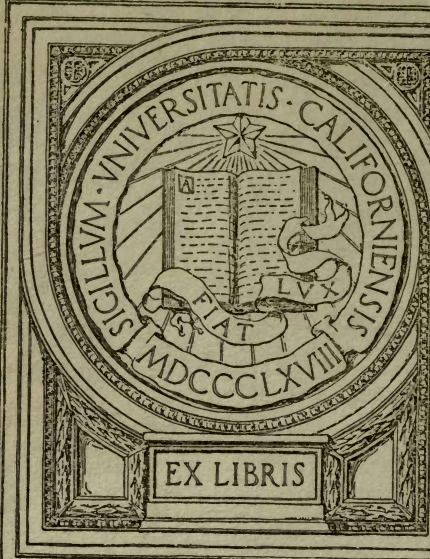
REPTILE LIFE



THE STORY OF REPTILE LIFE

THE FRINGED GECKO (*see p.* 80).

THE STORY OF REPTILE LIFE

BY W. P. PYCRAFT
F.Z.S., A.L.S., &c.

AUTHOR OF "THE STORY OF BIRD LIFE," "THE STORY OF FISH LIFE"

1905
LONDON: GEORGE NEWNES, LTD.
SOUTHAMPTON STREET, STRAND

PREFACE.

AMONG the higher animals at least, probably none are so generally and so universally disliked and mistrusted as the Reptiles. Tradition has done much to inculcate this antipathy; and the natural dread inspired by such as the snakes, has provided justification for its perpetuation.

If, however, it be true that "a fellow feeling makes us wondrous kind," then, surely, many of those who now regard the Reptiles as nature's outlaws, should be induced to reconsider their harsh verdict; since, as it is the purpose of this little book to show, like ourselves, these creatures are also called upon to battle with nature for a hold on life.

In the preparation of these pages I have received much kindly help from Dr A. Smith Woodward, F.R.S., of the British Museum of Natural History; and from Mr G. A. Boulenger, F.R.S., also of the Museum. For the most valuable assistance which they have given me I am grateful.

Those who may wish to pursue their enquiries into the story of Reptile Life yet further, will find a mine of information in Dr A. Smith Woodward's "Palæontology of Vertebrates," and Dr Gadow's volume on "Reptiles" in the Cambridge Natural History.

W. P. PYCRAFT.

LONDON, 1905.

CONTENTS.

LIST OF ILLUSTRATIONS.

THE STORY OF REPTILE LIFE.

INTRODUCTION.

THE story of Reptile Life is largely the story of a people, if we may so use the word, whose glory has departed. Just as in the study of the human race we are able to follow the histories of nations, their rise, glorious zenith, and decadence; so with the Reptile folk we may trace a similar course of evolution. The survivors of to-day are but a remnant; a feeble tribe, spurned and despised. Time was when they were the dominant forms of life upon the earth, so that we speak of the "Age of Reptiles": for millions of years — from the Permian to the end of the Jurassic era—they held sway, but were at last outnumbered and overpowered by the present reigning type of animal life — the mammalia. But their defeat is without ignominy, since, as we shall show later, their conquerors are at the same time their descendants. Similarly, the Reptiles are the descendants of the race which they in turn displaced.

Lowly in origin, and restricted in influence, these creatures nevertheless rapidly came to the fore; they spread themselves over the face of the earth, and took possession of the waters

thereof, and of the heavens above, many exceeding in stature all creatures that have ever lived either before or since. Waxing numerous they branched out into many tribes, each carving a way for itself. What the members of these several tribes were like, and how they have overcome their enemies; what weapons they have employed; what subterfuges they have resorted to; how they have conducted themselves as parents; and what their pedigrees disclose, is to be the theme of the following chapters.

But before we proceed further, it is essential that a clear idea should be formed of what constitutes a reptile. Save among experienced naturalists, only the very vaguest notions appear to exist on this head. Generally, a group of animals totally distinct is included in the popular idea of the class reptiles. These alien forms are the frogs and toads, newts and salamanders. Now between the reptile and the creatures just referred to there is a very wide difference. Both agree in being "cold-blooded," in having a backbone, and four limbs adapted for walking: but they differ fundamentally in that the young of the frog-tribe—certain peculiar exceptions apart—when they leave the egg do so in the form of "larvæ." That is to say they differ from their parents in that they are obliged to live in water and to breathe by means of gills like the fishes. Later, these gills disappear and breathing by lungs is substituted. But in this adult stage they still differ from the reptile in that the skin is naked, and richly supplied with glands for the purpose of keeping the skin moist—hence the

"sliminess" which makes these creatures so objectionable to many. Among the reptiles the young leave the egg in the form of the parent—that is to say, they *never* pass through a gill-breathing stage. Further, the body is invested in a scaly covering, and the skull moves upon the backbone by means of a single bony knob, instead of two such knobs, or "condyles" as they are called, as in the frog and its allies. Other characters there are whereby these two groups—the Reptiles and the "Amphibia"—may be distinguished, but we do not intend to discuss them here. They are of too technical a character for this little book.

CHAPTER I.

"BEAKED LIZARDS."

AFTER the elimination of the alien tribes referred to in our Introduction, we have left four large groups, the Crocodiles, the Tortoises and Turtles, the Lizards, and the Snakes, and lastly, a fifth, represented only by a single species, the Tuatera lizard of New Zealand. This creature, with certain fossil forms, constitutes the order *Rhynchocephalia*, or beaked "lizards."

Though but remnants of a fallen race, as we have just remarked, these four groups are so distinct one from another that it will be necessary to tell the story of their rise and evolution in as many separate chapters.

The distinctions which enable us so easily to discern the reptile from the amphibian, are based upon observations made upon living animals. A study, however, of the skeletons of the two groups would have led to practically the same results. But supposing there had been no survivors either of the Amphibia or the Reptiles, then the dividing line would have been very difficult to draw; for though the skeleton of any of the modern Amphibia differs conspicuously from that of any reptile now living, the same is by no means true of the more primitive types of these two groups. Indeed, even at the present day the greatest experts are not agreed as to the class to which certain very ancient fossils belong. One places them with the Amphibia, regarding them as members of the group known as "Labyrinthodonts," another with the Reptiles. These creatures, it is not surprising to learn, are ancestral types from which have probably sprung the living reptiles of to-day. Other and allied forms of the problematical types probably gave rise to some of the fossil species—the "Dragons" of the later chapters of this book. Be this as it may, belonging to the same geological era—the Permian—remains have been found of an undoubted reptile, known as Palæohatteria, which is represented to-day by an actual living descendant, the "Tuatera" of New Zealand. This "living fossil," as it has been called, is thus one of the most remarkable of existing reptiles, and forms in itself a quite distinct group, the fifth, to which reference has just been made. With an ancestry traceable for millions of years, this

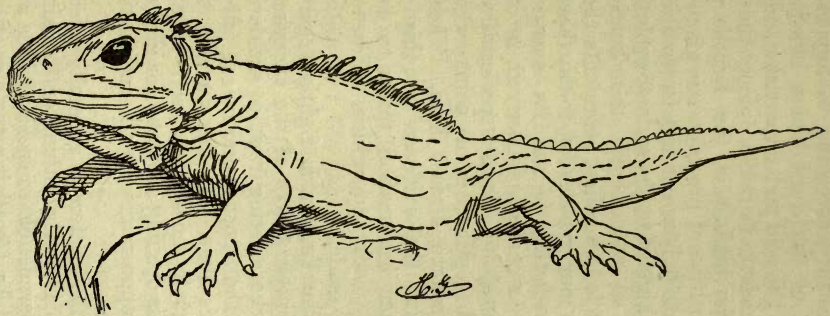


FIG. 1.—The Tuatera lizard (*Sphenodon punctatum*). This is one of the most remarkable of living reptiles, being a direct descendant of the earliest known reptiles.

wonderful creature, according to human standards, is one of the very bluest blood. Yet, measured by the cold and impartial standards of scientific criticism, it ranks among the lowest instead of the highest of the Reptile people. The proud position of precedence is given to the much less ancient house of the Crocodiles, these having risen highest in the scale of evolution.

