace. A, View of entire animal. B, Front end of carapace. C, Back view of same. D and E, Upper and under side of skull. F, Section of tail showing vertebræ inside the bony sheath.

sphere of plate-armour to an enemy. Still more wonderful, however, is the armour of the extinct Glyptodonts (Fig. 6), whose shield formed a single massive carapace, which may be as much as five feet in length, with a thickness of more than an inch of solid bone. These creatures could not, of course, roll themselves up, and they accordingly had their tails protected by a coating of bony rings closely articulated together, or by a number of plates of various sizes, as in Fig. 7. Moreover, some of them had a breast-plate on the under surface of the body, of which it is not very easy to see the necessity, since this aspect would not be exposed to attack. The huge carapaces of these Glyptodonts are often found on the Pampas, where they are said to be used as shelters by the natives. One would have thought that with such an armour the breed of Glyptodonts would at least have lived as long as the puny armadillos; but their extinction in long past epochs repeats the lesson that the race is not always to the swift, nor the battle to the strong.

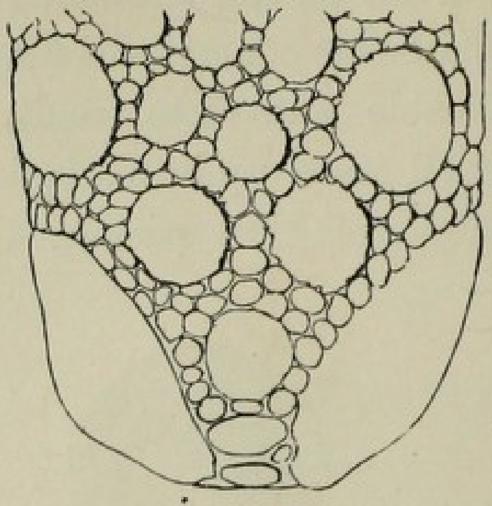


FIG. 7.—End of sheath of tail of a Glyptodont, much reduced.

Finally, as a last and very original type of mailed animals, we must mention the scaly ant-eaters, or Pangolins (Fig. 8), of Africa and Asia, which (pursuing our metaphor) appear to have come to the conclusion that a bony-plate armour is much too heavy for such warm climates, and have, therefore, adopted a light and elegant scale-armour composed of overlapping brown, horny scales, causing them to look much like an elongated cone of a spruce-fir endued with life. Even, however, this lighter and last type of armour does not appear to have been altogether a success in life's battle, since pangolins are comparatively scarce animals, few in species, and dragging on what seems to us a somewhat dull existence by the aid of nocturnal and burrowing habits.

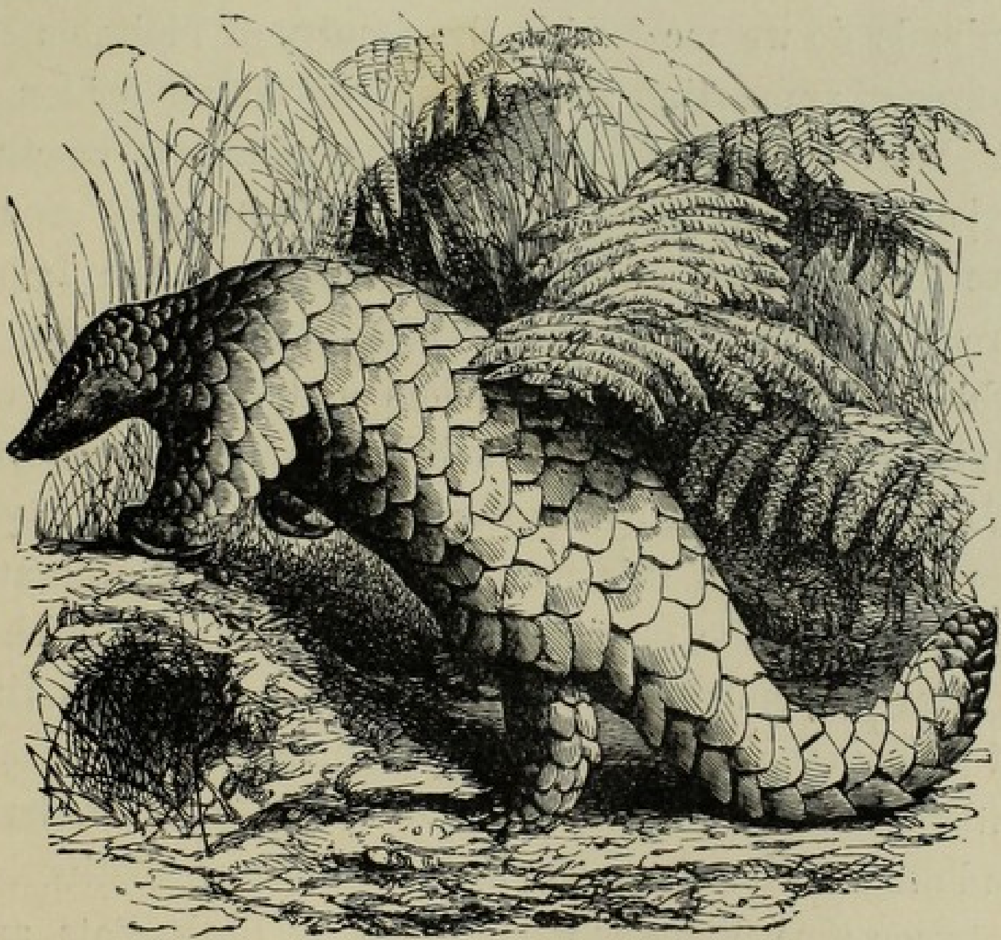


FIG. 8.—The Pangolin. (*After Tennent.*)

CHAPTER II.

FLYING ANIMALS.

ONLY in certain members of two great groups of animals do we meet with the faculty of flight, or the power of supporting their bodies in the air for longer or shorter periods by the aid of membranous or other expansions developed therefrom. These two groups are the Insects, constituting a class of the larger group known as the Arthropodous sub-kingdom, in which are also included spiders and crabs; and the Vertebrates, which form a sub-kingdom to themselves. Whereas, however, by far the great majority of Insects are endued with this faculty, among the Vertebrates it is only in the class of Birds that we meet with a similar preponderance of species which enjoy this kind of locomotion, although all the members of certain orders—the Pterodactyles and Bats—are similarly endowed. Moreover, we have to draw a distinction between true flight, as exemplified by Birds, Bats, and Insects, and what we may call spurious flight, of which we have examples in Flying Phalangers, Flying Squirrels, and Flying Fish. True flight is performed by an alternate upward and downward motion of the wings, or special organs of flight, and can be indefinitely prolonged until the muscular powers of the flyer are exhausted. On the other hand, spurious flight is merely a prolongation of a downward or upward leap by means of parachute-like expansions developed on the sides of the body, or, as in the Flying Fish, by passive extension of wing-like organs, and it can never be extended beyond the limits of the initial velocity of the original leap. This distinction between true and spurious flight is a very important one, since it shows us that the animals endowed with the former power are limited to four groups, namely, Insects, the extinct Pterodactyles or Flying Dragons, Birds, and Bats. Spurious flight, on the other hand, is found in Flying Fish, Flying Lizards, Flying Phalangers, Flying Squirrels, and Flying Lemurs. Among those animals capable of true flight a broad line of distinction separates the Insects from the Vertebrates in regard to the organs set apart for this particular purpose. Thus, whereas in Insects, all of which are provided with six pairs of legs, the wings, or special organs of flight, are frequently four in number, and are in all cases developed from the back of the body, entirely independent of the legs; in Vertebrates, where the number of legs never exceeds four, the two wings are always formed by special modification of the first pair of legs. It is therefore evident that although the wings of Insects, as performing similar functions, are analogous with those of Vertebrates, yet, as being structurally quite different, they are in no sense homologous with the same.

The special modification of the first pair of legs to subserve the purpose of flight in those Vertebrates which possess this power in its true form, may be taken as an indication that such Vertebrates have originally descended from others in which that power was not developed. Although we have no such guide in the case of Insects, yet the circumstance that in all those kinds which undergo a complete metamorphosis no traces of wings are observable in their larvæ, points with equal clearness to the conclusion that these creatures have been likewise derived from crawling ancestors, and that their power of flight is an acquired one. Those Insects which are unable to fly must not, however, be regarded as ancestral forms, since there is clear evidence that their wings have been lost or have become rudimentary. It has been already mentioned that while all flying Vertebrates have only a single pair of wings, many Insects are provided with two pairs of these organs; and from the tendency among Insects for one or other of these pairs of wings either to disappear or to be modified for other purposes, it would appear that a single pair is decidedly the best suited for flight.

We shall now proceed to trace some of the chief modifications in the organs of flight in the different groups of animals, commencing with Insects, in which, as already observed, we never meet with spurious flight.

In all the Beetles, or Coleoptera, which form the first order of Insects, the front pair of wings are modified into the well-known horn-like wing-covers, or *elytra,* beneath which the membranous second pair are neatly folded during such times as the creatures are not engaged in flight. In some kinds, such as the Stag-Beetle and the Water-Beetles, these wing-cases are long, and extend backwards to the hinder extremity of the body; but in others, like the well-known "Devil's Coach-Horse," they are extremely short. The modification of the front wings into wing-covers clearly indicates that Beetles are a highly specialised group; the extreme development of this specialisation occurring in certain species like the Oil Beetle, where the second pair of wings have also become rudimentary, so as to render their owner incapable of flight. In some degree a confirmation of this specialisation is afforded by the circumstance that Beetles are not known in the fossil condition so far down in the geological scale as are some of the more generalised groups of insects.

In the Bees, Wasps, Ants, and other members of the second order Hymenoptera, both pairs of wings are membranous and adapted for flight; the front pair being, however, considerably the larger of the two. In the Caddis Flies and other Neuroptera, both pairs of wings are likewise fully developed and membranous in structure, although differing in the mode of arrangement of their veins. Moreover, the hinder pair are frequently nearly as large as the front pair—a circumstance which seems to indicate that the whole group is a more generalised one. The development of the well-known minute scales on both pairs of wings in the

Butterflies and Moths readily distinguishes the Lepidoptera from all other insects, and likewise suggests that they form a much specialised modification of the class. Still greater specialisation as regards their organs of flight is, however, presented by the Flies and Gnats, constituting the order Diptera, in which while the front pair of wings are large and membranous, or hairy, the second pair are reduced to small, drumstick-like processes termed balancers, or *halteres,* which are of no sort of use in flight, and are typical rudimentary organs. The specialisation of the wing-structure in this group is, therefore, exactly the opposite of what occurs among the Beetles, where, as we have already seen, it is the first pair of wings which takes no part in flight. In the Cicadas and Bugs (Fig. 9), constituting the order Rhynchota, the wings, when present, are four in number, but the first pair may be converted into horny wing-covers, as in the Beetles. Like those of the next order, all the members of this group differ from the insects

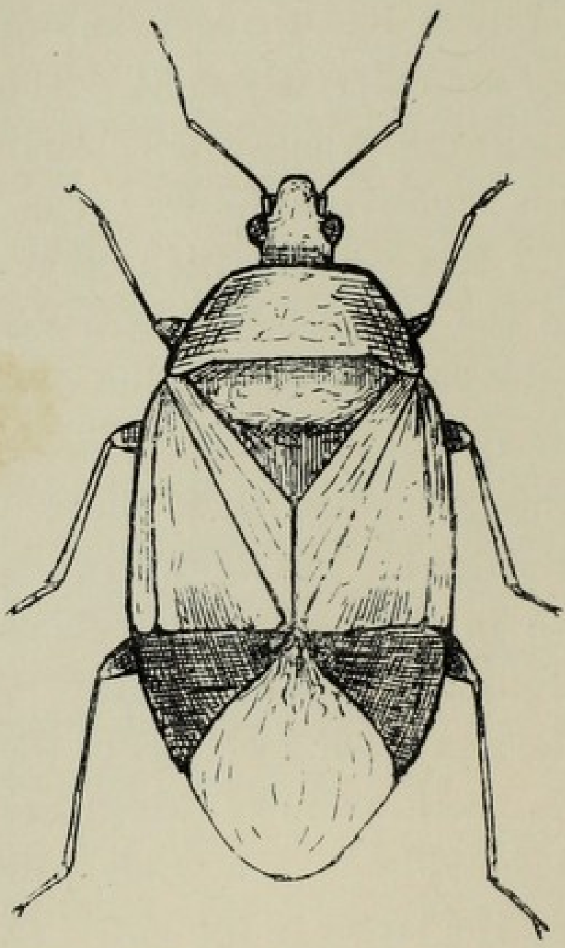


FIG. 9.—Enlarged view of a Flying Bug, with the wings closed.

mentioned above in that they do not undergo a complete metamorphosis before attaining their final perfect state. The last order that we have to notice is the Orthoptera, in which are grouped Grasshoppers, Cockroaches, and Earwigs. Except in a few parasitic and some other forms, all these insects are furnished with two pairs of wings, which differ, however, greatly in structure. Thus, in the Grasshoppers, Cockroaches, and Earwigs the front pair are leathery, and serve as wing-covers to the hinder pair, which are folded beneath them in a beautiful, fan-like manner. Whereas, however, in the Grasshoppers the first pair of wings still take some small share in flight, in the Earwigs they are extremely small, and serve solely as covers. The Earwigs, therefore, which many people believe to be incapable of flight, represent the extreme of wing-specialisation in this group of Insects.

This closes the list of flying creatures found among the Invertebrates, and we pass, therefore, to the Vertebrates, where we find our first examples of flight among the class of Fishes. In this group, however, in spite of assertions to the contrary, there is no instance of true flight; such fishes as are able to fly at all merely doing so after the spurious manner. The longest flights are made by the well-known Flying Fishes (Fig. 10), of most of the warmer seas, in which the first pair of fins is greatly elongated for this purpose. These fishes rise from the water with an upward impulse made by the sides of the body and tail, and they may remain above the surface for a distance of 200 yards. They do not usually reach a height of more than a few feet above the water, although they occasionally spring so high as to alight on the decks of ships. There are few more beautiful sights than to watch from the bows of a large steamer a shoal of Flying Fish as they rise one after another, with their quick meteor-like flight, and then as suddenly disappear beneath the dark waters.

Flying Fish, it may be observed, are first cousins of

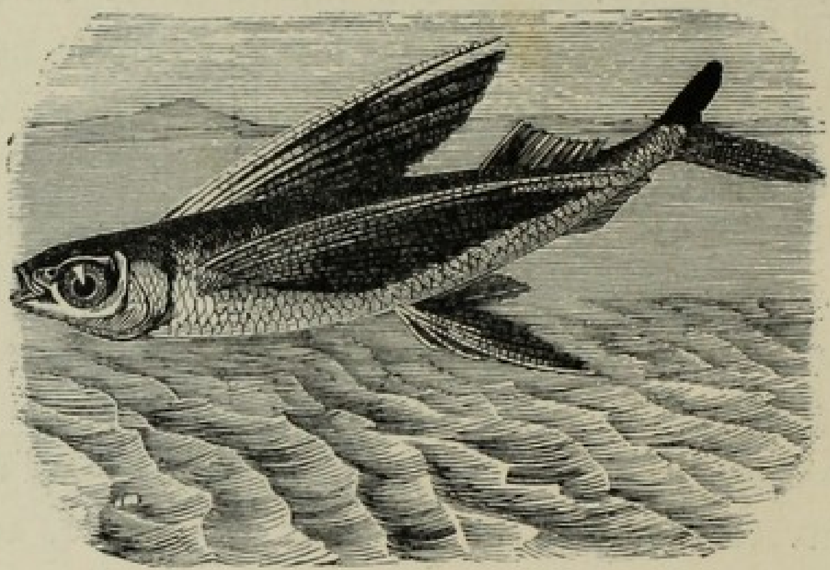


FIG. 10.—The Flying Fish.

the common Herring. The only other Fish endued with the power of flight are the Flying Gurnards, which belong to a totally different group, and of which there are three kinds inhabiting the Mediterranean and most tropical seas. All of them are larger and heavier than the true Flying Fishes, although they fly in the same manner.

It has been stated that a Frog from the Malay region uses the large webs on its feet as a kind of parachute in its descent from the trees on which it dwells to the water, but later researches do not lend countenance to this idea; and our next examples of flight must accordingly be drawn from the class of true Reptiles. Among living Reptiles there is no instance of true flight, although two groups are endowed with the power of spurious flight. The first example of this is the Flying Gecko, a small lizard, belonging to that peculiar group so well known in tropical climates from their habit of running up and down the walls of dwelling-houses. The Flying Gecko is an inhabitant of Borneo, Java, &c., and attains a length of about 7 inches. Its sides, limbs, tail, and head are furnished with loose expansions of skin which, becoming inflated with air, act as a parachute in the long, flying leaps which the creature is able to take from tree to tree. The true Flying Lizards, which range from India to the Philippines, have their parachutes constructed after a totally different fashion; the last five or six ribs being greatly elongated to support an expansion of the skin of the flanks, which forms a fan-like wing on either side. The late Prof. Moseley described these lizards in the Philippines as flying so rapidly from branch to branch that the extension of their parachutes could scarcely be observed; and also states that some kept on board ship were in the habit of flitting from one leg of the table to another.

Since the extinct Flying Dragons or Pterodactyles of the Mesozoic epoch, which are the only reptiles capable of active flight, are described at length in a later chapter, our allusion to them will here be brief. These extraordinary creatures, as shown in Fig. 11, were furnished with thin membranous wings, supported in front by the arm and fore-arm near the body, and at their extremities by the greatly extended joints of a finger corresponding either to the ring or little finger of the human hand. This membranous expansion was continued down the sides of the body to embrace the

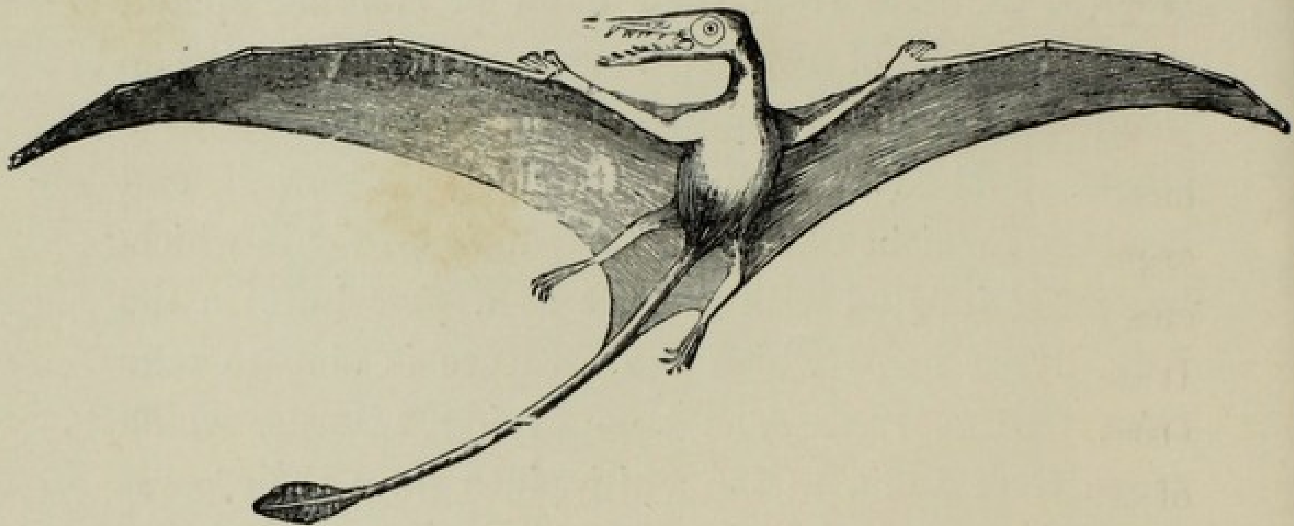


FIG. 11.—Restoration of a Long-tailed Pterodactyle. One-seventh natural size. (*After Marsh.*)

legs and the upper part of the tail; while in at least some of those species in which the tail was long, its extremity was furnished with a racket-shaped expansion of membrane (as in Fig. 11), probably used as a kind of rudder during flight. Some of these creatures were of enormous dimensions, having an expanse of wing estimated at upwards of 25 feet. That they were endowed with the power of true flight is perfectly evident from their general structure; as is especially shown by the strong ridge developed on the breast-bone for the attachment of the muscles necessary for the down-stroke of the wings. Their mode of flight was probably very similar to that of Bats, which they appear to have resembled in their wing-membranes, although the supports of those membranes, as we shall subsequently see, are arranged on a totally different plan in the two groups. It is, perhaps, superfluous to add that any resemblances existing between Pterodactyles and Birds are solely due to their adaptation to a similar mode of life, and that there is not the remotest genetic connection between them.

We come now to the Birds, in which true flight has attained the fullest development, and the whole organisation is profoundly modified to suit the exigencies of a more or less completely aërial mode of life. It is true, indeed, that certain birds, such as the Ostrich, Cassowary, and Penguins, are totally incapable of flight; but this incapacity is certainly an acquired one in the last-named birds, and there is a considerable probability that it was likewise so in the two former.

The great peculiarity whereby Birds differ from all other animals is the presence of their external covering of feathers. A feather, as we all know, is one of the most beautiful objects in nature; and its structure is an admirable instance of adaptation for a particular purpose. The uses of feathers are two-fold. In the first place, the small ones with which the body is clothed form the most perfect covering that can be imagined to ensure the maintenance of the high bodily temperature so essential to the active existence of a bird. Then, again, the larger and stronger feathers of the wings are the most efficient instruments for obtaining the utmost advantage from the resistance of the air to their strokes during flight. The peculiar nature of the wings of Birds may be summarised by the statement that whereas all other animals fly by means of expansions of the skin itself, these alone fly by means of separate outgrowths or processes developed from the skin.

The wing of a Bird, although constructed on the same fundamental plan as that of a Pterodactyle, differs altogether in the manner in which the bones corresponding to those of the human hand have been modified for the purposes of flight. In the wing of a Bird only three fingers are represented at all, and these probably correspond to the thumb, index, and middle finger of the human hand. Moreover, while the thumb is only represented by a small splint of bone, carrying the so-called "bastard wing," the bones of the index finger are flattened, and much larger than those of the third one, with which, in living birds, they are more or less closely united. This finger, therefore, forms the chief part of the extremity of the wing or pinion; but, instead of its bones being much longer than those of the arm and fore-arm put together, as is the case with the elongated outer finger (4th or 5th, as the case may be) of the Pterodactyle, it is much shorter; and, indeed, is frequently shorter than either the bone of the upper arm or those of the fore-arm alone. The finger, therefore, is the least important part of a Bird's wing, whereas the outer finger is by far the most important element in that of a Pterodactyle.

It would involve a large amount of detail to give a full description of the arrangement of the feathers of a bird's wing; and it must accordingly suffice to say, that the large flight-feathers carried by the pinion are known as the *primaries*, while those attached to the larger bone of the fore-arm are termed *secondaries;* the smaller feathers which overlie these being designated as the *wing-coverts.* In all living birds, as we have said, the bones representing the fingers are flattened, and those of the index and third fingers more or less united together. In the *Archæopteryx*, which is the oldest known bird and a contemporary of the Pterodactyles of the Lithographic Limestones of Bavaria, all the three fingers were, however, perfectly separate from one another, and each ended in a claw; while the index was not greatly larger than the other two. We have, therefore, in this bird a decided approach to reptiles; from which class it is considered that birds were originally derived.

In addition to their wings we must not omit to mention that the tails of birds form an important aid in flight, when they act as a kind of rudder. In all living birds the bones of the tail are extremely few in number, and all the large tail-feathers take origin close together, and are generally spread out in a more or less fan-like manner. Our old friend the Archæopteryx had, however, a very long lizard-like tail, with a pair of feathers arising from each of its numerous joints, after the manner of the feathers on an arrow. It will, however, be readily imagined that such a long unwieldy tail was by no means calculated to act as an efficient and compact rudder; and the shortened tails of modern birds appear, therefore, to be a decided improvement on the early type. It seems, indeed, that in all groups of Vertebrates capable of true flight a long tail has been found disadvantageous, since among the Pterodactyles the more specialised kinds found in Europe had discarded the long tail of the species represented in Fig. 11; and the same holds good with regard to the large toothless kinds found in the Cretaceous rocks of the United States. Again, the most specialised, or insectivorous Bats are remarkable for the shortness of their tails. From the relative shortness of its wings, coupled with the long unwieldy tail, it is probable that the Archæopteryx was but a poor flyer, and was, perhaps, altogether incapable of making the long-sustained flights of our modern birds, though it must undoubtedly have been a true flyer.

Birds vary greatly in the relative proportions of the component bones of the wing, so that among the strongest flyers we find that whereas in the giant Albatross of the tropical seas the bones of both the upper and fore-arm are enormously elongated, in the Swift that of the upper arm is so shortened and thickened as to be scarcely recognisable. The form and arrangement of the flight-feathers are, however, of still greater importance in modifying the shape of the wing, but the reader desirous of information on this subject must consult one of the numerous works on the structure of birds.

Coming now to the highest class of animals, the Mammals, we shall find that while true flight is only possessed by the whole of the members of a single order, spurious flight occurs among certain members of three widely distinct orders; and it is curious to notice the remarkable external similarity between some of these animals possessing the power of spurious flight, while they are structurally so different from one another.

Commencing with spurious flight, the first Mammals we have to mention are the Flying Phalangers of Australia, which belong to the great order of Pouched or Marsupial Mammals, described in a later chapter, and are closely allied to the so-called Opossums of the colonists. There are several genera of these curious and beautiful creatures, distinguished from one another by the character of the skull and the shape of the parachute, which may be either very broad or very narrow. This parachute consists of an expansion of the skin of the sides of the body, extending from the wrist of the fore-leg to the ankle of the hind-leg, with a smaller development between the neck and the front of the fore-leg. The Flying Phalangers are strictly nocturnal in their habits, and are able to take enormous flying leaps from tree to tree, during which they descend in the first part of their course, but acquire a slightly upward direction before they alight.

It is not till we come to the order of Rodents, or those Mammals which, like Hares, Rats, and Beavers, are provided with a pair of chisel-like gnawing-teeth in the front of each jaw, that we again meet with Mammals having the power of spurious flight. Among the most curious of these are the so-called Anomalures of Africa, which are small Rodents nearly related to the Squirrels. Here we find the parachute connecting both pairs of limbs together, as in the Flying Phalangers, but with the additional peculiarity that there is a spike-like rod of cartilage projecting from the elbow, which, by acting in the manner of a yard-arm, allows the width of the expansion to be greater than could otherwise be the case. This rod, together with the presence of a series of scales along the sides of the base of the tail—from which the creatures take their name—serves to distinguish the Anomalures from the Flying Squirrels. Of the latter there are three genera, mostly found in the oriental region, although a few species range into North America and Europe. These creatures (Fig. 12) exactly resemble ordinary Squirrels in general appearance and habits, with the exception of having a parachute connecting the front with the hind limbs, after the manner of the Flying Phalangers. In some species an additional membrane connects the root of the tail with the thigh, but this is wanting in others. The flight of the Flying Squirrels is precisely like that of the Flying Phalangers; and if the two were to be found together, it would be quite impossible to distinguish the one from the other during flight. Flying Squirrels, however, utter a sharp, squeaking cry during their flight, while the Flying

Phalangers appear to be silent. Ordinary Squirrels, as we all know, are capable of taking long leaps from bough

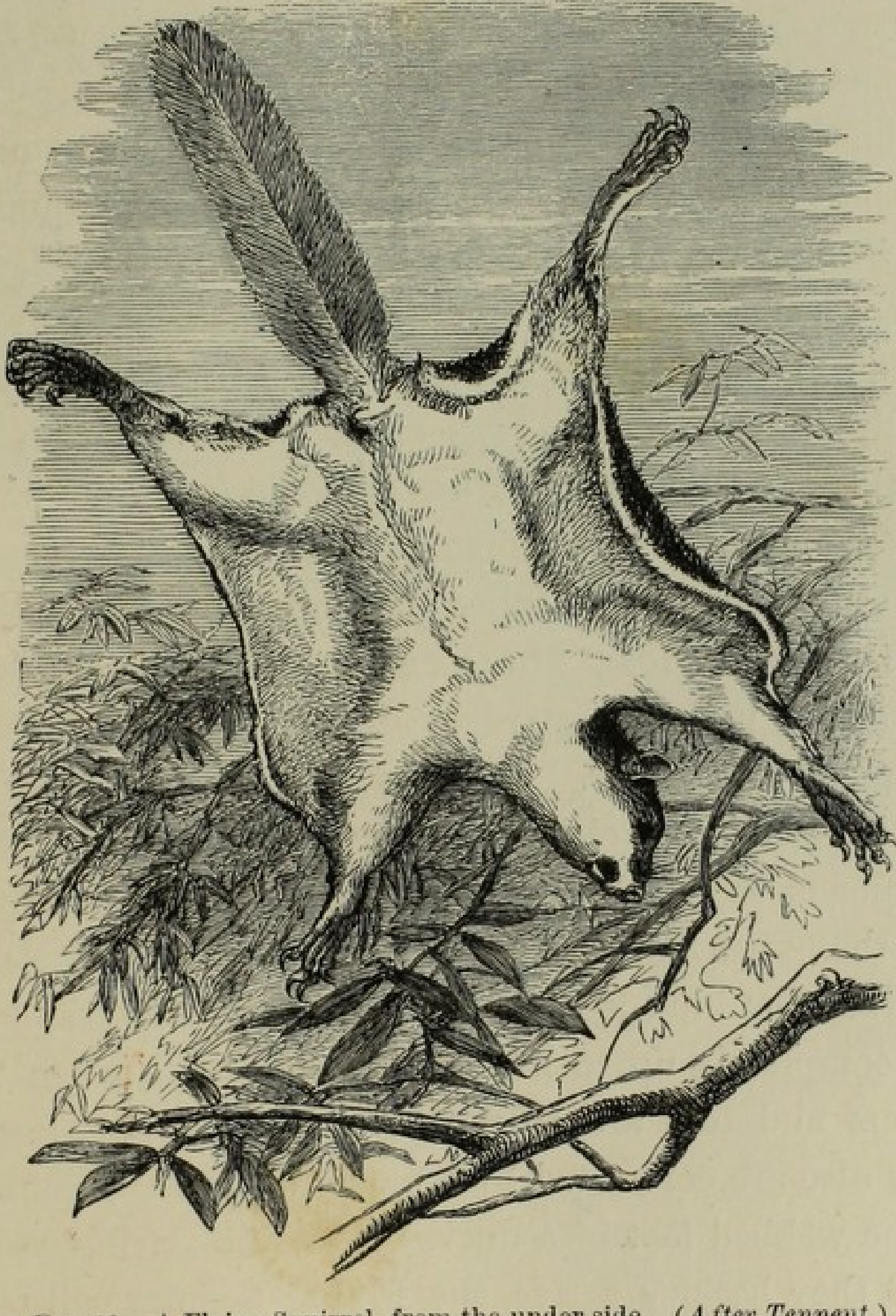


FIG. 12.—A Flying Squirrel, from the under side. (*After Tennent.*)

to bough, and in the Flying Squirrel it is merely an excess of this power which, owing to the development of the parachute, assumes the character of flight. A precisely similar connection obtains between the ordinary Phalangers and the Flying Phalangers. There are a large number of species of Flying Squirrels, which are mostly of comparatively small size, although one species, from the north-west of Kashmir, is as large as a rabbit. Although their cries may frequently be heard at night in the districts which they inhabit, Flying Squirrels are but seldom seen. Their flight may be extended to a distance of twenty-five or thirty yards.

The Flying Lemurs, of the Malay Peninsula and the Philippines, present a type of Mammal in which the faculty of spurious flight has attained its maximum of development. These animals come nearest, in general structure, to the so-called Insectivorous Mammals, such as the Mole, Shrew, and Hedgehog, and are, therefore, usually regarded as forming an aberrant group of that order. In them not only are the fore and hind limbs of either side connected together by an expansion of the skin of the sides to form a parachute, but the expansion of the skin also extends backwards between the hind legs, which it connects with the long tail completely up to its tip. Moreover, although the fingers and toes are only of the ordinary length, yet they also are connected by a membrane, in the manner of the webbed foot of a duck. At night, during which time they become active, the Flying Lemurs will take flights of upwards of seventy yards in length, and thus far outstrip the Flying Squirrels and Phalangers in this respect. Bats, as we shall notice shortly, are known to be closely allied to the Insectivores, and the

Flying Lemur seems to show us how an ordinary Insectivore may have become gradually modified into a Bat; for it would only require the elongation of the fingers and a somewhat greater development of the parachute to transform the Flying Lemur into a creature exceedingly like a Bat.

Bats, which are familiar to all of us, are the only Mammals endued with the power of true flight; and although they are evidently related, as shown, among other features, by the structure of their teeth, to the Insectivores, yet they are so different as to be entitled to rank as a separate order by themselves. In being the only truly flying Mammals they hold, as has been well observed, a position in the class precisely analogous to that occupied among the Reptiles by the Pterodactyles. That they have, however, no sort of connection with the latter group is perfectly evident from the structure of the fore-limb, or wing, which we now proceed to explain.

The wing of a Bat is composed of a thin naked membrane supported by a great extension of the bones of the fore-limb; this membrane being continued backwards to connect the hind-legs with the whole length of the tail. In the fore-limb, of which the skeleton is represented in Fig. 13, the bones of both the arm and fore-arm are relatively slender and considerably more elongated than usual. The thumb remains comparatively small, and ends in a claw; but all the other fingers—more especially the third or middle one—are enormously elongated, so that the third, fourth, and fifth, which have no claws at the end, are absolutely longer than either the fore-arm or the arm. Between these elongated spider-like fingers the wing-membrane is stretched, the whole structure permitting of the wing being folded, when at rest, in

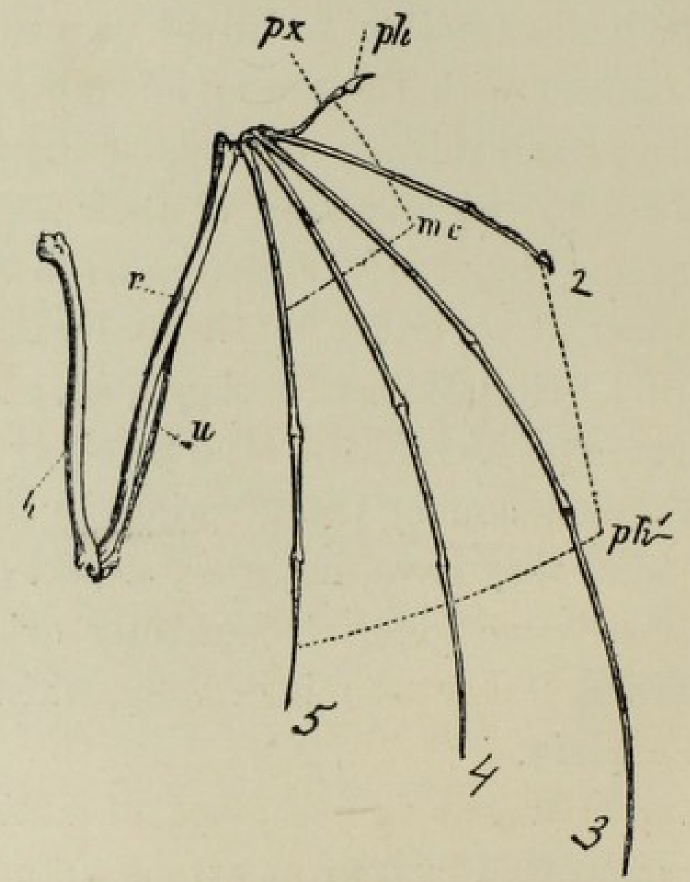


Fig. 13.—The bones of the right fore-limb of a Bat, seen from above. *h.* bone of arm; *r.u.* bones of fore-arm; *px.* thumb; *ph.* claw of thumb; *m.c.* metacarpus; *ph*¹, 2nd, 3rd, 4th, and 5th fingers.

the manner familiar to all. A comparison of Fig. 13 with Fig. 11, or, still better, with the figure of the skeleton of a Pterodactyle, given in the chapter on Flying Dragons, will show how essentially the wing of a Bat differs from that of a Pterodactyle. As we have said, the single finger supporting the wing-membrane of a Pterodactyle corresponds either with the one marked 4 or that marked 5 in Fig. 13 (probably the latter), and it may therefore be said that while a Pterodactyle flies with one finger, a Bat flies with its whole hand. Equally marked is the difference between the wing of a Bat and that of a Bird; the latter having only the first three fingers of the Bat's wing developed, and all of these being strangely modified from the ordinary form, while the chief elongation has taken place in the bones of the arm and fore-arm, instead of in those of the fingers, and flight is effected by the aid of feathers instead of by a membrane.

This completes our survey of the various modes of flight obtaining in the animal kingdom. In it we have indicated the difference between spurious and true flight, have shown how the former is but an extreme development of the long leaps taken by arboreal animals, and have suggested how it may have gradually passed onwards into true flight. We have also seen how the wings of the Invertebrate animals differ *in toto* from those of the Vertebrates; while among the Vertebrates true flight has been independently developed in three distinct groups—Pterodactyles, Birds, and Bats—on totally different structural lines; the latter instance thus affording us an excellent example of the way in which different groups of animals may be variously modified to occupy the same position in the realm of nature. The supersession of the Pterodactyles by the Birds as the lords of the air is in accordance with what we have observed elsewhere, namely, the replacement, with the advance of time, of a lower by a higher type of organisation. The Bats, indeed, which belong to the highest class of animals, appear to have been the latest in which the power of flight has been developed; but since most of them are of comparatively small size, and of more or less completely crepuscular and nocturnal habits, they have never entered seriously into competition with the Birds, so that both groups are found existing side by side in full development.

CHAPTER III.

SWIMMING ANIMALS.

In the preceding chapter we discussed the various structural modifications by means of which the members of different groups of animals are enabled to fly, or, in other words, to swim in the aërial ocean. From the observations there recorded, it is evident that all the creatures adapted for this peculiar mode of life have been specially modified for that purpose; flight thus always being a power which has been specially acquired, and not one which was an original attribute of any group of animals.

It is our purpose in the present essay to notice in a somewhat similar manner the various adaptations of the structure of certain animals whereby they are enabled to swim in the denser medium of water. And here we shall find that while there is conclusive evidence to show that in many instances this power is an acquired one, yet there are others which lead to the belief that in certain groups it is a primitive function. Some clue as to the groups in which this power of swimming is an acquired one, and those in which it is a primitive one, is afforded by the different modes in which aquatic animals breathe. Thus in fishes the air necessary to oxygenate the blood is obtained from that dissolved in the water itself by its constant passage over those peculiar comb-like organs, highly charged with blood, known as gills; such animals having, therefore, no occasion to come to the surface of the water to breathe. In other animals, however, such as Whales and Grampus (Fig. 14), atmospheric air is breathed directly by means of lungs, necessitating visits at longer or shorter intervals to the surface, and it is in such instances that we may safely infer that the adaptation to an aquatic life has been gradually developed from ancestors whose normal habits were terrestrial, since otherwise the gills would never have been lost. That animals whose original mode of life was a purely aquatic one have tended in some cases to assume a terrestrial existence is proved by the case of the Common Frog, which commences life as a gill-breathing, swimming creature, to all intents and purposes a fish, and ends by being an air-breathing reptile, as much at home on land as in the water, although retaining the power of swimming. On the other hand, the Seals and Otters show us how an originally terrestrial type of animal has become adapted to pass a large part of its time in the water, which has become its natural element.

The term "Swimming Animals" is, of course, a very wide one, since a considerable proportion of animals whose normal habits are terrestrial can, on occasion,

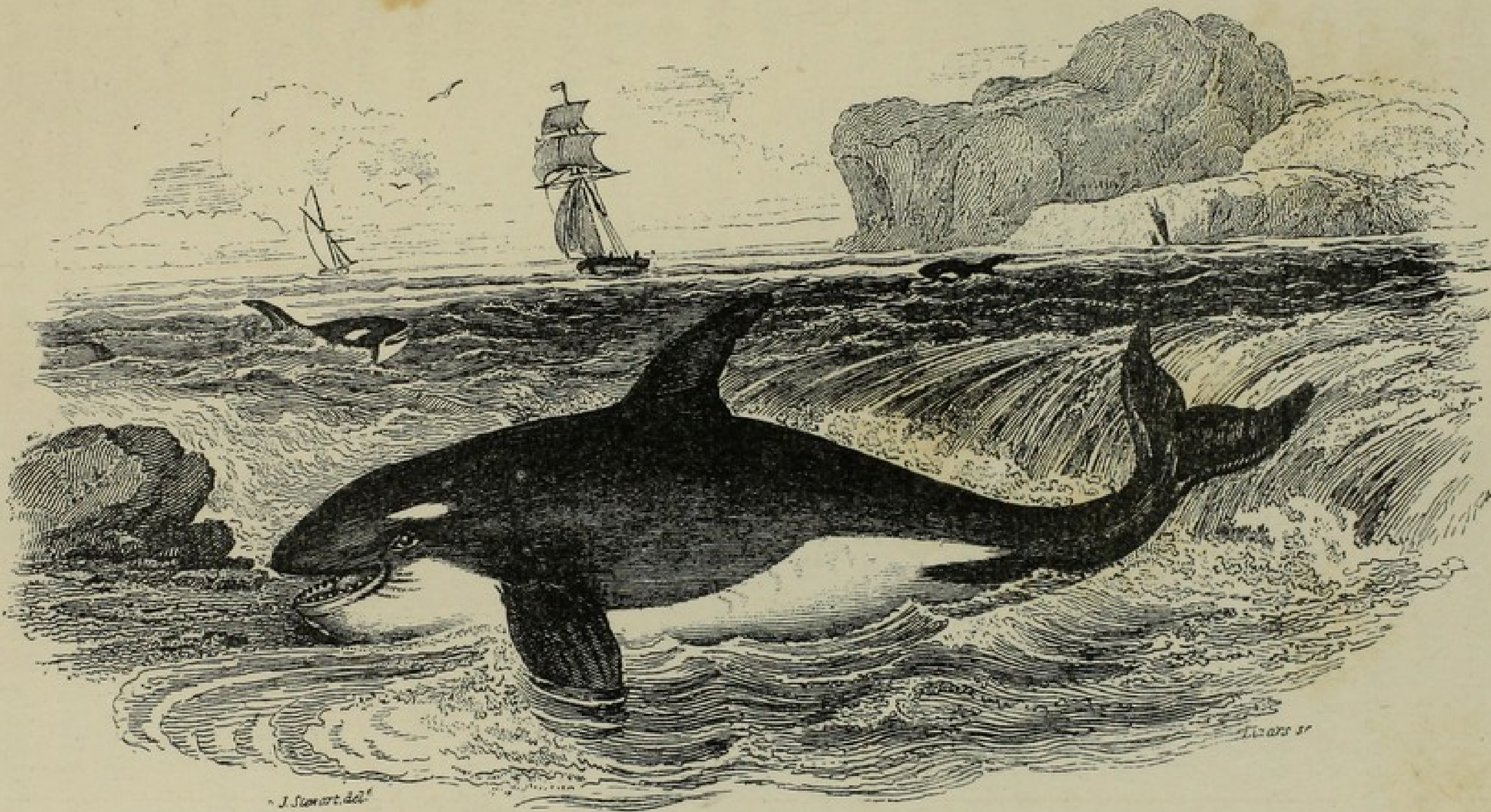


FIG. 14.—The Common Grampus, or Killer Whale. (*From Jardine.*)

swim with more or less facility. Our application of the term will, however, in the main be restricted to those creatures which pass a considerable amount, or the whole of their time in the water, and which have accordingly been more or less specially modified for that kind of life. Again, in many groups of purely aquatic animals, it is sometimes difficult to say which are true swimmers; a certain number leading an active life when young, and becoming more or less complete fixtures in adult life. We shall commence our survey with the Invertebrate Animals, treating them, however, in a somewhat briefer manner than the Vertebrates, and alluding only to some of the more striking adaptations of certain parts of the body for the purpose of swimming.

All are familiar with those disc-like masses of pellucid gelatinous matter so often thrown up on our sea-beaches, and popularly known as Jelly-Fishes; but to see them in their full beauty we should look down from the bows of a large vessel traversing the warmer oceans. There they may be seen in countless multitudes, extending as far down in the water as the eye can penetrate, and by daylight presenting various tints of pink and purple, while by night they are often phosphorescent. These Medusæ, as they are technically called, are gelatinous creatures shaped somewhat like an umbrella, the "handle" being formed by a mass of thick tentacles hanging down in the water. They swim by the alternate contraction and expansion of the "umbrella" or bell; the diameter of which may considerably exceed a foot. Medusæ belong to that great group of animals known as Zoophytes, which includes the Polypes, Sea-Anemones, and Corals. They afford an example of the so-called "alternation of generations;" being themselves developed by the division of a fixed polype into a number of saucer-like sections, which become free and swim away, and in turn lay eggs, again developing into fixed Polypes, like the original parent.