Whether, as some hold, the Tuatera, or Hatteria as it is also called, represents the stock from whence our reptiles of to-day have been derived, or whether it and its ancestor the Palæohatteria are offshoots derived, in common with the remaining living species, from the problematical reptiles, is a point which we do not propose to discuss here. Those who would examine the evidence on this matter will find much information ready to hand in Dr Gadow's book, to which reference has already been made.

Whether the Tuatera is rightly regarded or not as the representative of the ancestral stock from which the existing reptiles are derived, it is probably the most primitive of all living species of this class. On this account, then, it is fitting that it should be described, at least briefly, in this opening chapter; for many of its peculiarities appear again, with modifications, in other groups.

Although the Tuatera is generally referred to as a *lizard*, it is really nothing of the kind. It is no more permissible to speak of it as a lizard, than it would be to call it a tortoise or a crocodile. It stands by itself in a group apart from

all its contemporaries. The evidence on which this decision is based is of too technical a character for discussion here: we need only say that it rests upon the structure of the skeleton, and of certain internal characters related to the organs of generation.

Of the skeletal structures which appear again in other groups, sometimes strangely modified, we may mention one or two of the more important. The ribs, for example, in the Tuatera are remarkable for the presence of curious hook-like processes which project backwards from the middle of the upper portion of each rib, to overlap the rib next behind it. These "uncinate" processes occur elsewhere only among the Crocodiles and the birds. Behind the breastbone are found numerous rod-like bones embedded in the muscles of the belly. These are commonly known as the "abdominal ribs"; they occur again in the Crocodiles and the ancient "Labyrinthodonts" and "fish-lizards," and it is probable that from the fusion of similar bones the singular shield on the belly of the Tortoise has been derived. The teeth are quite remarkable. Numerous and irregular in size, they occur not only along the edges of the jaws, but also on the bones of the palate. These teeth are not renewed when worn out as in most other reptiles, but fusing with the edges of the jaws gradually wear away till, in very old individuals, the jaws become toothless. It is on this account that the name beaked lizards has been bestowed. Large males attain a length of about two feet and a half. Both sexes are alike save only in that the males have

a larger head and a stronger nuchal crest. Of a dark olive green, with small spots of white on the sides, the general appearance of the animal is sober enough. It is enlivened, however, by a row of pointed and slightly erectile spines along the ridge of the back and extending on to the tail. The under surface is clothed in moderately large scales, whilst those on the sides are so small as to give a granular appearance. The eye is large and has a vertical pupil. The tail is thick and compressed, and like that of many lizards, and at least one species of mammal—a mouse, which occurs in the island of Cyprus—is easily shed. This is an ingenious device which enables the owner to escape when seized by this organ. Among the lizards at least, when threatened, the tail is temptingly paraded, when, as soon as it is grasped, the creature makes a dash for liberty, the tail becoming detached with the slightest shock. The lost appendage is speedily renewed, and with it a new chance of escape from unpleasantly close encounters is gained. A similar regeneration does not, however, appear to take place with the mouse in question.

But perhaps more than on any other account the Tuatera is celebrated for the presence of a third eye seated in the middle of the roof of the skull. It should be mentioned, however, that this organ is now quite functionless and has shrunk to quite insignificant proportions. It is connected by a long stalk with what is known as the pineal gland, an outgrowth of the "primary fore-brain." Coming to the surface through a special aperture in the skull, between the parietal

bones — hence the name parietal eye — it is covered by a horny scale. At one time this eye was undoubtedly functional. But whether it served some peculiar need in the days of long ago, a need which has now ceased to exist, or whether it merely supplemented the normal lateral eyes which were then less perfect than now, no man can tell.

Perchance it is a survival of pre-reptilian days, that is to say of some larval condition, before the lateral eyes were developed.

The discovery of this eye is quite a modern achievement; and immediately the fact of its existence became known a vigorous search was instituted by anatomists the world over, with the result that a similar, but yet more vestigial eye was found in many other living reptiles, and in a large number of extinct forms. In many of the latter, indeed, this eye seems to have been of considerable size. This is especially the case in the old fish lizards, Ichthyosaurus. Besides the reptiles, however, the amphibia and fishes also show traces of this organ.

The Tuatera is, alas, verging on extinction. Bush-fires, wild-pigs, dogs and cats, and reptile-eating Maories and the advancement of civilisation have swept the Tuatera from the mainland of New Zealand, so that to-day it is to be found only in a few uninhabited islands. Here it dwells in the seclusion of a burrow which it digs for itself, and into which a hasty retreat is beaten on the slightest sign of danger. The Tuatera is a sociable animal, sharing its burrow with various kinds of Petrels, though, be it noted,

members of its own species are summarily evicted should they presume to attempt a lodgement.

The birds, by a mutual arrangement, occupy the left, and the Tuatera the right side of the chamber. It is interesting to note that whilst the dark burrow serves all the purposes of a nursery for the bird, which incubates its eggs, it is unsuitable for this purpose for the proprietors of the burrow, who, owing to their more phlegmatic temperament are compelled to seek the aid of the sun to bring their young into being. The hatching time covers a relatively enormous period—thirteen months, and is rendered further remarkable by the fact that the development of the embryo is, for a time, during the winter months, suspended so that the embryo may be said to hybernate within the egg.

Somewhat lazy in their movements as a rule, crawling at a slow pace and dragging the body and tail along the ground, when animated by the excitement of the chase they lift the whole trunk off the ground, and move with some speed. This is kept up, however, only for a few yards, when they grow weary and stop. During the greater part of the day they sleep; and are fond of lying in the water, being able to remain submerged for hours without breathing. They feed only upon other animals, and these they will take only when alive and moving about. During the night, and especially during the pairing season, they are said to croak or grunt.

CHAPTER II.

TORTOISES AND TURTLES.

FAMILIARITY certainly blinds our eyes to much that is wonderful in Nature. Perhaps in no instance is this more true than in the case of the creatures which form the subject of the present chapter. To the world generally the Tortoise is regarded as a somewhat uninteresting creature, the type of sluggishness and the source of the familiar ornamental commodity known as "tortoise-shell," whilst its cousin the Turtle has acquired undying fame on account of the excellent soup it affords when boiled! Yet, if we look but a little below the surface, really as well as metaphorically, we shall discover that these "ugly ducklings" occupy a really unique position in the animal kingdom.

This isolated position these creatures owe to the remarkable coat of mail which they have developed as a protection against their enemies. This armour, in the typical tortoise, takes the form of an inflexible shell investing the trunk, but leaving the head, tail, and limbs free. These, when danger threatens, can be drawn into the front and hinder apertures of the shell so that, being also armoured, a practically invulnerable mass is presented to the enemy.

Critically examined, this shell is found to be composed of an outer layer of horny plates or shields, superimposed upon a closely fitting series

of bony plates, which, like the horny covering shields, are also symmetrically disposed.

Generally, in armour-clad animals where the protecting covering is made up of horny shields covering bony plates, the horny outer layer exactly corresponds to the bony plate beneath it. This is not the case with the tortoises and turtles, or, to use a more comprehensive term, embracing all the members of this order, the Chelonians.

In the specimen from which this figure was drawn, the horny shields in question were removed from one side of the carapace, as this shell is called, so that their relationship one to another and to the bony elements beneath them, can be readily made out. If the exposed portion of the underlying bony shell be examined two sets of patterns can be made out on its surface. One is formed by shallow grooves, which represent the impress of the edges of the horny shields, the other by a series of curiously ziz-zag lines. These represent the sutures or rough jagged edges of distinct bones, which have a very remarkable history, inasmuch as one set—those which may be seen running down the middle of the back—are formed by table-like expansions of what are known as the "spines" of the vertebræ, or backbone, and therefore belong to the skeleton; whilst the remainder, those which take the form of bands, running at right angles to the backbone, and those which form the margin of the shell, are derived from bones originally embedded in the skin. They are this, and something more.

Since the day when they formed nodules of

bone embedded in skin, many and strange changes have taken place. The order of these changes none can tell, only the result thereof is ours, and this, without exaggeration, may be called startling. When we come to take

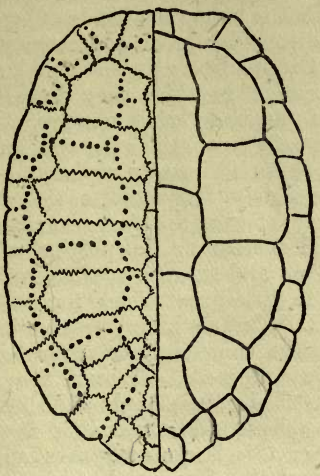


FIG 2.—The upper portion of the shell—carapace—of a tortoise, to show the form and position of the horny plates and underlying bones. The horny plates are indicated on the right hand side, the impression of their edges made upon the underlying bones is shown by dots on the left side. The bones are shown by jagged lines.

an inventory of the structures pertaining to the outside of these creatures—structures which, without previous experience, we might expect to find, since they are found in other reptiles—one of the first things to be missed would be

the skin, and the next the thick layer of muscles underlying this. Both are wanting in the trunk of the Tortoises! When we come to look deeper into this anomalous state of things we find that the bands of bone which we have just described as running at right angles to the long axis of the skeleton, that is to say the bands of bone running from side to side, have a strangely complex history. Originally, as we have said, nodules of bone embedded in skin, they have, with the wasting of the underlying muscles, come to lie at first directly upon the ribs, and later, fusing therewith, have ultimately replaced even these almost completely. So much so, that all that remains to-day, of what appear to be complete ribs, is the head thereof, or the portion which joins the backbone and the tip, or that portion which supports the little bones which form the margin of the shell. This we know, because in the very young tortoise complete ribs are present, but as development proceeds, all save the two ends become absorbed and replaced by the bones, originally, as we have said, belonging to the skin. Exactly how this is done requires an intimate knowledge of the changes which may take place in the tissues of animals, and these we cannot attempt to deal with here. Those who would verify these statements must consult more technical works than this little book, and bring with them at the same time the results of a scientific training.

The history of the breastplate of the tortoise is no less strange. Like the shell this is made up, externally, of symmetrically arranged plates

of horn, covering equally symmetrically arranged bony elements. There is no skin, save that represented by the horny shields, and no intermediate layer of flesh. The bony elements represent in part the bones of the shoulder girdle of other animals, and in part the peculiar "abdominal ribs" which we have already mentioned as a notable feature in the Tuatera "lizard." There is apparently nothing equivalent to the breast-bone of other reptiles to be found in the Tortoises.

The development of the shell has been accompanied by many other and profound changes in the form of the skeleton. Thus, the backbone, between the base of the neck and the base of the tail, has become virtually suppressed, its originally separate elements being greatly reduced, and immovably fused one with another. The reduction of the spine to its present almost vestigial condition has been a long process. The decline was inevitable directly the bony shell had acquired rigidity enough to prevent the movement of the backbone. As soon as this stage was reached a new order of things became established, and the material of the superseded spine became available for absorption and reincorporation into the newly developing structures. This is the fate of all useless organs in Nature; they are broken up, like old buildings, to contribute to the growth of new ones.

Yet another remarkable feature is the position of the limb-girdles. In all other animals the shoulder-blades lie on the *outside* of the foremost ribs; but in the Chelonians these bones are placed on the *inside* of the ribs, *i.e.* within the shell.

Similarly the haunch-bones which support the hind-limbs, in other animals lie behind the last rib, and near the surface of the body, in the Chelonians they lie, like the shoulder-blades, *within* the shell. The anomalous position of

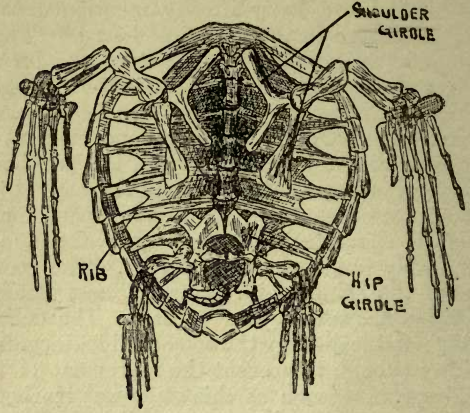


FIG. 3.—The skeleton of a turtle, viewed from the inside, after the removal of the breastplate. Note the position of the shoulder and hip girdles, lying *beneath* the ribs instead of above them.

these bones, however, is only a feature of adult life. In very young tortoises, where the development of the shell has only just begun, the shoulder-blades lie a little in front of the first rib, whilst the hip-bones are to be found just behind the last rib. But the broadening of the ribs caused by the excessive development of the external bony shields gradually creeps over the shoulder-blades in front, and the hip-bones behind, so that

at last they came to lie, as we see, entirely within the shell.

It is interesting to note that some few tortoises seem to have found that the inflexible bony shell, such as we have just described, needed yet further modification to make it a thoroughly trustworthy fortress against attack. This need has been met by developing a hinge either across the carapace, or across the plastron or breast shield. By this means one or other or both of the apertures of the shell can be closed completely as by a portcullis. The hinged carapace, be it noted, is found only in these species belonging to the genus *Cinyxis*, found in tropical Africa, whilst the hinged plastron has been independently acquired by several different tortoises in widely different parts of the world. Thus the little Spider-tortoise of Madagascar has the plastron so hinged that the front portion can be drawn up, so as to completely close the mouth of the shell. The Iberian tortoise of Spain and Morocco closes the hinder aperture of the shell in a similar manner. In this species, however, the hinge does not appear till comparatively late in life, and is best developed in females. Some six species of the genus Testudo, found in India, Madagascar, and S. China, can also close this end of the shell by raising the hinder half of the plastron. But the N. American species of the genus *Cistudo* have made a decided improvement on the mechanism adopted by the foregoing, inasmuch as these can raise both ends of the plastron, so that when the head, legs and tail are drawn in, and the "oak is sported," the

hungry enemy must either pass on to other game, or sit down and endeavour to take his prize by siege! As these creatures are able to live for long periods without food, siege tactics are not likely to succeed.

Before we leave the subject of the shell we must briefly comment on the remarkable carapace and plastron of the rare Leathery Turtle (*Dermochelys*) of the West Atlantic and Indian Oceans—the largest of all living Chelonians.

Like that of the Tortoises we have already examined, the shell is of dermal origin. That is to say, it is made up of bony growths developed in the outer skin; but here the resemblance ceases. For whereas in the Tortoises and Turtles generally these bony plates are symmetrically disposed, and, in the carapace sink down on to and become inseparably fused with the skeleton, in the Leathery Turtle they take the form of innumerable small plates interlocked one with another to form a mosaic. The carapace of this turtle is furthermore peculiar in that it remains permanently distinct from the skeleton, so that, when removed the ribs and vertebrae are revealed, muscle-covered, as distinct as in other reptiles. The horny shields which cover the shell generally in other Chelonians are here conspicuous by their absence; instead, the shell is covered with a smooth, leathery skin—hence the name, "Leathery Turtle."

The fundamental differences between the shell of the Leathery Turtle and that of other Chelonians has an important bearing upon the question of the origin of the two groups. The

mosaic-like plates of the carapace of the former resemble the plates of the bony armour of the crocodiles, and are probably derived from a primitive armature of this kind. If this be so, then the bony plates of other Chelonians must be regarded as a later development, the origin of which is yet to be discovered. This is the view most generally favoured at the present time, and accordingly, we must look upon the Leathery Turtle as the sole survivor of a primitive and independent group.

Parallels are always interesting, and it is seldom that they cannot be found in the animal world, however remarkable the instance we may have to match.

Thus, though the shell of the Tortoise has no counterpart among the living reptiles, we find a very close resemblance thereto in the shell of certain gigantic and extinct mammals—the S. American Armadillos, known as Glyptodonts. These creatures were encased, like the Chelonia, in a bony shell, which in some forms is as much as five feet long, and an inch in thickness. The structure of this shell resembled that of the Leathery Turtle, in that it was made up of a series of small bones closely interlocked to form a mosaic, but different therefrom in that each of these bony plates was covered by a horny shield. As in the Chelonia, the separate bones of the vertebral column were welded together to form a tube. The limb-girdles, however, did not occupy the anomalous position which they held in the Chelonia, inasmuch as they bore the same relation to the skeleton as in other animals.