Our next illustration is taken from the Crustaceans, among which the Lobsters and some of the Crabs are expert swimmers. In the Lobster and Cray-Fishes, where the tail is long, and furnished with five hinged and paddle-like plates, the most rapid motions in the water are effected by suddenly bending the tail beneath the body, and thus driving the creature forcibly backwards by the recoil of the water. Prawns and Shrimps have a similar mode of swimming; but those Crabs which, like the "Fiddlers," are free swimmers, have the terminal joints of the fifth pair of legs (and sometimes also those of the three next pairs) developed into flat paddles fringed with hairs. These claws are thus quite different from the pointed claws of the common Shore-Crab. Since Crabs and Lobsters breathe by means of gills, they may be safely regarded as primitive swimmers; those species which, like the Land-Crab, are terrestrial having acquired this habit, and thus having to put up with the inconvenience of keeping their gills constantly moist. We cannot take leave of the Crustaceans without mentioning the Barnacles, as represented by the common Acorn-Barnacle covering the rocks on our coasts, and the Stalked-Barnacle which is more commonly found on the bottoms of ships. In their young state these curious creatures are free-swimming Crustaceans, but after a time, becoming tired of a roving life, fix themselves on their backs by the front of their heads to some solid object, and then develop their well-known shells; the feather-like fan which protrudes from the aperture of these shells being the greatly modified legs, now acting as feelers for the purpose of capturing food. What induced the strange belief that the Stalked-Barnacles underwent a further metamorphosis to appear as Barnacle-Geese, passes ordinary comprehension.

Passing on to the Arachnids (Spiders and Scorpions) and Insects, we find that these creatures, whether aquatic or terrestrial, breathe atmospheric air by means of a system of tubes known as tracheæ, and we are accordingly led to conclude that such of them as are adapted to an aquatic life have acquired this habit. This is especially well shown by the instance of the Water-Spider, which, while agreeing in structure with other spiders, has the limbs fringed and somewhat flattened for swimming, and is in the habit, when diving in the water, of carrying down with it a bubble of air clinging to the hairs of the abdomen.

Among the Insects, the larvæ of many groups in which the perfect animals inhabit the air, such as the Dragon-Flies, May-Flies, and Gnats, are aquatic. Whereas, however, the larvæ of the two former groups are not swimmers, and, therefore, do not come within the scope of the present article, those of the Gnats are endowed in great perfection with the power of swimming. With their large heads and their tapering bodies, these ugly larvæ are probably familiar to most of us, swimming about in ponds and tanks with great agility by a sudden jerking motion of the body, or at intervals suspending themselves head downwards at the surface of the water for the purpose of breathing through a tube situated in the tail. Other insects are aquatic in the adult state. Some of the commonest British examples are the Water-Scorpion (*Nepa*) and Water-Boatman (*Notonecta*), both belonging to the order Rhynchota. These swim by means of the hind legs, which are, however, scarcely fringed in the former, although markedly so in the latter. The Water-Scorpion has two tail-like organs at the end of the body, which, when put in opposition, form a tube through which the creature can breathe without coming quite to the surface. The Water-Boatman, as its scientific name implies, has the curious habit of swimming on its back; when at rest for the purpose of taking in a fresh supply of air the long hind legs are extended nearly at right angles to the body, and thus recall a boatman resting on his oars.

The remaining aquatic insects are the Water-Beetles (Coleoptera), of which there are several families, in all of which both the larvæ and adults are aquatic, although the pupæ are quiescent and lie hidden in holes in the ground. The Water-Beetles are easily recognised by their oval, flat, and boat-like form, some of the species attaining a large size. Most of them swim entirely by the aid of their hind legs, which are greatly enlarged, flattened, and fringed. In the curious little "Whirligig" Beetles (*Gyrinus*), which are so often seen performing their mazy evolutions on the surfaces of ponds and rivers, the reverse of this arrangement obtains, the front pair of legs being enormously elongated, and the second and third pairs very short and paddle-like. The forward motion of these beetles is produced by these short paddles, while the curves are formed by the long fore limbs, which are darted out first from one side and then from the other, so as to change the direction of the body.

The last Invertebrate group we have to mention is the large one of the Molluscs, or Shell-fish. Here by far the greater number of species are aquatic, and breathe by gills, so that we may regard those which are swimmers as being primitively so. Although the adults of the Bivalve Molluscs are either fixed to some solid substance (Oysters), or are merely capable of leaping or turning (Cockles and Fan-shells), yet in their young state all these Molluscs are free swimmers, young oysters being provided with swimming-organs composed of delicate hairs. It thus seems probable that these locomotive habits have been transmitted to the young bivalves from originally free-swimming ancestors.

The ordinary Sea Snails (Gastropods), in which the adult creeps on solid surfaces by means of its greatly expanded "foot," are also free swimmers when first hatched, the swimming being effected by means of vigorous flappings of a pair of fins attached near the head. A similar structure and habits have been retained in the adult by the Pteropods, those small translucent Molluscs, of pelagic habits, so abundant in some of the northern seas, which afford a considerable proportion of the food of certain species of whales. A well-known writer states that "multitudes of these little things may now and then be seen on the surface of the water, fluttering with their wings and glittering in the sunshine, to be compared with nothing more aptly than a congregation of the more dressy of the Bombyx Moths."

Although not a true swimmer, the well-known Violet Snail (*Ianthina*) is able to float on the surface of the ocean, either by expanding its "foot," or by developing at certain seasons a peculiar membranous raft-like structure, the cells of which are filled with air, and beneath which the eggs are carried.

A totally different mode of progression through the water is adopted by that group of Molluscs technically known as Cephalopods, in which the head is surrounded by a circle of long prehensile arms, provided with adhesive suckers. This group comprises the existing Cuttle Fishes, Squids, Argonauts, and Nautili, as well as the extinct Ammonites (Fig. 15), and a host of other fossil forms. In the free swimming forms, locomotion is effected by the forcible expulsion of a jet of water from a funnel situated near the head, and directed forwards, the result of which is to propel the animal backwards. Minor aid in swimming is afforded either by expansions of the skin on the sides of the body, or by distinct fins near the tail; while many of these creatures aid their escape from foes by the sudden discharge of an inky fluid during their backward course.

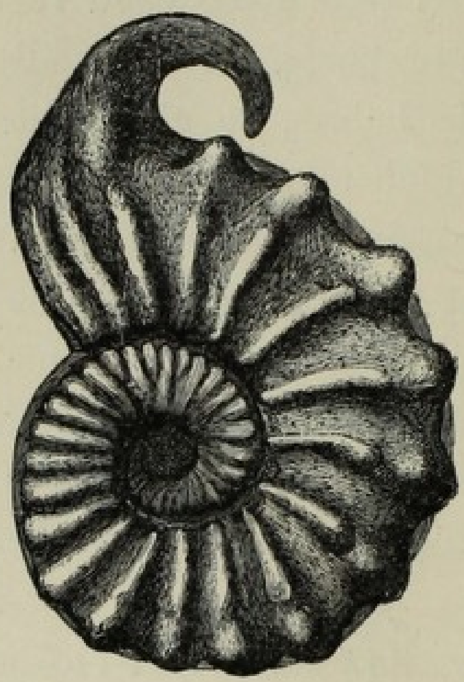


FIG. 15.—Shell of Ammonite. (*After Gaudry.*)

Our notice of swimming Invertebrates cannot be concluded without mention of those curious marine animals known as Sea-Squirts, and technically as Tunicates — a group usually placed in the neighbourhood of the Molluscs. Although in the adult state many of the Tunicates exist in the form of the bag-like squirts with which many of us are familiar, yet all are free-swimming creatures in the young condition. Moreover, certain of them, like the Salpæ, are pelagic throughout their existence; some of the latter forming chains composed of numerous individuals attached to one another. These Salpæ-chains vary in length, from a few inches to several feet, and swim on the ocean surface with a serpentine movement. The great interest attaching to these Tunicates is that the young exhibit certain structures closely simulating the primitive condition of the spinal column of Vertebrates, and thus suggest that they are degraded types allied to the original stock from which the Vertebrates themselves are descended. This is very important as regards the derivation of Vertebrates from aquatic animals;—an origin which we should naturally expect, seeing that fishes breathe by means of gills, and are, therefore, presumed to have had aquatic ancestors.

With the Fishes, which, with the exception of the Whales, are perhaps, of all animals, the most beautifully adapted for rapid motion through the water, we enter the great group of Vertebrates. The contour of an ordinary fish, such as the Perch (Fig. 16), is modelled on those lines best suited for cleaving the water, through which the fish is propelled mainly by the muscular tail with its terminal fin. The fins on the body act chiefly as balances, although aiding to a certain extent in propulsion. These body-fins in all fishes are of two types, namely, paired and median. The number of paired fins is two, the front pair corresponding with the fore limbs, and the hinder pair with the hind limbs of quadrupeds. In the Perch (Fig. 16), the front or pectoral pair of fins are seen immediately behind the head; the second or pelvic pair being placed below and slightly behind the pectoral ones. In many other fishes (as in Fig. 2, p. 5) the hinder pair of fins occupy, however, a position corresponding with that of the hind limbs of quadrupeds. The pectoral fins, although assisting to a certain extent in the motion of the fish through the water, act rather in directing its course than as propellers. Their chief function is, however, to maintain the balance of the body in the water; a fish which has lost one of these fins falling over to the opposite side. It will be observed from Fig. 16, that the pectoral fin of a Perch (as well as of most of our existing fishes) consists of a number of rays spreading out in a fan-like manner from the point of attachment to the body. A totally different arrangement obtains, however, in the pectoral fin of the extinct fish represented in Fig. 2, p. 5. Here

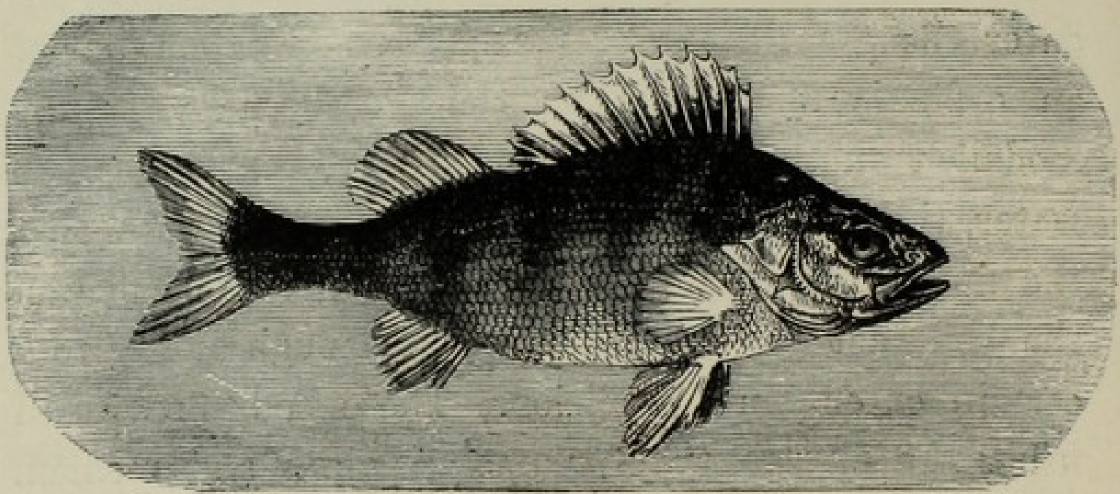


FIG. 16.—The Common Perch.

it will be seen that the fin consists of a central lobe covered with scales, from the edges of which the fin-rays project as a deep fringe. This more primitive type of fin is indeed very common among the extinct fishes of the Palæozoic rocks, and still persists in the Baramunda of the Queensland rivers, a figure of which is given in the chapter on "Mail-Clad Animals." The more important median fins are the dorsal on the back, and the anal in front of the tail. In many fishes (Figs. 2 and 16) there are two dorsal fins, one in front of the other; the front one being often large and spiny, and the hind one small and soft (Fig. 16).

The tail and tail-fin form, as we have said, the chief propeller of the fish; and it will be particularly noticed that the position of this fin is vertical. In swimming, as we may observe in an aquarium where fish are kept, the tail is rapidly and strongly bent from side to side, while the two lobes of its fin have an undulating motion, and thus act like the blades of a screw-propeller. A difference between the structure of the tail-fin in the two figured fishes recalls the one already noticed in the pectoral fin. Thus in the Perch (Fig. 16) the scaly part of the tail ends in an abrupt and almost straight edge, from which the rays of the fin form a nearly symmetrical fork. In Fig. 2, on the other hand, the scaled part of the tail is produced to a point, extending far back among the fin-rays, which are arranged unsymmetrically along its two edges. It is this latter mode of arrangement which is the older and more primitive.

In certain fishes which depart more or less widely from the ordinary form, there is a corresponding modification in the shape and functions of the fins. For instance, the Rays swim almost entirely by the aid of the greatly expanded pectoral fins, which have an undulating motion very similar to that of the median fins of ordinary fishes. On the other hand, in the Flying Fishes (see "Flying Animals," Fig. 10), the pectoral fins are enormously elongated, so as to act as organs of spurious flight. Again, snake-like fishes, as the eel, swim by lateral curvatures of the body, in the so-called serpentine manner.

The only other Vertebrate animals which breathe by means of gills, and can therefore be regarded as primitively aquatic, are the young, or larvæ, of the Amphibians (Frogs, &c.). The young Tadpole, as we all know, is an ugly, large-headed creature, swimming by means of lateral movements of its tail. This tail has a vertical fin-like expansion, differing, however, from the fins of fishes by the absence of the bony or cartilaginous rays found in the latter. We have already alluded to the remarkable metamorphosis undergone by the Tadpole, in the course of which the tail is lost, the gills are replaced by lungs, and the limbs developed. The adult Frog is an instance of an animal adapted to live partly on land and partly in the water, swimming powerfully in the latter element by the strokes of its long hind legs, of which the toes are fully webbed. The Tailed Amphibians, such as the Newts and Salamanders, are less specially modified than the Frogs, and may be completely aquatic. All the Newts and Salamanders, including the purely aquatic Giant Salamander of Japan, lose, however, their gills in the adult state; but these are permanently retained in the curious blind Proteus of the caverns of Carniola.

Among the true reptiles of the present day (all of which breathe by means of lungs during the whole of their existence), there are three groups among which aquatic forms occur. The first of these includes the Crocodiles and Alligators, which swim by means of their long tail and limbs. Although these animals are thoroughly at home in the water, where they spend a large portion of their time, their organisation has not been so modified for the exigencies of an aquatic life as to depart to any great extent from the normal type. The same remark will apply with still more force to our Common Snake, which is an expert swimmer. In the Sea-Snakes, however, which pass the whole of their life in the tropical seas, the tail assumes a vertically compressed and paddle-like form, and is thus nearly as efficient a propeller as the tail of a fish. These snakes always swim on the surface of the sea, but it is very doubtful if they can have given rise to the stories of the Sea-Serpent.

Among the Chelonians the Marine Turtles have been especially adapted for an aquatic life by the modification of their limbs into oar-like paddles; although it is quite clear that this structure is an acquired one. The Soft Turtles (Trionyces), of the rivers of the warmer regions of the globe, are almost equally good swimmers, although their feet, with the exception of being webbed, retain the ordinary type of structure. The Pond-Tortoise, now restricted to Southern Europe, although occurring in the superficial deposits of this country, is almost equally aquatic. Indeed all Tortoises (except perhaps the gigantic ones of the Galapagos and Mascarene Islands) are excellent swimmers, and thus afford a good instance of how some members of a group have gradually adapted themselves to an almost completely aquatic life.

If, however, the Turtles have been specially modified for an aquatic existence, still more markedly is this the case with the extinct Ichthyosaurs or Fish-Lizards (Fig. 17). As the structure of these reptiles is fully described in a later chapter, we need only allude here to the peculiar pavement-like structure of the bones of the paddles; this being the extreme modification which limbs have undergone for the purposes of an aquatic life. Since, as shown by the absence of gills and the indications of remnants of a horny covering to the body, there is abundant evidence that the Ichthyosaurs are descended from land animals, they occupy a position among reptiles precisely analogous to that held among Mammals by the Whales of the present epoch.

The long-necked Plesiosaurs, to which a special chapter is likewise devoted, were reptiles equally well adapted for an aquatic existence, but in which the modification of the limbs

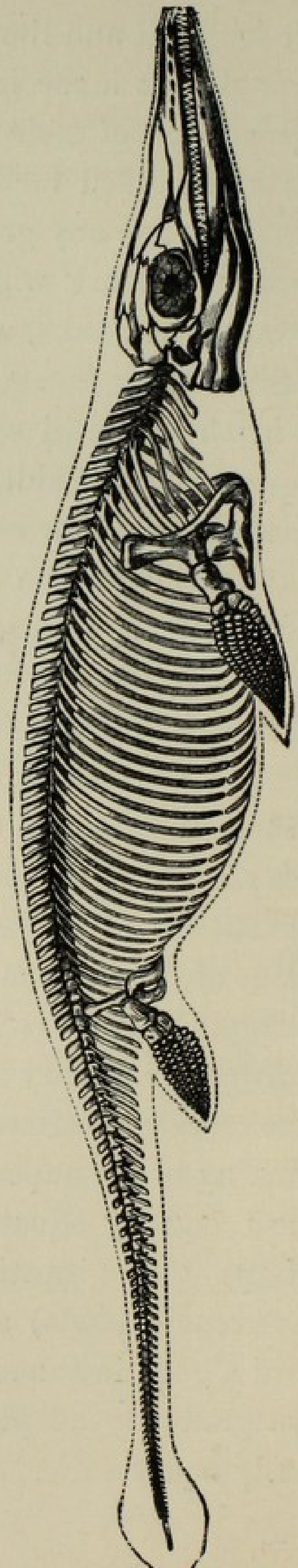


FIG. 17.—Skeleton of an Ichthyosaur.

into paddles had not been carried to the same degree as in the Ichthyosaurs. The evidence for the derivation of the Plesiosaurs from terrestrial reptiles is even fuller than in the case of the group last mentioned.

Before taking leave of the reptiles we have to allude to another totally different assemblage of extinct aquatic forms, which were much more closely allied to the existing Lizards, and many of which were of gigantic dimensions. These creatures are generally known as the Mosasaurs, and were first brought to notice during the last century, when a huge skull was obtained from the upper Cretaceous beds of Maastricht, on the Meuse; the Latin name of the group being taken from that river.

These Mosasaurs, of which a large number of kinds are now known, differ from the Ichthyosaurs and Plesiosaurs in that the joints of their backbone, instead of having both front and back surfaces either deeply cupped or nearly flat (Fig. 24) had cup-and-ball articulations, the cup occupying the front surface. This type of structure is common to existing Crocodiles and Lizards; but whereas in the former the ribs articulate with the joints of the backbone by means of long transverse processes jutting out from them, in the latter the ribs articulate directly with the aforesaid joints. Now the Mosasaurs have the latter mode of articulation, and, since they agree with the modern Lizards in the structure of their skulls, as well as in many other points of their bony anatomy, there can be no hesitation in regarding them as a group descended from the ancestral Lizards which have taken to an aquatic mode of life.

The Mosasaurs are confined to the Cretaceous epoch, and thus lived side by side with the Ichthyosaurs for the greater part of their term of existence, although they attained their maximum development in the very highest Cretaceous beds when the Ichthyosaurs and Plesiosaurs seem to have disappeared. For a short time, then, these creatures appear to have been the only gigantic marine Vertebrates, filling up the gap left by the disappearance of the Ichthyosaurs, which had not yet been occupied by the Whales. They were of carnivorous habits, as shown by their formidable teeth, and, like all groups of Vertebrates which have taken to a marine life, far exceeded in dimensions any of their terrestrial cousins, the length of some of the species being as much as forty feet.

We come now to the Birds, several groups of which are exclusively composed of species specially adapted for an aquatic life. Swimming birds, as a rule, support themselves on the surface of the water, taking occasional dives of longer or shorter duration, and, therefore, have no need to make any especial arrangements for breathing. They swim by using their legs as oars, the feet being webbed, and the toes folding up as the foot is brought forward after one stroke to prepare for a second. As we shall see, however, some species aid their swimming with their wings. All birds that swim have relatively short legs, which are generally placed far back on the body, since this position gives the maximum power in propelling the animal through the water.

There are six chief groups of swimming birds, namely, the Ducks, Geese, and Swans (Anseres); the Pelicans, Cormorants, and Darters (Steganopodes); the Gulls (Gaviæ); Petrels (Tubinares); the Divers, Auks, and Grebes (Pygopodes); and the Penguins (Impennes). There are, however, a few members of other groups, such as the Dipper among the Passerines, and the Coot among the Rails, which are also expert divers and swimmers. The circumstance, however, that in neither of these instances is the foot fully webbed—that of the Dipper being like the foot of a Thrush, and that of a Coot only having web-like expansions on the sides of the toes—indicates that the aquatic habits of these birds are of comparatively recent acquisition, and have not induced any strongly marked structural peculiarities.

The Anseres include by far the greater number of swimming birds, and the admirable adaptation of their form and structure to their mode of life is so well known as to require no further mention. The Pelicans and their allies differ from that group in that the web includes all the four toes of the foot (Fig. 18), instead of only the three front ones. In this group the Frigate Bird has a shorter leg than any bird of equal size. The Darters, or Snake-Birds, of which there are four species found in the warmer regions of the globe, and of which examples are generally to be seen in the Zoological Society's Gardens, are, however, those members of the group most interesting from our present point of view. These birds frequent fresh waters, and swim with the whole of the body submerged, so that only the head and upper part of the long and flexible neck are exposed. In this position they look not unlike snakes swimming on the water, when seen from a little distance. It does not appear that any use of the wings is made in swimming. The Gulls and Petrels, in which the hind toe of the foot is not included in the web, have longer legs than most swimming birds, and the legs themselves are placed nearer the middle of the body. Since these birds depend mainly upon their powers of flight for obtaining their food, most of them only make use of the surface of the water, upon which they float placidly, as a resting-place.

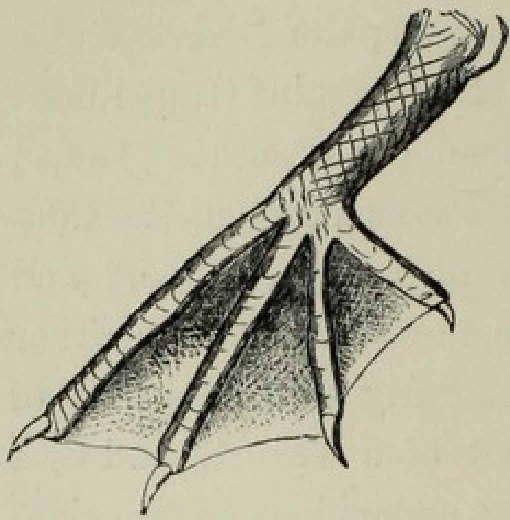


FIG. 18.—Foot of Pelican.

The Divers, Auks, and Grebes are, with the exception of the Penguins, those birds which appear to have been most profoundly modified for a life in the water, being equally at home both on and below its surface. In these birds the short legs are placed so far back that when on land the body is carried in a more or less nearly erect position, as we may observe in the Guillemots and Puffins of our coasts. Although the legs themselves are very short, yet the toes are elongated, so as to convert the feet into very powerful oars. Most of these birds look exceeding awkward when on land, and as they use both their feet and wings in diving, the water is undoubtedly the element in which they are most at home. Speaking of the Red-Throated Diver of Northern Europe, Mr. Dresser observes that "it swims low down in the water, and when uneasy or alarmed will submerge its body below the surface, leaving only the head and neck in view. When it dives it vanishes beneath the surface without noise or flutter, and propels itself along with its wings as well as its feet, frequently remaining for some time before it emerges to view again."

The most remarkable modification which birds have undergone for the purposes of an aquatic life is, however, presented by the Penguins of the Southern Ocean. These grotesque birds, some of which attain a very large size, are even more upright than the Puffins, and when arranged in lines on the cliffs of the Antarctic lands have been compared to regiments of soldiers. Their short wings, which are utterly useless for flight, and have but a very limited range of motion, are converted into flipper-like paddles, covered with short bristly feathers; their only use being as additional swimming organs. We have here, therefore, an instance of an organ originally modified for an especial purpose —flight—subsequently undergoing a kind of retrograde modification for a totally different use, although still retaining the structural peculiarities which it presents in ordinary birds. Certain features in the structure of the leg of the Penguins suggest, however, that these birds belong to a very primitive type.

We must not conclude our notice of swimming birds without reference to the extinct *Hesperornis*, of the Cretaceous beds of the United States. This remarkable bird, which was nearly six feet in length, shows evidence of its relationship to reptiles by the retention of a complete series of sharp-pointed teeth in both jaws. In the structure of its bones it appears to come nearest to the Grebes and Divers, but it differs from all other swimming birds in having lost (so far as can be determined) all traces of wings; and thus affords one of several instances where species long extinct are in certain respects more specialised than any of their living relatives.

Our remaining examples of Swimming Animals are taken from the class of Mammals, or Quadrupeds, as they are often popularly, though inconveniently, termed. And we shall find that in certain members of this group the adaptation to an aquatic life has been so complete as to have led to the loss of all external features characteristic of ordinary members of the class, and has thus induced the erroneous popular belief that the animals in question are really fishes.

In several groups of Mammals we find that a few species, or genera, have been more or less modified so as to become expert swimmers and divers. Instances of these are afforded by the Australian Duck-Bill among the egg-laying Mammals, the Otter among the Carnivores, the Beaver and Water-Vole among the

Rodents, and the Hippopotamus among the Ungulates. Since, however, none of these depart very widely from the normal type of structure, we may pass to the consideration of two groups, in which all the members have undergone more or less profound structural alterations solely and simply for the purpose of swimming.

The first of these groups is that of the Seals and Walruses, which form a special division of the Carnivores. Through the specimens exhibited from time to time in the Gardens of the Zoological Society, most of us are more or less familiar with the external form of the Seals (Fig. 19), and have also witnessed the exceeding gracefulness of their evolutions in the water. In all Seals the limbs are very short, and by the complete webbing of the toes, are converted into paddle-like organs. Although the amount of modification is greater in the hind than in the fore limb, yet in both the several digits of the feet still retain their external distinctness. In the so-called Eared-Seals (from which the seal-skin of commerce is alone obtained) and Walruses the hind feet are turned forwards beneath the body when the animal is on land, after the ordinary manner. In the true Seals, however (Fig. 19), these feet are always directed backwards, and thus act solely as propellers in the water. All the Seal tribe are clearly very closely allied to the ordinary land Carnivores; and the Eared-Seals and Walruses indicate the mode in which such animals have undergone a progressive modification until the extreme specialisation of the true Seals has been attained.

The second group, containing the Whales, Porpoises, Grampuses, Dolphins, &c., differs so remarkably from all other Mammals that it has been referred to a distinct order—the Cetacea. All the members of this group (Fig. 14) have, indeed, assumed such a completely fish-like appearance that it is even now frequently difficult to convince people that they are true Mammals. Their mammalian nature is, however, shown by their warm blood and four-chambered heart, by the circumstance that they produce their young in a living condition and nourish them by milk drawn from the udder of the parent, and also by their respiration being effected by the aid of lungs. The "spouting" of Whales as they come to the surface is, indeed, mainly due to the water of the sea being thrown up as the air from the lungs is forcibly expelled from the nostrils before the animal has quite reached the surface. We may add that the certainty that Whales are true members of the mammalian class is one of the strongest reasons against employing the term "quadrupeds" to denote that division of Vertebrates.

Although, as aforesaid, the general appearance of a Whale or Porpoise is fish-like, yet a more careful examination shows certain very important points of difference. In the first place, the tail-fin, or "flukes" as it is termed by whalers, is expanded horizontally instead of vertically. The reason for this horizontal expansion appears to be owing to the necessity the Whale is under of coming rapidly to the surface for the purpose of breathing; the upward and downward

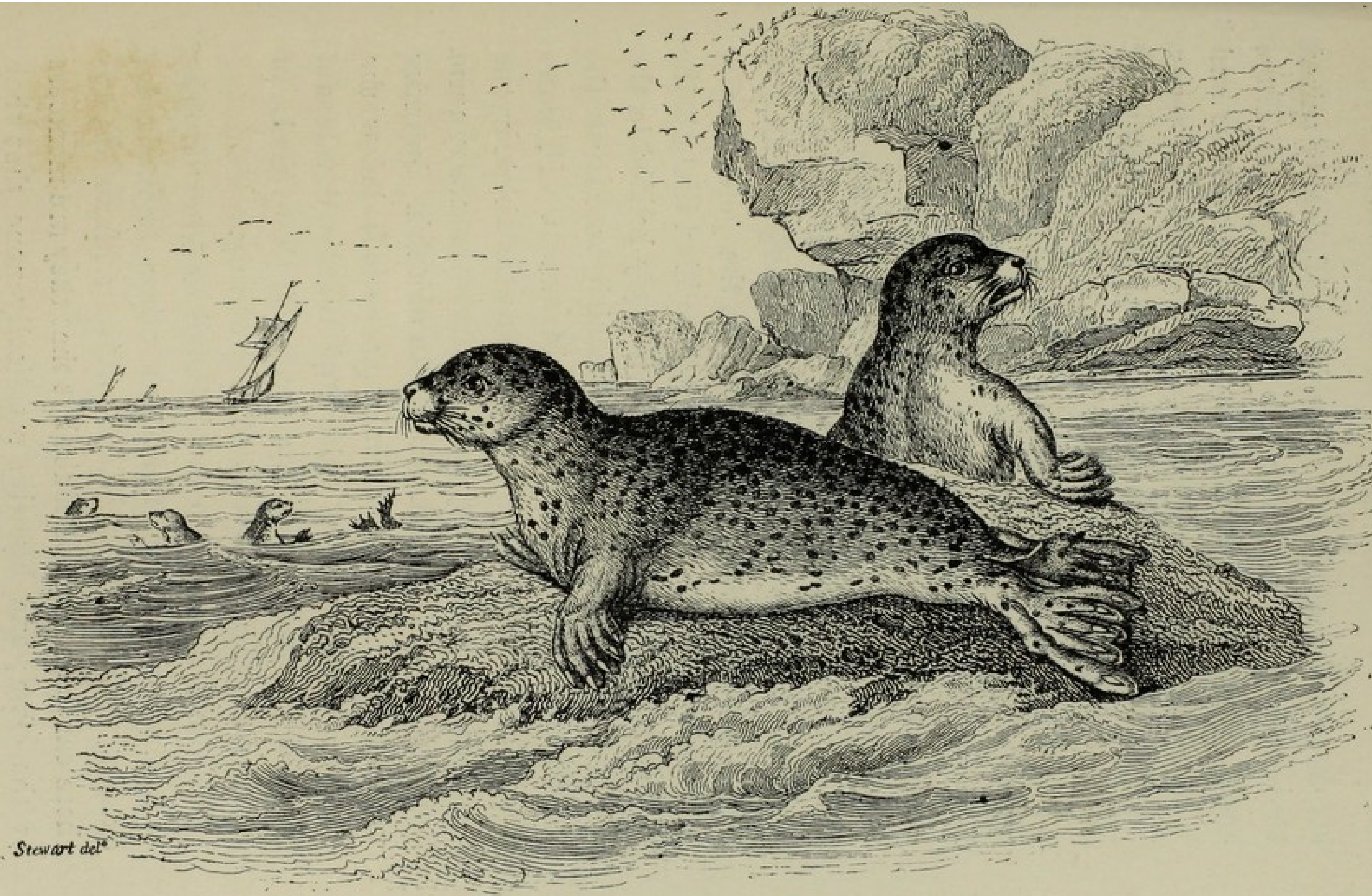


FIG. 19.—The Common Seal. (*From Jardine.*)

strokes of the powerful flukes being admirably suited to effect this object with the greatest speed. Then, again, the number and structure of the paddles and fins are quite different from those obtaining in fishes. Thus, a Whale (using this term for the whole group of allied animals) has only a single pair of flippers (Fig. 14), which correspond to the fore limbs of ordinary Mammals, and to the pectoral fins of fishes. These, however, although presenting certain peculiarities, are evidently only modifications of the normal mammalian fore limb, and are devoid of any structures corresponding to the fin-rays of fishes. They have lost all outward trace of the digits, being completely invested in a common integument. Then, again, the pelvic fins of fishes are wanting; the only traces of hind limbs being certain rudimentary bones found deeply bedded in the flesh of some of the species, which represent the aborted hind legs of quadrupedal Mammals. If, moreover, Whales have any unpaired fins the single one is situate on the back (Fig. 14), and its structure is quite different from that of the dorsal fin of a fish. In order to enable them to stay for long periods below the surface, the circulatory system of Whales develops a number of net-like arrangements of the vessels in which a supply of fresh blood is stored up.

It would involve too much detail to enter into the consideration of the numerous other resemblances existing between Whales and ordinary Mammals, but there can be no sort of doubt but that they are members of the class; and likewise practically none that they are descended from a group of originally terrestrial forms, the special modification having in this case been carried to a considerably greater degree than in Seals, which we know have undergone an analogous development. Naturalists are, indeed, not altogether in harmony as to the kind of terrestrial Mammals from which Whales have descended, but the probability is that such ancestral types were more nearly allied to the pig-like Ungulates than to any other type of Mammals with which we are acquainted. The Hippopotamus shows us how a pig-like animal may become amphibious, and there is no reason why a further development should not go on. It will, however, be understood that the terrestrial ancestors of the Whales have long since disappeared from the face of the earth; and it should be added that not a trace of the intermediate connecting forms has yet revealed itself to reward the anxious search of the palæontologist. The Cetacea are first known in the upper part of the Eocene division of the Tertiary period, and it thus seems quite clear that they were developed to fill the gap left in the life of the ocean by the disappearance of the Ichthyosaurs and Plesiosaurs at the close of the Secondary period; the general replacement of a lower by a higher type of organisation being apparently the great life-feature by which the early part of the former period is distinguished from the latter.

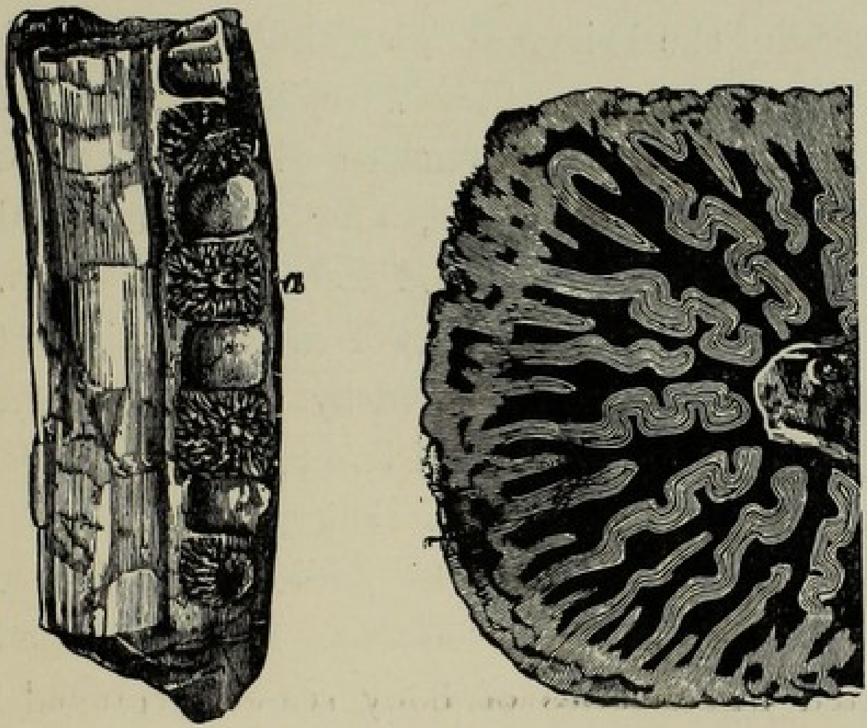
CHAPTER IV.

PRIMEVAL SALAMANDERS.

If we assume that naturalists are right in regarding evolution as the true explanation of the mutual relationships of living beings, and if we also take it for granted that fishes are the lowest representatives of vertebrated animals of which we have at present any cognisance, we should naturally expect to find in some of the lower rocks, at a period when fishes had already obtained considerable development, remains of animals in some respects connecting fishes with reptiles. This expectation is fully realised by the presence in the Coal-measures and lower Secondary rocks of a remarkable group of totally extinct animals, which may be popularly termed Primeval Salamanders, since their nearest living allies are to be found in the Efts of our own ponds, in the well-known yellow-and-black Salamanders of the Continent, and in the so-called Giant Salamanders of Japan and the United States, with the latter of which we have become more or less familiar of late years by means of aquaria.

It may save trouble, before going farther, to mention that although Salamanders and their kin are popularly spoken of as reptiles, yet they have really no right to such a high rank, since they show many signs of relationship with fishes, all of which are quite lost in recent reptiles. These creatures should rather be spoken of as Amphibians, by which title we shall henceforth allude to them when we desire to speak of them in a collective sense. Frogs and toads are likewise members of the same great group, of which one of the most distinctive features is that during their lives its members pass through a metamorphosis—thus changing from a purely aquatic creature (the tadpole) without limbs, and breathing by means of gills like a fish, to one which becomes capable of progression on land, with two pairs of legs, and breathing either entirely or partially by means of lungs, the gills being in some cases completely lost (as in the frog), but occasionally retained as subsidiary breathing organs. This change or metamorphosis, we may remark in passing, is of itself almost sufficient to prove the doctrine of evolution, being, in fact, nothing less than the actual transformation, under our very eyes, of a creature a little higher than a fish into one but little lower than a reptile; so little lower, indeed, that, as we have said, it popularly obtains brevet rank in that group. A feature by which the skull of an Amphibian can always be distinguished from that of a Reptile, at a glance, is found in the mode in which it articulates with the first joint of the back-bone or vertebral column. Thus, in Amphibians, as shown in Fig. 21, the hinder or occipital region of the skull is furnished with two processes, or condyles, which are received into a pair of cups in the first joint of the back-bone; an arrangement—and this is a very significant point—similar to that which obtains in Mammals. In Reptiles (and likewise in their near relations, the Birds), on the other hand, there is but a single knob-like occipital condyle, situated in the middle line, and received into a single cup in the first joint of the back-bone.

With this preliminary explanation we may proceed to the consideration of the Primeval Salamanders. In this country the first evidence of the bony skeleton of these creatures that was brought under notice was afforded by teeth from the New Red Sandstone (at the lower part of the Secondary system of rocks) of Warwickshire and Cheshire. These teeth, which are of conical form, are remarkable for the circumstance that when a transverse section of their base is made, and examined under a lens or microscope, the whole of the internal portion is seen to be made up of a most complex series of foldings, forming a peculiar and characteristic labyrinth-like structure (Fig. 20). From this feature the veteran comparative anatomist, Sir R. Owen, proposed the name of Labyrinthodonts, or Labyrinth-toothed Saurians, for the owners of these remarkable teeth; and although some of the smaller species subsequently discovered do not exhibit the same complexity of tooth-structure, this name may well be adopted as the technical designation of the whole group. By a masterly piece of induction the great anatomist also showed that certain gigantic skulls of the type of the one represented in Fig. 21, which had been discovered at an earlier date in the corresponding rocks of Germany, and whose owners have been named Mastodonsaurs, belonged to other species of the same group. It was further known at the same time that some curious hand-like footprints of a large unknown animal, for which the name of Chirothere (Hand-animal) had been proposed, were of not un-



A. B.

FIG. 20.—*A.* Fragment of jaw of a Primeval Salamander, showing sections of four teeth. *B.* One half of a tooth (*a*) greatly magnified.

common occurrence in the Cheshire and Warwickshire sandstones, and the idea naturally occurred that these were the tracks of Labyrinthodonts. Now, it is highly probable, although not absolutely certain, that this conjectural association of the tracks with the teeth and skulls is a true one; but, most unfortunately, the evil genius of the Professor led him to sketch a restoration of the Labyrinthodont, or Chirothere formed on the model of a gigantic frog; and although it was subsequently shown that the idea of a frog with a skull of a yard in length was totally impossible, yet, with the tendency of all errors to perpetuate themselves, we still see books (even some of them published within the last few years) disfigured by reproductions of this impossible tailless creature.

Instead of the Primeval Salamanders being modelled on the lines of a frog, they were, indeed, constructed after the fashion of a modern Eft or Salamander, having, in the adult state, four limbs adapted for walking, and a well-developed tail. Nearly the whole of them differed, however, from modern Salamanders, in that the chest was defended by an armour of three bony plates—one central and two lateral—ornamented with a sculpture similar to that shown in the skull represented in Fig. 21. In addition to this, other species had the whole of the under surface of the body protected by a series of bony scales, arranged in a chevron pattern; while in a few rare instances the whole of the body was covered with an armour of these bony scales. We thus see that the earlier members of this group come under the designation of mail-clad animals, of which we have treated in a previous chapter.

Another absolutely distinctive feature of the Primeval Salamanders is to be found in the structure of the skull. It will be seen from Fig. 21 that the whole of the upper surface of the skull behind the eye-holes, or orbits, is covered by a complete bony roof, extending continuously from the bone marked *P*, which immediately covers the brain-case, to the sides of the hinder part of the jaws. If we compare the skull of a crocodile with this figure, we shall find, in place of this continuous roof, a long open channel cut from behind each orbit in the direction of the bone marked *S. Temp.* to the back of the skull, while there is also a pair of oval vacuities in the region of the bones marked *Sq.* A Lizard has the hinder part of the skull still more completely opened out. The completely roofed skull of the Primeval Salamanders appears, indeed, to show signs of affinity with some of the earlier fishes; and there seems to have been a gradual tendency among Reptiles to emancipate themselves from this type of skull as time went on. For instance, the Fish-Lizards (Ichthyosaurs), which show signs of direct connection with the Primeval Salamanders in the somewhat folded internal structure of their teeth, and in their simply cupped vertebræ, are also those reptiles which exhibit the nearest approximation to this roofed type of skull; while the modern and highly specialised Lizards are those which depart most widely from it. It may be worth mention that some of those naturalists who are never satisfied with a name, unless it be one for which they are personally sponsors, have proposed to replace the well-established name of Labyrinthodonts by that of Stegocephalians, or Roof-skulled Saurians—a term sufficiently appropriate if no earlier one had barred the way to its adoption.

Another peculiar although not absolutely characteristic feature of the skull of the Primeval Salamanders is the net-like sculpture with which the external surface of all the bones is ornamented (Fig. 21). The reappearance of a similar sculpture in the skulls of Crocodiles has suggested that those reptiles may trace their ancestry directly back to the group under consideration. We must not, however, omit to mention the small round aperture which occurs in the bones of the skull immediately over the brain-cavity in all Primeval Salamanders, and is seen to the left of the letter *P* in Fig. 21. This aperture corresponds to one found in the skull of that curious New Zealand Lizard known as the Tuatara, which is one of the most primitive reptiles now living, having but little affinity with true lizards. In that creature this aperture overlies the rudiment of an eye now totally useless and lying deep down in the brain, but which was probably functional in the earlier ancestors from which the Tuatara sprang. The comparatively large size of this aperture in the Primeval Salamanders suggests the possibility that the central cyclopean eye may still have been capable of receiving some impressions of light, although it is probable that we should have to go back to some long-lost piscine, or even invertebrate ancestor, before we found it of any real use to its owner.

The majority of the Primeval Salamanders had their back-bone composed of biconcave joints much like those of ordinary fishes, or Fish-Lizards. In some of the earlier and more primitive forms the body of each

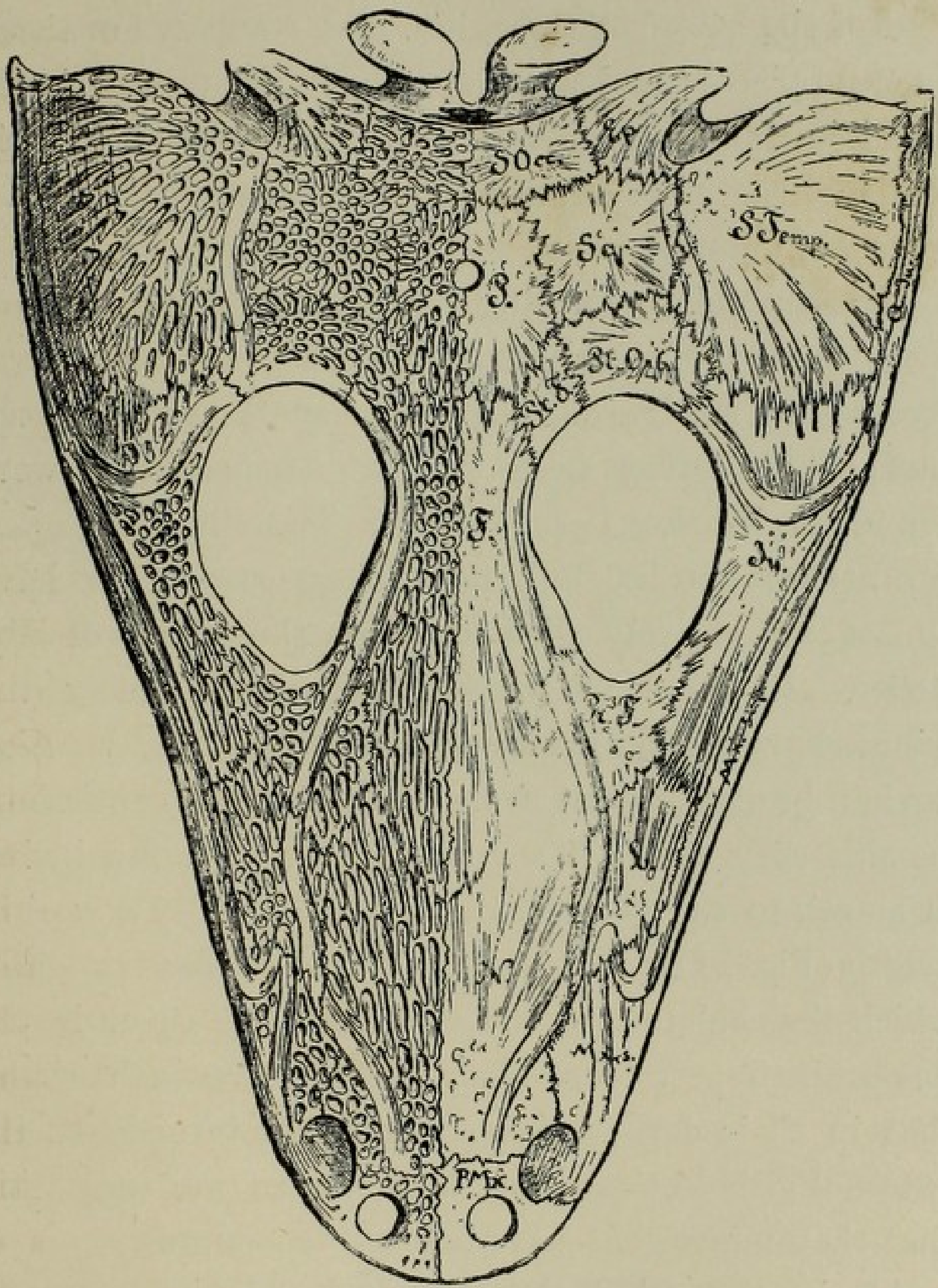


FIG. 21.—Skull of the Giant Primeval Salamander (*Mastodonsaurus*), one-sixth natural size. *S.Occ.*, supra-occipital bone; *Ep.*, epiotic; *P.*, parietal; *Sq.*, squamosal; *S.Temp.*, supra-temporal; *Pt.F.*, post-frontal; *Pt.Orb.*, post-orbital; *F.*, frontal; *Pr.F.*, pre-frontal; *N.*, nasal; *P.Mx.*, pre-maxilla; *Mx.Sup.*, maxilla; *L.*, lachrymal; *Ju.*, jugal; *Q.Ju.*, quadrato-jugal. On the right side of the skull (left side of Figure) the external sculptured layer of bone is shown, which is omitted on the left in order to show the contour of the individual bones. The large apertures are the eye-holes or orbits; the smaller shaded apertures in front, the nostrils; and the smallest of all the holes for the points of the tusks of the lower jaw. The projecting processes at the top of the Figure are the occipital condyles. (*After Fraas.*)

joint of the back-bone was, however, composed of three separate pieces; and since a very similar peculiarity is found in certain primitive fishes, we have again evidence of the close affinity existing between these two groups of animals.