In the structure of the skull several points are to be observed whereby the Chelonia differ from other reptiles. With these, in detail, we have no concern here; for our purpose it is enough to notice, firstly, that teeth are conspicuous by their absence. Their work is performed by horny sheaths which encase the jaws as in birds. That the ancestral Chelonia had teeth is very probable, and doubtless some day this fact will be established by the discovery of a fossil skull with teeth implanted in the jaws. In one other point the Chelonia and the birds agree—though this of course by no means implies relationship—and this is in the form of the lower jaw, which, instead of being made up of two separate halves, is fused into a single bone.

The breathing of the Chelonia has acquired certain peculiarities, inasmuch as, on account of the rigid walls of the shell, expansion of the chest cavity by the movement of the ribs and abdomen has become impossible. The lungs, which are complicated, spongy structures, are filled and emptied partly by the movement of the neck and limbs, which by their movement act as pistons, and partly by the action of the tongue bones, which are of great size. By these, when the neck is stretched out, the throat is alternately inflated and emptied by air drawn in through the nostrils. The deflation of the throat causes the air to be forced down the windpipe, the valves of the nostrils preventing its escape by any other way.

In every great group of animals we find that the struggle for existence has caused a gradual

dispersal of the members thereof, compelling them to seek a livelihood in an environment quite different to that of the centre from which they started. Thus we get an exchange constantly taking place between the inhabitants of the sea and those of the land. We find the crab deserting his natural element to climb palm-trees for cocoa nuts, and mammals which have adopted the life of fishes. Such an exchange, however, can only take place under certain conditions—the emigrants must adapt themselves to the requirements of their environment; and this brings about a more or less complete transformation of the body.

Among the Chelonia we have many instances of this. Originally terrestrial, some have adopted a fresh water habitat, others have taken to the sea. The modification which these aquatic forms have undergone are sufficiently well marked to render them easily distinguishable from their stay-at-home relatives. Hence we get Land Tortoises, Water Tortoises, and Turtles.

What the ancestral Tortoise may have been like we do not know, but its descendants do not appear to have found any great necessity to change their form after once the general architecture of the body had been determined on. This much is to be gathered from the fact that the fossil remains of these creatures, which occur in remote geological formations—the earliest known Chelonian occurring in the Upper Keuper of Würtemberg—differ but little from the same parts of the skeleton of its nearest modern representative. It is only in minor characters, divid-

ing the larger or smaller groups of species one from another, that modifications occur among the living Chelonia.

This conservatism is really very remarkable when we reflect that they were already an ancient group long before we have any record of the advent of the birds upon the earth. It seems difficult to realise that the conditions of life through such enormous periods of time can have affected them so little.

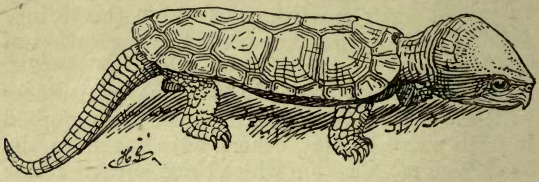


Fig. 4.—The big-headed tortoise. This creature is remarkable for the large size of the head and the extraordinary flatness of the shell.

In the history of the past, many animals have sought protection for the body by encasing it in armour-plate. It would seem, however, that such protection either ends in bringing about the extermination of the species by which it has been adopted, or in being discarded by later generations. The Chelonia afford an exception to this rule. Judging by the conditions of life which obtain to-day, it is not easy to see why this should be so, inasmuch as the Tortoises and Turtles do not appear to be beset by any more formidable enemies than their unprotected reptilian neighbours. The key to the mystery may

perhaps rest in their slowness of motion. Their unarmoured neighbours escape by flight, a way which is impossible to these sluggish creatures.

Land-tortoises may be readily distinguished by their feet. The toes are very short, with no trace of webs between them, and the hind-feet at least are club-footed. The peculiar form of these feet is the outcome of adaptation to the support of the remarkably heavy and inflexible body. To the weight and immobility of the trunk we may attribute the fact that the creatures are confined to the earth. Tree-climbing to them is an impossibility. They may delve below the surface, but they cannot rise above it. But this by the way.

The outer surface of the legs is covered with little horny scales, covering, in many cases, bony nodules, so that when drawn into the shell the mouth and hinder apertures thereof are effectually protected against attack. In some cases, as we have already remarked, these apertures are closed by raising the ends of the breast-plate.

Comparisons are said to be odious. Applied to human affairs this is often true. In natural history it is otherwise. Let us then contrast the method of barricading practised by the Tortoise with that of the remarkable South American mammal, the Armadillo. This animal, like the Tortoise, is encased in bony armour covered with horny plates. The great back-shield differs from that of the Tortoise among other things in its great flexibility, so that, having no breast-plate, the animal can curl itself up into a ball, leaving but a single aperture, which is closed by the tail.

and head-shield. How wonderfully this is done can be seen in the accompanying illustration.

Of the Land Tortoises, one of the most familiar, at least in Great Britain, is the "Greek Tortoise"

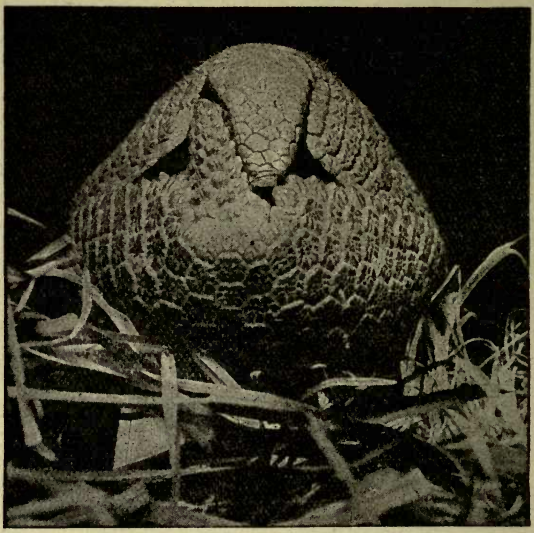


Fig. 5.—Armadillo rolled up.

(*Testudo iberia*), this being the species commonly offered for sale on barrows in the streets, from whence it finds its way into our gardens, and also, not seldom, our houses, being imported into the latter under the mistaken idea that it will kill the "black beetles."

The home of the Tortoise is N. Africa and S. W. Asia. It also occurs in Southern Andalucia, breeding in the sandy pine forests of the Marismas, near the mouth of the Guadalquiver.

There are three claimants, it should be mentioned, to the title of "Greek" Tortoise. The second, *Testudo Græca*, is a close ally of *T. iberia*, and occurs in the northern half of the Balkan Peninsula, Asia Minor, Syria, Italy, and the Islands of the Mediterranean.

The third is the genuine Greek Tortoise, *Testudo marginata*, since it is restricted to Greece proper, and is the only land tortoise which is found there.

These three species are very much alike in habits, and are exclusively vegetable feeders. They are very fond of basking in the sun, and extremely averse to getting wet, retreating to some sheltered place on the fall of the first few drops of rain. On the approach of winter they bury themselves in a hole in the ground, or in a heap of decaying leaves and there hybernate till spring.

The "Gopher" Tortoise of the South-eastern States of North America is a particularly interesting species on account of its curious habit of living in a burrow. The burrow, at its mouth, is only sufficiently wide to admit the body of the animal, and runs slightly downwards to a length of about four feet. The whole passage may be as much as two yards long, and gradually widens from the mouth inwards, terminating in a spacious chamber lined with branches of fir trees. Each burrow is inhabited by a pair of tortoises. When

the dew is on the grass, or after rain, they emerge to feed upon the grass, succulent vegetables, or fruit, varying this with gum which exudes from trees, especially the gum of the pine. This species is easily captured by the simple expedient of digging a hole in front of the entrance to the burrow, so that the animal when leaving its house immediately falls into the pit.

Beauty of form the Tortoise has not, but the coloration of the horny plates of the back, in some species, is certainly striking. This is especially true of a small group known as "elegant" tortoises. The majority belong to S. Africa; but perhaps the most beautiful of all is the "starred" tortoise (*Testudo elegans*) of India and Ceylon.