The amphibians forming the group under consideration made their earliest appearance, so far as our present knowledge entitles us to speak, at the early part of the great Coal Period. Thence they were abundant in the Permian and Triassic (New Red Sandstone) epochs, but in Europe appear to have almost or entirely died out by the time of the Oölite. In these early epochs they were widely distributed over the surface of the globe, their remains having been obtained from all the great continents. In size they varied from tiny creatures a few inches in length to the giants with a skull of fully a yard in length (Fig. 21). The perfect state of preservation in which the skeletons of the smaller forms occur in the fine-grained petroleum shales of the Continent shows that in their earlier stages they were furnished with external gills like modern Salamanders, thus indicating that they underwent a similar metamorphosis.

At the time that the Primeval Salamanders were so abundant, true reptiles were either totally absent (Carboniferous period) or represented by comparatively few forms (Permian), so that the *rôle* now taken by the latter was then to a great extent played by the former. We may thus consider that the place now occupied by Crocodiles was then held by the Mastodonsaur (Fig. 21), while many of the smaller forms played the part of the modern Salamanders and Lizards. Some other peculiar types developed extremely attenuated and elongated bodies, with the partial or complete loss of their limbs, and thus simulated the Blind-worms and Snakes of the present day; so that it would appear that all the places in Nature's economy now occupied by Reptiles and Amphibians, were as fully filled in those early epochs of the earth's history by these primitive creeping creatures.

That the Salamanders of the present day are directly descended from the Primeval Salamanders there can be no reasonable doubt. Indeed, if we were to take one of the Primitive Salamanders in which the skull, instead of being of the crocodile-like shape of the one shown in Fig. 21, were of the shape of a cheese-knife (parabolic), and were to make slits in the roof of this skull, to remove the sculpture from the same, and likewise to get rid of the ventral armour, and to slightly modify the structure of the back-bone, we should have a creature almost or quite indistinguishable from the existing Giant Salamander. We have already made allusion to the signs of a relationship exhibited by the Primitive Salamanders to the Crocodiles and the Fish-Lizards, but we have yet to mention indications of a kinship of far deeper interest and importance. In a later chapter reference will be made to that group of extinct Secondary Reptiles, known as Anomodonts, which are so remarkable as exhibiting unmistakable indications of affinity in respect to the structure of their bony skeleton with mammals. Now, if the reader will take the trouble to pay a visit to the gallery of extinct reptiles in the Natural History Museum at South Kensington, he will see displayed at the west end the entire skeleton of an enormous creature from South Africa known as the Pariasaur. This skeleton shows that its owner occupied a kind of half-way position between the Primitive Salamanders and the Anomodont Reptiles, so that it is somewhat difficult to say to which group it should be referred, it being not even known whether it had one or two occipital condyles. This and other equally remarkable fossil types render it, however, perfectly evident that the Anomodont Reptiles have been directly derived from the group forming the subject of this chapter; and there is a very strong presumption that we shall eventually be able to trace the origin of mammals to creatures more or less intermediate between those two groups; the Mammalian stock having probably branched off before the two occipital condyles of the Amphibian had merged into the single one of the Reptile. We may thus look with great veneration on the Primeval Salamanders, as the probable representatives of the ancestral stock of a large portion of the higher vertebrates of the present day.

CHAPTER V.

FISH-LIZARDS, OR SHORT-NECKED SEA-LIZARDS.

So long ago as the year 1814, when a fine example of a large skull (now in the British Museum) was figured by Sir Everard Home in the "Philosophical Transactions" of the Royal Society, the occurrence in the so-called Lias of the Dorsetshire coast of skeletons of huge and uncouth reptiles, strangely unlike any of their modern cousins, was well known. Five years later the same writer described other specimens, and proposed that these extinct Saurians should be known as the *Proteosaurus*, or Primeval Lizard; but about the same time the late Mr. König, some time keeper of the Geological Department of the British Museum, affixed to the specimens of these Saurians under his charge the name of *Ichthyosaurus*, or Fish-Lizard; and this name was adopted in the year 1821 by the late Rev. Mr. Conybeare, who, with the late Dean Buckland, did so much towards our knowledge of the structure of these and other fossil Saurians.

We have said that the Fish-Lizards have left their remains in those beds of rock which are called by the quarrymen Lias, or Layers (the name being derived from their banded and ribbon-like appearance); and before proceeding to discuss the structure of these creatures, a word is advisable as to the geological position of this formation. The Lias comprises a thick series of beds, usually of a bluish colour, lying very low down in that enormous series of rocks known as the Secondary system, of which the Chalk is the topmost member, while the middle part of the system is formed by the great series of Oölites and their accompanying clays. The Secondary system itself, it need hardly be said, lies upon the upper part of the Primary system, as represented by the Coal-Measures; while it is succeeded by the overlying deposits of the Tertiary system. In regard to the upper parts of the latter system, it may be possible to make some more or less vague approximation in terms of thousands of years as to their real age, but in the Secondary period any such approximation is totally impossible, and we can only reckon the age of the various beds by geological periods, as represented by the vertical thickness of overlying rock. Now, since the Chalk may exceed 1000 feet in thickness, and there are several deposits of equal bulk between this and the Lias, some faint idea may be thereby conveyed of the vast lapse of time by which we are separated from that period when the mud of the Lias was deposited in the shallow seas of what is now England. The Fish-Lizards were, however, by no means confined to this remote Liassic period, since they also occur not only in the underlying New Red Sandstone, or Triassic series, which forms the very base of the Secondary system, but likewise lived on through the period of the Oölites and Chalk, till they finally died out, so far as we are aware, with the close of the Chalk period. The Fish-Lizards are, therefore, characteristic of the Secondary period, so that when we pick up one of the joints of their backbones (of which more anon), we know that it must have come from some part of that great system, even though we find it embedded in the gravels lying above the Tertiary system. One other important point remains to be mentioned in connection with the beds in which the remains of these Fish-Lizards occur; and this is, that they

FIG. 22.—Skeleton of Ichthyosaur, or Fish-Lizard, from the Lias. (*After Gaudry.*)

are all deposits formed by the sea, so that we are led to conclude that these saurians were of marine habits. Again, it may be observed that whereas in the Lias the remains of the Fish-Lizards are usually found in the condition of more or less nearly complete skeletons, with every bone but little shifted from its natural position; in the overlying rocks the skeletons are dislocated and often imperfect. Although the latter condition renders us sometimes unable to restore the complete skeleton of these later forms, yet it has the compensating advantage that we are able to handle and examine the individual bones in a manner which is generally quite impossible with the skeletons from the Lias, where the bones are often distorted and flattened by pressure.

We are now in a position to consider a few of the more prominent features in the structure of these primeval saurians, of which the whole organisation is better known than that of most of the other reptiles of the same epochs. In the woodcut (Fig. 17, p. 54) we give a copy of Sir Richard Owen's restoration of the entire skeleton, together with a conjectural outline of the contour of the body when clothed with flesh and skin. It will be seen from this that the contour of the entire animal was of a whale-like type; there being no distinct neck, the body gradually passing into the tail, and the two pairs of limbs forming paddles, or flippers, adapted, like those of a turtle, for propelling the body through the water, and perhaps also permitting their owner to crawl awkwardly on the sea-shore in the same manner as the turtle does. From the circumstance that in the skeletons from the Lias (Fig. 22) the tail is nearly always broken at some distance from its extremity, it has been suggested that the tail was furnished with a terminal fin, after the fashion of the "flukes" of the Whales. In some instances the fine-grained Lias mud has even preserved traces of the

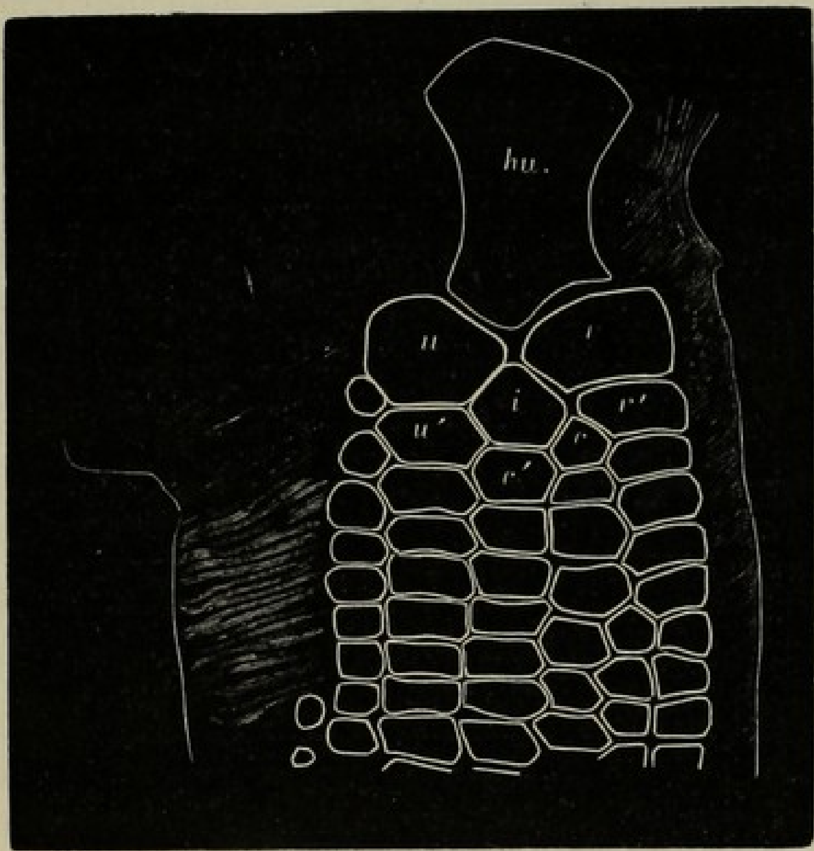


FIG. 23.—Part of one of the fore-paddles of a small Fish-Lizard from the Lias of Barrow-on-Soar. *hu*, bone of upper arm; *r*, *u*, bones of fore-arm; the other letters indicate the bones of the wrist, below which are the bones of the fingers.

outer surface of the skin of the Fish-Lizards, and we learn from this, and also from the absence of any traces of bony plates like those found in the skin of crocodiles, that the skin of these saurians was quite naked, and are thus shown another feature in which they resemble whales. Moreover, in certain very rare instances, as is shown in the beautiful example represented in Fig. 23, the contour of the soft parts of the paddles is accurately delineated in the stony matrix. We thus see that the fleshy part of the paddle formed but a comparatively narrow band in advance of the bony framework on the front border of the fin (right side of Figure); but on the opposite or hinder border (left side of Figure) we find the soft parts forming a broad fin-like expansion, admirably adapted to obtain the full advantage of the stroke of the limb in swimming.

As we are on the subject of the paddles, we may take the opportunity of noticing the very remarkable structure of their bony framework, which is quite unlike that found in any other animal, although evidently only a modification of the same ground-plan. In most of the higher vertebrates, as in man, the skeleton of the arm, or fore-limb, presents the following features: —The upper-arm has one long single bone; in the fore-arm there are two slender bones lying side by side and separated by an interval; the wrist has two rows of small cuboidal bones; while the limb terminates in five fingers, of which, with the exception of the thumb, each has three long-bones,* which are respectively separated from the wrist by a similar but somewhat longer bone. Turning to the fore paddle of the Fish-Lizard (Fig. 23), we easily recognise in the topmost bone (*hu*) the single bone of the upper-arm, although this has become much shorter and thicker than is

* In living reptiles the number of these bones differs in the individual fingers, but never exceeds three in the second finger.

usually the case. In the two short and angulated bones, marked *r* and *u*, it is more difficult to recognise the representatives of the long-bones of the fore-arm; but that they really are their representatives is at once shown by their position. Passing over the bones of the wrist, we find that the bones corresponding to those of the fingers, instead of being elongated and limited to three in each of the five fingers, are polygonal in contour, and arranged in as many as seven or eight longitudinal rows, while those of each finger (as shown in Fig. 17) are exceedingly numerous. The whole structure forms, in fact, a complete bony pavement, which in the living animal must have been perfectly supple, and thus have formed one of the most efficient and powerful swimming organs known in the whole animal kingdom. The paddles of the Whales resemble those of the Fish-Lizards in the great number of bones in each finger, but they differ in that the number of the fingers themselves does not exceed the universal five.

In the few words that we can devote to the skull of the Fish-Lizard, we may observe that the muzzle was produced into a more or less elongated beak (Figs. 17, 22), while the nostrils were placed close to the eye, and the soft parts of the latter were strengthened with a ring of bony plates surrounding the iris and pupil, as is the case in birds. The teeth were large and pointed, and implanted in a deep groove in the jaws. Their pointed crowns at once tell us that the Fish-Lizards were creatures of carnivorous habits, preying on other inhabitants of the Secondary seas. Curiously enough, in the approximation of the nostrils to the eyes, and also in their sharply pointed teeth, the Fish-Lizards present further resemblances to the Whales,—resemblances which we may probably explain by the similar conditions of life of these two widely different groups of animals.

Before leaving this brief notice of the anatomy of these saurians, a few words must be said as to the structure of the back-bone or vertebral column. It will be seen from Fig. 24 that the whole of this column forms a continuous series, tapering at the two extremities; and the various segments, or vertebræ, of the different regions of this column are so alike that it requires some practice to distinguish them. As is well known, each vertebral segment in all the vertebrate animals consists of an upper arch enclosing the spinal marrow, and of a lower sub-cylindrical body supporting the arch and underlying the marrow. As a rule, the body and the arch are more or less firmly united together, but in the Fish-Lizards they remain quite separate throughout life. Further, the body of each vertebra (Fig. 24) forms a disk, which is deeply concave at the two extremities, like the vertebra of a fish, and quite different from those of most living reptiles, in which the bodies of the vertebræ articulate with one another by a ball-and-socket joint. Another peculiarity of the back-bone of the Fish-Lizards is in the mode of attachment of the ribs. Thus each rib terminates in a fork, of which the two prongs articulate with the two knob-like surfaces on the side of the body of each vertebra, as shown in Fig. 24.

Some of the species of Fish-Lizards attained a length of from thirty to forty feet, and were thus truly Leviathans of the deep.

The result, then, of our survey of the chief structural peculiarities of these extinct saurians is to show that they were Whale-like marine reptiles of carnivorous habits, with a naked body, provided with four paddles,

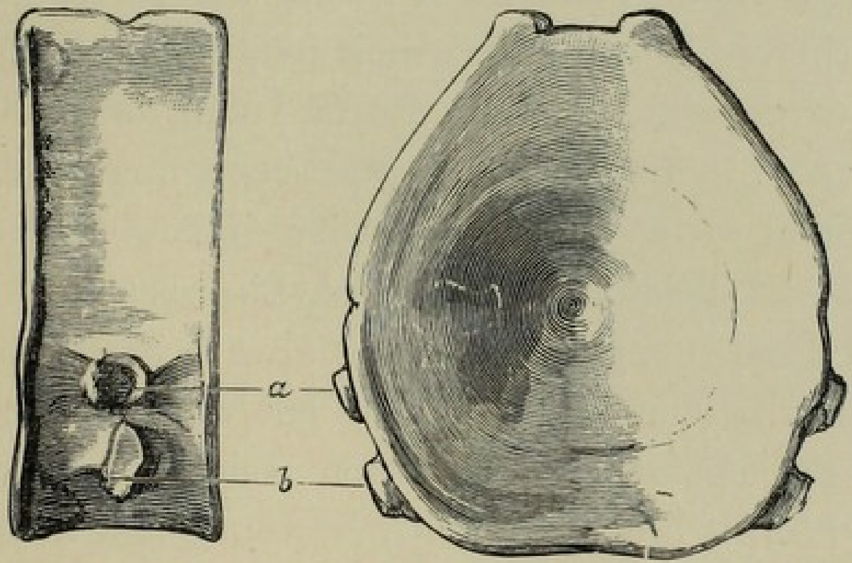


FIG. 24.—Side and end views of the body of one of the segments of the back-bone of a small Fish-Lizard. *a*, *b*, Surfaces for the attachment of the rib.

and probably with a tail fin, and that they had fish-like vertebræ, and a long, toothed beak to the skull. In certain American representatives of the group the jaws were, however, totally unprovided with teeth; and in these and allied types from the Oölites of England a third bone articulated with the bone of the upper-arm (*hu* of Fig. 23), thus making the structure of the paddle still more peculiar. How these toothless Fish-Lizards captured and held their prey is not very easy to understand; but it is possible that instead of living on hard mail-clad fishes like their toothed cousins of the Lias, their food may have been of a softer nature, such as cuttle-fishes.

In stating that the Fish-Lizards of the Lias subsisted largely on the mail-clad "Ganoid" fishes of the same epoch we may perhaps be thought to be drawing upon our imagination. This, however, is not the case, since we frequently find the whole contents of the stomach of these reptiles preserved within the cavity of their ribs, thereby showing that their food was composed not only of these fishes, but also of young individuals of their own genus. In very rare cases, moreover, there are found within the body-cavity of large individuals very small skeletons of other Fish-Lizards (Fig. 22); and since these young skeletons are always entire and belong to the same species as the one within whose body they are enclosed, it has been concluded that some Fish-Lizards brought forth their young in a living condition. This conclusion is certainly one of the most startling and unexpected results which has rewarded the students of this branch of palæontology.

Whether, when the name of Fish-Lizards was first given to these saurians, it was in the mind of its author that they were really related to fishes, cannot now be certainly known. It has, however, been subsequently suggested that these reptiles are the direct descendants of fishes; but since, like Whales, they breathed air by means of lungs, a recent writer has pointed out that if such descent were really the case it is almost certain that the Fish-Lizards would have continued to breathe air by means of gills, after the manner of fishes. And it is, therefore, considered probable that these saurians are the descendants of still earlier land reptiles; in which respect they again present another resemblance to Whales, which appear to have been derived from land animals probably more or less nearly allied to the hoofed mammals. If, now, we look back and endeavour to fix upon the ancestral type of creature from which the Fish-Lizards have probably been derived, we are led to select the Primeval Salamanders described in the fourth chapter as the most likely claimants to this position. In treating of that group we have mentioned the peculiar labyrinth-like internal structure of their teeth, from which the name of Labyrinthodonts has been derived. Now it is very suggestive that the teeth of most species of Fish-Lizards retain traces of this very remarkable labyrinthic structure; and since, moreover, the skulls of these saurians have certain peculiar features also found in those of the Labyrinthodonts, while the structure of the backbone is very similar in the two groups, it seems highly probable that the Fish-Lizards have been directly derived from ancient reptiles more or less closely allied to the Labyrinthodonts, if not from that group itself; and that as they gradually became more completely aquatic their limbs were developed into the very complex paddles of the typical forms.

In conclusion, we have already pointed out several remarkable resemblances between the ancient Fish-

Lizards and the modern Whales, and have regarded such resemblances as due to their similar mode of life. The Fish-Lizards may, indeed, be considered to have occupied that place in the Secondary period which is now held by the Whales; and it is curious to consider why these saurian devastators of the deep should have died out at the close of the Secondary period, to be succeeded during the Tertiary by the mammalian Whales.

CHAPTER VI.

PLESIOSAURS, OR LONG-NECKED SEA-LIZARDS.

In the last chapter we gave a description of the remains of those remarkable marine reptiles from the Secondary rocks known as Fish-Lizards, or Short-Necked Sea-Lizards; the general geological relations of the rocks in which their remains occur being there noticed in such a manner that any further allusion to them would be superfluous. The Fish-Lizards were, however, by no means the only reptilian inhabitants of those ancient seas in which the Secondary rocks were deposited. On the contrary, they were accompanied by another group of marine reptiles, equally well adapted for a marine life, but presenting such a totally different type of structure that no one can have any difficulty in distinguishing between the two. So different, indeed, are the skeletons of these two groups of creatures, that with very little instruction every person of ordinary ability ought at once to be able to say to which of the two any single bone he may pick up should be referred. Since the most striking feature in the skeleton of these reptiles, and also one whereby they are very broadly distinguished from the Fish-Lizards, is the great length of the neck (Fig. 25), they may be conveniently known as Long-Necked Sea-Lizards. Should, however, any of our readers have a fancy for a shorter and more technical term, there is one ready to his hand in the name Plesiosaur. Speaking of the long neck of these reptiles reminds the writer of an answer he received, when examiner at the Calcutta University, from a Bengali, in reply to a question as to the chief points of difference between a Fish-Lizard, or Ichthyosaur, and a Plesiosaur. The misguided student, apparently from having read that portions of the fossilised integuments of the Ichthyosaurs had been obtained, answered the question by stating that Ichthyosaurs were reptiles with a skin, but without a neck, while Plesiosaurs had a neck but no skin.

Like the Fish-Lizards, the Long-Necked Sea-Lizards lived throughout the whole of the Secondary period. Their skeletons, although less common than those of the Fish-Lizards, are preserved in an equally fine state of preservation in the Lias clays of Lyme-Regis and Whitby. Several of the species from the Lias are of comparatively small dimensions, not attaining a length of more than some 8 or 10 feet; but other kinds, more especially those found in the higher Oölitic and Cretaceous rocks, were of enormous dimensions, reaching to a length of 40 feet.

Our earliest knowledge of these strange creatures was mainly derived from the observations of Conybeare and Buckland, made in the earlier decades of the present century. So monstrous and strange did the skeletons of these reptiles appear to those early pioneers in the study of fossil animals, that they were not inaptly compared to a snake threaded through the body of a turtle.

The easiest manner in which we may gain a general idea of the structure of these reptiles will be by comparing them with the Fish-Lizards. Apart from the great difference in the length of the neck, one of the most striking points of distinction between the Fish-Lizards and the Long-Necked Lizards is to be found in the structure of their paddles. Thus, it will be remembered, in the former group the bone of the arm was extremely short, while all the bones of the fore-arm, wrist, and fingers were modified into a polygonal shape, and articulated together so as to convert the whole framework of the limb into a solid pavement-like structure.

In the Long-Necked Lizards, on the other hand, the arm bone (as seen in Fig. 25) is comparatively long, and shaped somewhat like a flattened club; while the bones of the fore-arm (Fig. 26), although remarkably short and flat, are by no means so short as they are in the Fish-Lizards. The greatest difference in the structure of the paddle is, however, to be found in the form of the bones of the fingers (Fig. 25), which, in place of being polygonal, are long and slender like those of ordinary reptiles. It is true, indeed, that the number of bones in each finger is considerably greater than in living reptiles, but the number of the fingers themselves does not exceed the normal five, and the bones of each finger are entirely disconnected from those of the adjacent fingers. The above essential differences in the structure of the paddles of the Long-Necked Lizards from those of the Fish-Lizards will be apparent by comparing Figs. 25 and 26 with Fig. 23. It was probably on account of the structure of the paddles, which departs less from the ordinary type than is the case with the Fish-Lizards, that Mr. Conybeare was led to propose the name Plesiosaur, derived from the Greek *plesios*, nearer, and *sauros*, a lizard.

Equally remarkable differences occur in the form and arrangement of the bones of the shoulder and haunches, but since their illustration would require a long detailed description, we shall pass them by, only mentioning that in the Long-Necked Lizards they form very large plate-like expansions on the lower aspect of the body.

A glance at the figures of the two creatures will at once show a great difference in the relative size of their skulls; that of the Long-Necked Lizard being comparatively short and stout, and thus adapted to be supported and rapidly moved by the long and slender neck. Important differences are also found in the form and arrangement of the individual bones composing the skulls, but it will suffice on this occasion to mention that the Long-Necked Lizards differ from their short-necked contemporaries by the absence of a ring of bony plates within the eye-ball,* and also by the circumstance that their long and sharp teeth are im-

* In Fig. 22 in the chapter on Fish-Lizards.

planted in distinct sockets, instead of being arranged in a continuous open groove. In the latter respect the creatures under consideration resemble crocodiles, and no other existing reptiles.

In the chapter on Fish-Lizards a woodcut (Fig. 24) of one of the joints of the back-bone, or vertebræ, shows that these are very short doubly-concave disks, and in the region of the back carry two small facets on their sides, with which the forked heads of the ribs are articulated. Moreover, the upper part of each vertebra, forming the arch through which the spinal marrow runs, is completely separated from the body of the vertebra (the only part shown in the figure),

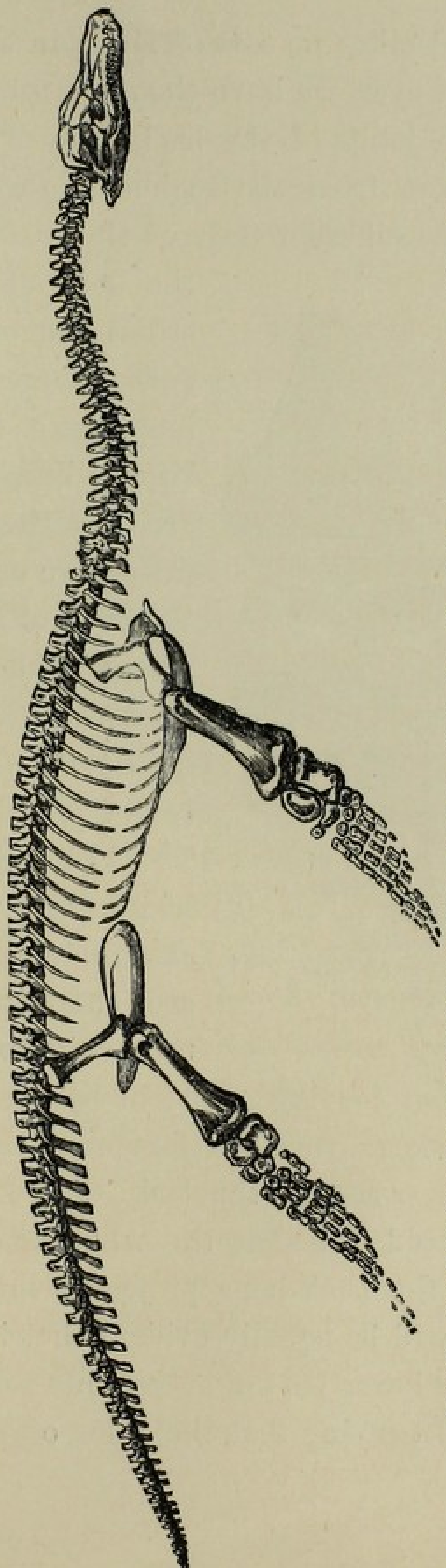


FIG. 25.—Greatly reduced restoration of the skeleton of a Long-Necked Sea-Lizard (Plesiosaur) of the Dorsetshire Lias.

and takes no sort of share in supporting the ribs. If, however, we have the opportunity of examining one of the joints of the back-bone of a Long-Necked Lizard taken from the region of the back, we shall find a very different state of things. Thus, in the first place, the body of the vertebra, although still more or less cupped at both ends, in most cases is considerably longer, so as to form a cylinder rather than a disk. Then, again, the upper arch for the spinal marrow is generally more or less closely united with the body of the vertebra, so that the whole structure forms one piece. Moreover, the sides of the body are quite smooth, having no trace of facets for the support of the ribs. The latter are, indeed, attached to long horizontal processes jutting out at right angles from the sides of the arch, and thus precisely similar to those with which we are all familiar when carving a sirloin of beef at table. It will be obvious from the foregoing that if we looked inside the cavity of the body of a Long-Necked Lizard, we should find that the whole of the bodies of the joints of the back-bone projected into the cavity; whereas it will be equally evident that in the Fish-Lizards only the lower part of such joints so projected.

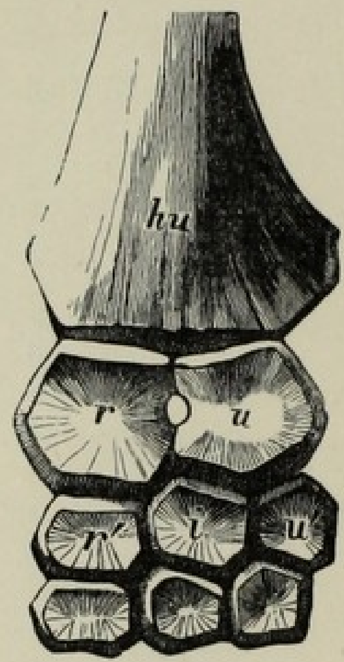


FIG. 26.—Part of the fore-paddle of a Long-Necked Lizard. *hu*, lower half of arm-bone; *r*, *u*, bones of the fore-arm; *r' i u'*, upper row of wrist-bones.

In saying that the sides of the bodies of the vertebræ of the reptiles under consideration have no facets for ribs, the reader should bear in mind that this applies only to the region of the back, since the small ribs which are found in the necks of these creatures are articulated with the sides of the bodies of the vertebræ.

In the general structure of the back-bone and ribs the Long-Necked Lizards come nearer to crocodiles than to any other existing reptiles.

Such, then, are the chief features of the bony framework of these curious reptiles. The absence of any trace of bony plates, like those found in the skin of the crocodiles, leads to the conclusion that the bodies of the Long-Necked Lizards were clothed with a smooth skin like that of porpoises. In regard to the habits of the Plesiosaur, we cannot do better than quote the words of Mr. Conybeare, who says: "That it was aquatic, is evident from the form of its paddles; that it was marine is almost equally so, from the remains with which it is universally associated; that it may have occasionally visited the shore, the resemblance of its extremities to those of the turtle may lead us to conjecture; its motion must, however, have been very awkward on land; its long neck must have impeded its progress through the water; thus presenting a striking contrast to the organisation which so admirably fits the Ichthyosaur [Fish-Lizard] to cut through the waves. May it not, therefore, be concluded (since, in addition to these circumstances, its respiration must have required frequent access to the air) that it swam upon or near the surface; arching back its long neck like the swan, and occasionally darting it down at the fish which happened to float within its reach? It may, perhaps, have lurked in shoal-water along the coast, concealed among the sea-weed; and, raising its nostrils to a level with the surface from a considerable depth, may have found a secure retreat from the assaults of dangerous enemies; while the length and flexibility of its neck may have compensated for the want of strength in its jaws, and its incapacity for swift motion through the water, by the suddenness and agility of the attack which they enabled it to make on every animal fitted for its prey which came within its reach."

Nothing that has been discovered since the date when the above passage was penned can suggest any more probable interpretation of the habits of these creatures.

The larger species found in the Lias attained a length of about 20 feet; but, as is so generally the case, we find the size of the species gradually increasing as we ascend in the geological scale, the culmination being reached in the period of the chalk, when, both in Europe and North America, we meet with species reaching to the enormous length of 40 feet, and the joints of whose backbone measured as much as 6 inches in diameter. These terrible creatures must indeed have been dragons of the deep, with a far more strange appearance than any of those imagined in fable.

The general dimensions, although perhaps not the absolute length, of these monsters were, however, greatly exceeded by those of a closely allied group of marine reptiles whose remains occur in the Oxford and Kimeridge clays of the great Oölitic series of rocks. These creatures, which are known by the name of Pliosaurs, although agreeing with the Long-Necked Lizards in the structure of their paddles and backbone, differ very widely from them in having enormous heads, for the support of which a short and thick neck is, of course, absolutely essential. A skull of one of these giants found on the Dorsetshire coast and exhibited in the Natural History Museum, is nearly 6 feet in length; while a hind paddle in the Dorset Museum measures upwards of 6½ feet, of which no less than 37 inches is taken up by the thigh-bone alone. The enormous biting power and destructive habits of these creatures is evidenced by their teeth, which are not unfrequently found in the Kimeridge clay, and one specimen of which is upwards of a foot in length from the tip of the crown to the base of the root. These teeth are readily distinguished from those of all other reptiles, not only by their huge size, but also by the triangular form assumed by their crowns; one surface of the triangle being usually nearly smooth, while the other two are ornamented with vertical ridges.

We may pretty safely assume that in the ancient seas of the Oölitic period the Pliosaurs acted the same part as is played by the ferocious Grampuses in those of the present day.

Turning from these latest modifications into which the Long-Necked Lizards were finally developed, and looking back at the earliest known representatives of the group, we find in the strata lying below the Lias, and thus forming the very base of the Secondary rock-series, the remains of a number of more or less closely allied forms, the largest of which did not exceed a yard in length. These small reptiles were evidently ancestral types of the larger species found in the Lias, but they exhibit certain structural features clearly indicating that they were in great part of terrestrial or fresh-water habits, and their whole organisation departs less widely from the general reptilian type than is the case with their successors in time. Thus we reach the conclusion that the Long-Necked Lizards, like the Fish-Lizards, were in all probability descended from small land reptiles, and have been gradually more and more modified for the exigencies of a purely marine life. In this respect, therefore, these ancient creatures present a precise analogy to the Whales and Porpoises of to-day.

CHAPTER VII.

TORTOISES AND TURTLES.

To many of us, the chief idea connected with turtles is that they are used to make turtle-soup; while in regard to tortoises our acquaintance is often limited to seeing a barrow-load of unfortunate specimens hawked about the streets, or to an individual or two kept in our own or a friend's garden, as a very unsociable kind of pet. We are also acquainted with these creatures by means of tortoise-shell, either in the form of combs or various ornamental articles; although the exact nature of this commodity—which, by the way, comes from turtles and not from tortoises —is frequently but very imperfectly known. Many people, indeed, have more or less hazy ideas as to what kind of animals tortoises and turtles really are. Thus, according to *Punch*, railway companies were wont to classify tortoises as insects; and the writer well recollects that during his undergraduate days his landlady purchased an unfortunate tortoise to take the place of a deceased hedgehog in the kitchen, for the purpose of eating black-beetles, and was immensely astonished when told that the tortoise was a vegetable feeder and had no sort of kinship with the hedgehog.

Tortoises and turtles, or, as it is frequently convenient to call them, Chelonians (from the Greek name of one species), are, however, in reality a very remarkable group, or order, of the great class of Reptiles; and their structure is so peculiar and interesting that a short glance at some of their chief features cannot fail to be instructive. We are, indeed, accustomed to regard many extinct groups of reptiles, like the Fish-Lizards,* as more *bizarre* and strange than any which now inhabit the globe; but if we were to be made acquainted for the first time with tortoises from their fossil remains, we should certainly consider them as far more extraordinary than any other types; and it is highly probable that the palæontologist who first made known such a remarkable type of reptilian structure would be charged with having created a totally impossible monster.

The most striking and peculiar feature about tortoises and turtles is the more or less complete bony shell with which their body is protected, on account of which they are noticed in the chapter on "Mail-Clad Animals." The accompanying woodcut (Fig. 27) exhibits a typical Chelonian, as exemplified by a land-tortoise. In this creature we see a fully developed bony shell, within which the head, limbs, and tail can be retracted, so as to afford a perfect protection for the entire animal. We have said that the shell of the tortoise is a bony one; but it will probably be at once objected that the "tortoise-shell" of commerce is about

* See Chapter V.

as unlike bone as it can well be. This apparent discrepancy can, however, be very readily explained. In a living tortoise, as is well shown in Fig. 27, the outer surface of the shell is completely covered over with a series of large shield-like horny plates, of which there is one row down the middle of the back, and a lateral row on either side of this middle one; externally to which we have a series of marginal shields, forming the border of the upper half of the shell. Similar horny shields also cover the lower part of the shell, which we shall notice shortly. The solid bony shell underlies these horny shields; the relations of the horny and bony constituents of the protecting shell being shown in Fig. 28, where the outer horny shields have been stripped off, leaving distinct grooves on the

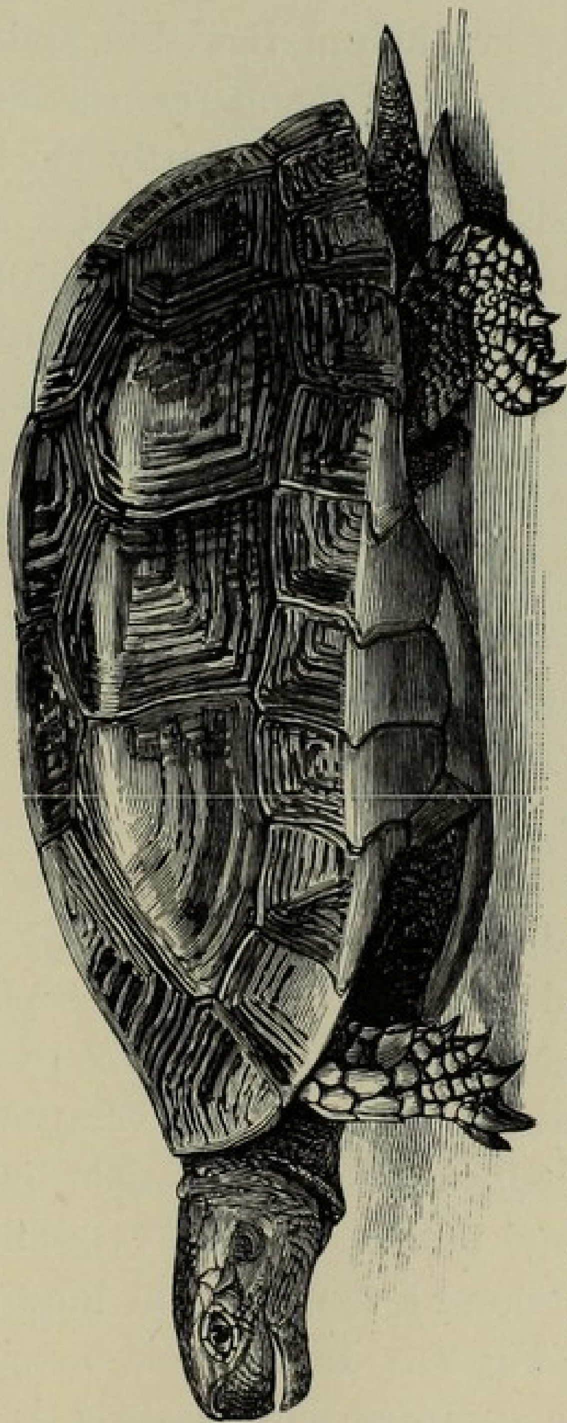


FIG. 27.—Side view of a Land-Tortoise, with the head and limbs protruded from the shell.

underlying bones at the lines of junction with one another. Now it is these horny shields which form the "tortoise-shell" of commerce; in the land-tortoises they are, indeed, very thin, and of no economical value, but in one of the marine turtles, known as the Hawksbill, they become greatly thickened, and furnish the well-known "tortoise-shell," so remarkable for its translucency and the beautiful coloration formed by the mottled blending of a full reddish brown with a lemon yellow. It will be noticed from Fig. 27 that in the land-tortoises these horny shields have their edges in apposition; but in the young of the Hawksbill turtle they overlap one another like the slates on a roof, although in the adult they become united by their edges in the same manner as in the tortoises.

Turning once more to Fig. 27, it will be seen, as we have already incidentally mentioned, that the shell consists of an upper vaulted portion covering the sides and back, which is technically known as the *carapace;* and also of a flattened lower plate protecting the chest and abdomen, to which the term *plastron,* or breast-plate, is applied. The carapace and the plastron are usually connected together by a comparatively short bony bridge, at the extremities of which are the notches for the fore and hind limbs, as is well shown in Fig. 27. In the land-tortoises this union between the carapace and plastron is complete; but in the marine-turtles, and also in some freshwater tortoises, there is no such bony union between the upper and lower portions of the shell. The characters of the plastron of the land-tortoises are shown in Fig. 29, from which it will be seen that there are six pairs of symmetrical horny shields, arranged on either side of

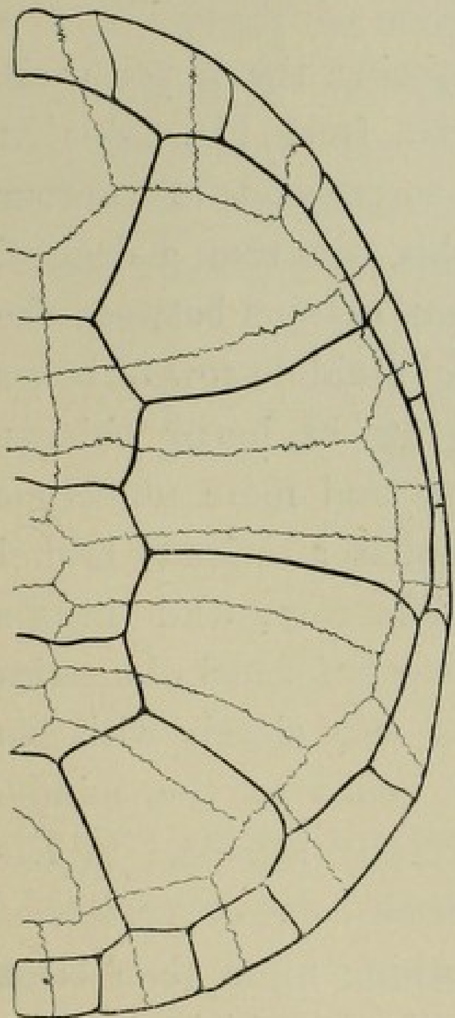


FIG. 28.—The right half of the upper shell, or carapace, of a Tortoise, with the horny shields removed. The thick black lines show the boundaries of the horny shields, while the zigzag lines indicate the divisions between the underlying bony elements of the shell.

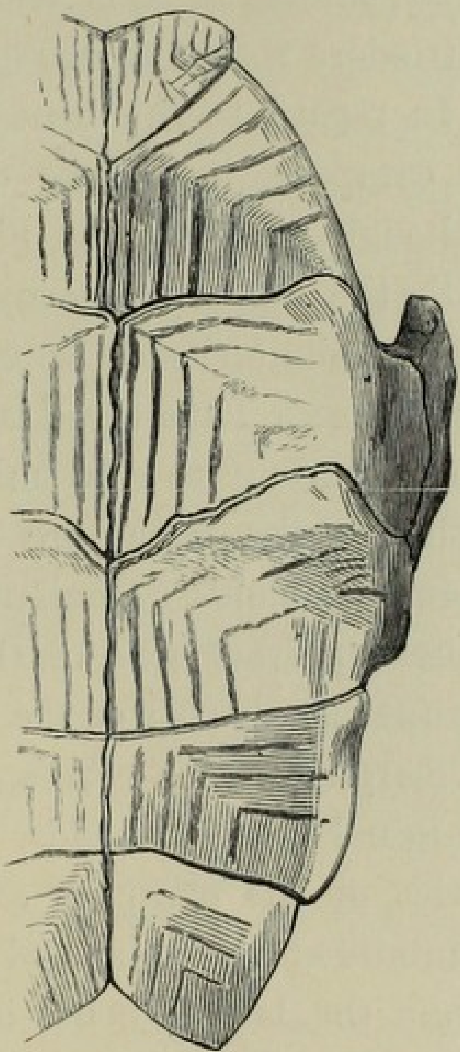


FIG. 29.—The middle and left side of the lower shell, or plastron, of a Land-Tortoise.

the middle line of the shell. This type of plastron is characteristic of nearly all the tortoises of the northern hemisphere; but in a smaller group, now confined to the southern hemisphere, there is an additional unpaired shield (Fig. 30, *i*, *gu*) dividing the first or gular (*gu*) shields of the plastron. This additional, or intergular, shield, as it is termed, is very frequently of a battledore shape, as in Fig. 30.