All the members of this group are conspicuous for their extremely convex carapace. The horny covering shields are either black with bright yellow lines radiating from the centre of each, or yellow with black radiating lines. The effect of this black-and-gold scheme of coloration is, in many species, heightened by the elevation of the scales into prominent bosses.

It might be imagined that such a plan of coloration would render the wearer extremely conspicuous. As a matter of fact, the reverse is the case; for it has been shown that these tortoises are very difficult to distinguish from the rocky ground of the grass jungles in which they live.

According to an old Sanskrit legend, the world is supported on the back of a gigantic elephant,

whose feet are planted on the back of a still more gigantic tortoise. What the tortoise took its stand upon the legend does not so much as hint at! This old legend, like so many legends, has a central particle of solid truth, inasmach as large species of tortoise occur both in Europe and North America, as far back as the Eocene, one species, indeed, from the Siwalik Hills of India having a carapace nearly six feet long.

These ancient giants have long since ceased to exist on the continents either of the Old or New World. They were, says Dr Günther, "unable to survive the changes of climate in the northern latitudes, or to coexist with the large carnivora, and especially with man, in the more congenial south. But there were two spots on the earth's surface where they continued to flourish to within a century or two of our time—viz. Madagascar and the neighbouring islands of the Western Indian Ocean, and the Galapagos Archipelago in the easternmost part of the Pacific."

They do not appear to have lived in Madagascar within historic times, having probably been cleared off from the inhabited parts of the island at the time when the first Europeans landed. But their skeletons occur in considerable numbers throughout the island.

In the islands north of Madagascar, however, these creatures dwelt in absolute security for ages, none of these islands, save the Comoro group, being inhabited either by man or large mammalia. As a consequence, with absolute freedom from enemies, they had nothing to do

but to eat, to multiply, to grow in stature, and possess the land. Thus, not only the larger islands of the Aldabra group—the Seychelles, Reunion, Mauritius, and Rodriguez—but also the smaller islands became peopled in incredible numbers.

The discovery of these island fastnesses by Europeans speedily brought about the downfall of these harmless creatures. Their vast numbers melted like the snow. Proving more wholesome and more toothsome food than turtle, every passing ship stopped to bear away as many as she could carry. Later, a still further drain upon their ranks was imposed by the settlement of naval and military forces, until speedily the supply became exhausted. Recourse was then had to importation from neighbouring islands, and we gather from the reports of the French India Company that in 1759 four small vessels were accordingly employed in bringing tortoises from Rodriguez to Mauritius. One vessel carried a cargo of no less than 6000, and altogether more than 30,000 were imported into Mauritius in less than eighteen months!

As a result the dawn of the nineteenth century witnessed the practical extinction of these wretched creatures on all the islands save the south island of the Aldabran atoll. Here a few stragglers still possibly remain, thanks to the rugged character of the land.

Of the tortoises of the Galapagos Islands much the same story must be told. At the beginning of the sixteenth century immense numbers existed in these islands. Now only three, Abing-

don, Albemarle, and Duncan Island harbour a few survivors.

Such is the lamentable history of these helpless victims, as collected with infinite pains by Dr Günther some five years since.

Isolated by the submergence of the lower land, these tortoises were prevented from interbreeding and the swamping effect of intercrossing, so that in time each group of islands, and in the case of the Galapagos, almost every island came to possess its own peculiar species.

Of the many species of these Galapagos tortoises which have been described, two only can be mentioned here. The first, and perhaps the most interesting of all, is Daudin's Tortoise, *Testudo daudini*, from the south island of Aldabra. A specimen recently in the collection of the Hon. Walter Rothschild was the largest living tortoise known. The length of its shell was 55 inches, or 67½ over the curve, and the weight 560 lbs. The species known as *Testudo abingdoni* is peculiar on account of the thinness of its shell, which is extremely delicate. A curious feature about the carapace of these Galapagos tortoises, or at least of the majority of the species, is the great size of the opening of the front of the shell, which presents a cave-like appearance, very different from the narrow crescentic aperture of the typical tortoise.

Water is hard to find in the islands where these tortoise live, and travellers have often found relief for their parching thirst in the fluid contained in the pericardium or membrane surrounding the heart. The naturalist Baur relates

an instance where he and his five companions, when thus suffering, found relief by killing one of the species known as *Testudo vicinia*, a native of Albemarle Island. They found no less than five cups of clear fluid in this receptacle. Similarly Darwin relates in his "Voyage of the Beagle" how that the contents of the bladder are also, under pressure, greedily drunk. The taste of the fluid is said to be bitter, whilst that of the pericardium is tasteless.

The difference between the fresh-water or pond Tortoises and Terrapins and their cousins of the dry land are generally by no means such as would strike one at first sight. So closely do they resemble one another, indeed, that some surprise might naturally be expressed that such different environments should have effected so little change. The only difference between the land and aquatic forms appears to be in the form of the feet, the aquatic species having webbed feet, which may even become paddle-shaped. A more careful examination of one of these pond-tortoises would, however, reveal modifications which are obviously special adaptations to their peculiar mode of life. Besides the change in the form of the feet to facilitate movement through the water, special breathing organs have been developed to permit of prolonged submersion. Thus in certain "soft-shelled" tortoises of the sub-order *Trionychoidea*, the mucous membrane of the throat is beset with thread-like processes richly supplied with blood. These act like the gills of fishes, fresh water being constantly taken in through the mouth and passed over the delicate blood-filled pro-

cesses which exchange the carbon dioxide of the blood for oxygen. But there is this difference between the breathing of the tortoise and that of the fish. In the former the vitiated water is expelled through the mouth, in the fish through one or more slits at the sides of the throat. The water breathing of these tortoises is supplementary to that of the lungs, and is effected in a perfectly rhythmical manner some sixteen times per minute, by the movement of the hyoid or tongue bones. Other water tortoises, such as the European Pond-Tortoise (*Emys orbicularis*), and the Sculptured Terrapin of North America (*Clemmys insculpata*), have developed accessory breathing organs in the shape of thin-walled bladders which open into the hinder end of the gut. The inside of these bladders is richly supplied with blood-vessels which are bathed by a constant exchange of fresh water, the bladder being incessantly filled and emptied through the vent. If one of these tortoises is suddenly taken out of the water the contents of these vessels will be instantly squirted out. Although this habit is well known, the source of the water is generally misunderstood, inasmuch as it is usually supposed to be the urine from the bladder.

Yet another extremely interesting modification which the pond-tortoises have undergone is that displayed by a large number of species forming the sub-order *Pleurodira*. These all have extremely long necks, and on this account apparently are unable to retract them so as to draw the head within the shell. Instead, they

curve the neck round to the right or left bringing it and the head under the eaves of the "carapace," hence the name side-necked tortoises. Of course in this way the whole of one side of the head and face is exposed. In most land-tortoises this would be a grave danger, but apparently in the aquatic regions the need for such effective protection is less urgent.

When, probably owing to overcrowding, some of the more adventurous tortoises essayed to make a living by the margins of pools and shelving banks of streams, and eventually in the water itself, they apparently found it expedient to exchange a vegetable for an animal diet, inasmuch as the water-tortoises of to-day are almost entirely carnivorous. To the carnivorous habits we may trace further peculiarities in the development of new traits of character called forth by the very different nature of the food. Preying on other living creatures, often more active and highly organised than themselves, their only chance of success is, not seldom, by cunning.

An admirable instance of this is furnished by the Snapping Turtle or "Snapper" (*Chelydra serpentina*), one of the largest of the pond-tortoises. Fishes are decoyed within striking distance by the artful display of two temptingly worm-like filaments protruding from the tip of the tongue, the rest of the animal being concealed in the mud. The consequences of touching these are far more serious than treading on the tail of the Irishman's coat! Larger prey this diabolical monster captures by stealthily ap-

proaching under the disguise of an old rotten log. This disguise is afforded by the fresh water algæ which grows luxuriantly on its shell, and on the mud which settles there.

The Snapper measures more than three feet from the snout to the tip of the tail, and has a geographical range extending from the Canadian Lakes, east of the Rockies, through the United States to Central America. It is held in wholesome fear, even by man himself, on account of the severe bites which it is capable of inflicting, and is besides cordially hated for the destruction it causes amongst food-fishes and water-fowl.