In regard to the bones composing the upper shell, or carapace, it will be observed, from Fig. 28, that although they by no means correspond in contour with the overlying horny shields, yet that a decided general similarity of arrangement obtains between the two series. Thus there is a single middle row of bones corresponding to the middle row of horny shields, although the bones are smaller and more numerous than the shields. Similarly there is a series of lateral bones on either side of the middle row; while in like manner the border of the carapace is formed of a series of marginal bones corresponding very closely with the marginal horny shields. The bones of the middle series of the carapace are severally attached to the summits of the spines of the back-bone, or vertebræ; while the lateral bones are nothing more than large expanded plates lying on the ribs, to which they are so completely welded that they are generally regarded as part of the same bone.

From this brief glance at the structure of the Chelonian shell, we are enabled to understand one of the most peculiar features of the organisation of these remarkable reptiles. This peculiarity is, that whereas the shoulder-blade in all other animals lies entirely on the outer side of the ribs, in the tortoises and turtles it is situated within the cavity enclosed by the ribs and shell. Similarly the haunch-bones, which in all other living animals lie close to the outer surface of the body, are likewise shifted within the cavity of the ribs and shell. To reach the shoulder-blades and haunch-bones the bones of the arm and leg are bent in a manner quite peculiar to this group of reptiles, so that they are readily recognised when found in a fossil state. We should, however, mention that the above peculiar

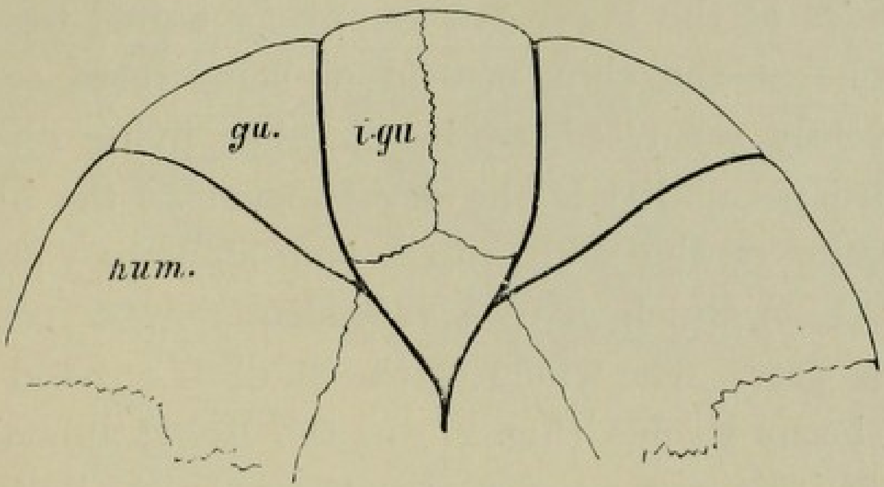


FIG. 30.—The front portion of the plastron of a Freshwater-Tortoise of the Southern Hemisphere, with the horny shields removed. The thick lines indicate the boundaries of the horny shields.

inside-out arrangement is only found in the adult condition; extremely young tortoises having the shoulder-blades and haunch-bones situated respectively in front of the first, and behind the last rib, and being gradually grown over by the plates developed upon these ribs.

One other peculiarity in the bony structure of the group still remains to be mentioned. It is probably well known to our readers that ordinary reptiles—such as crocodiles and lizards—are furnished with well-developed teeth, which are frequently of great size. In all Chelonians, on the contrary, teeth are totally wanting, and their function is consequently performed by the margins of the jaws, which form sharp cutting-edges, and are ensheathed with a coating of thick horn. This total absence of teeth is well shown in Fig. 27, and still better in Fig. 31, where the bones of the skull are represented with the flesh and skin removed. Another remarkable peculiarity of the Chelonian skull is found in the circumstance that the two sides of the lower jaw are firmly united together by bone at the chin, instead of being more or less completely separated, as in all other living reptiles. A third peculiarity is the development of the hinder extremity of the skull into a long spine-like process (Fig. 31, *o*), which gives a very characteristic contour to this part. The whole of the skull is covered over with horny shields (Fig. 27) in the living animal; so that in this respect the structure of the skull corresponds exactly with that of the shell.

In the entire absence of teeth, coupled with the horny sheathing of the jaw, and the solid union of the two bones of the lower jaw at the chin, tortoises resemble birds. Many, or perhaps all, of the birds of the Secondary geological epoch were, however, provided with a complete set of teeth, and it is therefore highly probable that we shall some day find the fossil remains of extinct tortoises which were also furnished with these useful implements, since there appears to have been a tendency in many groups of animals, and more especially in birds and their near relations the reptiles, to lose their teeth. Thus as already mentioned, the Fish-Lizards of the Cretaceous rocks of the United States are all characterised by the absence of teeth; and, as we shall subsequently have occasion to notice, a similar condition obtains in the Pterodactyles, or flying reptiles of the same deposits, by which feature they are widely distinguished from their Old World allies.

All the fossil tortoises and turtles at present known

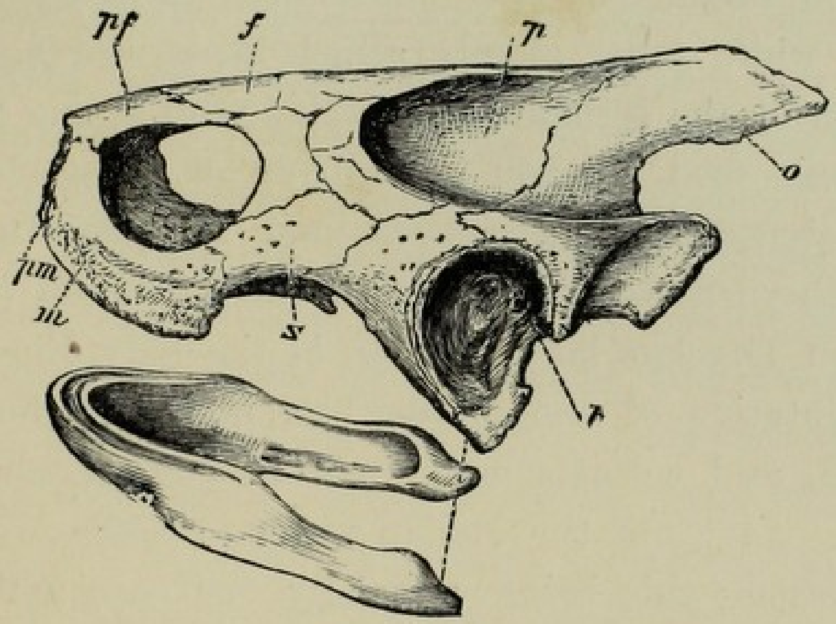


FIG. 31.—Left side of the skull of a Land-Tortoise, with the lower jaw displaced. *m*, *pm*, upper jaw; *s*, cheek-bone; *t*, cavity of ear; *f*, *pf*, bones over the eye and nose-cavity; *p*, hollow of the temples; *o*, posterior spine.

to us agree with existing types in the absence of teeth, as well as in the general characters of the shell; and we have at present (on the assumption that some mode of evolution is the true explanation of the mutual relationships of the different groups of animals) no evidence to connect the Chelonians very closely with any other type of reptiles. It is, however, quite probable that the bony plastron of the tortoises is an extreme development of the peculiar system of so-called abdominal ribs found on the lower surface of the body in crocodiles and many extinct groups of reptiles, such as the Fish-Lizards and Plesiosaurs; and it appears that the nearest allies of the Chelonians are to be found in the latter group.

Chelonians vary greatly in their habits, and the nature of their food. Thus the land-tortoises, as their name implies, are terrestrial, although all of them can swim; while some closely allied types are aquatic. The feet of the former are provided with strong claws, and their food consists exclusively of vegetables, of which they consume a vast amount. The pond-tortoise of Southern Europe, which, with the exception of the common Grecian land-tortoise, is the only European representative of the group, has, however, the feet webbed, and subsists on animal substances, such as worms. Many of the Indian water-tortoises are also carnivorous; this being especially the case with the well-known soft-tortoises of the rivers of the warmer parts of the globe. In those reptiles the shell is not provided with horny shields, but has the outer surface of the bones ornamented with a beautiful net-like sculpture, and merely covered with a thin skin. In the turtles, again, which are of marine habits, although they resort to the shore to deposit their eggs, the limbs have all the toes enclosed in a common scaly integument, so as to form paddles admirably adapted for swimming organs. While, however, the edible Green-turtle is of strictly herbivorous habits, the fierce Hawksbill is as purely carnivorous. Another very remarkable group of marine Chelonians is now represented only by the so-called Leathery-turtle, which differs from all other living forms in that the shell is represented only by a carapace composed of a number of small bones closely joined together, and forming a mosaic-like structure which is totally unconnected with the ribs. The living leathery-turtle attains a length of about five feet; but some allied fossil forms are estimated to have been as much as ten feet in length, and were thus veritable aquatic giants. The largest existing representatives of the true tortoises are, or were recently, found in certain islands of the Indian Ocean, and also in the well-known Galapagos (or Tortoise) Islands lying off the coast of South America. A magnificent series of these giant land-tortoises is now exhibited in the Natural History Museum at South Kensington. Many of these huge creatures, which have in some cases been completely exterminated by sailors, could readily walk off with a man seated on their back; and in the larger forms the length of the shell in a straight line is upwards of four feet. These dimensions were, however, vastly exceeded by certain fossil species found both in Northern India, the south of France, and elsewhere; the shells of some of these monsters attaining a length of six feet. The late Dr. Falconer, who was disposed to consider that the size was considerably greater than this, has indeed suggested that some of these huge tortoises may have lived on in India into the human period, and thus have given rise to the old Sanscrit legend that the earth was supported by a gigantic elephant standing upon the back of a still more gigantic tortoise; the legend being, however, discreetly silent as to what constituted the support for the tortoise.

In conclusion, we may say a few words as to the classification of Chelonians, leaving, however, out of consideration the leathery-turtle and its allies, in regard to the position of which there has been a considerable amount of discussion. Ordinary Chelonians are readily divided into two great groups, according to the manner in which the head is retracted within the shell. Thus, in the land-tortoises (Fig. 27) and their allies, the head is drawn directly within the margin of the shell by the bending of the neck in an S-like manner in a vertical plane. The plastron of this group is generally characterised by the absence of the unpaired intergular shield (Fig. 29), so that the two gular shields meet in the middle line. This group, as we have already mentioned, includes, with the exception of the soft tortoises, all the tortoises of the Northern Hemisphere and also the marine-turtles; but it is by no means confined to this hemisphere, although totally wanting in Australia. The name Cryptodirans, or hidden-necked tortoises, is applied to the members of this group. In the second great group, on the other hand, the neck is bent sideways, so that the head, when retracted, lies on one side of the front aperture of the shell near to one of the legs;

and the presence of an intergular shield in the plastron (Fig. 30) is absolutely characteristic. The members of this group are termed Pleurodirans, or side-necked tortoises, and, as we have said, are now exclusively confined to the Southern Hemisphere, and are the only Chelonians met with in Australia. In former epochs this group was, however, much more widely distributed, so that we may probably conclude that the Pleurodirans are an older and less specialised type than the Cryptodirans. A very remarkable gigantic fossil tortoise from Queensland and Lord Howe Island, which may probably be regarded as a member of the Pleurodiran section, is remarkable for having large horn-like prominences on the skull, and also for the bony rings with which the tail was protected, somewhat after the fashion of the Glyptodont Mammals (see page 16). Finally, the soft tortoises form a third group, allied to the Cryptodirans in the mode of retraction of the head, but distinguished by certain peculiarities in the structure of the skull and shell. From the presence of only three claws on the feet of the typical forms, this group is technically termed the Trionychoidea; and with it we bring to a close our remarks on tortoises.

CHAPTER VIII.

GIANT LAND REPTILES, OR DINOSAURS.

THE traveller from London to Hastings, by way of the South-Eastern Railway, on leaving the chalk hills of the North Downs, some short distance to the north of Sevenoaks, enters suddenly on a more open district, known as the Weald of Kent and Sussex. This district presents many remarkable and peculiar features, one of the most striking being the great prevalence of oak-trees in those parts having a clayey soil; and the traveller will not fail to notice that, in place of the chalk which he has just left, all the rocks of the district consist of alternations of beds of clay, sand, and sandstone. These peculiarities in the structure of the rocks continue the whole way to Hastings; and the tall cliffs of sandstone, on one of which are perched the ruins of the ancient castle, rising to the eastward of that town, and forming the most prominent features in the landscape of the neighbourhood, are too well known to require further mention. The whole of this extensive series of rocks, which attains a vertical thickness of many hundred feet, and has been much worn away by atmospheric action, and thrown into a series of folds, is considerably older than the chalk, from which it is separated by the beds known as the Upper Greensand, Gault, and Lower Greensand, and is collectively known as the Wealden series, or formation. Instead of having been formed, like the overlying chalk and other deposits, at the bottom of an ancient sea, the whole of the Wealden beds are of purely fresh-water origin—a circumstance abundantly proved by the fossils found in the beds themselves, which comprise fresh-water shells, and the remains of land plants and land animals, to the total exclusion of all marine organisms. It is, indeed, probable that the area of the Wealden strata, which originally extended from Kent to the Isle of Wight, once formed the delta of a mighty river, flowing into the North Sea, and draining a very considerable portion of Northern Europe, during that period of the Secondary epoch of the geological scale immediately preceding the one in which the greensand and chalk were deposited.

Apart from its many other points of interest to the geologist, as well as those which it presents to the botanist and the archæologist, the Wealden area has an especial and unique claim on the attention of the palæontologist. It was, indeed, mainly from the huge fossil bones obtained during the earlier decades of the present century from these deposits, by the late Dr. G. A. Mantell, of Lewes, that our first definite knowledge was acquired of that wonderful group of extinct land reptiles forming the subject of the present chapter. These creatures, for which Sir R. Owen has proposed the name of Dinosaurs (Gr. *deinos*, terrible, and *sauros*, a lizard), were certainly worthy of their name, for it is impossible to conceive more appalling monsters than those which we propose to briefly notice.

The labours of Dr. Mantell were mainly devoted to the Wealden rocks near the village of Cuckfield, in the neighbourhood of Brighton, where this enthusiastic worker obtained a great number of bones and teeth, which are now preserved as some of the treasures of the Natural History Museum. These specimens, imperfect though many of them were, enabled their discoverer to affirm that the old delta of the Weald was once inhabited by several kinds of extinct reptiles, totally unlike any existing forms, and some of which vastly exceeded in size any land animals now living. By patient research Mantell was enabled to arrive at a fair approximation to the general form of the skeletons of some of these strange and uncouth inhabitants of a former world; but from the fragmentary condition of the remains of other species, and the extreme peculiarity of their structure (as now known by entire skeletons), he never even dreamt what weird creatures he had been the means of first bringing to the notice of the scientific world.

One of the first, and at the same time one of the strangest, of these Giant Reptiles discovered by Mantell, was definitely determined from the evidence of its detached teeth, which are of not uncommon occurrence in some of the Wealden beds, and one of which is shown of the natural size in the accompanying woodcut (Fig. 32). These teeth have peculiarly compressed crowns, with well-marked flutings on the outer surface, and serrated lateral edges. In many of them the summits of the crowns are found to be worn quite flat by mutual abrasion; from which it is evident that these teeth indicate a reptile of herbivorous habits, which was also of gigantic size. From the somewhat distant resemblance presented by

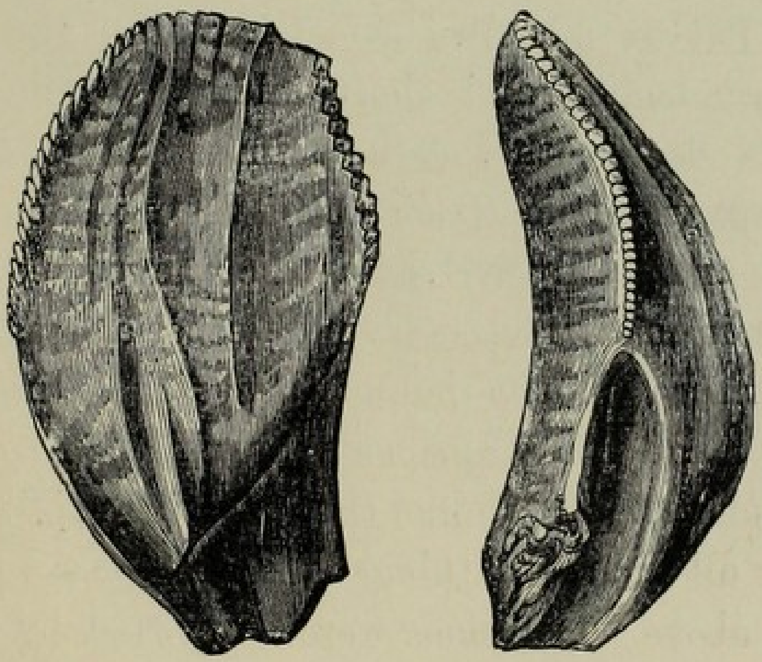


FIG. 32.—Outer side and profile of the crown of a tooth of the Iguanodon. Natural size.

them to the very much smaller teeth of a living American lizard known as the Iguana, Dr. Mantell proposed to call the huge Wealden monster the Iguana-toothed Reptile, or Iguanodon. In the course of time numerous more or less nearly entire bones of this creature were obtained, when it was found that the thigh-bone of some specimens considerably exceeded a yard in length. This at once gave a clue to the enormous bulk of these reptiles, since the corresponding bone of the largest existing crocodile scarcely exceeds a foot in length. By calculating the relative proportions of the other bones it was eventually estimated that the Iguanodon was a creature about 30 feet in length, with a body as large as that of an elephant; and that it walked on all four feet like a crocodile. Accordingly, many years ago a restoration of the Iguanodon was set up in the gardens of the Crystal Palace, modelled somewhat after the fashion of a large-bodied and short-tailed crocodile. After Mantell's death other earnest investigators occupied themselves with the structure of the skeleton of this creature, and finally arrived at the unexpected conclusion that in many respects—more especially as regards the structure of the haunch-bones and limbs—the skeleton made a very curious approximation to that of birds, and was quite unlike that of living reptiles.

As we all know, all things come to those who wait, and the above conclusions were supported by the discovery, some few years ago in the Wealden deposits of Belgium, of a number of nearly perfect, although much crushed, skeletons of the Iguanodon. These wonderful discoveries have enabled the Belgian naturalists to mount several entire skeletons in the Brussels Museum, in a gallery of which they now stand as the most marvellous restorations of extinct animals of the Secondary epoch yet known in Europe. Fig. 33 gives a greatly reduced representation of one of the larger of these skeletons, of which the total length is about 33 feet. It will be seen from this figure that the creature habitually walked on its hind legs, doubtless partly supported by its powerful tail, in a bird-like attitude. The fore limbs were considerably shorter than the hind ones; and the hands were extremely powerful, and probably served to assist the creature in

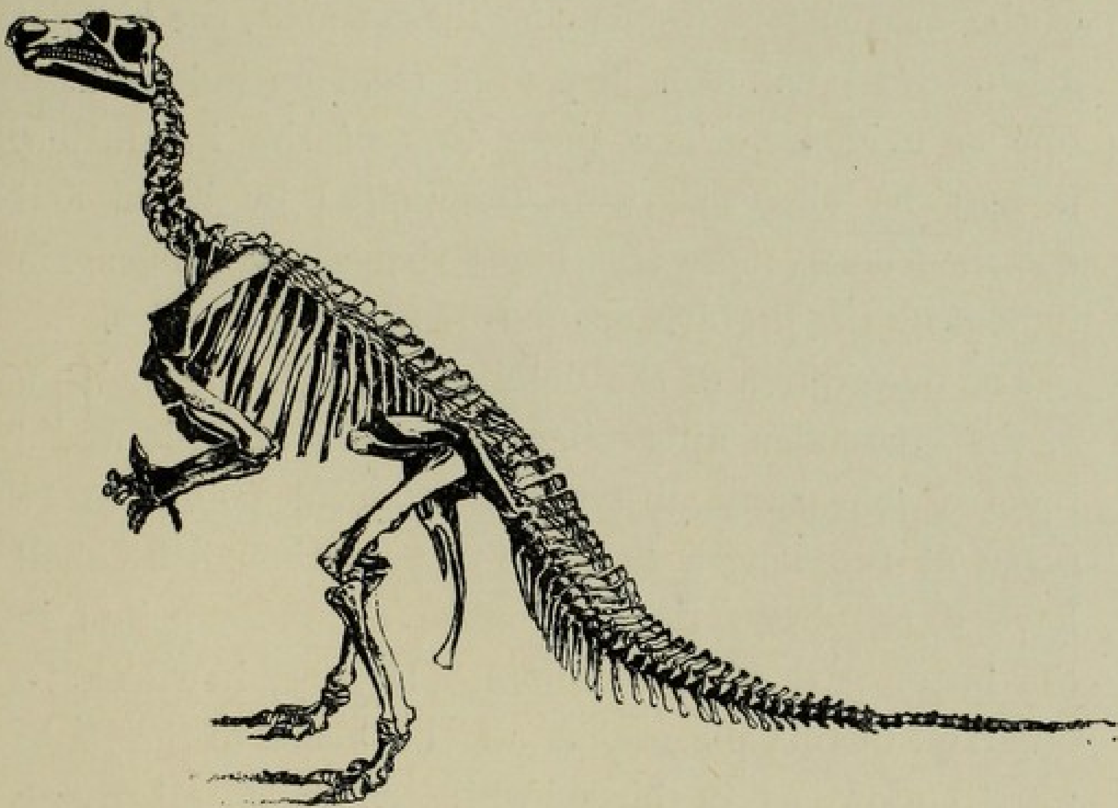


FIG. 33.—Restoration of the skeleton of the Iguanodon. About one-seventy-fifth the natural size.

bringing to its mouth the leaves and fruits upon which we may assume it subsisted. There was a long series of teeth, similar to the one represented in Fig. 32, on the sides of both jaws; but the muzzle was quite toothless, and may perhaps have been sheathed in horn, like the beak of turtles. The extreme shortness of the fore limbs is of itself sufficient to indicate that the Iguanodons really walked on their hind legs like birds; but if we require further evidence on this point it is ready to our hand. Far in the Wealden sandstones of Hastings there have been found numerous series of impressions of huge three-toed hind feet, corresponding exactly in size with the three-toed feet of the Iguanodon; and, since there are no impressions of the smaller fore feet among these tracks, the bipedal gait of the Iguanodon is proved from an independent line of evidence. The three toes of the Iguanodon, it may be observed, were terminated by broad and flattened bones more like hoofs than claws, thus again indicating the herbivorous nature of these reptiles.

The description of the details in which the skeleton of the Iguanodon approximates to that of birds would involve too many abstruse anatomical points to be given at full length in these pages, although we shall have some observations to make on these points in the latter part of the chapter. It may, however, be observed in this place that all the bones of the limbs were hollow, as in birds, while those of all living reptiles are solid. Then the two long and rod-like bones descending from the haunches behind the thigh-bone are essentially bird-like in form and position, and differ totally from the corresponding bones of crocodiles and lizards. Again, the reduction of the number of hind toes to three, and the close relationship of the upper bones of the ankle to those of the leg, are strong points of resemblance to birds. It is true, indeed, that in birds the three parallel long-bones of the foot found immediately below the ankle in the Iguanodon are fused into a single bone, while the ankle-bones are respectively united with the latter and the bones of the leg; but in a fossil reptile from the chalk of the United States, which may be regarded as a distant cousin of our Iguanodon, the arrangement of these bones is so like that obtaining in birds, that the difference is merely one of the degree to which specialisation (as naturalists call these peculiar modifications from the ordinary type) has been carried.

Indeed, to those who believe in the evolution of organised nature, it now appears evident that birds have originally taken their origin from some kind of extinct reptile more or less closely allied to the ancestors of the Iguanodon.

From the absence of any trace of bony plates, like those found in the skin of living crocodiles, accompanying the skeletons of the Iguanodon, we may safely infer that these creatures had an entirely naked skin. In regard to their food, we know that palms and cycads grew abundantly in England during the Wealden period, and it is hence highly probable that the fruits of these plants formed a considerable part of the nutriment of these ancient reptiles.

The sight of a herd of these giant Iguanodons, many of which stood over 20 feet in height, stalking on their hind limbs among the old Wealden forests and overtopping many of its trees, must have been a spectacle in comparison to which a drove of elephants in an Indian jungle would be tame and commonplace.

A totally different type of Giant Land Reptile from the Sussex Wealden was first indicated to Mantell by a huge bone of the upper arm, or humerus as it is anatomically termed. This stupendous bone, which is now in the Natural History Museum, has a length of upwards of fifty-four inches, and approximates in form to the corresponding bone of the crocodiles, being solid throughout, and thus totally different from the very much smaller arm-bone of the Iguanodon. As being the largest form with which he was acquainted, Mantell proposed to call the reptile represented by this bone the Pelorosaur, from the Greek *peloros*, vast, and *sauros*, a lizard. For a long period little or nothing more was known of the structure of this huge creature, but at length specimens were obtained from the Wealden of the Isle of Wight which indicated the nature of its teeth and various parts of its skeleton; while valuable information was also afforded by specimens obtained from the Kimeridge and Oxford clays, which underlie the Wealden beds. It is true, indeed, that the specimens from the Isle of Wight have been described under a different name from the Sussex remains, but they differ only in minute points of detail. The tooth shown in woodcut 34 is that of the Isle of Wight reptile, to which the name of Hoplosaur (armed lizard) has been applied. It will be seen that this type of tooth is quite different from that of the Iguanodon, the outer surface of the crown being convex, without flutings, and with smooth edges; while the inner surface is concave and spoon-like. Specimens of similar teeth from the Sussex Wealden, which evidently belonged to the Pelorosaur, are much larger than the figured tooth. The structure of the haunch-bones of these creatures is very different from that of the Iguanodon, and more like that of the crocodiles, so

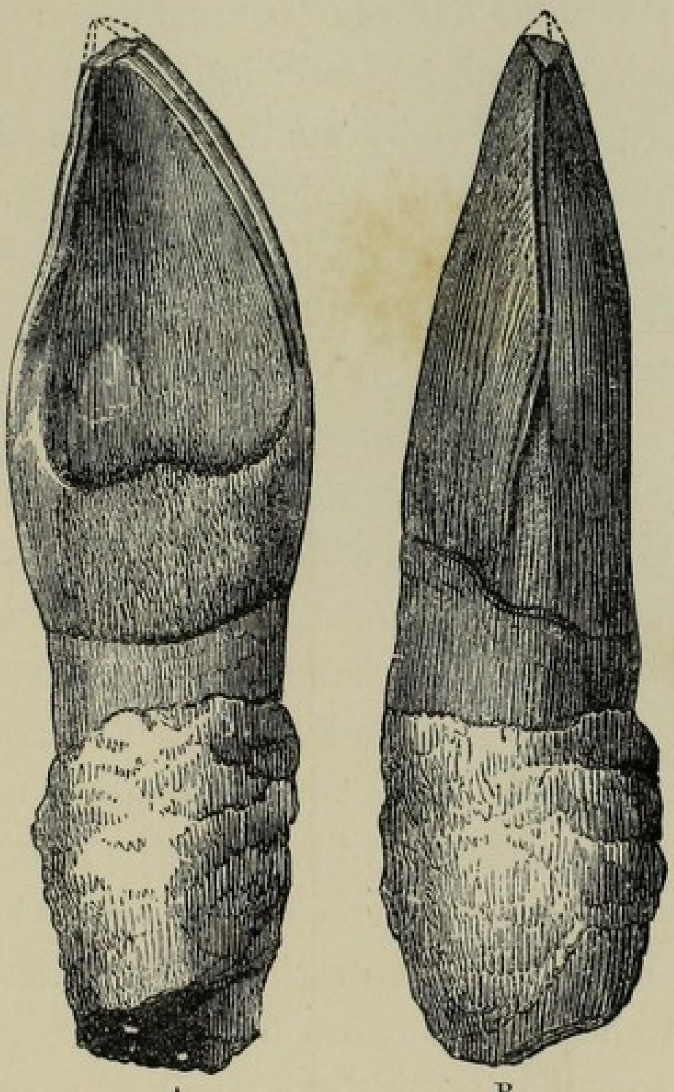


FIG. 34.—Inner side (A) and profile (B) of a tooth of the Hoplosaur. Natural size

that it is perfectly evident that these reptiles exhibited no especial bird-like affinities. They may, indeed, be more correctly compared with crocodiles, which they resembled in walking on all four feet, although in many points of their organisation they were allied to the Iguanodon; these mutual resemblances and differences thus serving to indicate that the latter has probably been derived from reptiles more closely resembling crocodiles.

The teeth of the Hoplosaur, although so unlike those of the Iguanodon, likewise indicate that their owners were of herbivorous habits. The gigantic bulk of these creatures is indicated not only by the arm-bone mentioned above, but also by another arm-bone obtained from the Kimeridge clay, which measures 57 inches in length, as well as by the thigh-bone of the allied Cetiosaur (whale-lizard) from the still older Stonesfield slate of Oxfordshire, which is upwards of 64 inches in length. The latter dimensions—stupendous as they seem—are, however, exceeded by another thigh-bone from the United States, which actually measures upwards of 74 inches, or 6 feet 2 inches in length. The owner of this enormous bone has been appropriately named the Atlantosaur, and appears to have been the largest land animal yet known, alongside of which a full-grown elephant would be a mere pigmy. The total length of another nearly related but somewhat smaller American species known as the Brontosaur is, indeed, estimated to have been as much as 80 feet.

Another peculiarity of these gigantic reptiles, which must not be passed over, occurs in the structure of the joints of the backbone, or vertebræ. In creatures of such enormous bulk, if the vertebræ were solid their weight would probably be an impediment to the free movements of the body; and we accordingly find that these vertebræ were excavated into large hollow chambers, thus illustrating a principle of construction well known to engineers. A similar feature is known elsewhere only in birds, where these chambers are filled with air. We must not, however, omit to mention that similar chambers occur in the vertebræ of the smaller members of the group under consideration, the reason for which is less easy to see.

The third great group of Giant Land Reptiles was first definitely brought under the notice of the scientific world by the late Dean Buckland, the celebrated Professor of Geology in the University of Oxford, as far back as the year 1824. The Professor had observed that in the Stonesfield slate of Oxfordshire, to which allusion has already been made, there were not uncommonly found teeth of the peculiar type of the one shown in woodcut 35; although many of them were of considerably larger dimension than the figured specimen. It will be seen from the figure that this type of tooth (of which only the crown or exposed portion is represented) differs very widely indeed from the teeth of the Iguanodon and Hoplosaur.

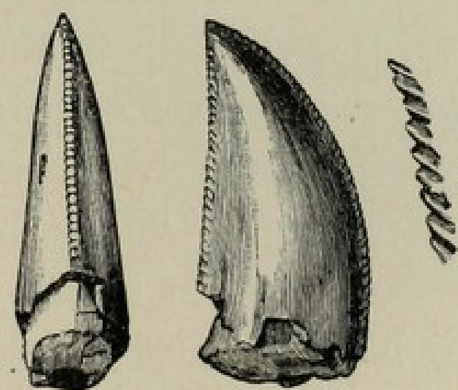


FIG. 35.—Profile and side of the crown of a tooth of a Megalosaurian Reptile, with part of the serrations enlarged.

Thus the crown of this tooth is much flattened from side to side, with sharp, cutting fore-and-aft edges, of which the front one is highly convex, while the hinder one is either nearly straight or somewhat concave.

Moreover, one or both of these cutting-edges were jagged like a saw, indicating that these formidable teeth were adapted for tearing and rending flesh. This led Dr. Buckland to conclude that the old Stonesfield reptile, to which these teeth once belonged, was of carnivorous habits; and since the bones found in the same deposits indicated a creature of comparatively huge dimensions, he proposed that it should be known as the Megalosaur, or Great Reptile. Since, however, the thigh-bone of the Megalosaur does not exceed a yard in length, it is obvious that the creature was vastly inferior in point of size to the Hoplosaur and its kindred.

Similar teeth were subsequently found by Dr. Mantell in the Wealden beds; and by discoveries afterwards made both in Europe and the United States, it was eventually found that the Megalosaur was merely one representative of a group of Giant Land Reptiles characterised, among other peculiarities, by the possession of teeth of the type described above, and also by having sharply curved claws adapted to aid these teeth in seizing and destroying living prey. While, therefore, the Iguanodons and the Hoplosaurs of the Secondary period may be compared to the herbivorous elephants and hippopotami of the present fauna of the globe, the place of the lions and tigers of to-day was occupied in the same early epoch by the Megalosaurs.

Although these Megalosaurs walked upright, like the Iguanodons, which they also resembled in having hollow limb-bones, there is a very important difference between these two groups of reptiles in regard to that part of the skeleton which includes the haunch-bones, and is technically known as the *pelvis* (from the Latin word for a basin, in allusion to the basin-like shape of the human pelvis). Now since it is to a great extent from the structure of the pelvis that the affinity between Giant Reptiles and Birds has been proved to exist, it is worth while to pay some attention to this point; although the reader must make up his mind not to be frightened by the unavoidable use of a cer-

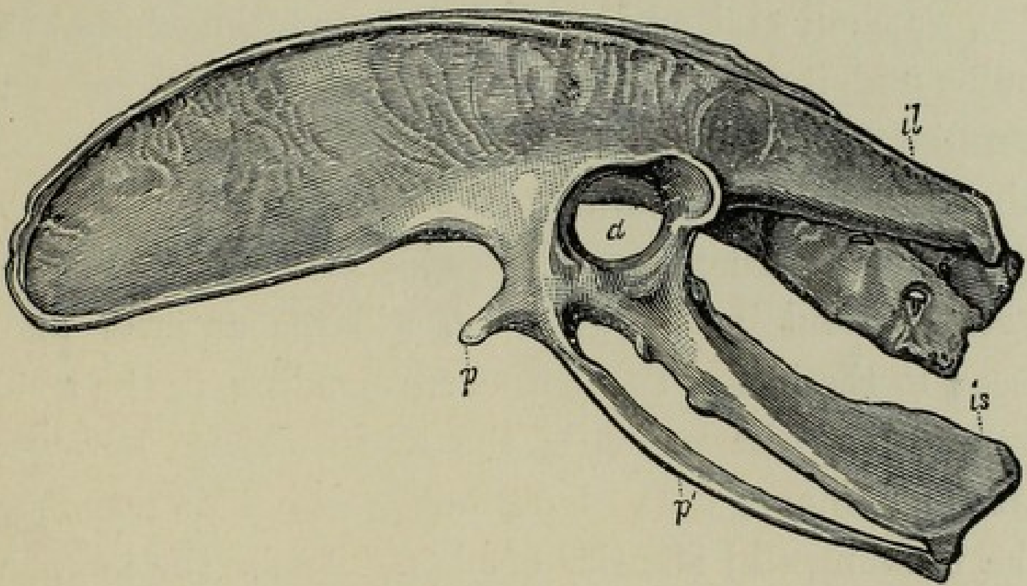


FIG. 36 —Left side of the pelvis of the Kiwi. *il*, haunch-bone or ilium; *p*, *p'*, pubis; *is*, ischium; *a*, cup for head of thigh-bone. (*After Marsh.*)

tain number of technical terms for bones which have no vernacular name. If, then, the reader will direct his attention to Fig. 36, which represents one side of the pelvis of the New Zealand wingless bird known as the Kiwi or Apteryx, he will observe that the haunch-bone extends as a deep vertical plate a long distance in advance of the cup for the reception of the head of the thigh-bone. He will also see that the inferior portion of the pelvis is composed of two bars of bone respectively known as the pubis and ischium, lying nearly parallel to one another and directed behind the aforesaid cup for the thigh-bone. The pubis, or more anterior bone, also gives off a small process (*p*) projecting from its upper end towards the head of the animal. Now this type of pelvis is found, at the present day, only among birds, that of lizards and crocodiles being quite different. If, however, we turn to the figure of the skeleton of the Iguanodon (woodcut 33), we shall find, as already briefly mentioned, that the pubis and ischium (seen to the right of the leg) run parallel to one another, and are directed backwards after the fashion obtaining in birds. It is true, indeed, that in the Iguanodon the pubis is shorter than the ischium; and it also gives off a large anterior plate (seen to the left of the leg) corresponding to the small process *p* in the pelvis of the Kiwi. These, however, are but minor points of difference which do not affect the fundamental identity of plan. Again, the haunch-bone of the Iguanodon extends far in advance of the cup for the head of the thigh-bone, and thus once more follows (or, as we should rather say, leads) the bird-fashion. These peculiarities in the structure of the pelvis of the Iguanodon, coupled with other features in its organisation, ought to leave no doubt, in the minds of all unprejudiced observers who hold the doctrine of evolution, that there is some direct affinity between the extinct Giant Reptiles and the modern wingless birds.

Turning now to the pelvis of the Megalosaur, of which a greatly reduced representation is given in

Fig. 37, it will at once be apparent that we have to do with a widely different type of structure. Thus we notice, in the first place, that the haunch-bone extends but a comparatively short distance in front of the cup

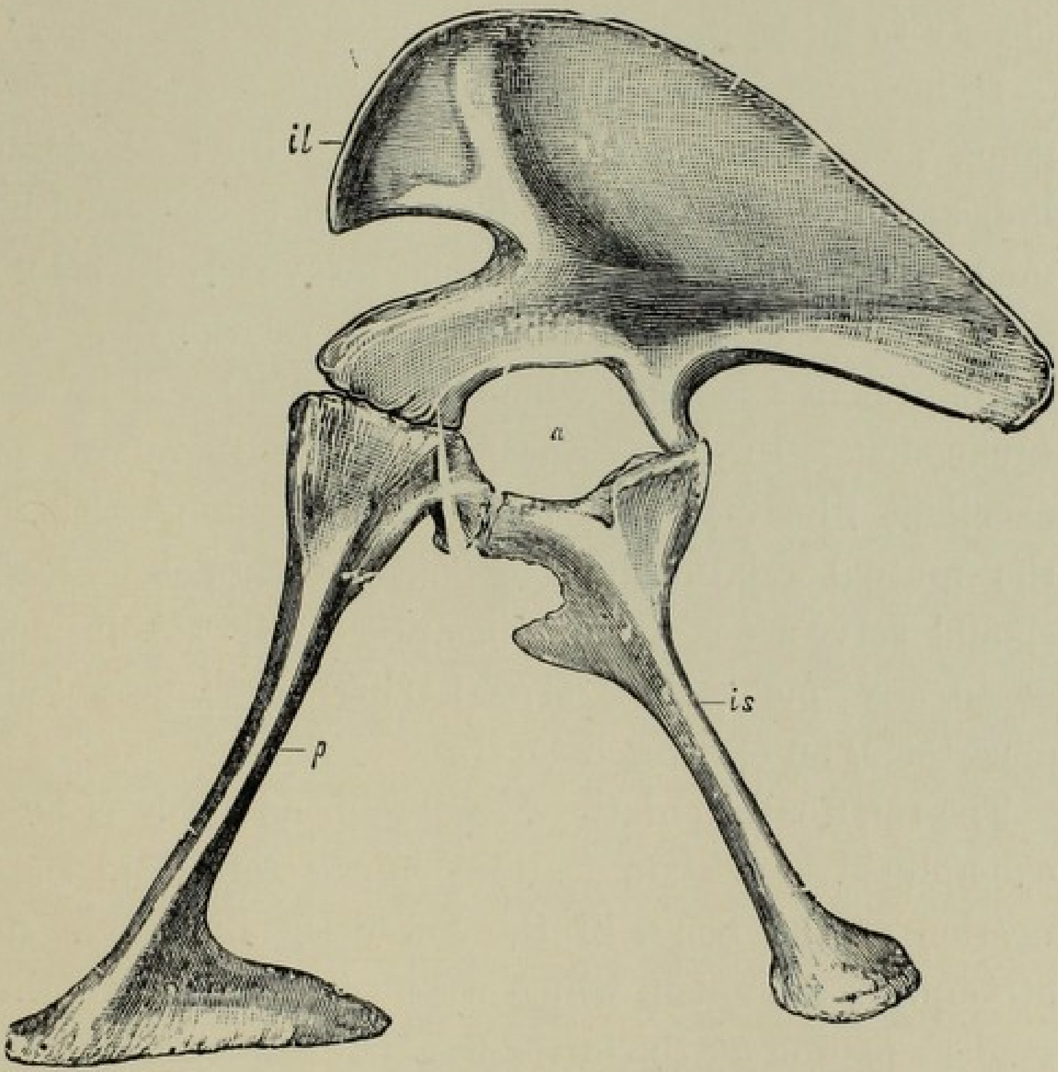


FIG. 37.—Left side of the pelvis of Megalosaur. One-twelfth natural size. Letters as in Fig. 36. (*After Marsh.*)

for the head of the thigh-bone. Then, again,—and this is by far the most important feature—the pubis is directed forwards instead of backwards, and thus, instead of lying parallel with the ischium, is placed at a very open angle to that bone. This form of pelvis, although differing in some details, is, indeed, of the general type of that obtaining in modern crocodiles; and thus serves to show that in this respect the Megalosaur (and likewise the Hoplosaur) were more nearly related to ordinary reptiles, and less closely to birds, than is the case with the Iguanodon.

If, however, we were led to conclude from the foregoing facts that the Megalosaur presented no closer indications of affinity with birds than is exhibited by modern crocodiles, we should be grievously in error; for not only does it exhibit such a relationship, but exhibits it in a manner which is not displayed by the Iguanodon. In this respect we have, therefore, an excellent illustration of that extreme complexity in the mutual relationships of extinct animals, which should serve as a warning against hasty conclusions as to any one extinct type having been the actual ancestor of an existing creature.

The relationship of the Megalosaur to birds is best exemplified by certain features in the form and connection of the bones of the lower leg and ankle, in attempting to explain which we must again crave the reader's pardon for the introduction of a certain number of unavoidable technicalities.

Most of us are probably aware that our own ankle consists of two rows of small bones, of which the upper row includes the heel-bone, and the huckle-bone (corresponding to the well-known "huckle-bone" of a leg of mutton); while the lower row has four smaller bones. Now in moving the foot on the leg, as in the action of walking, it is evident that the joint is situated between the two long-bones of the leg and the upper row of the ankle, *i.e.*, the heel-bone and huckle-bone. In a crocodile, on the contrary, the ankle joint occurs between the upper and the lower rows of the ankle, so that the heel-bone and the huckle-bone move with the leg-bones. In a bird there is yet one step further on this, for not only does the movable joint occur between the upper and the lower rows of the ankle, but the huckle-bone and the heel-bone are respectively united with the two long-bones of the leg, so as to form practically single bones; while the bones of the lower row of the ankle similarly unite with the long-bones supporting the toes, so as to form that single slender bone, with three pulley-like lower surfaces, with which we are all familiar in the leg of a fowl (see Fig. 47, B, p. 151). An adult bird, therefore, while having an ankle-joint, has no separate ankle-bones. In a young bird, however, as we may see for ourselves in the case of a young fowl on our dinner-table, the lower end of the so-called "drumstick," or main bone of the leg, is incompletely united to the bone itself, so that it can be readily detached; this detachable portion being, in fact, the bird's true huckle-bone.

Now in the crocodile, as we have already mentioned, the huckle-bone, although moving with the leg-bone, remains perfectly separate therefrom; but in the Megalosaur we find a condition exactly intermediate between that obtaining in the crocodile and the adult bird. This will be apparent from Fig. 38, where we see the lower end of the leg-bone of the Megalosaur with the huckle-bone closely applied to it, and probably immovably united thereto during life by cartilage. This condition is, indeed, precisely similar to that which exists in the young fowl; and thus, we have, so to speak, displayed before us the actual manner in which the leg of a reptile has become converted into that of a bird, the young bird carrying with it the history of its origin fully apparent to all who will but read Nature's secrets aright. When, however, we make this statement we by no means intend to imply that the Megalosaur or any of its immediate kindred were the direct ancestors of birds, but only that they were more or less closely allied to such unknown ancestral types.

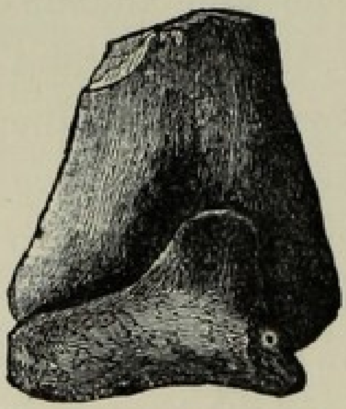


FIG. 38.—The lower end of the leg-bone of Megalosaur, with the huckle-bone attached to it. (*After Gaudry.*)

There are almost equally remarkable resemblances in the structure of other parts of the leg of the Megalosaur to that of birds, but the feature indicated is amply sufficient for our present purpose.

The group of which the Megalosaur is our typical example is a large one, and contains some species with a thigh-bone upwards of a yard in length, down to tiny little creatures scarcely as large as a rabbit. These reptiles were widely spread over nearly the whole globe; their remains having been obtained from the Secondary rocks of Europe, India, South Africa, North America, and even as far north as Behring Strait. Some of the smaller species, like those found in the Lithographic limestones of the Continent and in the United States, probably took considerable leaps with their long hind legs, and must thus have resembled the smaller kangaroos of Australia.