For this destruction, however, the Snapper pays a heavy toll, inasmuch as young Snappers are caught in considerable numbers by his arch-enemy man, for table purposes. Their capture is effected by a hook baited with pieces of fish; but the tackle used must be of the strongest, for a hooked Snapper is not taken without a struggle. Only the young are esteemed, the adults being uneatable owing to the strong odour of musk which pervades the flesh.

The "Alligator Turtle" (*Macroclemmys temmincki*), a very near relative of the Snapper, and very like it in size and appearance, is even more ferocious, perhaps we should say courageous. When danger threatens, instead of retreating within its shell it assumes a defiant attitude. Raising itself on its legs, with open mouth, it throws itself upon its assailant with great spirit, shooting out the head as far as the long neck will allow, and at the same time throwing the body forwards, often with such impetus as to

bring it to the ground should the object aimed at be missed. The strength of the jaw is surprising. One of these creatures has been known to bite a piece clean out of an inch plank.

The cunning of the disguise of the Snapper is equalled only by one other pond-tortoise—the "Mata-mata" (*Chelys fimbriata*). The back of the shell in this animal, as in the Snapper, bears a close resemblance to an old sunken log, but the guise has been acquired by somewhat different means, large conical bosses, divided from one another by deep valleys, giving the appearance of rough bark, and thus taking the place of the algæ on the shell of the Snapper.

Like the Snapper, the Mata-mata has assumed a disguise in order to increase the effectiveness of a lure by which unwary fishes and other prey may be brought within reach of the mouth. The lure in the present case takes the form, not of brightly-coloured filaments from the tongue, but of ragged-looking flaps of skin projecting from the head and neck. The ear-flaps and the flaps of skin on the throat are kept in constant motion, and thereby attract the attention of passing fishes and other curious creatures which, drawing closer and closer, are at length brought near enough to the mouth to be suddenly engulfed by the inrush of water down the throat of the artfully concealed monster.

The Mata-mata is a native of the rivers of Guiana and Northern Brazil, and is perhaps the most bizarre-looking of all its tribe. It is a really big tortoise, attaining a length of more than three feet when fully adult.

From the pond-tortoises we pass, by a very natural transition, to the Marine Turtles. In them we see the final results of adaptation to an aquatic life. Whilst the general form of the body has undergone little or no change, the limbs have become completely transformed into swimming paddles. In the fore-limbs the extent of the changes is extremely marked. Neither in the fore nor the hind limbs are digits any longer to be distinguished; in accordance with their new functions in both limbs they are enclosed within a common skin, so that the once walking limbs have now become "paddles," superficially bearing the strongest resemblance to the paddles of the old fish lizards—the Plesiosaurs and Ichthyosaurs, to be described later—the Penguins among the birds; or the Whale tribe among the Mammals. In all these cases, just as in the turtles, the paddles have been evolved by the modification of limbs originally used in quite other ways. Another point of interest with regard to the paddles of the turtles is, that whilst those of the fore-limbs were of great length, the hinder pair were extremely short. The explanation of this, of course, is obvious—the long paddles were used as propellers, the short ones as rudders. The same applies also to the ancient Ichthyosaurs, and to the modern whales. In the latter, indeed, the hind-paddles have disappeared altogether, the work of steering being undertaken by the tail. In some other cases, to be discussed as we proceed, we shall find this arrangement exactly reversed—the hind-limbs developing at

the expense of the fore, so that these became in time reduced to the merest vestiges.

Ill-fitted as they are for a life ashore, yet the females, at anyrate, are obliged to sojourn here awhile, at least once a year, when they come to deposit their eggs. Other aquatic reptiles, such as the ancient Plesiosauria and Ichthyosauria, seem to have avoided this necessity by retaining the eggs within the body until they hatched—that is to say, they were viviparus.

Gigantic as some of the tortoises have become, they are surpassed by their sea-dwelling cousins the turtles, the species known as the Leathery Turtle, sometimes weighing as much as a ton. This animal, however, is like other giant forms, verging on extinction. We shall see indeed as we proceed how often Nirvana has been achieved by the reptile-people through the gateway of over-growth.

The Green-turtle or "edible-Turtle" (*Chelone mydas*), and the Hawks-bill Turtle (*Chelone imbricata*), in so far as the general shape of the body and paddles is concerned, are extremely like the Leathery Turtle just described, yet, as has been pointed out earlier in this chapter, they are only in a very remote degree related—their similarity is due to what is called "convergence of development," and not to community of descent. It is this same convergence, this adaptation to environment, which has produced the community of likeness, which has been pointed out between such widely different forms as the turtle, the fish-lizards, and the whales.

The Green-turtle is the species which plays

so conspicuous a part in our great public feasts. The home of this creature is in the Atlantic, Indian and Pacific Oceans, and throughout this vast area it roamed at one time in abundance, though the numbers are now greatly reduced. Large specimens attain a weight of more than three hundredweight.

It is from the horny shields of the Hawksbill Turtle, of tropical and sub-tropical seas, that the world's supply of tortoise-shell is obtained. The removal of these shields is in many cases accompanied by the most revolting barbarity. The miserable victim is held over a fire till the heat makes the coveted horny plate part from the bony shell, after which the poor beast is allowed to escape to the sea—there to die a lingering death. This end is not, however, believed in by the brutes who inflict this torture. They believe that once in the sea a new set of plates will be developed, and thus a crop will be assured for future harvests. Such is the practice of the Singalhese. The natives of Celebes are more humane. Their prisoner is killed by blows on the head, and the body immersed in boiling water, with the desired result.

Shields are rarely thick enough to use for commercial purposes as they leave the body. Accordingly several are welded together by being heated in oil or boiled. Even the shavings can be melted and moulded into large pieces.

Other species of turtles there are, but considerations of space not only forbids their

mention, but compels us to omit much that we would have said about the species which we have selected for discussion.

CHAPTER III.

CROCODILES.

FEROCIOUS and repulsive in appearance, the Crocodiles of to-day nevertheless are a most interesting and highly important group. To them belongs the distinction of being at once the largest as well as the most highly organised of all the living Reptiles.

Their origin is still a mystery. The earliest known members of the group carry us back to the Liassic period; but previous to this there had existed in the still older Keuper formations crocodilian forms which, though more primitive in structure in some respects, were yet too specialised in others to render it possible to regard them as the ancestors of the Crocodiles of the Lias and their living descendants. That the Crocodiles, in a wide sense,—that is, including the very early forms of the Keuper formations—are related on the one hand to the remarkable Tuatera Lizard (Hatteria), and on the other to the still more remarkable and extinct Dinosaurs, there can be no doubt. More remotely the group appears to be related to the Tortoises and the extinct Plesiosauria, the long-necked fish-lizards of the Trias and Lias.

Though in general appearance Crocodiles look very much like gigantic lizards, yet a closer examination will show that this resemblance is rather accidental than due to a community of descent. The peculiar lizard-like form we must regard as the common inheritance of all the reptiles; and variations on this are the result of modification in adaptation to environment.

Among living Crocodiles and their direct ancestors, the rough outline of this primitive form have been more or less faithfully preserved, and this because they have escaped extreme specialisation in any one direction. Though aquatic in habits, yet, like the Newts among the Amphibia, the land has never been entirely forsaken. Among living Crocodiles the shore is the repository for the eggs, and to the shore they resort for the daily sun-bath. Further, they are frequently compelled to travel overland in search of water when the streams which give them harbour dry up. That their extinct ancestors, and the yet older forms which preceded them, led similar lives, is almost certain. Indeed evidence is forthcoming which makes this conclusion irresistible.

If, superficially, the changes which the environment has effected are not great, yet direct adaptations to environment can be easily discovered. Externally the most obvious are the webbed feet, the bony armour, and the enormous tail, which is used as a propeller; and after these the position of the eyes and nostrils. Internally modifications of the skull and of the soft part of the palate have taken place, which enable the

animal to drag its prey under water, and yet save itself from drowning by the inrush of water into the open mouth. In other words, it must drown its prey without drowning itself. To do this the hinder margin of the tongue is raised into a transverse fold, which is met by a similar fold hanging from the back of the roof of the mouth, and known as the velum palatinum. When the edges of these two folds meet, the mouth cavity is completely shut off from the throat, and consequently from the entrance to the gullet and windpipe.

If we turn to the skull we shall find that besides this peculiar modification of the soft parts of the mouth, other and very considerable changes have taken place in the form and arrangement of those bones of the palate which are concerned in the formation of the respiratory passages. As a result of these changes the creature is enabled to lie submerged and open-mouthed, in wait for his prey, the while breathing as freely as if on land. To understand the nature and extent of this peculiar modification, a brief sketch of the method of conveying the air to the windpipe and lungs in reptiles, unmodified in this respect, will be helpful. In them the nasal passages, traced from the snout backwards, open into the roof of the mouth near the middle of the palate, the air passing from thence to the aperture of the windpipe at the back of the throat or pharynx. Now in the Crocodiles these passages are continued backwards to the extreme hinder end of the skull, so that the air is conveyed from the nasal passages backwards directly into the pharynx, which, as we have already seen, is, by a special

arrangement of folds produced by the tongue and the velum palatinum, completely shut off from the mouth. Thus, though the mouth may be filled with water, the animal can breathe with impunity, by simply thrusting the tip of the snout above the water, which would not be possible if the posterior apertures of the nostrils opened in their usual place.

This peculiar arrangement, be it noted, is not an institution of yesterday, but the result of a slow series of changes, which took ages of geological time to accomplish. The remains of the ancient Crocodiles of the Jurassic period show that in them the change had already begun. From thence onwards to the Cretaceous, the completion of this important passage was slowly pushed forwards to its final accomplishment.

The position of the external nostrils, to which reference has been made, is obviously the result of a more perfect adaptation to aquatic life. If a living specimen be examined it will be noticed that these apertures are seated at the extreme tip of the snout, and directly raised above its surface. They can be closed at will, so as to exclude the water, when the animal is completely submerged, whilst from their peculiar position they enable the animal to breathe, so long as they can obtain air, even while the rest of the body is below the surface, and the mouth open, since the water is excluded from the air passage at the back of the throat by the mechanism just described.

The old Jurassic Crocodiles have revealed yet other important facts which throw light upon the course of the evolution of their descendants,

Perhaps the most important of these facts is that which concerns the relative lengths of the fore and hind limbs. In the fossil forms in question the hind-limbs are conspicuously the longest; and this continues to hold good until Tertiary times, since when the differences have greatly diminished. From this we may gather that among the earlier members of the family the hind legs played a more important part in swimming than now. Gradually, however, this work became thrown upon the tail, and in proportion as it took up the work of the legs the latter diminished, according to the law of the substitution of organs. That is to say, the tail developed at the expense of the legs.

The fore-limb reveals a still more startling piece of evidence concerning the past history of the group. This time we glean our information not from the remains of bygone days, but from the developing embryo of living Crocodiles. Herein we find that the small bones or phalanges of the fourth or fifth fingers are more numerous than in the adult. Thus, in the fourth finger we find seven, and in the fifth finger six phalanges in place of four. Before development is complete these additional phalanges have disappeared. To the initiated the discovery of these little temporary bones threw a ray of light upon the gloom which enshrouded the early origin of the Crocodiles, using the word in its widest sense, and not merely to include the former, which had lived from the Jurassic onwards. They showed that the stock from which this illustrious house derives its origin was probably of more strictly aquatic habits than

was hitherto supposed. And for this reason. Strictly aquatic animals, which use their limbs in swimming, have commonly adopted the plan of increasing the length of the hand and foot by adding to the number of these little phalangeal or finger bones, as witness the old Fish Lizards, the Turtle, and the Whales among the mammals. The inference is, then, that the temporary presence of similar additional bones in the hand of the developing Crocodile is a reminiscence of an ancient swimming organ long since obsolete. That it was never completely paddle-shaped, as is the turtle or whale, we may be sure, inasmuch as both these are too highly specialised ever to be reduced again to the normal hand or foot from which they were derived. That the inference will some day be abundantly proved by the discovery of some "new" fossil, we may predict with tolerable safety.

Whether these long-handed ancestors were really more aquatic in their habits, or simply used the limbs more than the tail in swimming, we cannot of course say. But we have positive evidence to show that a very near ally of the living Crocodiles actually did exchange the amphibious for a purely aquatic life.

The creature in question (*Geosaurus suevicus*) has long been known from fragments obtained from the Jurassic, but the intensely specialised character of the animal has only recently (1892) come to light through the researches of Dr Fraas, a German naturalist. He has shown us that it resembles its contemporaries of the Jurassic in that the hind-limbs are

longer than the fore. Here, however, resemblance, both to fossil and recent crocodiles ceases. inasmuch as the lizard-like form is completely transformed by adaptation to an exclusively aquatic, and probably marine life. This adaptation has produced a remarkable but superficial likeness to its contemporary the Ichthyosaurus. The fore-limbs were paddle-shaped, whilst the hind-limbs were of considerable length, and terminated in a broad, webbed foot. They probably

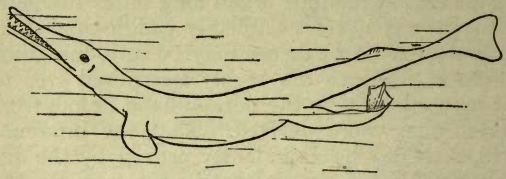


FIG. 6.—Outline Restoration of an extinct Crocodile specially adapted for an exclusively marine life.

performed the work of locomotion, whilst the tail, of great length, and terminating in a broad fin, served as a rudder. The paddle-shaped fore-limbs were probably used only as balancers.

That these limbs are the result of specialisation for the purpose of swimming there can be no doubt, and it is equally certain that this peculiar transfiguration can only have taken place after they had ceased to be used as supports for the body on dry land. The development of the paddle-shaped fore-limb has resulted in many profound structural changes in which only the four fingers have escaped. Thus the upper arm bone, or humerus, lost its characteristic shape,

and became modified to form a broad, much-compressed cylinder, whilst the fore-arm and wrist are still more strikingly changed. In the former, instead of a pair of moderately long and stout rods, we find a pair of greatly expanded plates; whilst the latter, instead of being made up of a series of small bones, is represented only by one large and one small quadrangular plate. The thumb has undergone the same flattening process, the first joint or metacarpal bone forming a broad semilinear plate instead of a slender rod; the second joint or first phalanx being similarly modified, but in a less marked degree. The four fingers have undergone little or no change. During life the whole of this limb was completely invested by the skin, like a hand which is thrust into a fingerless glove. The accompanying illustration will show at a glance, not only what this transformed hand looked like, but how great a change it has undergone when compared with the limb of a modern crocodile.

The hind-limb, though less profoundly changed, is yet conspicuously modified. The thigh-bone is relatively of enormous length, being as long as the shank and foot combined. The latter has retained only a vestige of the fifth toe, whilst the bones of the first or great toe have, like the thumb, become greatly flattened. They differ, however, from those of the thumb in that their length greatly exceeds their breadth. During life this limb appears to have served the purpose of a long oar.

The body of the Crocodiles, like that of other

Reptiles, is completely invested in a covering of horny scales; and underlying these, in certain parts of the body, is an armour-plating of bone. The more important features of these scales, and of the bony armour, we propose now to briefly outline.

If these scales be carefully examined, there will be found in the centre of each of those of the sides, belly, and tail, and especially those of the lower jaw, a little dot or pit. At this spot the scale is soft, and at the bottom of the pit, careful dissection would show the delicately sensitive terminations of a nerve. On the lower jaw instead of a pit we find little wart-like prominences, also provided with sensory nerves. Through these delicately constructed channels the body is kept in touch with the outer world.

The bony armour is made up of a series of closely interlocked square plates, each plate corresponding in size to the horny scale above it, and having a peculiar honey-combed appearance on the outer surface. In the majority of living Crocodiles this armour is confined to the upper surface. A large cluster occurs in the neck, and behind this follows a huge shield investing the whole of the back. Only in the Caimans (p. 69) do we find similar bony plates on the belly.