Briefly summing up the result of the foregoing observations, we find that the Giant Land Reptiles may be divided into three great primary groups presenting the following distinctive features. In the first group, as represented by the Iguanodon, the teeth were adapted for grinding, and had compressed crowns, ornamented with ridges on the outer side; the limb-bones were hollow; the pelvis was bird-like; and the mode of progression was bipedal. In the second group, as exemplified by the Hoplosaur, we have nearly or quite the largest known land animals; their teeth were spoon-like, and adapted for vegetable food; the limb-bones were solid throughout; the pelvis was not very unlike that of a crocodile; and the mode of progression was quadrupedal. Finally, in the third group, of which we took the Megalosaur as our type, the teeth and claws were adapted for capturing and devouring living prey; and although the pelvis approximated to the crocodilian plan, yet in the structure of the leg and ankle these reptiles (in which the limb-bones were hollow) made a closer approximation to birds than is presented even by the Iguanodon.

The above-mentioned remarkable variations of structure presented by the members of the three foregoing groups might well have been supposed to exhaust the peculiarities displayed by the Giant Land Reptiles. In the very topmost beds of the Secondary rocks of the United States there occur, however, the remains of another group of these creatures, which appear to indicate a special modification of the original stock from which the Iguanodons took their origin, and present some of the most *bizarre* and strange creatures yet revealed to our astonished gaze in a country where fossil animals appear to have run riot as regards strangeness. The occurrence of these creatures in the topmost cretaceous rocks, at a period just before the whole group of Giant Reptiles became extinct for ever, is like the final "flare-up" at the close of a display of fireworks, and suggests that the extreme specialisation to which these creatures had finally attained rendered them unsuitable for the wear and tear of life, and thus conduced to their final extinction.

The reptiles forming this group or sub-group are collectively known as the Armoured and the Horned Dinosaurs. Their pelvis is a modification of that of the Iguanodon, usually exhibiting the backward direction of the pubis and ischium; but the limb-bones were solid, and either the body was covered with huge bony plates and spines, or long horn-cores, like those of the oxen, were present on the skull.

The Armoured Dinosaurs were first made known to us by more or less imperfect skeletons discovered in the Lias, Kimeridge Clay, and Wealden formations of England. One of the best known of these reptiles is the so-called Stegosaur, of which a considerable portion of the skeleton was found some years ago in digging a well in the Kimeridge clay at Swindon; this specimen being now preserved in the Natural History Museum. Entire skeletons subsequently found in the United States show that in this extraordinary creature the back was protected by a series

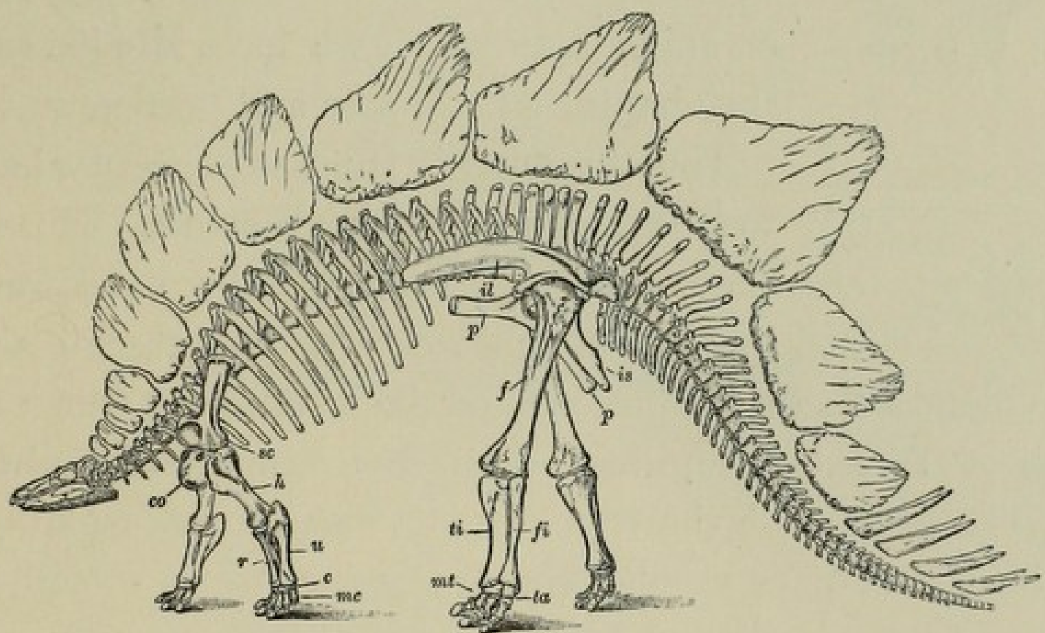


FIG. 39.—Restored skeleton of Armoured Dinosaur. About one-sixtieth natura size. *sc*, shoulder-blade, or scapula; *co*, coracoid; *h*, upper arm-bone, or humerus; *r*, *u*, bones of fore-arm, or radius and ulna; *c*, wrist or carpus; *mc*, metacarpus; *il*, haunch-bone, or ilium; *p*, pubis; *is*, ischium; *f*, thigh-bone, or femur; *ti*, *fi*, bones of lower leg, or tibia and fibula; *ta*, ankle, or tarsus; *mt*, metatarsus. (*After Marsh.*)

of enormous bony plates, standing on edge from the spines of the back-bone, and the whole skeleton thus presenting the remarkable appearance shown in Fig. 39. Towards the end of the tail these plates were replaced by spines. The skull was devoid of horns, and somewhat resembled that of the Iguanodon, although more depressed. The teeth of these reptiles resembled the specimen shown in Fig. 40, and were simpler and relatively smaller than those of the Iguanodon, although constructed on the same fundamental plan. This diminution in the size of the teeth, we may observe in passing, appears to be an instance of that tendency to a reduction or disappearance of the teeth in the specialised forms of many groups of animals to which we have alluded in the chapter on tortoises and turtles.

FIG. 40.—Side view of the tooth of Armoured Dinosaur. Enlarged. (*After Marsh.*)

The Armoured Dinosaurs were also well represented in the Wealden (where they were first discovered by Dr. Mantell), although we have at present no evidence as to the nature of their skulls. One of these Wealden reptiles, which has been named the Hylæosaur (from the Greek *hulé*, "wood," in allusion to the Wealden, or wooded country), carried a formidable row of large flattened spines forming a crest down the back. The other, termed *Polacanthus* (many-spined), is remarkable for having had the whole region of the loins and haunches protected by a continuous sheet of bony plate-armour, rising into knobs and spines, after the fashion of the carapace of the Glyptodonts.*

The earliest evidence of the existence of the Horned Dinosaurs occurs in the greensand of Austria, but the specimens hitherto obtained from these deposits are too imperfect to give us any definite insight into the organisation of these reptiles. We accordingly turn

* See Chapter I.

to the upmost Cretaceous rocks of the United States, where the remains which have been unearthed must excite the envy of all European palæontologists.

As their name implies, one of the most striking features in the organisation of these uncouth monsters is the presence of large horn-cores on the skull, as

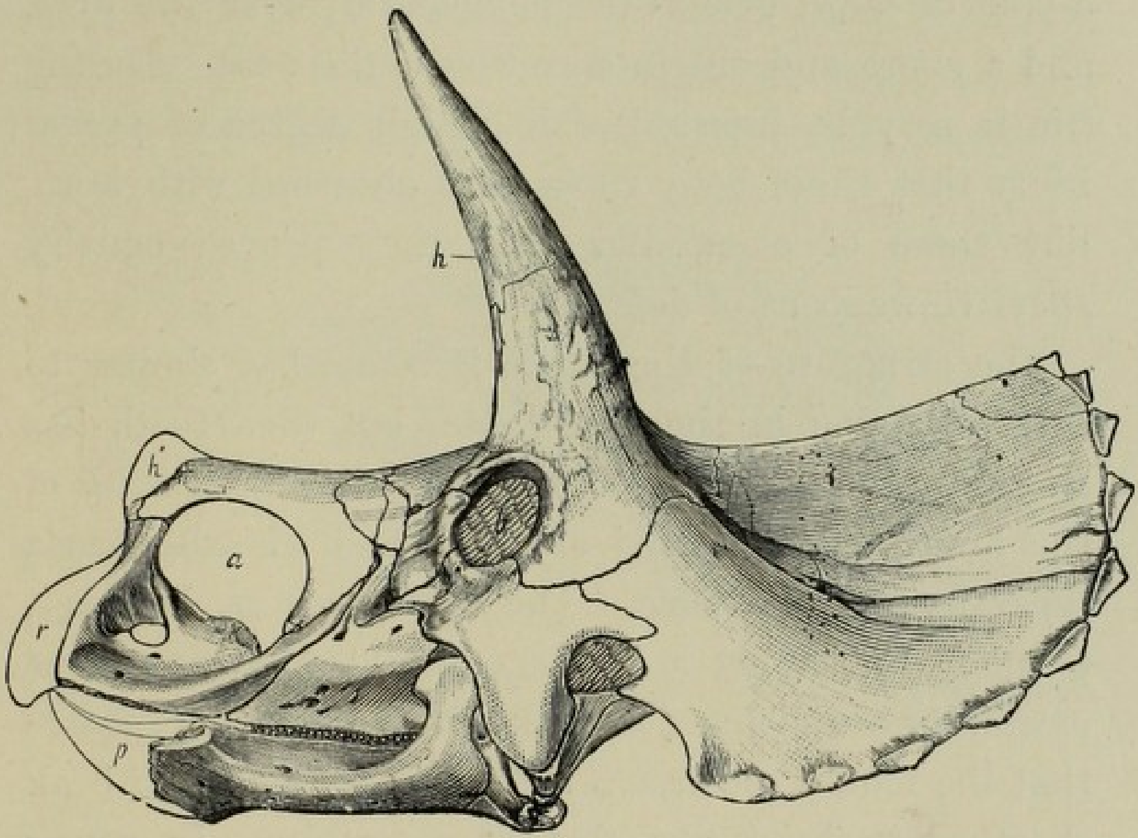


FIG. 41.—Side view of the skull of Horned Dinosaur. One-twentieth natural size. *a*, nostril; *b*, eye; *hh'*, horn-cores; *r*, upper part of beak; *p*, lower part of beak. (*After Marsh.*)

shown in Fig. 41. The skull of which we give a figure is remarkable not only for its gigantic size—the length of the specimen, which is said to indicate an immature individual, being about six feet—but also for its peculiar armature and structure. An imperfect skull of another species exceeds these dimensions, huge as they are, and is estimated when entire to have had a length of over eight feet. No other known animals, except whales, have a skull making any approach to these dimensions; that of the huge Atlantosaur being very small in comparison with the bulk of its owner. The skull before us is likewise remarkable for its wedge-like form when viewed from above, and carries a pair of large horn-cores immediately over the eyes, and a short and single core above the nose. During life it may be inferred with a high degree of probability that these bony cores were sheathed with horn, like those of oxen, and that they proved equally effective weapons of defence.

The structure of the teeth is somewhat similar to that obtaining in the Iguanodon, but each tooth has two distinct roots. As in the latter, the extremity of the lower jaw is devoid of teeth, and likewise has a separate terminal bone. The upper jaw is, however, peculiar in having a distinct toothless bone at the extremity of the muzzle; so that it would seem probable that the mouth of these reptiles formed a kind of beak sheathed in horn like that of a tortoise. In young individuals the front horn-core is a separate bone, but in the adult it became firmly united to the underlying bones, so that in this respect we have a precise analogy with the horn-cores of the giraffe. The brain of the creature is very minute—relatively smaller, indeed, than in any known Vertebrate; this, however, might have been expected from the diminutive size of the brain in other Dinosaurs, since, in the same groups, large animals always have relatively smaller brains than their smaller allies.

From the restored skeleton represented in fig. 42, it will be seen that the pelvis of the Horned Dinosaurs is quite unlike that of any members of the group; the pubis being constructed on the plan of that of the Iguanodon, but with the loss of the bar running backwards parallel with the ischium.

With this brief reference to the Horned Dinosaurs, we close our survey of the Giant Land Reptiles. In a short sketch like the present it is, of course, impossible

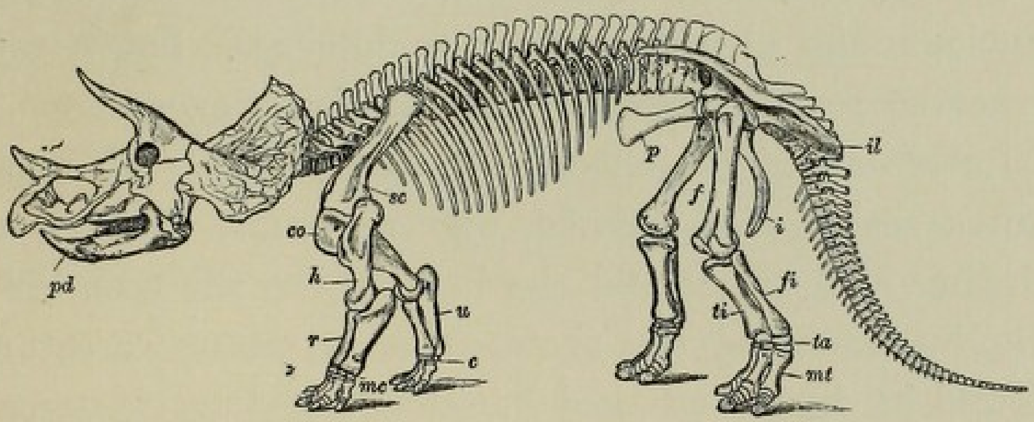


FIG. 42.—Restored skeleton of Horned Dinosaur. About one-eightieth natura size. *pd*, lower part of beak; *i*, ischium. Other letters as in Fig. 39. (*After Marsh*.)

to do more than glance at a few of the more striking features of the organisation of these most extraordinary creatures. The reader who has followed us throughout will, however, have acquired some general idea of their chief peculiarities and affinities: and he may profitably endeavour to realise in his mind's eye the aspect of a world in which the land-surface was peopled by these uncouth reptiles, of all shapes and sizes, while the air was tenanted by the weird Flying Dragons, described in the succeeding chapter.

CHAPTER IX.

FLYING DRAGONS, OR PTERODACTYLES.

Legends of Flying Dragons were rife both among the ancients and also during the middle ages, but it was reserved for the great founder of the science of comparative anatomy—Cuvier—to show that such creatures really once existed, and were not merely the dreams of the poet and the herald. In the year 1784 Collini described the skeleton of a strange creature found in the fine-grained limestones of Bavaria, so extensively quarried for the use of the lithographer, which he regarded as indicating an unknown marine animal. When, however, this curious specimen came into the hands of Cuvier, about the year 1809, he recognised it as the remains of a reptile endowed with the power of flight, for which he proposed the name of Pterodactyle—a term compounded from the Greek words for a wing and a finger. In thus proving, once for all, the former existence of Flying Dragons, it must not, however, be supposed that Cuvier thereby authenticated the old legends which represented these creatures as capturing human beings, and being themselves in turn destroyed by valiant champions. These real Flying Dragons, on the contrary, existed long ages before man or any of the higher types of mammals had made their appearance on the globe; being, indeed, characteristic of the Secondary epoch of the geologists, the relations of which to the present epoch have been indicated in the chapter on Fish-Lizards.

Before the master-mind of Cuvier indicated the true affinities of the original specimen of the Pterodactyle, one naturalist had regarded it as a bird, and another as a bat, and it will therefore be interesting to glance at the chief features in the bony anatomy of these creatures, to see how the great anatomist was justified in his conclusions. For this purpose we give a figure in the woodcut on page 141 of the skeleton of a small Pterodactyle obtained from the Lithographic limestones of Bavaria, and remarkable for its beautiful state of preservation. It will be seen from this figure that the neck of these creatures is comparatively short, with but few joints, or vertebræ, in which respect it is unlike that of a bird. The skull is, however, wonderfully bird-like in the figured specimen, although in some species it is much shorter and more lizard-like. There are, however, certain features in the structure of the skull, into the consideration of which it would be difficult to enter in the present volume, by which it is at once distinguished from the skull of a bird. The presence of a number of sharply pointed teeth (shown in Fig. 43) was, indeed, at one period regarded as another point in which Pterodactyles differed from birds; but it has been subsequently found that many if not all the birds of the Secondary epoch were provided with teeth, while in some Pterodactyles those organs were wanting as shown in Fig. 45. The most ready means of distinguishing a Pterodactyle from a bird is, however, to be found in the structure of the fore-limb. Thus it will be seen from Fig. 43 that the "hand" of a Pterodactyle carries three fingers furnished with claws, and a fourth extremely elongated finger which has no terminal claw, and supports the membranous wings. It is on the whole probable that this elongated finger corresponds to the little finger of the human hand, the thumb being probably represented by the small splint-like bone seen at the wrist in the figure; and in any case the finger in question is the outermost one, whether it correspond to the ring-finger or the little finger of the human hand. Now in the wing of a bird, on the contrary, neither of the bones corresponding to the fingers are greatly elongated, while the longest of these modified fingers is the one representing the index or fore-finger of the human hand, and is, therefore, the very opposite of the elongated finger of the Flying Dragons. This essential difference between the structure of the wing of a Pterodactyle and that of a bird is of such radical importance as to indicate that the Flying Dragons could not possibly have been the ancestors of birds; which, as we have mentioned in the preceding chapter, were more probably descended from those extraordinary reptiles known as Dinosaurs.

The shield-like bone seen in Fig. 43, lying in the middle of the chest in front of the back-bone, corresponds to the breast-bone of a bird, and, like that of the majority of birds, has a keel projecting in front

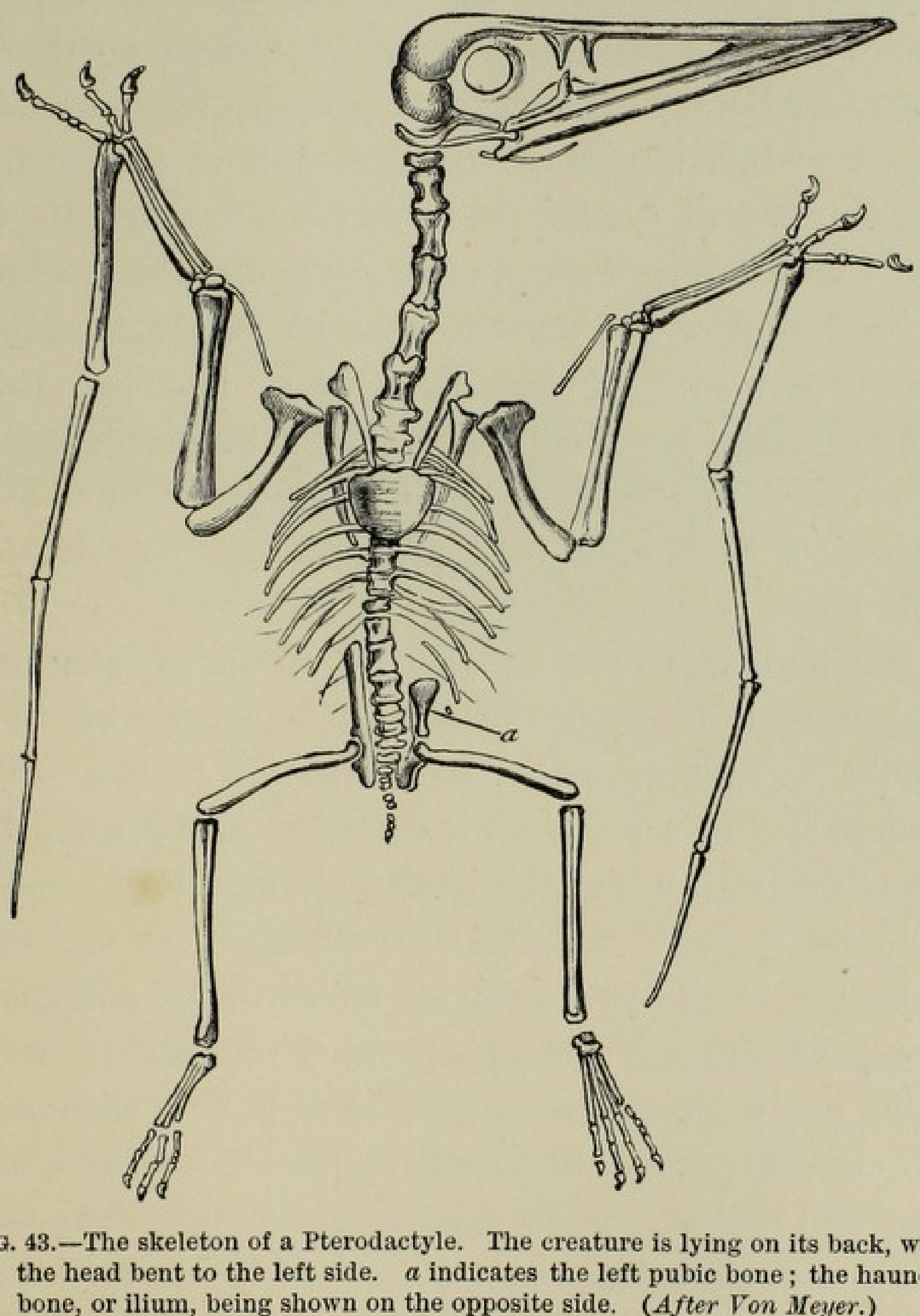


FIG. 43.—The skeleton of a Pterodactyle. The creature is lying on its back, with the head bent to the left side. *a* indicates the left pubic bone ; the haunch-bone, or ilium, being shown on the opposite side. (*After Von Meyer.*)

for the support of the strong muscles of the breast necessary to move the wing in flight. This remarkable similarity between the breast-bone of a Pterodactyle and that of a bird is a good instance of what comparative anatomists term an adaptive resemblance; that is, a resemblance caused by the circumstance that a particular organ or bone has to subserve the same purpose in two particular instances, and not as indicating any direct relationship between the owners of such structures. It will further be observed from the figure that the skeleton of the Pterodactyle differs from that of an ordinary bird by the absence of the so-called "merry-thought" or furcula. Since, however, that bone is either rudimentary or absent in the flightless birds allied to the ostrich, it cannot be regarded as a feature of first rank in distinguishing Pterodactyles from birds.

Having thus shown that Flying Dragons cannot be classed with birds, it remains to mention why they should be placed with reptiles rather than with mammals. This point is, however, at once decided by the circumstance that the skull is jointed to the backbone by a single knob-like articulation, or condyle, instead of by the two condyles found in all mammals (see page 68). If further proof were wanting, it is found in the circumstance that each half of the lower jaw consists of several totally distinct bones, as in all birds and reptiles; whereas in mammals it is composed of but a single piece.

With this glance at the general features of the skeleton of the Flying Dragons, we may proceed to notice some of the peculiarities of the different kinds of these creatures, and also what is known as to the structure of their wings. The true Pterodactyles, as is shown in Fig. 43, are readily characterised by the extreme shortness of the tail; but in another group, also found in the Lithographic limestones, the tail is as long as that of a lizard. The members of this second group are known as Rhamphorhynchs, and the restoration shown in Fig. 44 is taken from a beautiful example found some few years ago, in which the impression of the delicate membrane of the wing is preserved with as

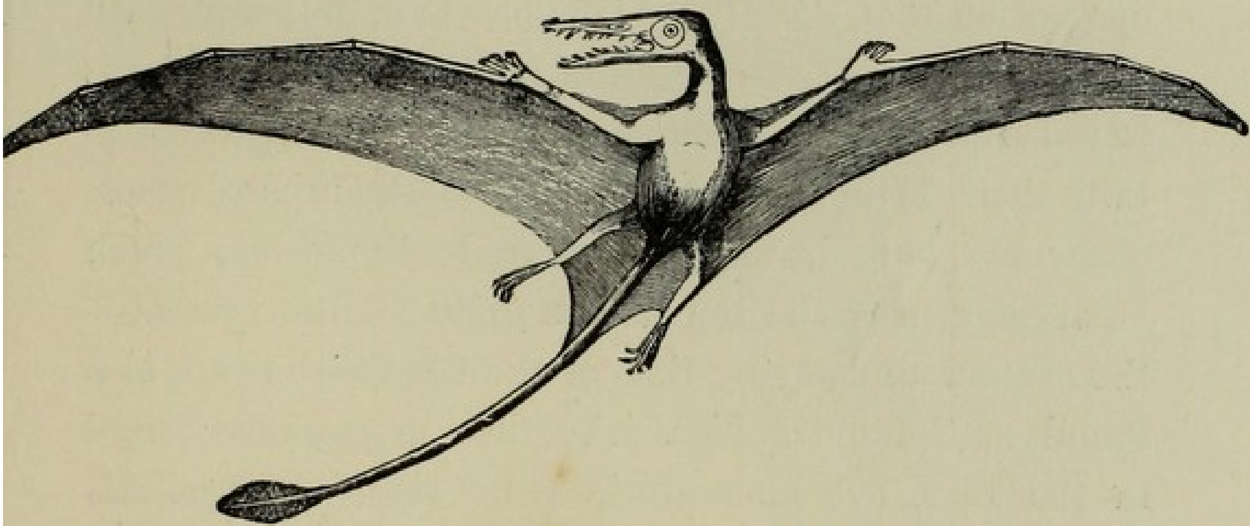


FIG. 44.—Restoration of a Long-tailed Pterodactyle, or Rhamphorhynch. One-seventh natural size. (*After Marsh.*)

much sharpness as if made but yesterday. This and other specimens show that while the front edge of the wing was supported by the elongated outer finger the wing extended backwards to embrace the greater part of the hind limb, while the extremity of the tail was furnished with a racquet-shaped expansion of membrane which probably served the purpose of a rudder during flight. Curiously enough, a slab of Lithographic limestone preserved in the museum at Haarlem exhibits a sinuous trail which is believed to have been caused by the extremity of the tail of one of these creatures as it walked across the soft mud now consolidated into stone. The impression of the wings shows that these consisted of a soft leathery membrane, probably something like that of the wing of a bat; and it is quite evident that there were no feathers either on the body or the wings. The body, like the wings, was, indeed, in all probability entirely naked; and this circumstance militates against the suggestion that the Flying Dragons were warm-blooded creatures, since a protection of either fur or feathers is found necessary in the case of birds and bats to maintain their high temperature. The Rhamphorhynchs occur not only in the Lithographic limestone, which is situated near the top of the great Oölitic system—the system underlying that of the Chalk—but are also found in the older Lias. Another group, also found in the Lias, are characterised by their short skulls and the superiority in size of the front over the hinder teeth, in consequence of which they are known as Dimorphodonts.

Perhaps, however, the most remarkable forms found in the whole group are the toothless types, or Pteranodonts, of which a skull is shown in Fig. 45. In these creatures teeth were totally wanting, and the jaws were probably sheathed in horn, like those of tortoises, while the hinder or occipital region of the skull was produced into an enormous flattened spine, which also recalls a feature found in the tortoises (see Fig. 31, page 107). Whereas most of the forms we have hitherto noticed did not exceed a rook in size, some of the Pteranodonts were of enormous dimensions, one of them having a skull measuring upwards of four feet in length, and its expanse of wing being probably about twenty-five feet. These Pteranodonts are found in the chalk of the United States; but species nearly as large occur in the chalk of this country, although they were furnished with a powerful armature of teeth, and have been described under the uncouth and exceedingly misleading name of Ornithochirans

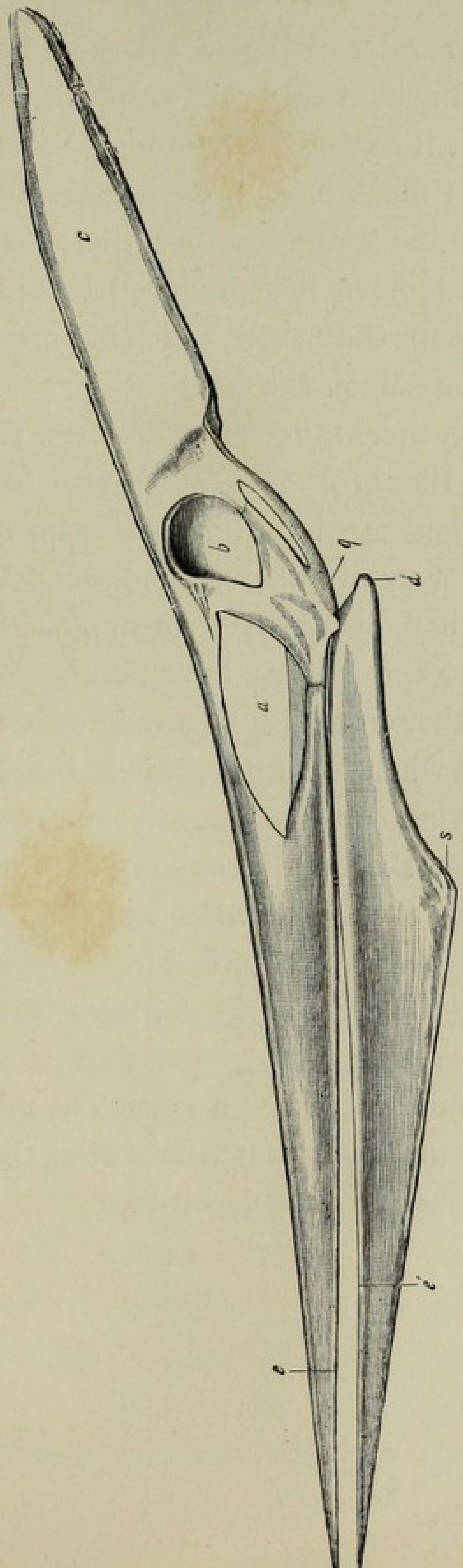


FIG. 45.—Left side of the skull of a Pteranodont. One-sixth natural size. *a*, Vacuity in front of the eye; *b*, Socket of the eye; *c*, Occipital spine; *d*, Angle of lower jaw; *e*, Extremity of upper, and *é*, of lower jaw; *q*, Articulation of the skull proper with the lower jaw; *s*, Points where the two branches of the lower jaw diverge. (*After Marsh.*)

—the hand or wing of all the Flying Dragons being, as we have already said, as much unlike that of a bird as it well can be. These huge monsters flying through the air must have been a marvellous sight, and they afford one more instance that the wildest dreams of romance have not produced creatures one whit more wonderful than those which at one time had a corporeal existence upon the earth.

That the Flying Dragons were capable of sustained flight, like birds and bats, seems to be beyond reasonable doubt. It is further evident that the toothed forms were of carnivorous habits, and it was suggested years ago, by the late Dean Buckland, that while the smaller species may have subsisted on the dragon-flies and other insects that are known to have lived at the period when the Lithographic limestone was laid down, the larger ones may have preyed on fishes, and perhaps also on the small contemporaneous mammals. It is difficult to suggest what kinds of animals formed the food of the large toothed forms from the English chalk; but in the case of the toothless American monsters it may be pretty safely said that, if they preyed on fish, they must have had a capacious mouth and gullet, and swallowed their prey whole, after the fashion of pelicans and other fish-eating birds.

CHAPTER X.

GIANT BIRDS.

THE only birds existing at the present day which in any sense merit the epithet gigantic are the Ostriches of Africa and Arabia, the Rheas of South America, the Cassowaries of Papua and North Australia, and the Australian Emus; and even the largest of these—the male Ostrich—seldom exceeds seven feet in height. The researches of palæontologists have, however, revealed to us that these four groups are but survivors of a more extensive assemblage of Giant Birds which was once spread over a considerable portion of the globe, and some of whose members as much surpassed the Ostrich in size as the latter exceeds the Rheas in this respect. Indeed, with our present knowledge of the meaning of the geographical distribution of animals, the very circumstance that existing Giant Birds are more or less closely allied, and are found scattered over the globe in areas widely separated and disconnected from one another, would of itself have been sufficient to indicate that they are the remnants of a group which was at one time of much larger extent, and inhabited regions where such creatures are now unknown. It is unfortunately the case that there are still many gaps in the chain which should link all the existing Giant Birds together, but we may confidently hope that the progress of geological research will little by little reduce the number and length of these gaps.

All the Giant Birds, it may be observed, both living and extinct, are linked together by their incapacity of flight, and the consequent absence of that strong bony ridge or keel which we may observe on the breast-bone of a duck or a fowl, and the presence of which is essential to form a firm support for the powerful muscles required to move the wings. Whether, however, this incapacity for flight is a feature which was always possessed by the Giant Birds, or whether it has been gradually acquired by disuse, is a question which has exercised the minds of those best fitted to decide it; but the probability is that it is an acquired one. Moreover, in saying that the Giant Birds are incapable of flight, it must by no means be inferred that all birds in that condition have any affinity to this group. On the contrary, the opposite is the case, since in the extinct Dodo of the Mauritius we have an instance of a huge pigeon which had evidently lost the power of flight; and the superficial deposits of New Zealand have yielded the remains of a large rail and a goose which were also in the same predicament. These and other flightless birds differ, however, essentially in several parts of their organisation from the true Giant Birds, and thus have no sort of connection with the subject of this chapter. There are, however, certain birds, namely, the little Kiwis of New Zealand, which, although by no means entitled to rank as Giant Birds in the proper sense of that term, yet as being closely related to the typical members of that group, must find a place therein. Before, however, we can consider the fossil members of this group, it is necessary that we should have some idea of the general structure of the leg of a bird, since it is this part of the skeleton which is most commonly met with in a fossil condition, and which affords the most important clue as to the size and affinities of the bird to which it belonged. Some observations on this point have already been made in the chapter on Giant Reptiles; but since those were mainly directed to showing the resemblance between the leg of a bird and that of a reptile, they are not well suited to our present purpose.

A bird's leg, then, as shown in Fig. 46, B, is composed of four segments; the upper, short one corresponding to the human thigh-bone, and the lowest representing the toes, which are composed of several small bones. Between these two segments are the two long and slender bones shown in the figure. The upper and longer of these two (Fig. 47, A) corresponds with the human leg-bone, *plus* the huckle-bone welded on to its lower end. The lower and shorter bone, of which another example is shown in Fig. 47, B, is a very remarkable bone indeed, and may be conveniently called the cannon-bone. It is really composed of three separate long bones, of which the ends remain free at the lower extremity and carry the toes, and also of the lower part of the ankle welded on to the upper end. The middle long bone corresponds exactly with the cannon-bone of a horse, the nature of which is ex-

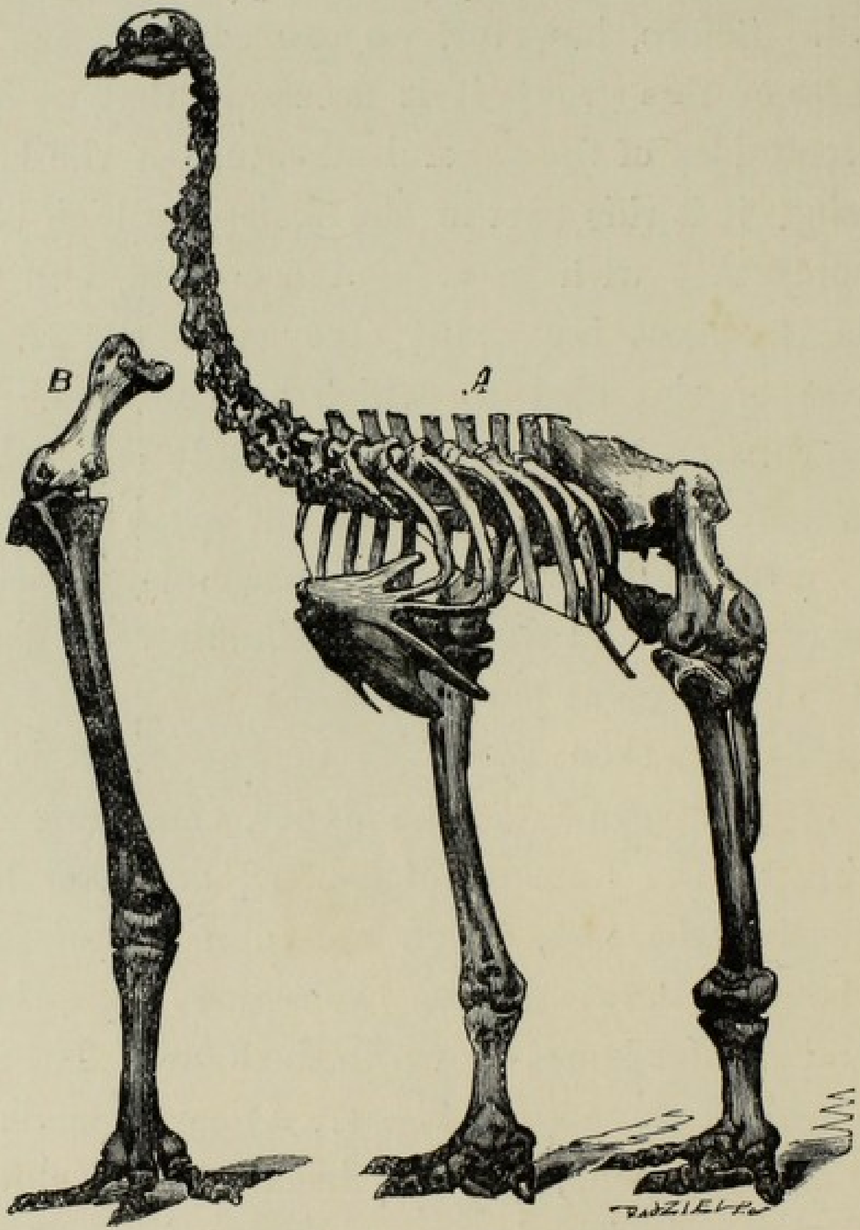


FIG. 46.—Skeleton of the Elephant-footed Moa (*A*), and right leg of the Giant Moa (*B*). *A*, about one-eighteenth; *B*, about one-twenty-third natural size. (*After Owen.*)

plained in the chapter on "Rudimentary Structures;" and the whole compound bone would correspond with the metatarsus of the extinct three-toed horse known as the Hipparion, if its three metatarsals were welded together, and these again with the bones of the lower half of the ankle. It will, accordingly, be evident that a bird is an odd-toed animal like a horse (that is to say, the toe representing the middle one of the typical five is symmetrical in itself and larger than either of the others), having a cannon-bone, but no separate ankle-bones; the upper ankle-bone or huckle-bone having become welded on to the leg-bone, and the lower ones similarly united to the cannon-bone. In these respects, therefore, a bird is a very specialised kind of creature, as departing widely from the original type. With these necessary anatomical explanations, we shall be in a position to enter on the subject of the extinct Giant Birds.

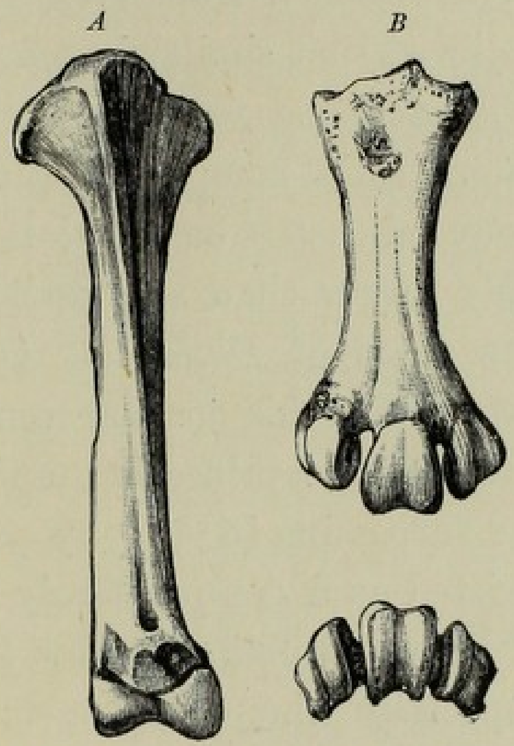


FIG. 47.—Leg-bone (*A*) and cannon-bone (*B*) of Moas. Reduced.

The first of these extinct birds brought to the notice of the scientific world were the Moas of New Zealand, in which islands the only existing representatives of the group are the diminutive Kiwis. The original determination of the former existence of these giant birds affords, indeed, an interesting instance of the certainty of anatomical deductions, when made with proper care and sufficient knowledge. Thus in 1839 a man brought to Sir R. Owen the broken shaft of the thigh-bone of some large animal, which he stated had been obtained from New Zealand, where the natives believed that similar bones were those of a large eagle. The specimen was a somewhat unpromising one, but after careful comparison the Professor confidently pronounced that it belonged to an extinct bird considerably larger than any ostrich, for which he proposed the name of *Dinornis*. Other specimens soon after brought to this country established the correctness of this bold identification, and showed that giant birds far surpassing in size any previously known must have existed at a comparatively recent date, and in extraordinary numbers in New Zealand. In the swamps—especially the well-known one of Glenmark, near Canterbury—these bones, and in some cases nearly entire skeletons, are very abundant; while in caves there have been obtained not only parts of skeletons with the skin still adhering to them, but even well-preserved feathers, and broken egg-shells. Although the Maoris well know that these remains belonged to gigantic birds, and give them a name of which the word Moa is generally considered to be a corruption, yet there is some difference of opinion as to whether their ancestors ever saw these birds in the flesh; some authorities considering that they were killed off by the race which is believed to have inhabited New Zealand before the advent of the Maoris. Still, in any case, Moas must have existed up to a very late epoch; and it is even said that the "runs" made by them were visible on the sides of the hills up to a few years ago, and may, indeed, still be so.

The leg-bone of a Moa may be at once known from that of all living Giant Birds by the circumstance that on the front surface of its lower end, immediately above the huckle-bone, there is a narrow bar of bone forming a bridge over a small groove (this being distinctly shown in Fig. 47, A). In the Giant Moa, of which the leg is represented in Fig. 46, B, the leg-bone attains the enormous length of one yard, and in an allied species from the South Island its length is upwards of 39 inches. The cannon-bone (as may be seen in the figure) is comparatively long and slender, and is more than half the length of the leg-bone. A skeleton of a smaller individual in the Natural History Museum has an approximate height of 10½ feet, and we thus conclude that the larger birds did not stand less than 12 feet. There were other species of true Moas, of about the dimensions of a large male ostrich, although of stouter build; and resembling the larger birds in having only three toes to the feet, and not the slightest trace of a wing.

Alongside of these giants there were, however, other species of much smaller size, in which there were four toes to each foot, and the cannon-bone was relatively much shorter (Fig. 47, B). Thus the Dwarf Moa, of which the Natural History Museum possesses a complete skeleton, was not more than three feet high, while Owen's Moa was of still smaller dimensions.

There were also other species of this group nearly as large as an ostrich.

Perhaps, however, the most remarkable of all these birds is the Elephant-footed Moa (Fig. 46, A), which, although by no means equal in height to the Giant Moa, was of much more massive build. In this extraordinary bird the leg-bone is much shorter and thicker than in the Giant Moa, while the cannon-bone is so short and thick that it almost loses the character of a "long bone." In one unusually large example of the last-named bone, while the length is only $9\frac{1}{2}$ inches, the width at the lower end is upwards of $6\frac{1}{2}$. By the side of such a bone the cannon-bone of an ox looks small and slender, and the effects of a kick from such a leg can be better imagined than described.

The total number of kinds of Moa inhabiting New Zealand was probably at least twenty, and, from the enormous accumulations of their bones found in some districts, we may assume that these creatures were extremely common, and probably went about in droves. Nothing like this bird fauna is known in any other part of the world; and its exuberance may be probably explained by the absence of mammals from New Zealand, so that when the ancestors of the Moas once reached these islands they found a free field for unlimited development. The nearest allies of the Moas are the small Kiwis; but whereas the latter have long pointed bills for probing in soft mud after worms, the bills of the Moa were short and broad like those of the Ostrich. Moreover, although the Kiwis have no wings visible externally, they retain rudimentary wing-bones, which have totally disappeared in the Moas. The plumage of the Moas appears to have been of the hair-like nature of that of the Kiwis. Since the latter differ from the Ostriches in that the females are larger than the males, we may assume that the same condition obtained among the Moas. The Kiwis are further remarkable for the enormous proportionate size of their eggs; and if anything like the same relative proportions held good with those of the Moas, the egg of the Giant Moa must have been of stupendous dimensions. It is, however, probable that the eggs of the larger Moas were relatively smaller than those of the Kiwis.

Passing to Australia, we find in the superficial deposits remains of a bird as large as some of the medium-sized species of Moa, but at once distinguished by the absence of a bridge of bone at the lower end of the leg-bone. This bird, known as *Dromornis,* is, however, as yet but very imperfectly known, so that we are to a great extent in the dark as to its affinities, though it was probably a distant giant relation of the Cassowaries.

Before we again meet with fossil giant birds we have to cross the whole extent of the Indian Ocean to Madagascar. Here there occurs the enormous bird known as the *Æpyornis,* the existence of which was first revealed by its eggs, found sunk in the swamps, but of which bones—mostly imperfect—were subsequently discovered. One of these enormous eggs measures three feet in its longer circumference, and $2\frac{1}{2}$ feet in girth; its cubic contents being estimated at rather more than two gallons. The leg-bone of this bird has no bony bridge at its lower end, and the cannon bone (of which only a portion is known) is as wide as that of the Elephant-footed Moa, but much longer and thinner. The natives search after the eggs of this bird by probing for them in the soft mud of the swamps with long iron rods.

The Moas, Dromornis, and Æpyornis indicate, then, three totally distinct groups of Giant Birds; and since their various habitats occupy islands on both sides of the Indian Ocean, it is a fair presumption that their common ancestors originally inhabited some part of the great continental mass of the Old World. Support is afforded to this hypothesis by the occurrence of the Ostriches on the west, and the Cassowaries and Emus on the eastern side of the same great ocean. Moreover, there is historic evidence to the effect that Ostriches, which are now confined to Africa and Arabia, formerly existed in Baluchistan and Central Asia; and since their fossil remains occur in the Pliocene deposits of Northern India, there is little doubt that at least this group of Giant Birds originated in the northern part of the Old World. Again, the Indian deposits already mentioned have also yielded remains of a bird differing from the Ostrich in having three in place of two toes, and thereby agreeing with the Cassowaries and Emus, to which it was doubtless allied, and thus indicating that these birds likewise had their original home on the great Euro-Asiatic continent, from whence they have gradually migrated southwards till they reached regions free from the large carnivorous mammals of the continents.

Looking back through the Tertiary rocks of Europe to see if we can find there traces of ancestral Giant Birds, it is not till we come to the Lowest Eocene, or period immediately below the London Clay, that our search is rewarded. Here, however, both in England, France, and Belgium, we meet with limb-bones and other remains of Giant Birds, which, from their huge size, must almost certainly have belonged to the group under consideration. In this bird, which is known as *Gastornis*, the lower end of the leg-bone has a bony bridge, as in the Moas; and since this is a feature common to the great majority of flying birds, it suggests a community of origin between them and the Giant Birds; the loss of this bridge in the living members of the latter thus being an acquired character. Although we are still very much in the dark as to the real affinities of the *Gastornis*, yet it appears to be more nearly related to the Moas and the Dromornis than to any other birds, and it might, therefore, have well been one of the ancestors of the group. Another closely allied bird is found in the Eocene of the United States, while others have left their remains in the Tertiary deposits of South America.

This is at present the extent of our knowledge of the former distribution of Giant Birds; but it may be confidently expected that whenever the Tertiary formations of Northern Africa and Southern and Central Asia are fully explored, we shall be rewarded by the discovery of other kinds, which will tend to more or less completely blend together those at present known to us, and which will also show how these have gradually migrated, since the Eocene Period, from the great continental northern mass to those southerly areas wherein some have existed up to a comparatively late period, and where others still remain as the sole living witnesses in the Old World of a group which has all but passed away.

CHAPTER XI.

EGG-LAYING MAMMALS, OR MONOTREMES.

UNTIL recently it was an axiom in Zoology that Mammals * were broadly distinguished from Birds and Reptiles by the circumstance that their young were born into the world in a living condition; whereas in the two latter groups the young were developed from eggs laid by the parent, although in a few Reptiles the eggs were hatched within the body of the parent itself. Within the last few years, however, it has been found that two most remarkable Mammals confined to the Australasian region differ from all other members of the same great class, and resemble Birds and Reptiles in that they actually lay true eggs from which the living young are in due course hatched. This remarkable discovery has shown that the living animals in question are more widely separated from all other existing Mammals than had previously been considered the case; and since we have in late years become acquainted with an extinct group of fossil reptiles which shows some remarkable signs of affinities with these egg-laying, or oviparous Mammals, our ideas of

* Popularly known as quadrupeds, see page 13.

the mutual relationships of Mammals and Reptiles have undergone a very considerable change.

Before proceeding further, it will be necessary that we should become acquainted with the names and external features of these peculiar and aberrant types of mammalian life, which have fortunately been preserved to us among many other strange forms peculiar to the Australasian region, and have thus enabled us to trace, however imperfectly, the connection which seems once to have existed between Mammals and Reptiles. The most peculiar in external appearance of these two mammals is the one commonly known as the Duck-bill, and scientifically as the *Ornithorhynchus anatinus* (Fig. 48). The most striking feature about this strange animal is the presence of the duck-like horny beak ensheathing the mouth, from which the creature takes both its popular and scientific names; and which, when skins were first brought to Europe, was deemed so extraordinary as to give rise to a suspicion that the specimens were "made up," after the fashion of the well-known monstrous animals of the Japanese. Peculiar as the beak undoubtedly is, it is not, however, of primary interest, since it is one of those structures already alluded to as acquired features, and is not inherited from very remote antiquity; so that there is no sort of connection between this beak and the beak of a bird, beyond the fact that both are used for the same purpose. The Duck-bill has a total length of about 23 inches, of which 2½ are formed by the beak, and five by the tail. The body is covered with a thick coat of fur, generally of a full umber-brown colour, and inclining either to rufous or to black in different individuals; the under-parts and a ring round the eye being yellowish, or grayish-white. The tail is broad and flat, and thus well adapted to act as a rudder in swimming; while the feet are fully webbed, and thus proclaim the aquatic habits of the creature. The beak is black above, and yellow and black below. The limbs are remarkable for their shortness, their length being even insufficient to keep the body from touching the ground.

In the adult animal there are no teeth in the jaws, their function being performed by a few hard and flat horny plates, aided by the horny edges of the jaws themselves. In young individuals there are, however, a small number of well-developed teeth in the hinder half of each jaw, which fall out before the animal attains its full dimensions. The structure of these teeth is unlike that found in any other living mammal; the chief peculiarity being the presence of a groove running from back to front, and bordered by ridges bearing cusps on either side. The presence of these deciduous teeth has only recently been made known; and we may safely infer that the ancestors of the Duck-bill were provided with a full set of permanent teeth, which have gradually tended to disappear. This rudimentary condition of the teeth in the Duck-bill is indeed another instance of that tendency to the loss of the teeth in certain groups of animals to which allusion has been made in Chapter VII.; and the complete loss of the teeth occurs in the second representation of the present group, to be noticed immediately.

The Duck-bill chiefly frequents the still and open pools, thickly covered with aquatic plants, which are of common occurrence in the Australian rivers. In the banks of these pools the burrows of these creatures are constructed; the entrance being concealed among the water-plants, and frequently opening some distance below the level of the water. From the entrance the burrow takes an upward direction in a somewhat serpentine course, and may run for a distance of some 20 feet before it ends in a chamber situated far above the level of the water, and lined with dry grass. In this chamber, which may have a diameter of some 18 inches, the eggs are laid, and the young in due course hatched therefrom. The young when first hatched are entirely naked, and their beak is soft and fleshy, so that it can be readily applied to the milk-glands of the mother, which merely open on the surface of the body, and are not provided with nipples. This feature of the nurturing of the young by milk-glands, in spite of the peculiarities of internal structure to which we shall allude later on, and the oviparous reproduction, at once proclaims that the Duck-bill is a true mammal, although a very lowly representative of the class.

The second representative of the group includes the Spiny Anteaters (*Echidna*), of which one species occurs in Australia and New Guinea, and a second and larger one only in New Guinea. A figure of the Australian species is given in Fig. 49.

Dickes del.t Lizars sc.

FIG. 48.—The Duck-bill of Australia. (*From Jardine.*)

From the appearance of this animal in the figure, there would seem but little ground for classifying it in the same group as the Duck-bill; and it is mainly from the evidence of the peculiar internal structure that the two are put together in the zoological system. The skull, in place of the expanded beak of the Duck-bill, has a long slender cylindrical beak, covered with horn, with the nostrils at the extremity. There are no traces of teeth at any stage of existence; and the tongue is very long and slender, and capable of being protruded for a considerable distance from the mouth, to collect the ants on which the creature feeds. The fur is more or less thickly intermingled with stout spines, like those of a hedgehog; the tale is rudimentary; and the short limbs are furnished with stout and extremely powerful claws, which may be either three or five in number.

In calling these animals Anteaters the reader will bear in mind that they have nothing whatever to do with the true Anteaters of South America, which belong to the so-called Edentate order of Mammals; and that they are equally distinct from the Banded Anteater of Australia, which belongs to the Pouched or Marsupial Mammals. In view of this similarity of names it will perhaps be better if the Latin term Echidna be taken as the popular as well as the scientific name of the Spiny Anteaters.

The Australian Echidna is characterised by having five claws to each foot, and is subject to considerable variation in size and colour, and also as to the relative abundance of spines in the fur. The New Guinea, or Three-toed Echidna, is larger than many specimens of the common species, and usually has but three claws to each foot.

Echidnas are usually found in rocky and mountainous districts, and are of nocturnal and burrowing habits; their powerful claws enabling them to bury themselves in the ground with extraordinary rapidity. If dug out from their burrows during the day, they appear sluggish and stupid, crouching to the ground with the head between the legs, and thus presenting a mass of spines to an enemy. The eggs of the Echidna have, indeed, been found and described; but it appears that the development of the young is less well known than in the case of the Duck-bill.

Having now introduced our readers to the personal appearance and habits of the Duck-bill and the Echidna, we are in a position to enter into the consideration of some of the more striking features of their structure, and of their relationship to other groups of animals.

We have already stated that these creatures agree with other mammals in suckling their young from milk-glands on the body of the female parent, and are therefore rightly included in the great class of Mammals. They also agree with other mammals in that the skull articulates with the first joint of the back-bone, or first vertebra, by means of two knob-like prominences known as *condyles.* In this respect they differ from Birds and Reptiles, in which this articulation takes place only by a single condyle; but it is very noteworthy that two condyles are found in the Amphibians (Frogs, Newts, &c.).* In their warm blood these creatures also agree with other mammals; but this is a feature of no importance from a classificatory point of view, since it is found in Birds and Mammals which we must regard as being independently derived from cold-blooded animals. Again, although the Duck-bill and the Echidna, as necessarily follows from their warm blood, have a four-chambered heart like all other mammals, yet it is noteworthy that the heart contains certain peculiarities connecting it in some degree with the three-chambered heart of Reptiles. These animals differ, however, from all other mammals in that the tubes for carrying off the waste products of the body have but a single common aperture, precisely as in Birds and Reptiles, and they are therefore generally described as the Monotremes, or Monotremata, by which name we shall henceforth refer to them.

Two other remarkable peculiarities connected with the skeleton require notice in some detail. Exclusive of the Monotremes, all mammals, without exception, have only two bones on either side of the body by means of which the arm is connected with the trunk, and which are collectively spoken of as the shoulder-girdle. These bones are respectively the shoulder-blade at the back, and the collar-bone in front; the head of the arm-bone being received into a cup-like cavity in the lower end of the shoulder-blade. Now in the Monotremes we find, in addition to the shoulder-blade,

* See page 67.

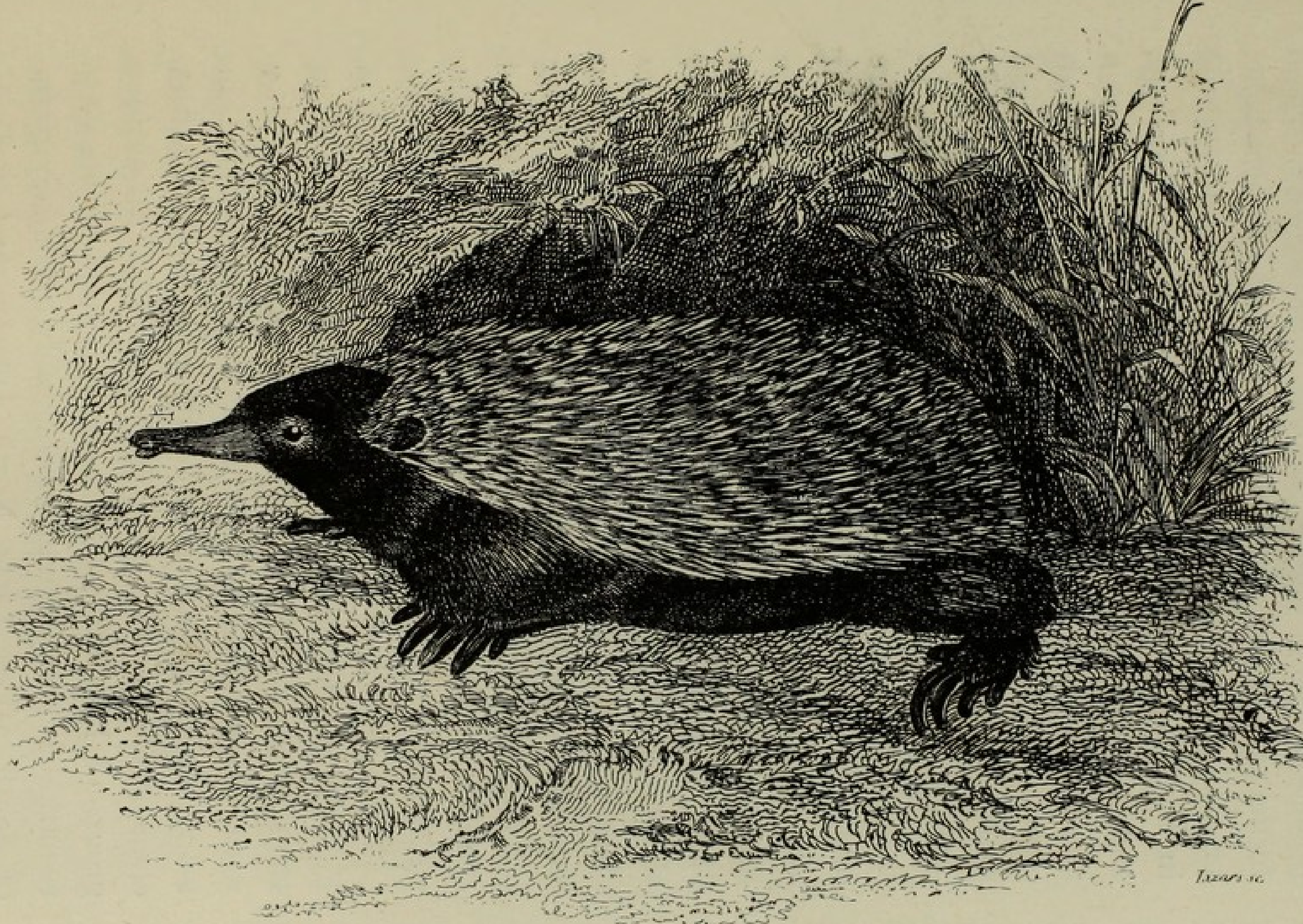


FIG. 49.—The Spiny Anteater of Australia (*Echidna aculeata*). (*From Jardine.*)

a smaller bone known as the coracoid-bone, which forms part of the cavity for the head of the arm-bone, precisely as in the reptilian shoulder-girdle represented in Fig. 50. Further, in advance of the coracoid-bone, and below the shoulder-blade, the Monotremes have a third bone in the part of the shoulder-girdle corresponding to the one marked *p. cor.* in Fig. 50, which should likewise be known as the precoracoid, although it is often termed the epicoracoid. We thus see that in this part of their shoulder-girdle the Monotremes are totally unlike all other mammals, and resemble that extinct group of Reptiles of which this part of the skeleton is shown in the woodcut. A further resemblance to Reptiles is, however, indicated by the presence of a peculiar T-shaped bone lying on the front of the chest between the collar-bones or clavicles, and hence termed the interclavicle; this interclavicle occurring not only in that group of Reptiles to which the figured shoulder-girdle belongs, but also in Lizards, Fish-Lizards, and other types.

With regard to the shoulder-girdle represented in Fig. 50, it should be observed that in all existing Reptiles the precoracoid (*p. cor.*) becomes united either with the coracoid or the shoulder-blade, so that in many cases it cannot even be recognised as a distinct element at all. The same is the case with all extinct groups of Reptiles, with the sole exception of one very remarkable group found in the early Secondary rocks of South Africa, India, North America, and parts of Russia, and known, from their peculiar types of teeth, as the Anomodonts, or Anomodontia. In Amphibians (Frogs, &c.) there is, however, likewise a distinct precoracoid, which in some extinct types not improbably approximated to the form shown in Fig. 50; although in frogs the precoracoid forms a simple rod-like bone.

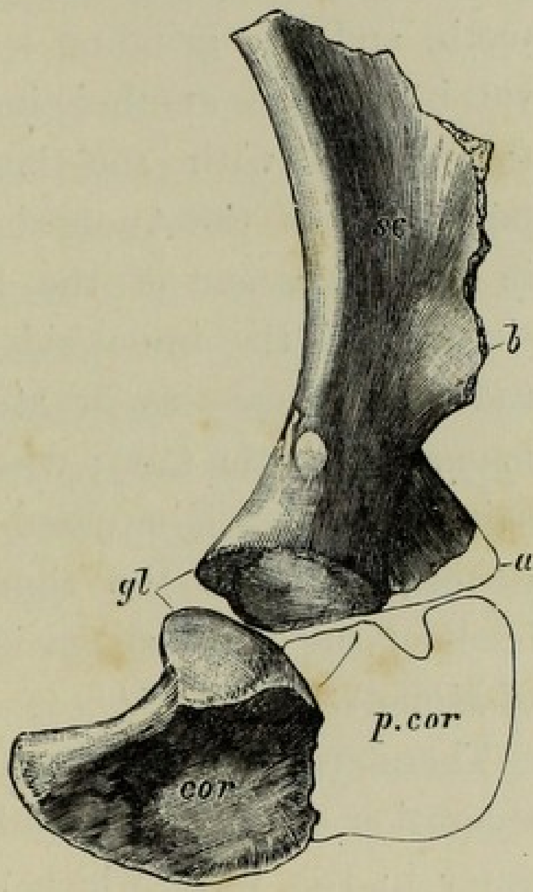


FIG. 50.—The right side of part of the shoulder-girdle of an Anomodont Reptile. *sc*, shoulder-blade; *ab*, processes of do.; *cor.*, coracoid bone; *p. cor.*, precoracoid bone; *gl*, cavity for head of arm-bone. The shaded portion is from an Indian and the unshaded from an African specimen.

We find, therefore, that the only known animals possessing both a coracoid and a precoracoid as separate elements distinct from the shoulder-blade* are the Monotreme Mammals, the Anomodont Reptiles, and the Amphibians; and since we have shown that in other respects the Monotremes are to a considerable extent intermediate between Reptiles and other Mammals, there arises a strong presumption that the Echidna and the Duck-bill are the last remnants of a group of animals which were veritable connecting links between Mammals, Reptiles, and Amphibians. Now among the Anomodont Reptiles—

* In adult Monotremes the coracoid unites by bone with the shoulder-blade.

and in these alone among the whole class—we find in many cases that the jaws were armed with teeth which were arranged in three groups corresponding to the incisive, or front teeth, the tusks, or eye-teeth, and the grinding teeth, of Mammals; so that we have here another indication of the affinity of this group with the latter. Another remarkable peculiarity of the Anomodonts is that the perforation in the lower end of the bone of the upper arm is situated on the inner side—or side corresponding to the little finger—as in Monotremes and many other mammals (as the Cat); whereas in most other reptiles this perforation is situated on the outer side—or side corresponding to the thumb. The upper arm-bone itself of the Anomodonts is also wonderfully like that of Monotremes.

There are, indeed, many other features into the consideration of which it would be quite out of place to enter in this work which also lead to the same conclusion. We must, however, remember that Anomodonts agree with all other reptiles in having only one condyle by which the skull articulates with the backbone; and this difference may be a bar to regarding them as the direct ancestral types of Mammals. The extinct Amphibians known as Labyrinthodonts, in which there were two condyles to the skull, are, however, as stated in Chapter IV., so closely allied to the Anomodonts that it is in some instances difficult to draw a line of distinction between the two; and the conclusion has therefore been reached that the Labyrinthodont Amphibians, Anomodont Reptiles, and Monotreme Mammals have all taken origin from one common amphibian stock; the Anomodonts retaining marked evidences of their kinship to the Mammals which have been totally lost in all other reptiles.

Such, then, is very briefly the chief deductions which can be drawn from the life-history and structure of the Duck-bill and Echidna as to their affinities with other groups of animals; and it is curious to reflect that but for the preservation in a remote part of the world of these two representatives of a group which must in all probability have been once abundant, we should have been utterly unable to trace this wonderful relationship of the mammals to the earlier types of reptiles and amphibians.

At present we have, indeed, no absolutely conclusive evidence of the former existence of mammals allied to the living Monotremes, although there is a certain amount of evidence tending in this direction. Thus in the Secondary rocks, dating from the Trias to the Chalk, and also in the lowest beds of the overlying Tertiary, we meet with a number of small mammals characterised by a very peculiar type of grinding-teeth. The crowns of these teeth (Fig. 5), consist of two or three longitudinal ridges carrying distinct cusps, and separated from one another by deep grooves, which may be either one or two in number. This type of tooth, which is quite unlike that found in any of the higher mammals, presents a certain approximation to the deciduous teeth of the Duck-bill; so that it is not improbable that in this group of extinct mammals we may really have forms allied to the ancestral Monotremes. Some further evidence in favour of this view has, indeed, been recently published in the United States, where certain bones of these mammals have been described as the coracoid and interclavicle — an interpretation which, if correct, will prove their affinity to the Monotremes. For the present we must, however, wait in the confident expectation that future discoveries will some day reveal to us the remains of extinct animals allied on the one hand to the existing Monotremes, and on the other so closely connected with the Anomodont reptiles and the Labyrinthodont amphibians as to render it very difficult to give a definition of either mammals, reptiles, or amphibians.

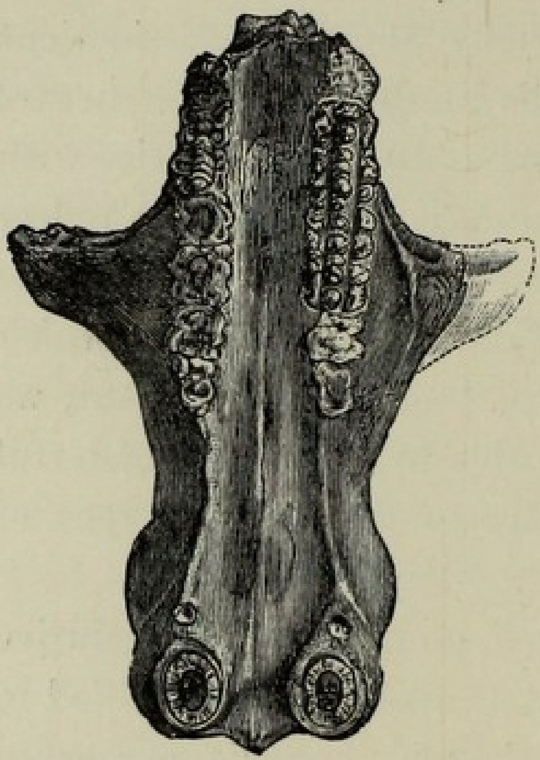


FIG. 51.—Palatal view of the imperfect skull of a Secondary Mammal (*Tritylodon*). Two-thirds natural size.

CHAPTER XII.

POUCHED MAMMALS, OR MARSUPIALS.

In the preceding chapter the reader was introduced to the living representatives of the Egg-laying Mammals, collectively forming the group to which zoologists apply the name of Monotremes. In the present chapter it is our intention to bring before his notice another and much larger group of Mammals, forming one step higher in the zoological scale, and like the Monotremes characteristic of Australia and some of the adjacent islands, although having one outlying family in America. These creatures are known as the Pouched Mammals, or, in scientific phrase, Marsupials, the name being derived from the pouch (Latin *marsupium*) in which the greater number of the species carry their helpless young for a long period after they have first been introduced into the world; this peculiar method of nursing being familiar to all who have seen the Kangaroos in the Zoological Society's Gardens. This pouch is not, however, universally present throughout the group, so that it cannot be taken as the especial characteristic feature of all the members; and we are thus driven to find some other character which will hold good for all. Such is found in the circumstance that in all cases the young are born in a very imperfect and partially developed state, so that they resemble little sacs or lumps; the young of the great Red Kangaroo not being larger than our thumb. In this exceedingly helpless and imperfect condition they are transferred to the nipples of the female (which are placed within the pouch when this is present), whereon they hang without much signs of life, gradually growing as they are nourished by the milk, which is squirted down their throats by a special muscle.

In addition to this peculiarly early birth of the young, and the very general presence of a pouch, the Marsupials present several other curious structural features, into the consideration of which it is not easy to enter in a work like the present. It may, however, be observed that they differ from other Mammals in the circumstance that when milk-teeth (as the temporary set of teeth which occur in the human infant are termed) are developed, there is only one such tooth in either side of each jaw, corresponding to the last milk-tooth of the child (see Chapter XIV.). It appears, indeed, that we have here the first commencement of the development of a series of milk-teeth, which, in their full stage, as seen in the child, are intended for use during the period that the jaws are increasing in size; so that the permanent set may be of larger size than would otherwise be possible. The absence of a full series of milk-teeth at once indicates the low organisation of the Marsupials; and this is fully confirmed by the structure of their brain, and many other parts of the body.

As already observed, the Marsupials are mainly confined to the Australian region, the only exception being the Opossums of America; and not only are they mainly confined to that region, but they and the Monotremes are the only Mammals found there, with the exception of a few Bats, two or three rat-like Rodents, and the remarkable native Dog, or Dingo, the latter having not improbably been introduced by human agency. This remarkably circumscribed area of distribution would of itself lead us to conclude that the existing Marsupials are survivors of an old and therefore lowly type of Mammalian life, since so many of the products of Australia and New Zealand are so utterly unlike those of other parts of the globe, and present affinities to types long extinct elsewhere. Thus, in Queensland alone, we have the peculiar fish known as the Baramunda (see page 6), which is the direct survivor of fossil fishes found in the oldest Secondary rocks of Europe; while in New Zealand the scarce Tuatara Lizard is almost equally closely related to fossil Lizards of the same European rocks. These *primâ facie* conclusions as to the antiquity of the Marsupial type are fully borne out by actual facts, since the Secondary rocks of England, such as the well-known Stonesfield slate of Oxfordshire, and the Purbeck beds of Dorsetshire, as well as many of the equivalent rocks in the United States, have yielded jaws of a number of small fossil Mammals, many of which were evidently very closely related to some of the living Australian Marsupials. In the Eocene, or lowest portion of the Tertiary period, Australian types of Marsupials seem to have disappeared from Europe; but we there meet with remains of fossil species of the American group of Opossums. These data indicate that Marsupials were widely spread over the globe at an early period of the world's history, and while the greater number of types disappeared from both the Old and New World to find a refuge in Australia, the Opossums lingered on for some time in Europe, but finally retreated to America, in the southern portion of which continent they are represented by a considerable number of species. At the time that Australia was cut off from land communication with the rest of the world it is probable that the higher types of Mammals—such as Carnivores (Dogs, Cats, Weasels, &c.), Rodents (Rats, Hares, &c.), and Ungulates (Horses, Cattle, Elephants, &c.)—had not yet come into existence, and these types were accordingly never able to obtain an entrance into that island-continent. Thus protected from the competition of the higher Mammals, the Marsupials have there developed a large number of types differing very widely from one another in external appearance, although in all cases retaining the features peculiar to the order.

The earliest evidence of a Marsupial of the Australian type brought to the notice of Europeans was far back in the last century, when one of the animals known as Phalangers (which the Australian colonists will persist in calling Opossums) was captured in the island of

Amboyna—an outlier of the Australian region—and described by a naturalist. The state of zoology at that date was, however, far too imperfect to admit of the importance of the discovery meeting with due recognition.

A still more important discovery was, however, made in the year 1770, during one of the voyages of the great Captain Cook, when Sir Joseph Banks and others of the party landed on the coast of New South Wales, and for the first time were made acquainted with the now well-known Kangaroos. The species which was then first revealed to the eyes of Europeans was the largest of the group, and is commonly known as the Great Red Kangaroo; but many other species have been since observed, one of which is represented in Fig. 52. We can well imagine the astonishment with which Banks and his party gazed for the first time on the herd of Kangaroos in their native wild; the strange form of these creatures, with their long hind limbs, short fore paws, and enormous tail, together with the huge leaps by which they progress, marking them out as totally different from any Old World animal. The Kangaroo may, indeed, be regarded as what naturalists term a very specialised kind of animal, since we find several more or less nearly allied creatures, in which the fore and hind limbs are not so disproportionate in length, and which, therefore, depart less widely from a normal type of structure. The advantage of the leaping mode of progression and the upright position of the body to the Kangaroo appears to be that the

FIG. 52.—Parry's Kangaroo. (*From Jardine.*)

young can thus be much more safely carried in the pouch during the long journeys that these animals are compelled to take across the Australian wastes, in search of water, than would be the case if the body was placed in the ordinary horizontal position.

Kangaroos are members of one primary group of Marsupials mainly characterised by the form and

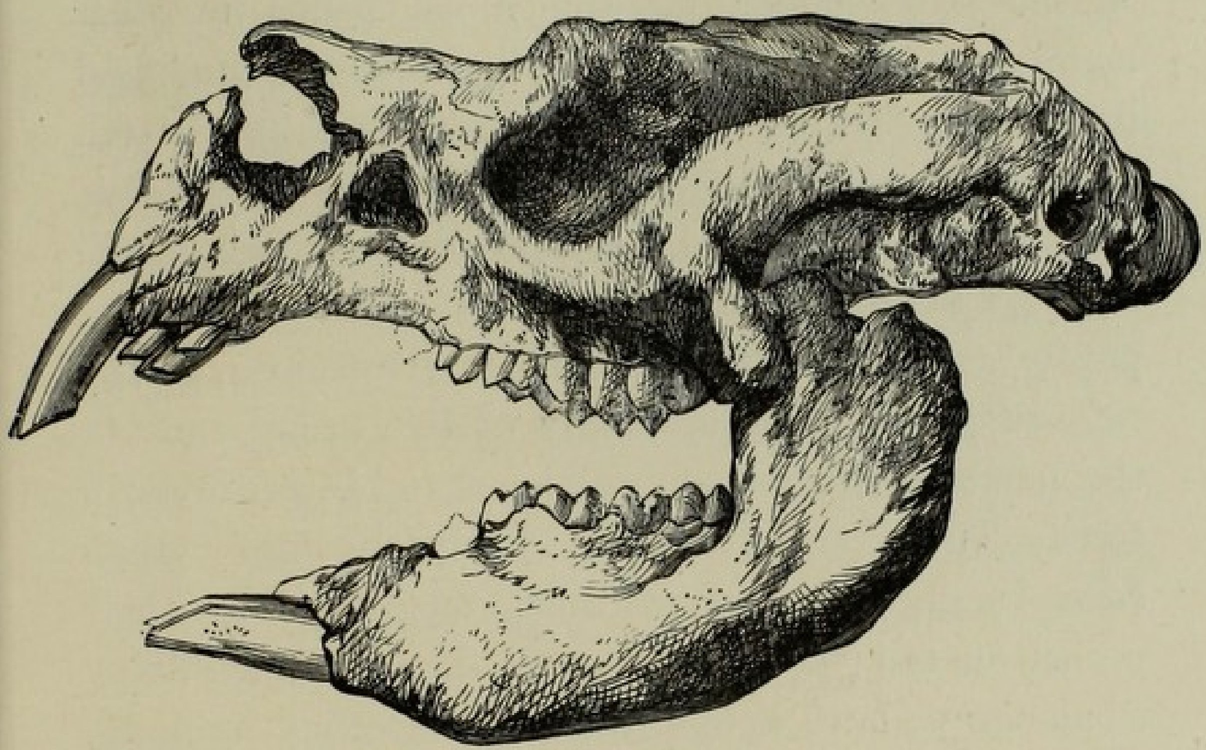


FIG. 53.—Side view of the skull of a gigantic extinct Kangaroo-like animal. One-tenth the natural size. (*From Owen.*)

arrangement of their teeth. Thus the front or *incisor* teeth, as they are technically called, are of a chisel-like form, and separated by a considerable interval from the hinder or grinding-teeth, as is well shown in the accompanying figure (53). There is only one pair of these incisor teeth in the lower jaw—or at all events only one pair which is of any functional importance—while, as in the figure, there are usually three pairs of such teeth in the upper jaw. From the presence of this single pair of lower cutting teeth, the Marsupials of this group are known as Diprotodonts (two front teeth).

To this group belong the true Kangaroos, of which the largest species is taller than a man; the smaller Kangaroos popularly known as Wallabies, as well as the still smaller Rat-Kangaroos, being its other members. All these creatures live on the ground, and progress by leaps; but in New Guinea and North Queensland, we meet with the curious Tree-Kangaroos, in which the fore and hind limbs are of nearly equal length, and the habits of the creatures themselves are purely arboreal. The Phalangers (Opossums of the colonists) form another family of this group, most of the members of which are nocturnal and live entirely in trees. The majority of these Phalangers simply climb from bough to bough, or hang suspended by their prehensile tail; but some species—hence termed flying Phalangers—have a fold of skin connecting the limbs, and are thus enabled to take long flying leaps from tree to tree, like the flying Squirrels, to which they present an extraordinary external resemblance. These creatures afford, indeed, a remarkable instance how the same place in the *rôle* of nature may be occupied by totally different groups of animals, which, from the necessary adaptation of their structure to the same mode of life, attain a more or less close similarity of form.

Allied to the Phalangers is the curious Koala, a stout, clumsily built creature somewhat resembling a small bear, by which name it is indeed commonly known to the colonists. The Wombats, which are the only other living representatives of the Diprotodont group, differ from all the other forms in having only a single pair of upper front teeth. These animals are about the size of a Badger, and furnished with immensely powerful claws, with which they dig the deep burrows in which they dwell.

We have already said that the largest living Kangaroo is somewhat taller than a man, but some of the extinct species found in several parts of Australia attained considerably larger dimensions. All these creatures were, however, comparative dwarfs besides the huge extinct Australian animal of which the skull is shown in Fig. 53. This animal, technically known as the *Diprotodon*, and fully as large as a Rhinoceros, was allied in the structure of its teeth to the Kangaroos; the fore-limbs were, however, nearly as long as the hind ones, so that the creature doubtless walked in the ordinary manner.

The whole of the Diprotodonts, both recent and fossil, are confined to the Australian region, so that we must regard them, in all probability, as a specialised offshoot which has arisen there from the ancestors of the more generalised group now to be noticed.

All the remaining Marsupials differ from the Diprotodonts in that their teeth form a more regular series, without any very marked interval; the front teeth being small, and flanked laterally by a larger conical tooth corresponding to the tusk, or *canine*-tooth (Fig. 54, *a*) of the dog. The hinder teeth, moreover, have sharply pointed crowns, and are adapted for a carnivorous diet. There may be as many as five front (incisor) teeth on either side of the upper, and four in the lower jaw; and from this large number of front teeth it has been proposed to call this assembly of Marsupials the Polyprotodont (numerous front teeth) group. Remains of extinct members of this group are common in the Secondary rocks of North America and Europe, the lower jaw represented in Fig. 54 illustrating the large number of teeth so characteristic of several of these animals.

We take, as an example of the group, the Tasmanian Thylacine (Fig. 55), commonly known to the colonists as the Wolf. The latter name, as well as the Latinised Thylacine (Pouched Wolf), is applied to this animal

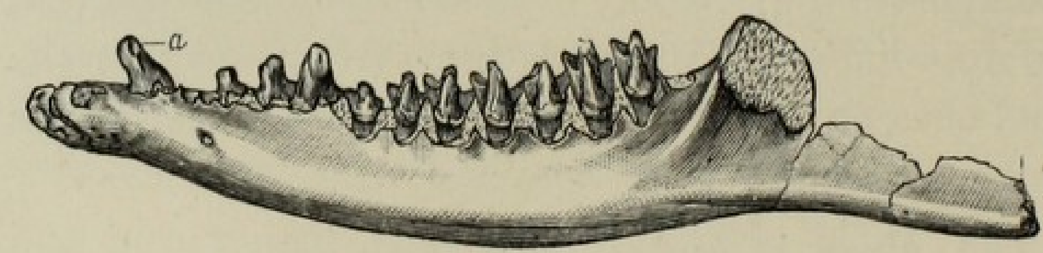


FIG. 54.—The left side of the lower jaw, with the front teeth broken off, of a Secondary Marsupial. (*After Marsh.*)

from its peculiarly dog-like appearance, which is especially shown in the long and pointed muzzle, the general contour of the body, and the long tapering tail, like that of a pointer. The Thylacine, which is the largest of the Polyprotodonts, may indeed be regarded as playing the part of the wolf in Tasmania,

FIG. 55.—The Australian Thylacine. (*From Jardine.*)

and the damage inflicted by it on the flocks of the settlers is, or was, very considerable. Equally destructive is the smaller animal known as the Tasmanian Devil, which is more like a large cat in size and appearance. The civet-like animals known as Dasyures are allied forms ranging over all the Australian mainland, where they are the largest carnivores. Another family of Polyprotodonts is represented by the elegant little creatures known to the colonists as Bandicoots, some of which are not larger than a mouse. A larger species, known as the Rabbit-eared Bandicoot, has long hind legs, and leaps somewhat after the manner of a kangaroo.

The most interesting of all the Australian Polyprotodonts is, however, the so-called Banded Anteater, since this animal makes the nearest approach to the extinct Marsupials of the Secondary rocks. This elegant little creature, in which the back is marked by alternate light and dark transverse stripes, feeds on ants, which it gathers up by means of its long and slender tongue. With the exception of certain forms, such as the Dolphins and Porpoises, which have a great number of simple conical teeth, the Banded Anteater has more teeth than any other living mammal; and it may probably be looked upon as the most ancient type of mammal now living upon the globe.

Here we must mention the so-called Marsupial Mole —a small burrowing animal, of a golden-red colour, with enormous front claws, recently discovered in the deserts of Central Australia.

The only other Marsupials are the Opossums of America, which are readily distinguished by the absence of a pouch in which to carry the young. In consequence of this, the young of some species are carried upon the back of the female, with their tails tightly twisted round the tail of their parent, which is arched for this purpose over its back. All the Opossums are of carnivorous habits, while the Crab-eating Opossum is peculiar in being partly aquatic. As we have already said, Opossums are most abundant in South America, where the mammalian fauna is mostly of a low grade of organisation; and they make their first appearance in the Eocene Tertiary of Europe.

Such, very briefly, is the history of the Marsupials of the present day—a history deeply interesting to the zoologist as showing how, humanly speaking, a type of animals, characteristic of an early part of the earth's existence, has been preserved to us in one remote region by the complete isolation of an island-continent, and in another by the retiring habits of its representatives and the absence of severe competition in the struggle for existence.

CHAPTER XIII.

DOGS AND BEARS.

COMPARATIVELY few animals belonging to a single order are more unlike one another, both as regards external as well as internal characters, than the bears and the dogs, their dissimilarity being indeed so marked, that not even the most unscientific person experiences the slightest difficulty in distinguishing between the two groups. Both groups, it need scarcely be observed, are members of the great order of Carnivorous mammals, although the bears depart from the ordinary rule in subsisting on a mixed diet. The former group, as is well known, comprises a comparatively small number of species, among which the European brown bear, the closely allied Syrian bear, and the Isabelline bear of the Himalaya, the North American grizzly bear, the Indian sloth bear, and the Polar bear are typical examples, which are usually well represented in the living state in the gardens of the Zoological Society, and whose skeletons and stuffed skins may be seen in the Natural History Museum. In the latter, and far more numerous group, are included the wild and domestic dogs, the wolves, jackals, foxes, and fennecs, together with some less typical forms, which need not be further alluded to on this occasion.

So wide, indeed, is the gap between these two groups, that naturalists have not only placed them in distinct families, but have even brigaded the family of the bears, together with that of the weasels, badgers, otters, &c., and that of the racoons, in a common section to which they have given the name of the arctoid or bear-like carnivores, while they rank the dogs in another section of equivalent value, to which the name of the canoid, or dog-like carnivores, is applied. That this division is a perfectly natural one so far as regards the animals existing at the present day there is no doubt; but when our investigations are carried back to the consideration of the varied forms of carnivorous animals whose remains occur in the rocks of the Tertiary, or latest geological period of the earth's history, it has been found that animals then existed which so completely bridge over this gap that there appear to be no distinctive characters by which the bears and the dogs can be absolutely separated from one another. It will of course be apparent to the reader that when we have to determine the mutual relations of extinct fossil animals we have to depend solely upon the structure of their bones and teeth, and we can therefore say nothing as to the appearance of these old-world forms when clothed with flesh and fur. Fortunately, however, in the present, as in many other instances, the bones and teeth are amply sufficient to give us a very fair idea of the relationship of the fossil to the living forms, although the ardent palæontologist cannot but help wishing that he had the power of casting a glance on those long-past periods when our earth was comparatively young and inhabited by the marvellous host of extinct animals whose modern descendants have so woefully diminished both in size and numbers.

Making, however, the best of our opportunities, and not wasting time in futile regrets at being unable to recall that which has passed away for ever, we may, before proceeding to the consideration of the fossil forms, briefly contrast a few of the more striking features in the organisation of a dog (under which term it will be convenient to include wolves, jackals, foxes, *et hoc genus omne*) with those of a bear, as in all such investigations it is advisable to make ourselves thoroughly acquainted with the well-known before we attempt the consideration of the comparatively unknown.

A dog, in this general sense, is characterised externally by his comparatively slight and slender build, long limbs, well-developed tail, and above all by the circumstance that he walks only on his toes—or, as naturalists say, is digitigrade—his wrist and heel being carried far above the ground. The figure of the jackal (Fig. 56) gives a good idea of the external form of the dogs. A bear, on the contrary, is of an exceedingly bulky and clumsy build, has short and thick limbs, a mere apology for a tail, and in walking applies the whole length of his foot to the ground, or, in other words, is plantigrade. It will be unnecessary to enter here into the consideration of the well-marked differences in the structure of the soft internal parts of these animals, or, indeed, of the greater part of the skeleton, and we may therefore, in the main, confine our attention to those of the skull and teeth, which, as being the parts more commonly preserved in the fossil state, demand the especial consideration of the

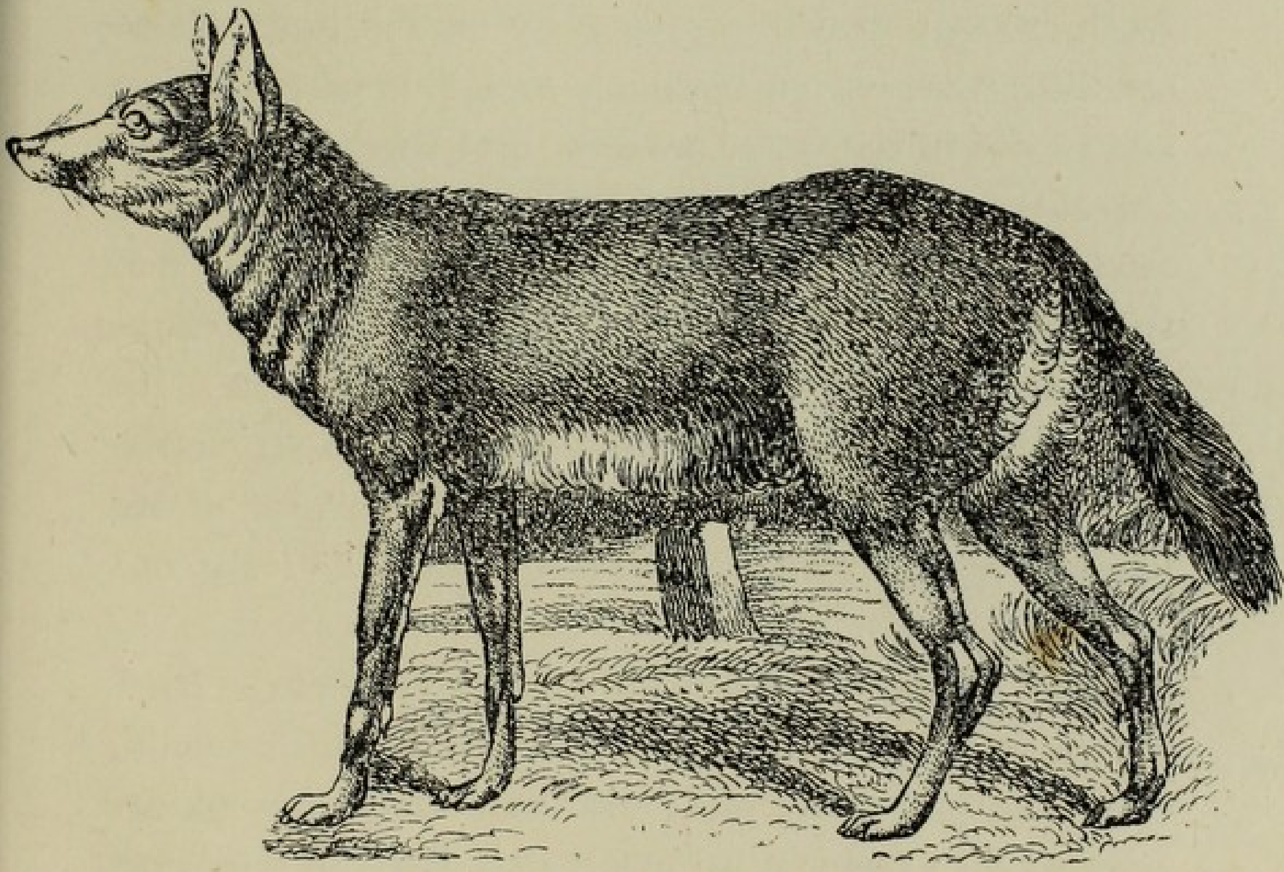


FIG. 56.—The Jackal. (*From Jardine.*)

palæontologist. There is, however, an important point in regard to the bones of the fore-limb of carnivores which cannot be passed over, namely, that in the arm-bone or humerus of the cat tribe and some extinct dog-like species the inner side of the lower end is perforated by a small hole, which is totally wanting in the corresponding bones of the dog and the bear.

The skull of a dog conforms to the general structure of the whole animal in its light and graceful shape, and is characterised (among many other features) by the presence of a bladder-like bone, covering the under part of the internal ear, which is scientifically known as the "bulla." The solid bony roof of the palate does not extend farther back than the last tooth, and the teeth are arranged in a gracefully curved line. There are altogether eleven teeth on each side of the upper, and twelve in the lower jaw; the first three being called the cutting-teeth, the fourth the eye-tooth, which is readily distinguished by its tall crown, the next four the false grinders, and the remainder (two in the upper and three in the lower jaw) the true grinders. The general arrangement of these is indeed precisely similar to that which obtains in the Civet, a figure of the upper teeth of which is given in Chapter XIV. (Fig. 64). The most important features of these teeth are that the last two in the upper jaw are triangular in shape (as is shown in woodcut 57), the hinder being much smaller than the preceding one, and that they are mainly adapted for crushing, although they have an imperfect cutting-edge on their outer side; while the third tooth from the hinder end of the jaw, which is termed the "flesh-tooth," is longer than either of the other two, and has a much higher crown, with a sharp cutting-edge, which bites with a scissor-like action against the similarly elongated and high-crowned "flesh-tooth" of the lower jaw. This type of tooth structure indicates a creature whose diet consists mainly of animal subtances.

Turning now to the bear's skull, we shall find on examination that it is altogether of a stouter and more massive type, while the bladder-like "bulla" which we noticed in the dog, is altogether wanting, and is replaced by a nearly flat plate, and the bony roof of the palate extends considerably behind the last tooth; the grinding teeth themselves being arranged in a nearly straight line. In young animals there is the same number of teeth as in the dog; but in the adult the second and third false grinders are frequently shed.

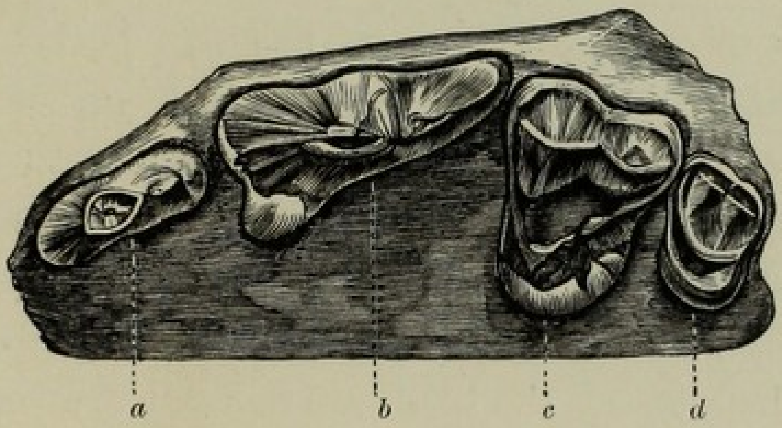


FIG. 57.—The last four left upper teeth of a Wolf. *a*, false grinder; *b*, flesh-tooth; *c*, first grinder; *d*, second do.

The hinder teeth, however, differ very widely from those of the dog, the last two in the upper jaw being rhomboidal instead of triangular in shape, and having still flatter crowns, while the last is the larger (instead of the smaller), and is very much elongated. The upper "flesh-tooth" shows this contrast still more markedly, for instead of having its crown both longer and taller than the crowns of the two hinder grinders, it is very much shorter, with a crown not higher, and lacking the sharp cutting-blade found in the corresponding tooth of the dog. In the teeth of the lower jaw very similar differences may be observed, the crown of the "flesh-tooth" being no higher than that of the succeeding tooth, while its length is only equal to that of the latter, instead of exceeding it by twice its own length. The "eye-teeth" are moreover stouter, with relatively lower crowns than those of the dog. It is of course obvious that the broad flat crowns of the hinder grinding-teeth of the bear are adapted to a vegetable or mixed, rather than to a purely flesh diet; and it is noteworthy that in the Polar bear, which subsists to a large extent on fish and putrid seal- or whale-flesh, there is a tendency to a rather greater development of the cusps of its hinder teeth than in its congeners, whose food consists to a great extent of vegetable or soft animal substances. In the Indian sloth-bear, on the other hand, which feeds largely upon honey, insects, &c., the teeth are reduced to a very small size in proportion to the dimensions of the skull.

If now we carry ourselves back in imagination to a period in the earth's history, which although comparatively late from a geological point of view, yet is very early indeed from a human one, we find evidence of the existence in northern India, as well as in several parts of Europe, of a huge bear-like animal, which has received the somewhat inappropriate name of the hyæna-bear (in scientific language *Hyænarctus*). This creature lived in India at a time when the Himalaya was but a comparatively low chain of hills, and ages before England was separated from the Continent, in a period which is termed by geologists the Pliocene. Now if we ask ourselves in what respects this bear-like creature differed from any modern bear, we must answer that while its skull and limb-bones have the massive and bulky characters of existing bears, yet we find certain features showing that we are at least one step away from these modern specialised types. Thus, to take one instance from the limbs, the bone forming the elbow has an extremely prominent termination, or "funny-bone," and in this respect resembles the corresponding bone of the dogs and differs from that of the bears. The teeth, however, show us in a much more unmistakable manner what a marked approach this animal makes to the dogs. Thus, the "flesh-tooth" in both jaws has a long and cutting crown totally unlike that of the bears; having, indeed, the same structure as in the dogs (Figs. 57, 60), although of a rather more complex type than in any existing species. Moreover, the two grinders of the upper jaw, instead of presenting long oblong crowns, have nearly square crowns in most species, while in one very peculiar species from India they tend to assume the triangular form of the dog's grinders. In the small species, of which the upper grinders are shown in wood-cut 58, the crowns are longer than usual, although much shorter than in the true bears. The hyæna-bear, which rivalled in bulk the huge American grizzly, was, therefore, to all intents and purposes, a bear show-

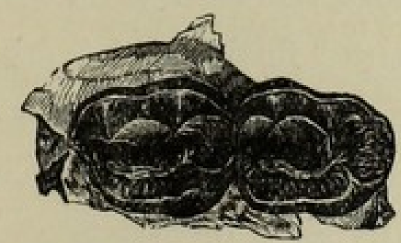


FIG. 58.—The two left upper grinders of an extinct Bear (*Hyænarctus*).

ing most unmistakable evidence of its relationship to the dogs in the structure of its teeth; and we may thus be justified in assuming that this terrible animal was largely carnivorous in its habits. Closely akin to this hyæna-bear is another huge extinct animal from the uppermost Tertiary of South America, in which it is said that the bone of the arm retains the perforation now found in the cats, and thus gives us one more clue to the descent of the bear. In this creature, which is known as the Arctothere, the

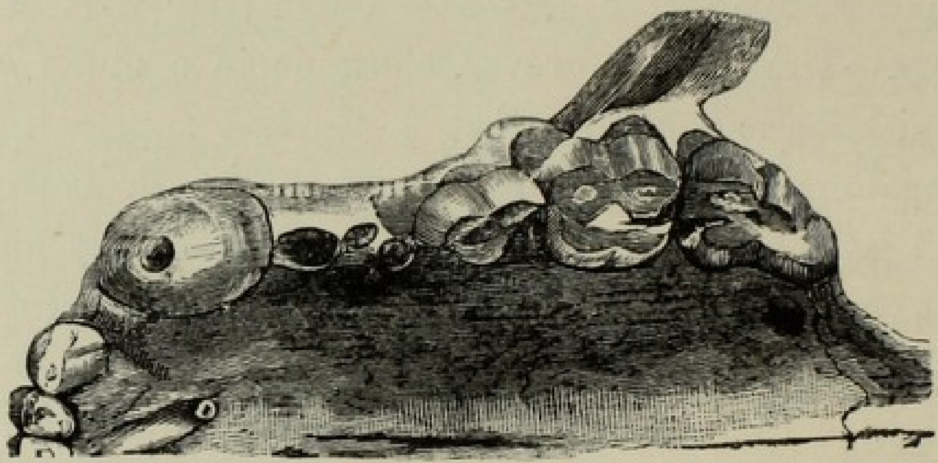


FIG. 59.—The left half of the upper jaw of an extinct South American Bear-like animal. Much reduced.

grinding teeth of the upper jaw (Fig. 59) have quite lost the elongated crowns found in the true bears; and the "flesh-tooth" (the third from the right side of the figure) approximates very strongly to that of the dogs.

Taking one more step back in time to the middle division, or *moyen age* of the Tertiary period, technically known as the Miocene epoch, we meet with a creature which unfortunately has no English name, and which we must therefore be content to recognise under the designation of the Dinocyon. This animal was of the size of a bear, but had teeth like those of a dog, although it was in all probability plantigrade, and it had a perforated arm-bone. Here, then, we have at length reached an animal where our definition of a dog and a bear begins to fail us, in spite of the "stretching" we have given these definitions when discussing the hyæna-bear. Yet one step still further back—to the lower part of the Miocene and the upper part of the preceding or Eocene epoch—the dawn of the Tertiary period—and we find an animal, the so-called Amphicyon in regard to which it appears to be impossible to say whether it partakes most of the nature of a dog or of a bear. The best known species of the amphicyon was of the approximate dimensions of a wolf, but others were larger. They had teeth—more especially the "flesh-teeth" (Fig. 60)—precisely like those of a dog, with the exception that there were three in place of two grinders in the upper jaw, and the general build was also dog-like, with a perforation in the lower end of the arm-bone. The skull has, however, the bladder-like "bulla" of the dogs, but the animal applied the whole soles of its feet to the ground in walking after the old-fashioned plantigrade manner, and made no attempt to assume the more advanced digitigrade progression of the dogs.

Here, then, it is evident that we have to do with an animal that is quite as much a dog as a bear, being, in fact, a veritable "missing-link;" and consequently a source of sad trouble to those systematists who wish to assign every creature to a fixed place in their cut-and-dried schemes. Thus we find that while some palæontologists have regarded this troublesome amphicyon as a plantigrade dog, and consequently place it among the canoid animals, other writers consider it as a dog-toothed bear, and refer it to the arctoid group. The truth is, however, that we must recognise in this early canivore the common ancestor from which both bears and dogs have taken their origin; both groups having thence tended more and more to diverge from one another with the advance of time, till they finally have assumed their present extreme differences, which, as we have already observed, are apparent to the most unscientifically disposed mind. Accepting this convergence of the two groups as a proved fact, we must accordingly regard the separation of the dogs and bears into two distinct families as merely a convenient classification for their existing representatives, rather than a real primary division.

The interest of the amphicyon does not, however, cease with its relationship to the bears and dogs, since it also shows evident signs of cousinship with other lower Miocene and upper Eocene carnivorous animals, which appear to connect the dogs with the civets, and thus with the hyænas and cats. One of these early connecting types is known as the dog-civet (*Cynodictis*), and appears to have been an animal closely allied both to the amphicyon and to the true civets; so that we have good evidence for regarding bears, dogs, and civets as having originated from one common stock more or less closely allied to our amphicyon. Since, moreover, the hyænas and cats (under which name we include lions, tigers, and their allies) are evidently derived from a stock more or less nearly related to the earlier civets, we are enabled to trace back all these wonderfully different types of carnivorous animals to a very few ancestral stocks.

A like pedigree has been already traced out in many other groups of animals, and as our knowledge (imperfect as it must necessarily always remain) gradually increases by slow, although we hope sure, steps, we shall look forward to do the same for other groups, till we find the whole of the animals of the present day forming the twigs of one huge ancestral trunk.

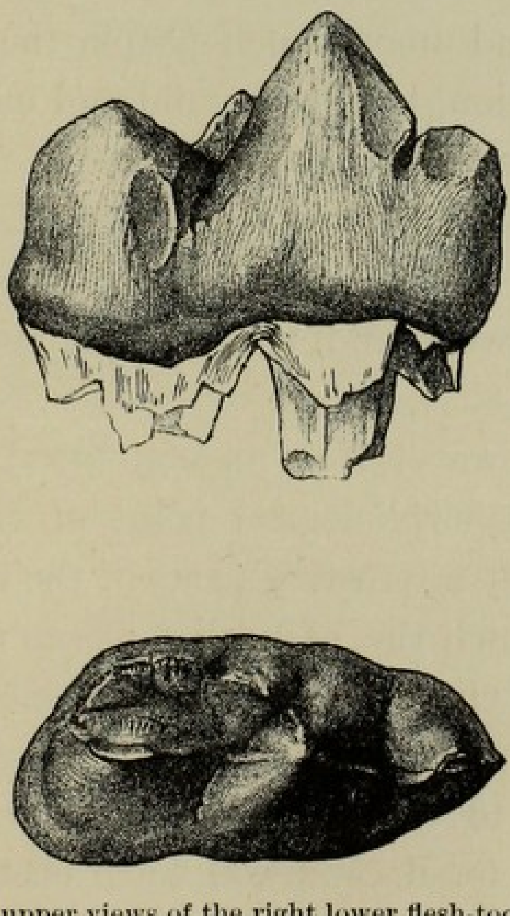


FIG. 60.—Outer and upper views of the right lower flesh-tooth of the Amphicyon. (*After Kittl.*)

CHAPTER XIV.

TEETH AND THEIR VARIATIONS.

To most persons the chief interest in connection with teeth is an unpleasant one, owing to the circumstance that through an artificial mode of life these highly important organs are subject to a premature decay, and thus fail to perform satisfactorily their proper function. With less civilised and savage races this, however, is not the case, and among such people the teeth, almost without exception, last in a sound and useful condition throughout life; being gradually worn down to their very roots with advancing age, and thus showing a natural connection between the capacity of the teeth to withstand wear and the normal span of human existence.

Regarded, however, from an anatomical, or, in modern phraseology, a morphological point of view, teeth are among the most interesting parts of the animal organisation with which the naturalist has to deal, owing to the great and characteristic variations they display in the different groups of Vertebrate, or Back-boned Animals, and to the frequency with which they are preserved in a fossil condition when other parts of the skeleton have either perished or are only preserved in a very imperfect condition. True teeth are found only among the Vertebrate animals; and we propose to take a short glance at some of the most striking variations displayed by them among certain groups of the class of Mammals, although some mention will also be made of those of the lower types.

Curious as it may seem at first sight, the researches of modern naturalists have now conclusively proved that primarily teeth are neither more nor less than special modifications of certain bony structures found in the external skin of some of the lower Vertebrates, of which the best known example is afforded by the hard granules in the skin of the Sharks, commonly known as shagreen. The teeth of some fishes depart, indeed, but very slightly from these simple bony granules; and a gradual transition can be traced from these simple teeth to the most complex types of teeth found in the whole Vertebrate group.

In speaking of these simple teeth as bony structures, we take leave to employ the word bony in a somewhat popular sense, since, strictly speaking, teeth are not composed of true bone. Indeed, in the majority of Vertebrates, teeth consist either of two or three perfectly distinct structural elements, which can be easily recognised by the naked eye. Thus in the human teeth, for instance, the outer surface of the exposed portion, or *crown*, as it is technically called, is seen to be uniformly coated with a bluish-white and highly polished substance of exceeding hardness, conveniently known as the *enamel*. On looking at the grinding surface of a tooth which has been somewhat worn, it will be seen that this enamel forms only a comparatively thin outer layer, and that the inner part of the tooth consists of a yellowish substance, which is much softer, and is termed the ivory or *dentine*. Further, when a human tooth is removed from its socket, it may be observed that the *root*, or embedded portion, is overlain by a very rough-looking bony substance, known as *cement*, which directly overlies the dentine. In the human teeth this cement is, indeed, confined to the root, but in some other Mammals it also extends on to the crown, where it overlies the enamel. We thus see that the crown of a tooth may consist of three distinct elements, of which the dentine forms the central part, this being overlain by the enamel, and this again by the cement.

In many Fishes teeth are distributed irregularly, or at other times in a well-defined pattern, over the whole of the surface of the mouth; and we also find that certain Reptiles have the roof of the mouth more or less covered with teeth. In the majority of the higher Reptiles—such as Lizards and Crocodiles—the teeth are, however, confined to the margins of the upper and lower jaws, where they form a single row, with the base of each tooth either embedded by an undivided root in a groove or socket of the jaw-bone, or absolutely welded to the bone itself. A common type of Reptilian tooth has the crown forming a more or less compressed cone (Fig. 61), with a pair of sharp-cutting edges, which may or may not be furnished with saw-like notches.

In the great majority of Reptiles the whole of the teeth are of the same pattern, although in some cases —as the Crocodiles and Alligators—one or more of the teeth in either jaw may be much larger than the others; and in a few extinct types (Fig. 62) the teeth are divided into three distinct series. As one tooth comes into use it is succeeded from below by the germ of another, which gradually grows up and absorbs its roots till the old tooth finally drops out, this process going on without intermission during the whole life of the animal, so that a practically endless succession of teeth is developed. Some of the varieties assumed by

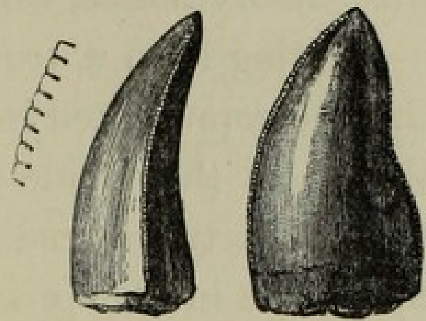


FIG. 61.—The crown of a tooth of an extinct Reptile, with a magnified view of the notches on the margin.

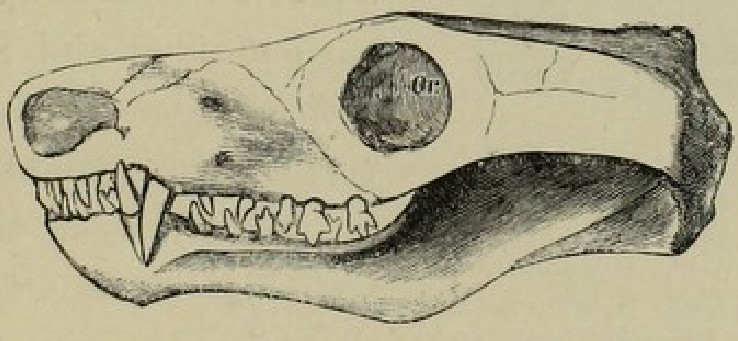


FIG. 62.—Skull and teeth of an extinct South African Reptile.

the teeth of extinct reptiles are noticed and figured in Chapter VIII., among which we may especially call attention to the fluted and serrated type obtaining in the Iguanodon (Fig. 32), and the spatulate modification seen in the Hoplosaur (Fig. 34). Other extinct reptiles have flattened and pavement-like teeth adapted for crushing the shells of crustaceans and molluscs. Passing these reptilian teeth, interesting as they are, with this cursory notice, we turn to those of mammals.

Starting from a tooth of the simple conical type of the one represented in Fig. 61, it is possible to evolve therefrom the whole of the curious modifications of tooth-structure found in the higher Vertebrates. The first stage in the process is the development of small points, or cusps, on either side of such a cone, as is seen in the hinder teeth of the skull of the extinct reptile shown in Fig. 61. A further step is for these side cusps to become nearly or quite as large as the original main cone (Fig. 63, *A*), and then to be twisted round upon the same, so that in the upper jaw (as is shown in the hinder teeth of the Civet, figured in woodcut 64), each upper tooth has one inner and two outer cusps, while exactly the reverse arrangement obtains in the teeth of the lower jaw (Fig. 63, *B*). The addition of extra cones or cusps to this triangular form of tooth, with alterations of the simple cusps into ridges, either by union with one another, or by flattening in one direction or another, or by increase in their height, will produce all the complicated types of hinder teeth found in the higher Mammals.

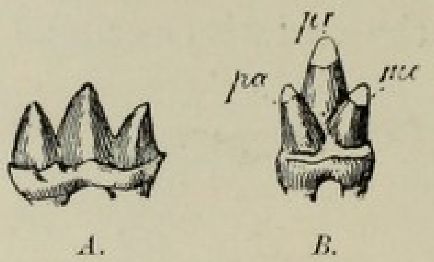


FIG. 63.—Teeth of Secondary Mammals, enlarged. *A*, Side view of lower tooth of a species with the three cusps in the same line. *B*, Do. of a lower tooth of a species in which the cusps form a triangle. *pr*, outer cusp; *pa*, anterior do.; *me*, posterior do.

Before going any further, we must, however, notice some of the points by which the teeth of Mammals are distinguished from those of Reptiles. Exclusive of certain peculiar types like the Porpoises and Dolphins, the teeth of Mammals are not similar to one another throughout the jaws, but are arranged in groups of different sizes and series. Thus in the upper jaw (Fig. 64), there are commonly three simple front, or *incisor*, teeth with chisel-like crowns; then comes the single large *tusk*, behind which are the *cheek-teeth*, of which the number is very frequently seven, although

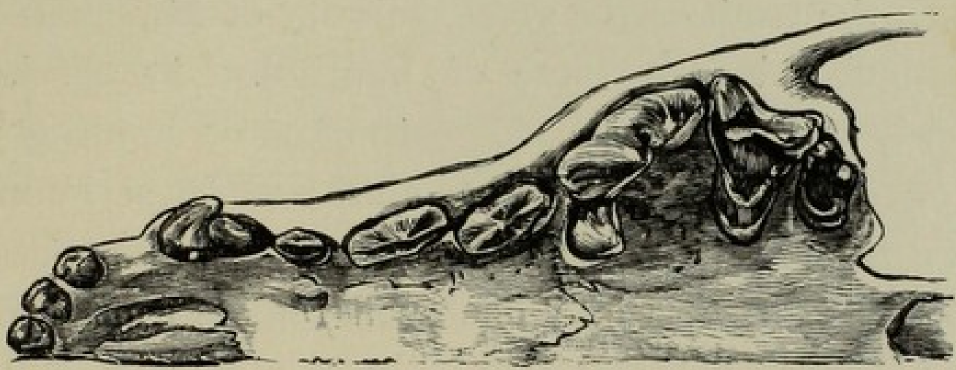


FIG. 64.—The teeth of the left side of the upper jaw of the Indian Civet.

there are only six in the figured jaw. In those Mammals which live on an animal diet, the three or four foremost of the cheek-teeth (Fig. 64) retain a more or less close approximation to the original compressed conical form, only the hinder ones acquiring broad and flattened crowns adapted for masticating or grinding. But in some of the herbivorous species, on the contrary, as the Horse, all the teeth behind the tusk may acquire these greatly developed and flattened crowns.

In the division of the teeth into incisors, tusks, and cheek-teeth, the peculiar extinct Reptile from South Africa, of which the skull is shown in Fig. 62, agrees with Mammals, although it differs in that each cheek-tooth is fixed in the jaw by a simple undivided root, whereas, in all mammals (with the exception mentioned), these teeth are implanted by two or more roots; the number of these roots being greatest in the hindmost teeth, as all those who have had the misfortune to part with a *back-grinder* under the hands of the dentist know only too well.

Again, there is another very important feature by which the teeth of the great majority of Mammals are distinguished from those of Reptiles. As we have already mentioned, the old teeth of most Reptiles are being continuously and irregularly replaced by new ones throughout the life of their owners; but in Mammals there is only one such replacement during the whole of life, and that only of a certain definite number of the teeth. Thus in Chapter XII. it has been shown that among the Pouched Mammals there is only one tooth on either side of each jaw which is so changed, that tooth corresponding to the eighth tooth from the front in Fig. 64. In the case, however, of a Mammal with a dentition like that represented in the figure last mentioned, all the teeth in advance of the last two, with the exception of the small one immediately behind the tusk, have been preceded by *baby-*, or *milk-teeth*, that is to say, with teeth corresponding to such of those of the human child as are gradually replaced by larger successors with advancing age. The last teeth of a Mammal,—two in Dogs and Civets (Fig. 64), but three in man,—have, however, no such milk-predecessors, and are hence called *true grinders;* the teeth between these latter and the tusk, which are only two in number in Man, against four in the Civet, Dog, and Pig, being termed the *false grinders.*

This single definite replacement of a certain number of teeth—it may be of only one, or it may be of seven or eight on either side of each jaw—is, therefore, a peculiar feature of Mammals, and indicates the highest and most nearly perfect phase of the development of the tooth-series.

Having thus acquired a general idea of some of the more important characteristics distinguishing the teeth of Mammals as a whole, we are in a position to enter into the consideration of their structure in any particular group. Perhaps one of the most interesting of

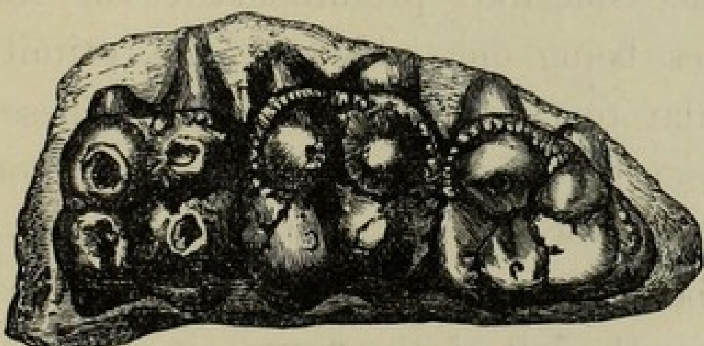


FIG. 65.—The last three left upper cheek-teeth of an extinct Pig.

all groups in regard to the gradual development of a highly complex structure in the cheek-teeth of the modern forms, is that of the Hoofed or Ungulate Mammals; or that extensive order which includes the three great groups of Pigs, Deer, Antelopes, and

Cattle; Tapirs, Rhinoceroses, and Horses; and, lastly, Elephants. The animals of the first group are all related to one another by the structure of the feet, in which the two middle toes are symmetrical to one another; and we can trace in this, as well as in the two following groups, a gradual increase in the complexity of the teeth, as we proceed from what naturalists term the generalised to the specialised types; the latter being, it need hardly be mentioned, mainly characteristic of the present day and the latest geological period, while the former are mostly of earlier origin.

The simplest form of cheek-tooth in this group is found among certain extinct animals closely related to the modern Pigs, three of these teeth being represented in Fig. 65. It will there be seen that the crown of each of these teeth carries four comparatively low and simple cone-like prominences; the number of these cones being one added to the primitive type of triangular tooth mentioned above. These cones, it will be observed, are separated from one another by a +-shaped shallow depression or valley; and when their summits become somewhat worn down by use (as in the tooth on the left of the figure), it will be seen that nearly circular islands of dentine are exposed. The figure also shows that the last tooth is rather larger than either of the others; this being still more markedly the case with the corresponding tooth in the lower jaw. In the modern Pigs this last lower tooth (Fig. 66) becomes still larger; while, as may be seen from the figure, the cones of all the teeth have now lost the simple form of the earlier species, and have been thrown into "puckers," so that when worn the exposed islands of dentine have an irregular shape with "crinkled" edges. From the hillock-like formation of these teeth in the Pig family, the term *bunodont* (Gr. *bounos*, a hillock) has been proposed for this type of dental structure. In correlation with this comparatively simple type of cheek-teeth, it should be mentioned that the Pigs have incisor teeth and large tusks in both jaws; while their feet agree with those of ordinary mammals in having the middle metacarpal and metatarsal bones (or the bones immediately below the wrist and ankle) separate from one another.

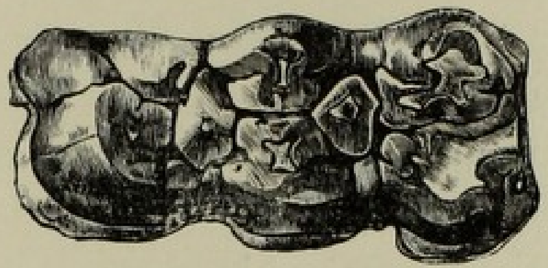


FIG. 66.—The last right lower cheek-tooth of a Pig.

From the type of tooth represented in Fig. 65, other fossil forms exhibit a complete transition to the imperfect tooth represented in Fig. 67. In addition to the immaterial point of its larger dimensions, it will be noticed that the latter has five cones, a minute cone

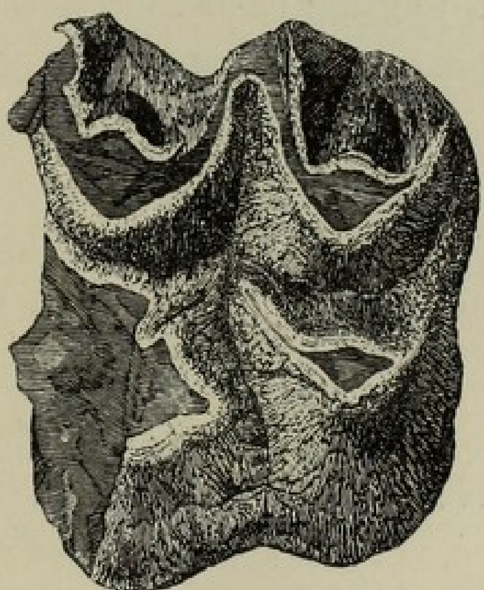


FIG. 67.—An imperfect left upper cheek-tooth of an extinct Selenodont pig-like animal.

visible in Fig. 65 having now developed into one of nearly equal importance with the others. The most remarkable feature connected with this type of tooth is, however, that all the cones have been compressed from side to side, and have acquired a crescent-like curvature, so that the worn surfaces of dentine are crescent-shaped, and the cones themselves should more properly be described as crescents. Hence this type of tooth has been described as the *selenodont* (Gr. *selene*, the moon, and hence a crescent) modification. It will be observed that in this form of tooth the crescents are still low, and the valleys separating them quite shallow; and it is further evident that the complicated grinding surface thus produced is one better adapted for the thorough mastication of substances like grass than that of the teeth shown in Fig. 65, thus enabling its owner to obtain a better sustenance out of such herbage. With Fig. 68 we come to the tooth of another extinct animal of this group, in which the fifth crescent has been lost, while the four main crescents have become decidedly more deeply curved and somewhat higher, although the bottom of the intervening valleys is still more or less distinctly visible. The worn surfaces of dentine, it will be noted, are quite V-shaped.

FIG. 68.—A right upper cheek-tooth of an extinct animal intermediate between the Pigs and the Deer.

Thus far we have succeeded in tracing the gradual modification of the bunodont tooth of a true Pig into one with a selenodont form, although of a low-crowned type; and we may infer from this that the owners of the latter type of teeth tended to depart more and more completely from the mixed diet of the Pigs towards the purely herbaceous diet of the Deer and Cattle. So far, however, as we are acquainted with these intermediate animals, their general type of organisation appears to have been very like that of the Pigs. We have now, however, to consider the teeth of the modern Deer and Cattle, which we shall find to be of a still more complex type. Fig. 69 shows a somewhat worn cheek-tooth of one of the smaller Deer, which will be seen to be but a step in advance of the tooth represented in Fig. 68, the outer crescents having now become still more compressed and flattened, and both these and the inner ones having acquired a considerably greater elevation, so that the bottom of the valleys between the crescents is no longer visible. In some other species of Deer, as well as in many of the Antelopes, the crescents of the teeth become very much taller (Fig. 70), so that the intervening valleys form deep pockets, with narrow entrances, and the whole type of tooth is so utterly unlike that of the Pigs that, when the intermediate extinct types were unknown, it is small wonder that the older naturalists failed to recognise the intimate connection that really exists between the Pigs and the

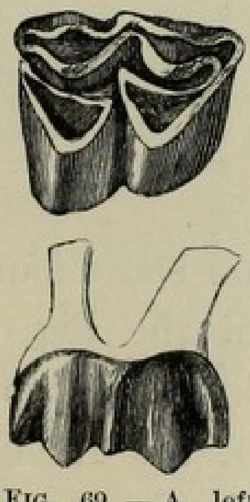


FIG. 69. — A left upper cheek-tooth of a Deer. Viewed from the grinding surface and from the outer side.

Ruminants, as the Deer, Cattle, &c., are often conveniently termed. Finally, in the Oxen the crowns of the teeth become still taller, with the deep valleys between the crescents more or less completely filled up with cement. Side by side with this remarkable modification of the cheek-teeth, the Ruminants have undergone other equally notable structural changes, some of which we may briefly mention. Thus, in the first place, all the true Ruminants have totally lost their upper incisive teeth; the lower ones, as we may see in the Cow and the Sheep, biting against a hard pad in the upper jaw. Then, again, the two separate metacarpal and metatarsal bones found respectively in the fore and hind limbs of the Pig, have fused together to form the well-known "cannon-bone," so characteristic of the limbs of the Ruminants. While, finally, in place of the simple stomach of the Pig, we find all the true Ruminants furnished with that peculiarly complex type of divided stomach necessary for the function of "chewing the cud" or ruminating.

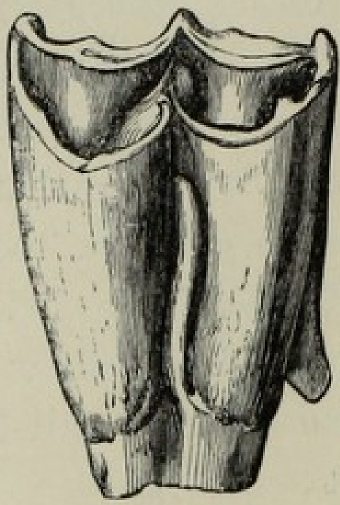


FIG. 70.—A left upper cheek-tooth of an Antelope. This tooth is less worn than the one in the preceding figure.

All these modifications of structure are admirably suited to the mode of life of the Ruminants. Thus the height of the crowns of the cheek-teeth, and the complex grinding surfaces which they present, are necessary to withstand the excessive wear to which they are subjected in the process of chewing the cud, and thus reducing the fibres of grass to a fine pulp. Probably also this increased height of teeth enables their owners to enjoy a longer duration of life than was possible to the Tertiary ancestors of the Ruminants. Then, again, the consolidation of the bones of the lower part of the leg into a single shaft is far better adapted to withstand the strain of supporting long-limbed and large-bodied animals when galloping at a rapid pace than would be a limb with the separate bones of the Pig. Indeed, the most specialised Ruminants, such as the beautiful Antelopes of South Africa, seem to be so admirably adapted to their mode of life that it is impossible to imagine how this type of animal life could be improved upon.

When we turn to the second great group of Ungulates, or that which contains the Tapirs, Rhinoceroses, and Horses, we shall find that a precisely analogous series of modifications has taken place in the structure of the teeth and feet, although it has followed a different plan. All these animals are characterised by the middle toe in each foot being symmetrical in itself; and whereas all the ancient forms, as well as the living Tapirs and Rhinoceroses, have at least three toes to each foot, the highly specialised Horse, as we all know, has but a single very large toe to each limb. This reduction of the number of toes and the accompanying lengthening of the whole limb, has resulted in a speed which is out of all comparison with that which can be attained by the clumsy Rhinoceroses and Tapirs, and can only be equalled by that of the Antelopes and Deer.

The cheek-teeth of the Rhinoceroses and Tapirs are formed on a somewhat different plan from that obtaining in the previous group, as may be seen by comparing

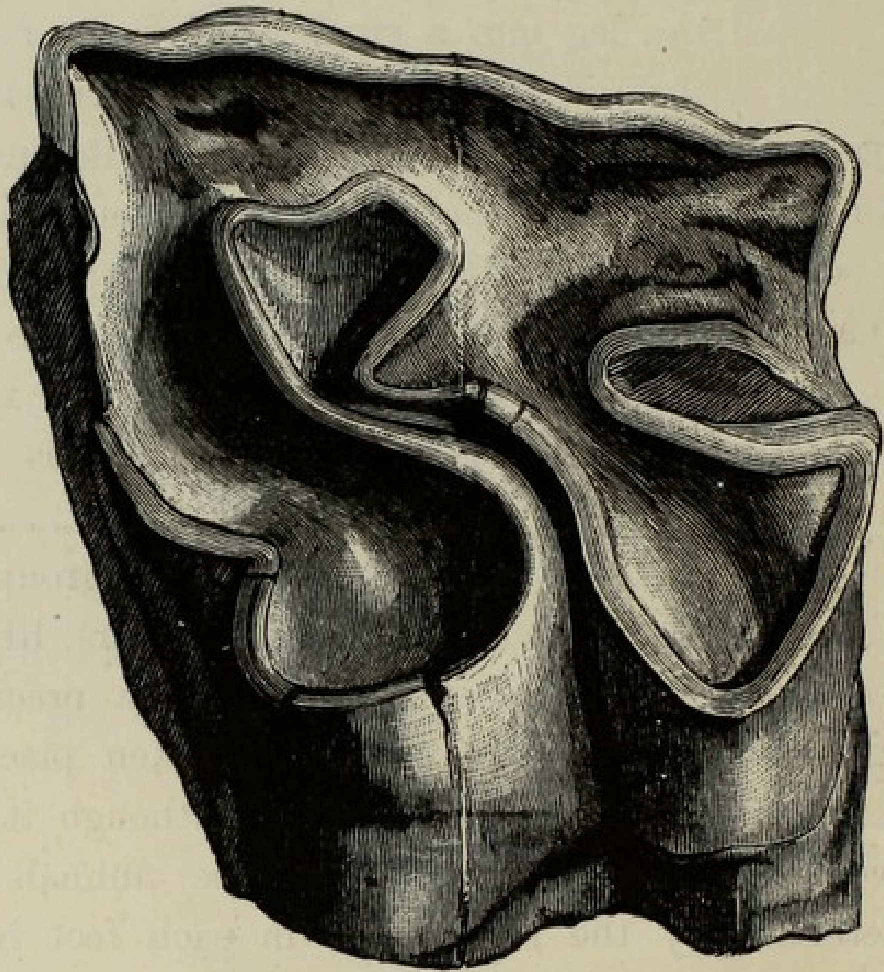


FIG. 71.—A left upper cheek-tooth of a Rhinoceros.

the figure of a Rhinoceros tooth, given in Fig. 71, with the earlier figures. This plan of structure consists, indeed, of an outer wall, with two oblique ridges or crests running towards the inner side of the crown, where they terminate in somewhat expanded pillars. When somewhat worn, the surfaces of dentine on such a tooth present the very characteristic pattern shown in the figure, which at once enables us to say to which group its owner belonged. This peculiar type of tooth may be readily derived from the four-columned tooth of the primitive Pigs (although it is not for one moment to be supposed that Rhinoceroses, &c., are descended from Pigs) by the union of the two outer cones to form the outer ridge, and also by the junction of each of the outer cones with the corresponding inner cone to make the transverse crests. The crown of the Rhinoceros's tooth, as seen in the figure, is comparatively low, and the valleys between the ridges and crests are shallow, and not filled with cement. The teeth of Tapirs are of the same general type, and so also are those of all the extinct Tertiary Ungulates of this group, from some of which, as Professors Huxley and Marsh have so clearly shown, the modern horse appears to have been evolved.

The cheek-teeth of Horses (Fig. 72) have, however, been so strangely modified from this generalised type by the great increase in the height of their crowns, and the complexity of their grinding-surfaces, produced by foldings of the enamel of the longitudinal and transverse ridges, that it is at first sight somewhat difficult to see how the different portions of such a tooth correspond with those of the tooth of a Rhinoceros. By the aid, however, of Fig. 72, which represents a cheek-tooth of an extinct horse-like animal, we may endeavour to trace this correspondence, although the difficulty of this is unfortunately somewhat increased by Figs. 72

and 73 being taken from teeth of opposite sides of the jaw. It is, however, quite evident that the parts marked *pa* and *me* in Fig. 72 correspond with the outer wall of Fig. 71; while *pr* and *hy* in the former represent the inner termination of the transverse crests in the latter. Further comparison of the two figures will convince us that the parts marked *pl* and *pp* in Fig. 72 are the equivalents of the middle portions of the two transverse crests in Fig. 71. A comparison of Figs.

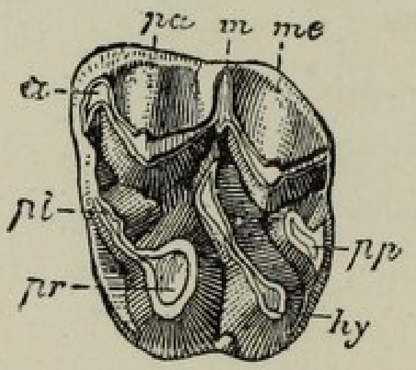


FIG. 72.—A left upper cheek-tooth of the extinct horse-like Anchithere. (*After Osborn.*)

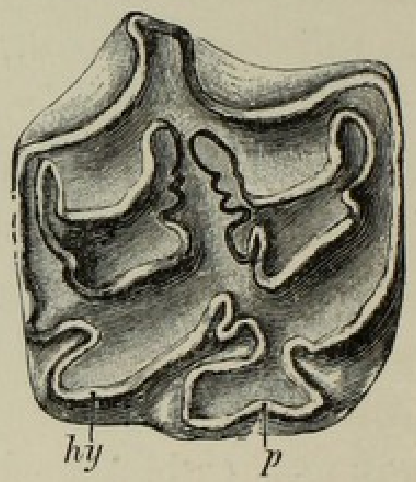


FIG. 73.—Grinding surface of a right upper cheek-tooth of a Horse. *p*, corresponds with *pr*, and *hy* with *hy* in Fig. 72.

72, 73 will show their unity of plan, the central islands in the latter representing the hollows or valleys in Fig. 72, which have now become completely enclosed by the enamel, and are filled by the white cement.

The height of the crown of one of the grinders of a Horse is, as most of us know, more than three inches and the admirable grinding surfaces formed by alternations of three substances of different hardness, arranged in the complex manner seen in Fig. 73, is self-apparent.

Horses fed on the hard substances given to them in European stables will often live to at least five-and-twenty years of age, and it is perfectly evident that this comparatively long duration of life could never be attained if these animals were not furnished with the long-crowned teeth we have just described, since the short-crowned and simple teeth of a Tapir would be entirely worn away by such a diet at a very much earlier period.

We see, then, in the Horse an animal which, in the structure of its teeth and limbs, has attained, so to speak, to the same platform of specialisation as that on which the Deer and Antelopes stand, but has reached it by a totally different ladder. It is, indeed, as if two engineers had, after many intermediate steps, at last perfected two machines, each equally well fitted for the same purpose, and each resembling one another to a certain extent in their general plan of construction, but yet differing very decidedly in details. And it cannot be too strongly impressed upon the reader what a powerful argument this gradual evolution of the teeth in two allied stocks of animals, towards the same relative perfection of structure, affords to the doctrine of a general evolution of the whole animal kingdom.

Our last illustration of the gradual increase in the complexity of the structure of the grinding teeth in the Ungulate order, as we proceed from the old extinct generalised types (and some allied ones which still survive) to the specialised forms characteristic of the world of to-day, will be derived from the peculiar group of Elephants. At the present time, it need scarcely be mentioned, there are but two species of Elephant, both nearly related, but one being confined to the African Continent and the other inhabiting India and some of the adjacent regions. In the later Tertiary period of the earth's history Elephants were, however, much more numerous, and were then spread over the greater part of the surface of the globe, having been obtained from Europe and Asia, as far north as Siberia, North and South America, and North Africa. Many of these extinct Elephants, and, indeed, all of the earlier ones, differed very remarkably from the living species in the much simpler structure of their teeth; these species being known as Mastodons, a term which has now become almost a popular one.

In common with true Elephants, Mastodons differ from other Mammals, in that, instead of having all their cheek-teeth in use at the same time, the hinder ones gradually come up in an arc of a circle behind the tooth in use at any one particular period, which is gradually worn away and shed. Further, the teeth gradually increase in complexity from before backwards, the most anterior ones in some cases not having more than two ridges (Fig. 74), while the hinder ones are much more complex (Fig. 76). It results from this peculiar mode of succession that there are never more than portions of two, or at most of three, teeth on either side of each jaw in use at any one time. Fig. 74 shows that the simple cheek-teeth of a Mastodon are really constructed on the same general plan as those of a Pig (Fig. 65), the outer cones having more or less completely united with the inner ones to form two transverse ridges. In some of the earlier teeth of the Mastodon there may be only two such ridges (Fig. 74), but in the later ones the number of ridges is generally either three or four (Fig. 75), with additional imperfect ridges at the two extremities. In such a tooth (Fig. 75), it will be seen that the transverse ridges are low and roof-like; the valleys separating one ridge from another being broad and comparatively shallow, without any of the substance known as cement at their bases. When the enamel on the summit of such ridges is worn through by the abrasion of the teeth of the upper jaw against those of the lower, oval or trefoil-shaped islands of the underlying dentine are revealed, as in Fig. 76. The latter figure exhibits the last tooth of a Mastodon in which there are five complete transverse ridges, this being the most complex form of tooth found in any of the Mastodons.

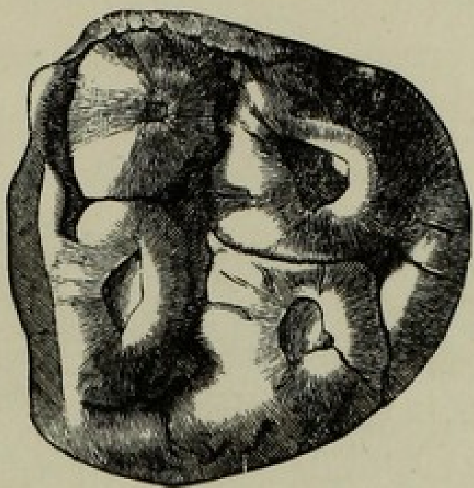


FIG. 74.—An anterior cheek-tooth of a Mastodon.

In certain Tertiary rocks in India lying along the southern flanks of the great range of the Himalaya there are, however, found enormous numbers of teeth of peculiar species of Elephants, which, while resembling in many respects those of the Mastodons, have a considerably greater number of ridges. Moreover, the ridges themselves are relatively narrower and taller, so that the depth of the intervening valleys is likewise increased. These valleys also contain a certain amount of the third constituent of mammalian teeth—the cement—so that their bases are partially filled up by it.

From the teeth of these Intermediate Elephants, as they may be conveniently called, the step is but very

FIG. 75.—A left upper cheek-tooth of a Mastodon in an unworn condition.

short to those of the modern or true Elephants. In these, as shown in Fig. 77, the difference from the teeth of the Mastodon is so great that without the intermediate forms it is difficult to trace the correspondence between their respective elements. In the true Elephants, indeed, the transverse ridges of the teeth have not only been greatly increased in number, so that there may be as many as twenty-five in the last tooth of certain species, but they have also been so much increased in height and narrowed in width that they assume the form of thin plates, which may be six or eight inches in height, and the sides of which are almost parallel. The valleys between these plates, as they may now be called, have likewise become thin and deep slits, which are completely filled to their very summits with the cement. Thus, comparing Fig. 77 with Fig. 76, it will be apparent that each of the elongated discs seen in the former, which consists of a layer of enamel surrounding a strip of dentine, corresponds to the transverse ridges of the latter; while the spaces between the discs in Fig. 77, which are composed of cement, represent the open valleys of Fig. 76.

The surface of such an Elephant's tooth forms, indeed, a millstone most perfectly adapted for grinding vegetable substances, consisting as it does of parallel ridges composed of elements of different degrees of hardness. Such a tooth, with its height of nearly eight inches in some species, takes many years to wear away; and with a succession of six of these teeth gradually increasing in size and complexity from the first to the last, we are well able to understand how the Indian Elephant can live fully to the age of a century. It is also equally evident that the more simple and lower-crowned teeth of the Tertiary Mastodons must have been worn away at a far more rapid rate; so that we are justified in saying that these animals could not have attained anything like the length of life enjoyed by their modern descendants.

There is a considerable amount of variation in the structure of the grinding-teeth of the true Elephants, although all of them resemble to a greater or less degree the specimen represented in Fig. 77. In the African elephant, however, the discs of dentine, surrounded by their border of enamel, are much wider in the middle than in the figured tooth, and thus assume a lozenge shape. In this respect, therefore, the African

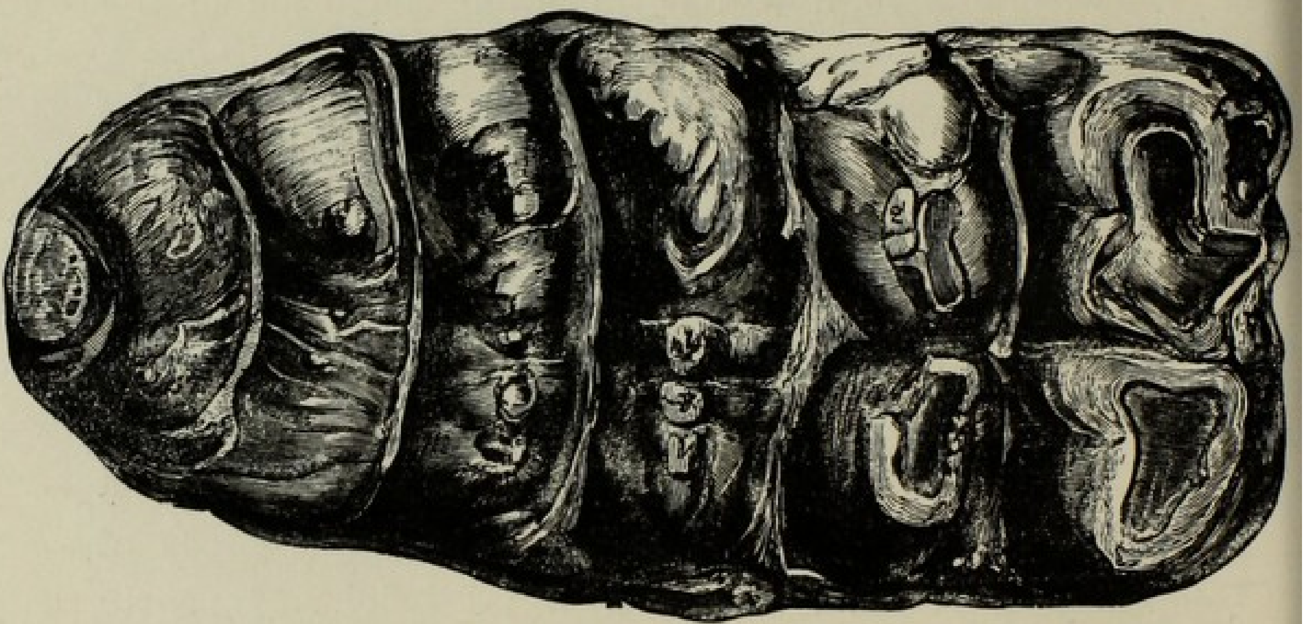


FIG. 76.—The last left upper tooth of a Mastodon, with the enamel of the two first ridges perforated by wear.

elephant is a more generalised or old-fashioned kind of animal than his Indian cousin; and we may observe, in passing, that the African continent is now remarkable for containing a number of old types, such as Hippopotamuses, Giraffes, and Aard-Varks, which have totally disappeared from other regions, although, as we know from their fossil remains, they were once widely spread over the globe. Thus, Hippopotamuses (or shall we say Hippopotami ?) once ranged over the greater part of Europe, extending as far north as the southern parts of our own islands, and were also common in Northern India; the same being true of the Giraffes, with the exception that their remains have not hitherto been found in Britain.

The most complex type of teeth is, however, attained by the Indian Elephant, and the closely allied Mammoth, which in the latest geological epoch ranged over the greater part of Europe, and whose frozen carcases are from time to time washed out from the so-called "tundras," or superficial deposits of Siberia, to be exposed to human view after having been buried for countless centuries. In these two species the plates of the teeth are narrower and more numerous than in the tooth represented in Fig. 77, so that the even surfaces of dentine form still narrower stripes. At first sight it seems difficult to believe that the Elephant now inhabiting the burning plains of India should be closely allied to a species which formerly roamed over the icy regions of Siberia, but there are two considerations which show how little value such objections have. Thus, in the first place, there is considerable evidence that the climate of Siberia, although doubtless always cold in winter, was formerly less severe than at present. We have, moreover, evidence in the case of the Tiger how an animal can support the extremes of heat and cold with no alteration of its structure. Many people, indeed, if they were asked to mention the *habitat* of the Tiger, would say India, little knowing that this creature ranges in China and thence to Siberia into extremely high latitudes. The skins of these northern tigers are far handsomer than those from India, the hair being long and comparatively shaggy, so as to protect its owner from the bitter cold. The case of the Indian Elephant and the Mammoth is a precisely similar one, the existing Indian species having, as we all know, an almost naked skin, while the Siberian Mammoth was clothed with long shaggy hair, as we learn not only from its frozen remains, but also from the rude pictures of the living animal drawn many centuries ago on fragments of its own tusks by the old pre-historic hunters of the Dordogne.

In mentioning tusks, we should not forget that the modern Elephants differ from many of the old Mastodons in having tusks only in the upper jaw, while in the latter they were also present in the lower. We have, therefore, here also another instance of the greater specialisation of the recent types.

In showing that with the advance of time the Elephants have gradually developed an extremely complex type of grinding-tooth from a comparatively simple one, we find that they occupy a parallel position with that held by the other two great groups of the Ungulate order.

There is, however, one very important point whereby the Elephants differ from these two groups, namely, that they have not undergone any contemporaneous modification in the structure of the foot. The feet of an Elephant are, indeed, of an exceedingly primitive type, having five complete toes, and being more like those of the very earliest Ungulates of the Tertiary period than is the case with any other living member of the order, except the little Hyrax or so-called Coney of the Bible. The explanation of this absence of modification in the structure of the foot of the recent as compared with the extinct Elephants is, however, not far to seek. By reason of their huge bulk these animals have had no need to fear the attacks of other creatures, so that there was no necessity for the development of a limb suitable for extreme speed, while the huge bulk of their bodies of itself also

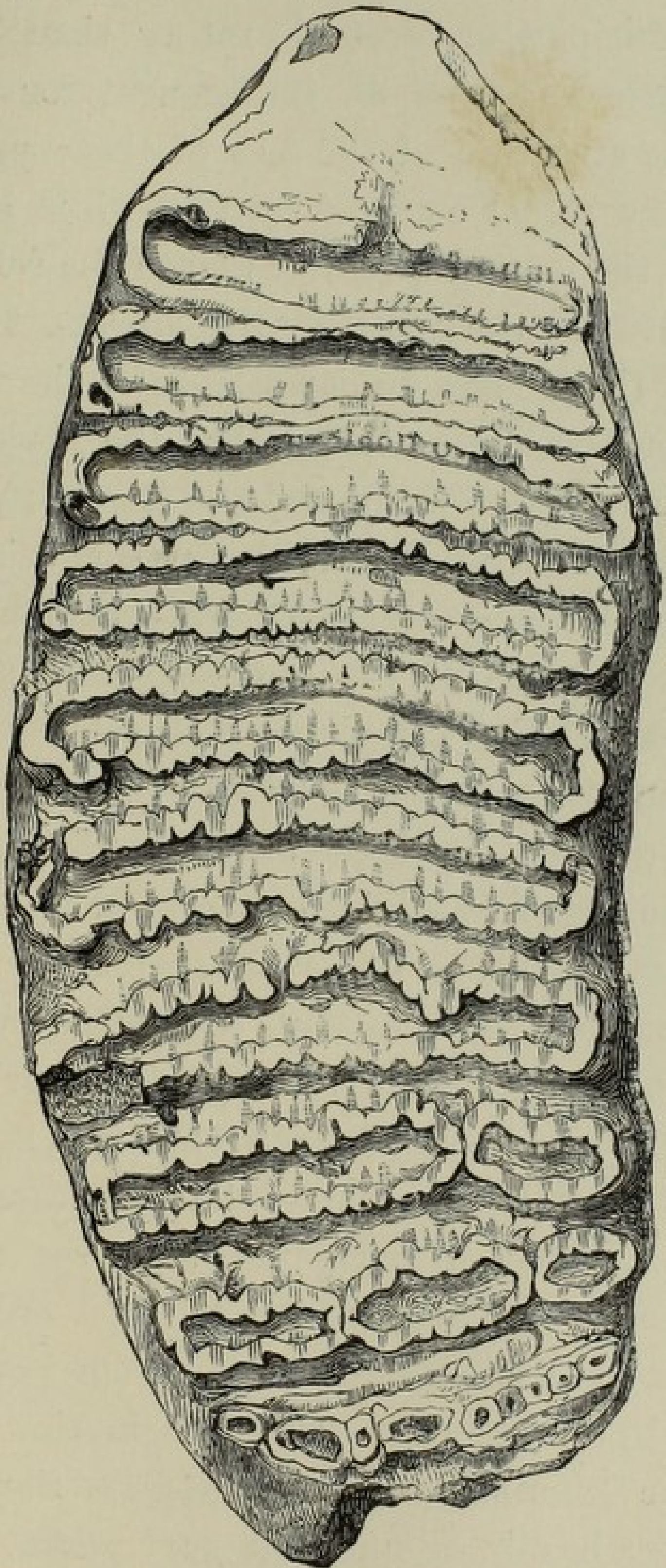


FIG. 77. A right upper tooth of an Elephant, in a half-worn state.

required the retention of a type of limb constructed on principles of strength rather than elegance. Hence there has been no inducement for any alteration in the structure of the feet of these ponderous brutes as time rolled on; and so that while it requires the aid of the man of science to trace the relationship existing between the tooth of the ancient Mastodon and that of the modern Indian Elephant, the veriest tyro would not hesitate to declare that the skeletons of the same two creatures indicated the closest relationship.

To sum up the results of this brief survey of some of the more striking features connected with the cheek-teeth of the Ungulate Mammals, we may say that all the Ungulates of the lower Tertiary deposits had low-crowned teeth of comparatively simple structure; and that those of all the three groups into which the order is divided can be derived from a type of tooth not far removed from that possessed by the ancestors of the Pigs, the latter type being itself a modification from the still more primitive triangular type. In all the three groups of Ungulates, the crowns of the teeth have tended to increase in height and in complexity of structure with the advance of time; those Ungulates with the tallest crowned teeth being characteristic of the most recent period of the earth's history. Finally, that while in the groups containing the Ruminants and the Horses the structure of the feet has been modified *pari passu* with that of the teeth, to produce limbs capable of carrying their owners at an extremely rapid rate, in the Elephants, where there is no need for swiftness of flight, the feet have not undergone this adaptive modification, so that the whole structural alterations have been confined to the teeth.

In conclusion, we venture to think that sufficient has been said to show what an extremely interesting study is that of teeth. These organs are, indeed, interesting not only from their curious and often beautiful forms, but also, as we have striven to show in the foregoing paragraphs, as affording a concise and, so to speak, epitomised summary of the degree of evolution which any particular group of animals has undergone in the course of time.

CHAPTER XV.

HORNS AND ANTLERS.

In the chapter on "Mail-Clad Animals," we treated of what may be termed the armature of animals for passive resistance; while in the present one it is our intention to consider certain forms of armature adapted either for active resistance or for actual attack. Many forms of this type of armature, such as the tusks and claws of the Cat-tribe and other Carnivores, the pincers of the Lobster, the sting of the Bee and the Scorpion, and the poison-fang of the Adder, will at once present themselves to the mind of the reader; but on this occasion we propose to confine our attention to those types of armature commonly known as horns and antlers, which are now met with only among the Hoofed or Ungulate Mammals; although, as we shall mention in the sequel, the former were also developed in past epochs among a lower group of animals.

It will, first of all, be essential to thoroughly understand what we mean by the terms "horn" and "antler," since, although both are purely English words, there is often great confusion in their application; the term horn being often applied to an antler, although the converse misnomer is never met with.

Commencing with antlers, it is scarcely necessary to say that the organs so named are the branching bony protuberances borne upon the heads of the males of most species of Deer during a certain part of the year. The nature of these appendages is well shown in the woodcut on page 229, drawn by Mr. H. A. Cole, from the head of a Fallow-Deer shot in Epping Forest in 1884. In the figured species the extremities of the antlers are flattened out, and are accordingly termed palmated; but in the Red Deer, and most other species, they are more or less nearly cylindrical throughout the greater part of their length.

The most characteristic feature of the outer surface of an antler is its ruggedness, which reminds us somewhat of the bark of a tree, and is taken advantage of in the manufacture of so-called "buckshorn" knife-handles, &c. Antlers are, indeed, almost quite peculiar in that they represent, when fully formed, an entirely dead structure borne by a living animal as part and parcel of itself, and their mode of growth is very interesting. Thus, some time after a stag has shed its antlers, there appear on the summit of the skull two small velvety knobs, very tender and sensitive, and supplied by an unusual number of blood-vessels. These knobs, which are deposits of bony matter, very rapidly increase in size, and soon begin to branch into a number of so-called tines, and finally assume the form of the complete antlers. It will thus be evident that even when fully grown the new antlers are still entirely covered with the soft skin known as the "velvet," beneath which the blood-vessels carry the blood to all their parts. With the final completion of their growth, and the cessation of the deposition of bony matter from the blood over the greater part of the antler, there is formed, however, at the very base, just above the point where the antler joins the protuberance on the forehead from which it takes its rise, a rough prominent ring of bone. This protuberant ring, which is commonly known as the "burr," and is often used to form the end of whip-handles, serves to constrict the blood-vessels at this point, so that henceforth no blood is carried over the antlers. In consequence of this deprivation of blood, the "velvet" rapidly dries up, and either peels off, or is rubbed off by the animal against the stems and branches of trees. The antlers are then complete, and their owner steps proudly forward from the sequestered glades in which he has lain concealed during the period of their growth as the "monarch of the glen."

This, then, is the mode of development of antlers; and after they have served their purpose as weapons of offence during the fierce encounters which take place between the males during the breeding season, the living bone beneath the skin at the base of the burr is absorbed, and the antler, or dead bone, is shed, to be again renewed in the same manner as before.

Another point in connection with antlers is, however, noteworthy—namely, that they gradually increase in complexity as the age of the animal advances. Thus, the head of the Fallow-Deer represented in Figure 78 evidently belongs to a fully-grown buck, for a young animal would have had much simpler antlers. Indeed, in the fawns of the first year the antlers of the Red-

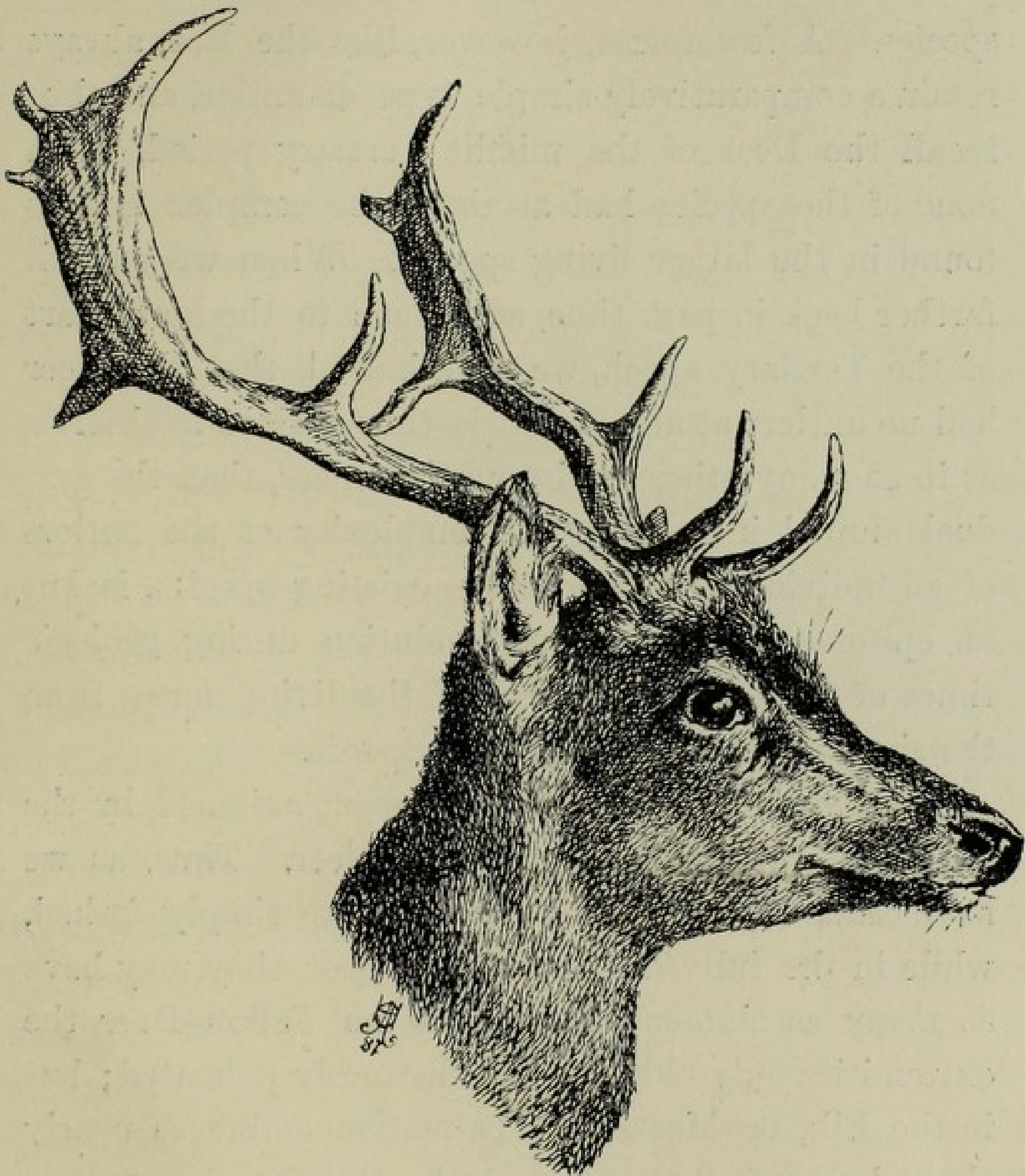


FIG. 78.—Head of Fallow-Deer, to show branching and palmated antlers.

Deer consist only of a single prong, with a short front tine; and year by year as they are renewed they acquire a greater and still greater number of tines and branches, till they finally attain the complete stage, when their owner is termed a "royal hart." And a similar gradual increase in complexity takes place in the case of the Fallow-Deer and most other species. A few forms, however, like the Roe, always retain a comparatively simple type of antler, and thus recall the Deer of the middle Tertiary period, when none of the species had attained the complex antlers found in the larger living species. When we go still farther back in past time, and come to the lower part of the Tertiary epoch, we find, indeed, that the Deer had no antlers at all; and it is thus curious to observe, as in so many other analogous instances, that the gradual annual increase in the complexity of the antlers of an individual of one of the existing species, is but an epitome of the gradual evolution during geologic times of the complex antlers of the living forms from the simple ones of their early ancestors.

Great variation occurs in the form assumed by the antlers of the different species of deer. Thus, as we have said, in the Roe the antlers are simply forked, while in the fully-developed Red Deer they may have as many as sixteen points. In the Fallow-Deer the extremities only (Fig. 78) are distinctly palmated; but in the Elk, or Moose, the palmation embraces nearly the whole of the antler, and attains an enormous development. Of the species with cylindrical antlers those which attain the greatest development in this respect are the Canadian Wapiti, the great stag of the Thian Shan range, and some allied species from Tibet and Persia. But the antlers which are found fossil in the peat and cavern-deposits of this country indicate that the predecessors of our own Red Deer attained equally gigantic dimensions. The extinct Gigantic Irish Deer had, however, the finest antlers of any member of the family, their expanse from tip to tip sometimes exceeding 11 feet. Alone among the deer tribe, the Reindeer of the northern regions of Europe and America has antlers in the female as well as in the male; thus indicating that in this instance the function of these appendages is connected with something else besides the combats of the males during the breeding season.

Having said thus much in regard to antlers, our next theme is that of horns, which we shall find to be of a totally different nature. The woodcut (Fig. 79) shows the upper part of the skull and horns of an Antelope. These horns are supported on bony prominences arising from the forehead, without any "burr" at their base, and forming, in fact, part and parcel of the skull itself. During life they are permeated by blood-vessels which traverse the whole of their interior, and they are coated by the hollow sheaths, to which the term horn is properly restricted. In structure these horny sheaths are merely a specially modified kind of skin, somewhat analogous to our own nails; and they are connected with the underlying horn-core by soft tissue and blood-vessels. Thus the horns of an Ox, Sheep, Goat, or Antelope, are essentially living structures—as we may see for ourselves in the case of an Ox or Cow which has had the misfortune to wrench off its horn from the bony horn-core; and are thereby totally different from the dead antlers of the Deer. Moreover, with one remarkable exception, of which more anon, horns are never branched, and are never shed from their bony cores. In many instances, as in the Oxen, they are also common to the male and female; although those of the former are the larger. As in the case of Deer, we find, however, that the earliest Oxen and Antelopes were devoid of horns, and that these appendages show a gradual increase in size as we ascend in the Tertiary period to the present day.

The one exception among the hollow-horned Ruminants (as the animals with true horns are often called), in which the horns are branched and are annually shed from their cores, is the Prong-buck of North America. In this elegant Antelope the horns have a single branch, and curve backwards in a hook-like manner. Another type of cranial appendage is exhibited by the well-known Giraffe, of Africa, which has a pair of short bony protuberances on the forehead differing from those of any of the preceding forms. These protuberances, which are some three inches in length, are cones of bone resting upon the forehead, from which in the young state they are entirely separate, although in old animals they become firmy united by bone with the skull. They are completely covered with skin, and seem to be of no possible use to their owner. They appear to correspond with the bony pedicles supporting the antlers of the deer, and may, perhaps, be regarded as remnants of larger appendages found in certain extinct animals, which appear to have been in some respects intermediate between antlers and true horns.

The creature in which this intermediate type of cranial appendages occurs is the huge extinct Sivathere, of the Upper Tertiary deposits of Northern India, which is the largest known representative of the

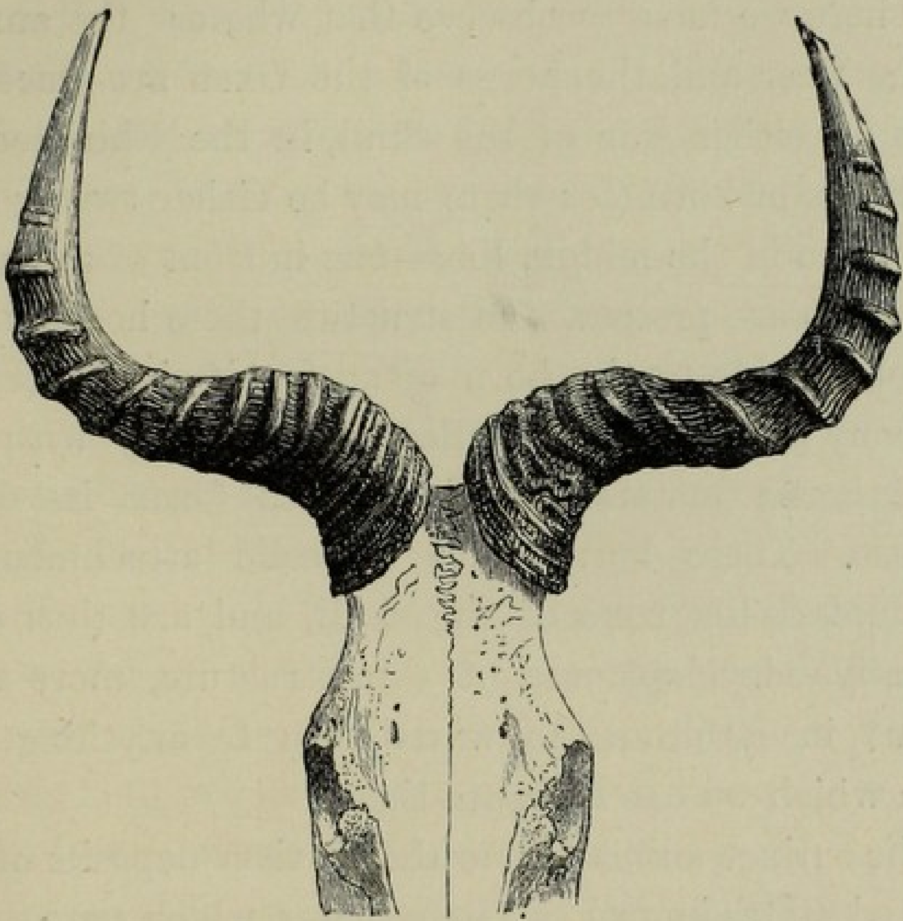


FIG. 79.—Upper part of skull of Hartebeest, to show horns. (*From Günther.*)

Ruminants, or cud-chewing Mammals. This animal was provided with huge wide-spreading antlers (although it is here difficult to say whether we should use the term antler or horn), somewhat like those of the Elk, but apparently permanently attached to the skull, since they show no sign of a "burr" at the base. They were, in all probability, always covered either with skin or with very thin horn, and thus seem to indicate that the difference between an antler and a horn is not so great as appears to be the case when our studies are confined to living animals.

The last form of horn we have to mention among existing animals is that found in the Rhinoceroses. And here we have to observe that whereas the antlers of the Deer and the horns of the Oxen are placed in pairs on either side of the skull, in the Rhinoceroses the horns or horn (for there may be either two or one) are placed in the middle line—one in front of the other when two are present. In structure these horns would be comparable to the horn of an Ox, if the latter had no bony core, and were filled up internally with the same horny material as that which forms its outer surface. These horns have no solid attachment to the underlying bone of the skull, and are thus only excessive developments of skin-structure, more analogous in structure to warts than to anything else with which we can compare them.

The extinct animals from the Tertiary deposits of the United States known as Titanotheres, which were somewhat akin to Rhinoceroses, are distinguished by having a transverse pair of bony horn-cores above the nose, which during life were doubtless sheathed in horn. Again, the Uintatheres (so named from the Uinta Mountains), of the same region, form another strange extinct type of huge Ungulates, having as many as three pairs of bony horn-cores; and thus being the most extraordinary creatures of this group of animals at present known to us. In addition to the horns the skulls of the males were armed with long and formidable tusks in the upper jaw, somewhat like those found in certain extinct tigers.

The above are the three great types of offensive armature with which the skulls of existing Mammals are provided, and they are all of them, as already observed, found in the order of Hoofed Mammals, and nowhere else, at the present day. If, however, we go back to the long-distant Mesozoic epoch, or period at which our chalk was deposited at the bottom of the sea, we find that certain herbivorous species of the gigantic reptiles known as Dinosaurs, which are described in Chapter VIII., were provided with paired bony horn-cores on their skulls (Fig. 41), so exactly resembling those of our own Oxen that some of them when found detached were actually described as belonging to an extinct Bison. In the later Tertiary beds of Australia we also find a huge tortoise with somewhat similar horn-cores on its forehead; and since the horn-cores, both in this and the preceding instance, so closely simulate in structure those of the Oxen, we may fairly infer that they were similarly sheathed with true horns during life.

Thus we learn that in long past epochs not only was the place of the larger herbivorous Mammals of the present day taken by various forms of giant herbivorous reptiles, but that those reptiles were actually armed with weapons precisely similar to those of the Mammals of the present day. So true is it that there is "nothing new under the sun."

CHAPTER XVI.

RUDIMENTARY STRUCTURES.

If we turn to the word "rudiment" in any English dictionary we shall find it defined somewhat after the following manner, viz. "a first principle or element; the original of any thing in its first form; that which is first to be learned." While we shall also find the words "rudimental" or "rudimentary" explained as "initial; pertaining to rudiments."

Now we may presume that it was in this sense of the word "rudiment" that the terms "rudimentary structures" or "rudimentary organs" were originally applied to certain animal structures or organs, which, while appearing to be of no use to their owners, seemed to foreshadow structures fully developed and of functional importance in other creatures. At the time when these terms were first applied (it need scarcely be observed) the doctrine of special creations was almost universally accepted; but even then it is extremely difficult to see how there could be any philosophical defence for this use of the terms, since, if the structures so named were really primitive rudiments, their existence almost *ipso facto* implied some sort of genetic connection between the creatures in which they are found and those in which the kindred structures were functional.

With the advent of the doctrine of evolution, and the more careful investigations into the structure of animals which had by that time taken place, a total change of view as to the real nature and import of these so-called rudimental structures at once ensued. Thus it was soon found (not by conjecture, but from actual circumstantial evidence) that, in place of being the beginnings of structures which eventually became functional, these rudiments were really the remnants of structures which had once been functional but had now become useless. This change of view necessitates, therefore, that the term "rudiment" in zoology must, at least very generally, be used in precisely the opposite sense to the one in which it is employed in ordinary parlance.

In order to make this application of the term quite clear, we may mention one or two illustrations taken from our own dress. For instance, at a time when people wore elastic-sided boots more frequently than they do now, the fronts of the boots were often ornamented with a set of "dummy" laces and lace-holes. These "dummy" laces being quite useless were, therefore, essentially rudimentary structures, which had been, so to speak, retained as an ornament. Again, the small black patch at the top of a judge's wig is the last remnant of his black cap or hat, and is, therefore, a useless rudimentary structure. Another case is afforded by the little pocket-like fold at the end of a university hood, which really represents the peak of the monk's cowl. Many other similar cases will occur to the reader, but the above are sufficient for our present purpose.

Some of the best instances in nature of rudimentary structures are to be found in the feet of the Hoofed or Ungulate Mammals, or that great group which includes Horses, Rhinoceroses, Cattle, Deer, Elephants, &c. In the Elephant and many of the earlier extinct members of this group each foot (as we have already mentioned in the article on "Teeth and their Variations") was furnished with five complete toes, each of which was supported by a separate bone, connecting it with the wrist in the fore limb, and, with the ankle in the hind limb. These five connecting bones in the fore limb (to which we will confine our attention) correspond with those forming the upper part of our own hand, and, as following the wrist or *carpus*, are termed the *metacarpal* bones, or *metacarpus.* With the exception of the elephant the number of the fingers and metacarpals in all living Ungulates is, however, always less than five, the first finger, or that corresponding with our thumb, having invariably disappeared. In the Even-Toed Ungulates, such as Pigs, Deer, and Cattle, where the middle pair of fingers or hoofs (corresponding to our third and fourth fingers, the thumb being reckoned as the first) are always symmetrical to one another, we find as we advance to the more specialised species a gradual diminution in the relative size of the second and fifth metacarpals, as compared with the middle pair. Thus in certain extinct Pig-like Animals the whole of the four metacarpals were large, and completely separate from each other; while all the four toes were fully applied to the ground in walking. In the Pigs, however, the outer (2nd and 5th) metacarpals have become much reduced in size; while their small toes, as we may see any day for ourselves, only touch the ground when the animal is walking on soft or marshy ground. A still further diminution in the size of these lateral metacarpals is presented by the foot of the extinct creature shown in Fig. 80, where we find that they are only represented by small splints of bone (2 and 5) occurring at the upper and lower ends of the two middle metacarpals. In this animal these middle metacarpals (3 and 4) still remain separate from one another, but in the Deer, Sheep, and Cattle they have become completely welded together to form a single bone, known as the "cannon-bone." In some Deer the outer metacarpals are represented merely by splints at the upper end of this cannon-bone, and in others by similar splints at its lower end. In the Sheep and Oxen the upper splints have totally disappeared, while in the Giraffe both upper and lower splints are wanting, so that the metacarpus is represented only by the cannon-bone, composed of the originally separate 3rd and 4th metacarpals. With this more or less complete

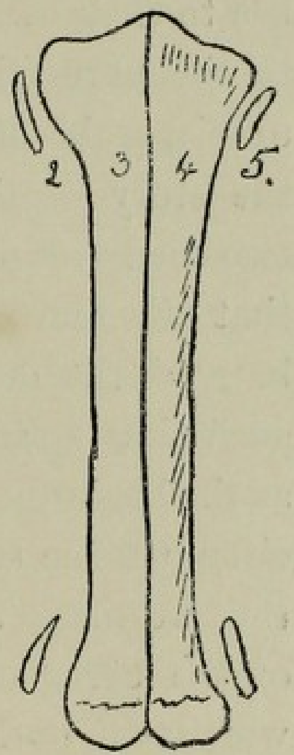


FIG. 80.—The bones of the upper part of the foot, or metacarpus, of an extinct Even-toed Ungulate (*Gelocus*).

loss of the outer metacarpals, the hoofs of the corresponding digits have likewise gradually diminished in size, till we find them represented in cattle merely by the small and totally useless so-called "spurious hoofs," while in the Giraffe they have totally disappeared.

These "spurious hoofs" and the metacarpal splints are therefore rudimentary structures, of no possible use to their owners, but of the greatest possible interest to the naturalist, as telling in the clearest and most unmistakable language (if but the lesson be read aright) the story of the gradual evolution of the specialised two-toed foot of the modern even-toed Ungulates from that of a four-toed ancestor. That this history cannot be read the other way forwards, so as to make us regard the "spurious hoofs" and the metacarpal splints as the beginnings of functional toes, is obvious from the circumstance that it is only among the later formations that we meet with two-toed Ungulates; the majority of the early ones being four-toed. One other point worthy of notice is that one of the most specialised representatives of this group—the Giraffe—has succeeded in totally getting rid of these superfluous rudimentary organs, both externally and internally.

Precisely an analogous series of changes has taken place among the Odd-Toed Ungulates (Rhinoceroses, Tapirs, and Horses), in which the third, or middle, toe and metacarpal are always symmetrical in themselves. Thus the earliest extinct members of this group were furnished with five complete toes; in the Tapir the first toe (thumb) has disappeared, and the fifth is rather small; while in the Rhinoceros the disappearance of the fifth leaves only three functional toes, of which the middle one (third) is much the largest. Passing over some intermediate forms, we find in the extinct horse-like animal known as the Hipparion, the lateral toes have become very small, short, and useless, while their metacarpals are reduced to slender bones lying along the sides of the large third metacarpal. Finally, the modern horse has totally lost the lateral toes, and their metacarpals (2nd and 4th) are merely represented by small splints lying parallel to the upper end of the third metacarpal—now known as the cannon-bone—in the same position as the upper splints (2nd and 5th) in Fig. 80. Here then, again, we have true rudimentary organs—the remnants of bones once functional—which are not only of no sort of use to their owner, but, on the contrary, are absolutely injurious to him, since it is from inflammation, due to hard work, arising in these bones which gives rise to the disease known as "splint" in horses.

Except for the presence of these "splints" the horse appears to our ideas to be an absolutely perfect type of animal; and, indeed, so far as we can see, is the supreme development of which the Odd-toed Ungulate stock is susceptible. If the horse were unknown, and the rhinoceros and tapir the only representatives of the Odd-toed group, it might have been readily conceived that their speed and agility could be improved by diminishing the number of their toes, and lengthening their limbs, but no one can suggest any improvement in the general structure of the horse, which is in every way adapted for the attainment of the highest speed, coupled with endurance and power.

Of perhaps still greater interest are the rudiments of hind limbs found deeply imbedded in the bodies of purely aquatic mammals, such as Whales and Dugongs, in which, as is well known, there is not the slightest external trace of such limbs, although the fore limbs are large, and modified into powerful paddles. The woodcut, Fig. 81, shows these structures.

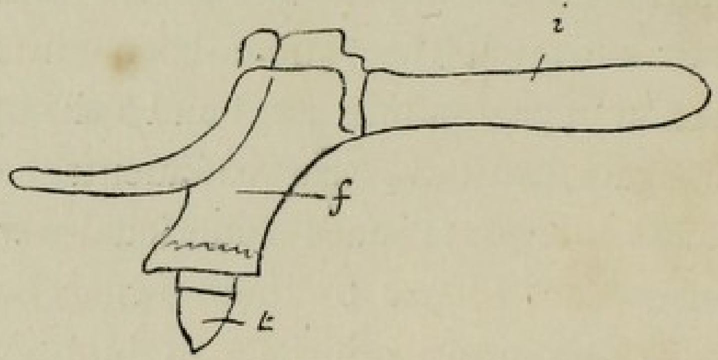


FIG. 81.—Side view of the bones of the rudimentary hind limb of the Whale. *i*, pelvis; *f*, thigh-bone; *t*, leg-bone.

as found in the Greenland Whale. The long horizontal bone represents the pelvis of ordinary mammals; while the nearly vertical bone (*f*), which is about eight inches long, appears to correspond to the thigh-bone, and the little nodule *t* is the sole remnant of the bones of the lower leg. In the Sperm Whale even these useless remnants of a hind limb have completely vanished, although parts of the pelvis still remain. Many considerations have led to the conclusion that Whales have originated from land mammals, and become gradually adapted to a completely aquatic condition; and the existence of these traces of a hind limb is, therefore, of especial importance from this point of view.

Much the same story is told by the Dugongs and Manatees, all the living species of which have lost every trace of a hind limb; although in a fossil Miocene species known as the Halithere, there was a pelvis, and a small but well-formed thigh-bone, clearly showing relationship with a four-limbed creature. The so-called coracoid process of the shoulder-blade of ordinary mammals is another excellent instance of a rudimentary structure. As we have already mentioned in the chapter on Egg-laying Mammals, this small process, which in the young animal ossifies from a distinct centre, is the sole remnant of the large coracoid bone found in the shoulder-girdle of birds and reptiles.

Teeth likewise furnish many very interesting cases of rudimentary development. It has, indeed, been stated that rudiments of teeth occur in very young Parrots, but this does not appear to be really the case; no trace of these organs being found in any existing birds. Since, however, the birds of the Secondary epoch had useful teeth, we may expect some day to find their rudiments in some of the Tertiary birds. One of the most remarkable instances of rudimental teeth occurs in the Greenland Whale, in which minute teeth are developed beneath the plates of "whalebone" or "baleen," with which the upper jaws are covered, although they never cut the gum. Again, the Narwhale, of the Arctic Seas, has one enormously long tusk—usually the left one—projecting from its head; while that of the opposite side is quite rudimentary, and remains as a little nodule in the gum, resembling the kernel of a nut in its shell. Among the Hoofed mammals, modern horses usually have but six grinding-teeth in the upper jaw; but occasionally a small seventh tooth, known as the "wolf-tooth," comes up in front of all the others. This small useless tooth, which falls out at an early period, represents a much larger and useful tooth found in the earlier members of the group to which the horse belongs. Many other mammals possess rudimentary teeth; thus bears have three little knob-like teeth between the upper tusk and the flesh-tooth, which are of no sort of use, and are soon lost. They correspond, however, to the well-developed anterior cheek-teeth found in the dog and the civet. Many bats, again, show one or more exceedingly minute, almost microscopic teeth, wedged in between the larger ones, and clearly pointing to their relationship with other bats in which these small teeth were large and functional.

Mention must not be omitted of the so-called "vermiform appendage" of that peculiar little pouch found at the junction of the large and small intestine in the human subject, and known as the *cæcum-coli*. Not only is this little appendage absolutely useless, but its presence may even be the cause of death, since there is at least one instance known where death has ensued from a cherry-stone having become firmly fixed in it.

This appendage of the cœcum, as the "cœcum-coli" is called in comparative anatomy, is, however, the rudiment of an organ attaining an enormous size in some of the lower mammals, such as the horse and rhinoceros, in which it serves as a kind of supplemental stomach to aid in the absorption of the large quantity of food consumed by these animals.

Equally noteworthy is the little point of cartilage found in the outer rim of the ear of many persons, and shown at *a*, in Fig. 82. This little point, the existence of which was first brought to notice by Darwin, seems undoubtedly to be the last remnant of the extreme tip of the pointed ears of the lower animals. Its existence appears to be very inconstant, even in members of the same family, for in one family known to the writer it is present in the father, but absent in three out of four of his children.

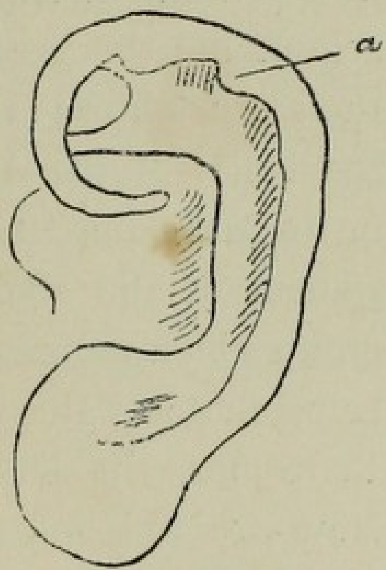


FIG. 82.—The human ear.

Perhaps, however, the most interesting instance of a rudimental organ in the whole animal kingdom is the central eye, of which mention has been made in the chapter on "Primeval Salamanders," found buried deep in the brain of the lizard-like Tuatara of New Zealand. Here we actually have a perfect eye, fitted with cornea, lens, and pigment all complete, but totally concealed from all access of light. That this central eye is the remnant of one that was originally functional does not admit of doubt; but whether we have to go back to invertebrates before this was the case is, as mentioned in the chapter referred to, still a matter of uncertainty.

Among birds we may notice many instances of the wings having become rudimentary owing to the disuse of the power of flight. This occurs to a greater or lesser extent throughout the whole of that great group comprising the Ostrich, the Cassowary, the Kiwi, and the extinct Moas (Fig. 46, p. 150) of New Zealand: all the bones of the wing having completely disappeared in the last-named birds. There are also numerous instances of the abortion of the wings in that larger group which includes all other birds; well-known cases being those of the Dodo of Mauritius, the Solitaire of Rodriquez, the Great Blue Water-hen (*Notornis*) of New Zealand, and the Great Auk; all of which, with the possible exception of *Notornis*, have become extinct from their incapacity to fly.

Insects, again, present us with many instances of rudimentary organs. Thus in the extensive group of Flies (Diptera) the hinder pair of wings, which are found fully developed in the Dragon-Flies (Neuroptera), have become aborted into organs like minute drumsticks, projecting from either side of the body, and known as "halteres," or balancers. In the Beetles (Coleoptera), on the other hand, it is the front wings which have been modified—not, indeed, so as to be absolutely useless, but so as to serve the purpose of covers to protect the delicate second pair which are carefully folded beneath them. In the same class the female glow-worm has, however, completely lost her wings, although they are retained in a closely allied Italian species. The fleas have both pairs of wings represented merely by very small scales, which are thus typical rudimentary organs.

We might go on indefinitely multiplying instances, but those we have cited are sufficient to show that rudimental structures must be regarded as the useless relics or remnants of structures or organs that were originally functional and useful; their occurrence only in the later and more specialised representatives of individual groups at once traversing any contention that might be raised as to their being the commencements of organs which were subsequently to become functional.

In thus gradually tracing an organ or bone first to its decadence, and then to its final rudimentary condition or complete disappearance, we have before us one of the most weighty pieces of evidence in support of the doctrine of evolution that can be adduced. No hypothesis, indeed, but that of evolution can possibly offer any rational explanation of rudimentary structures; whereas this doctrine assigns a satisfactory and definite reason for their existence. On the old view of the separate creation of every species, the existence of the useless, and to some extent harmful, splint-bones in the horse's foot is absolutely inexplicable in any way that will commend itself to a thoughtful and unbiassed mind. The following instance will, perhaps, serve to illustrate this point more fully. All of us are aware that paddle-wheel steam-vessels were in use long before those propelled by a screw were invented. Now if a naval architect had to alter a paddle-steamer into one driven by a screw, we should not be surprised to detect in the altered vessel traces of the foundations of the paddle-boxes, or part of the axle that once turned the paddle-wheels. If, however, this architect were ordered to construct a screw-steamer new from keel to deck, and actually went out of his way to build the foundations of paddle-boxes, and the ends of the axle for paddle-wheels, which were not only ugly and absolutely useless, but also an actual impediment to the free use and working of the ship, no one would have a moment's hesitation in declaring that such a man was utterly unfit for his business.

THE END.

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