Why this armour was originally assumed, and why it is still retained, we can only guess. Probably it was developed as a protection against collision with rock and tree-trunks in time of flood. There seems some foundation for this view inasmuch as the fossil species Metriorhynchus

and Dakosaurus were quite defenceless, and these are known to have been marine forms, and therefore removed from dangers of this kind. *Notosuchus* of the Cretaceous was also defenceless, and apparently a swamp-dweller. The one or two species of armoured marine crocodiles must be regarded as originally river crocodiles which had not had time to lose their armour before extinction overtook them. A form known as *Teleosaurus*, of the Lower Oolite, had dorsal and ventral armour.

Long descriptions of the internal organs would be out of place here, but a few brief comments on one or two which will serve to bring out the differences between the Crocodiles and other Reptiles should certainly be acceptable.

The organs of sense are well developed. The eyes, in addition to an upper and lower eyelid, are provided with a peculiar sheet of membrane which can be drawn across the eyeball. This is known as the nictitating membrane, and is exceedingly thin and transparent. Its movements carry over the eye a watery fluid secreted by a special gland, and thus its surface is kept constantly moistened. When under water this curtain is drawn over the eye as a protection, its transparency being so great as to leave vision unimpaired.

The position of the eyes and nostrils are directly connected with the habits of the animal. Both are placed on the top of the head, projecting considerably from the surface. This arrangement allows the animal when in the water to breathe and see at the same time whilst

the body is submerged. In this way prey can be approached unsuspected.

The external ear, too, has been directly modified in accordance with the peculiar habits of the animal. Its aperture lies in a deep recess overhung by a flap of skin provided with muscles, which by their contraction close the aperture and prevent the inrush of water. Like the eyes and nostrils, the aperture of the ear is on the surface of the skull, so that hearing as well as sight and smell is possible when the animal is submerged.

The tongue is large, and fixed to the floor of the mouth, so that it can be raised, but not protruded as in lizards. Its surface is covered with numerous tiny wart-like processes, which form the centres of touch and taste. The peculiar fleshy fold which runs across the back of the tongue, and the part it plays in the breathing of the creature when in the water, we have already described (p. 48).

The lungs have attained a high degree of perfection, and resemble those of birds. They differ, however, both from those of the birds and those of the tortoises in that, instead of being attached to the roof of the chest cavity, they are quite free.

The stomach and heart demand a passing notice, inasmuch as both these organs are more highly developed than in other reptiles.

The stomach seems peculiarly small, when we remember that these huge creatures can swallow very large animals, man himself sometimes falling a victim. Large prey is, however, not

swallowed whole, but torn to pieces by the powerful jaws and teeth, aided by violent and sudden wrenches of the body from side to side. Thus, in a very short space of time the carcase is broken up and swallowed piecemeal. Having regard to the carnivorous diet, the structure of the stomach is peculiar, inasmuch as its walls are thick and fleshy as is the gizzard of a grain-eating bird, which it furthermore resembles in that the inner walls of this gizzard are hardened. This stomach, however, differs from that of birds in that of the two compartments, of which it is composed, the first forms the gizzard-like portion, whilst the second and much smaller has glandular walls secreting digestive fluids. In birds the glandular lies in front of the muscular portion. In flesh-eating birds the walls of the stomach are thin, and one would have expected to find the same conditions obtain in the case of the Crocodile. If the stomach is small, the capacity of the gullet is considerable, and it is in this ante-chamber to dissolution that the prey is stored, being gradually thrust backwards as digestion proceeds.

The heart differs from that of all other Reptiles, and agrees with that of the higher animals—birds and mammals—in that it is divided into four chambers, though the separation of the arterial and venous blood is not as complete as in the bird or mammal.

Finally, we may remark that the Crocodiles differ from all other Reptiles, as well as from the Birds, in that the chest containing the heart and lungs is, as in the mammals, shut off from the

abdominal cavity containing the rest of the viscera by a muscular partition: though this, it is to be remembered, is of a different origin from the mammalian partition known as the diaphragm.

The more perfect condition of the lungs and heart, and the separation of the chest from the abdominal cavity are points of exceeding interest, foreshadowing the still more perfect conditions of the organs in the more highly organised birds and mammals, which at the time when the earliest Crocodiles flourished had not yet made their appearance on the earth.

So far, perhaps, it may be objected, this chapter has savoured more of the museum and dissecting room than of living Crocodiles. Although this is, in a measure, true, yet it is contended that the facts which we have been discussing are just those which will enable us to appreciate the more fully the various phases which make up the life-history of these animals. In studying these creatures in their wild state, or even in Zoological Gardens, these somewhat technical details fall into their proper places, and losing whatever appearance of pedantry which paraded by themselves they may appear to possess, will be regarded as so many keys unlocking as many separate mysteries, and thereby giving us an insight into the great mystery of all—how the Crocodile came to be.

To see the Crocodile—using this term in a wide sense to include all living species of the group—in a wild state we must travel beyond the confines of Europe, though earlier in the

world's history they occurred here. Indeed, remains of several kinds of Crocodiles, long since extinct, occur in different geological formations of the British Islands, finally becoming extinct during Tertiary times. To-day, we meet with these Reptiles only in the tropical and subtropical regions of America, Africa, Asia, and Australia.

To the observer watching these animals for the first time, whether at large or in captivity, the first thing probably to attract his attention would be their remarkable resemblance to a log of wood, a resemblance heightened by their absolute stillness. This likeness is obviously advantageous to the Crocodile, especially when lying in wait for prey in the water. Thereby they pass for what they seem to animals coming to drink, which in consequence approach unsuspecting to quench their thirst, and are then seized by the nose, dragged down into the water, and held there till drowned. Once the jaws have closed on a victim they rarely lose their grip. Man himself does not escape. In India a long roll of victims has to be recorded every year, and these are chiefly women who come to the river for water or to wash clothes therein. Men have been known to regain their freedom from this terrible foe by digging their fingers into the creature's eyes. The opportunity to do this, however, but seldom occurs, and probably even then may lose it in their terror. Strangely enough, in some places, though Crocodiles swarm, man is never attacked. Possibly because other prey is plentiful.

Swamps and pools, and the banks of rivers are the common haunts of Crocodiles, though some frequent estuaries, and from thence stray far out to sea.

How these creatures have slowly adapted themselves to their environment we have already seen. We may therefore now pass on to describe the different types of Crocodiles, and the characteristic features and habits of some of the more important species.

Whether the Crocodiles of to-day should be regarded as representing but a single group, or divided into two separate families, is a moot point with naturalists. Those who hold the latter view consider the Gharial of the rivers of western India and Arakan, and the False Gharial of Malaysia as representatives of a distinct family, the direct descendants of the long-snouted crocodiles of the Cretaceous, whilst the Alligators, Caimans and Crocodiles they regard as descendants of a short-snouted type of the older Jurassic period.

The Gharial and False Gharial are to be distinguished externally by the length of the snout and slenderness of the teeth. There are besides certain distinguishing features to be found in the skeleton, but into these we need not enter.

But little is known of the habits of the Gharial although in its native rivers it is common enough. The remarkably long snout of the species, and the peculiar slenderness of the teeth are probably adaptations to facilitate the capture of its prey, which appear to consist almost entirely of

fish. It is interesting to note in this connection, that the Gangetic dolphin (one of the mammalia), which lives in the same rivers, has a similarly elongated snout and teeth of the same slender type. As this creature is also a fish-eater, the elongated beak is probably also the result of adaptation to the same end. A full grown Gharial may attain a length of twenty feet or even more, though this length is far exceeded by a closely allied species—*Rhamphosuchius crossidem*—long since extinct, which attained a length of fifty feet. The tip of the snout in the Gharial is greatly expanded, and in the male this expanded portion is surmounted by a hollow hump on the top of which the nostrils are placed Apparently this hump comes within the category of sexual ornaments, for when the nostrils are closed it can be inflated like a bag. Feeding only on fish, this species rarely attacks man, and it is probably on this account that it is held sacred by the Hindus in many parts of India. Cases are on record, however, which show that large individuals, at least, will occasionally select human victims; but such instances appear to be rare.

Crocodiles may be distinguished from Alligators by the fact that, in the former the fourth tooth of the lower jaw fits into a notch in the upper jaw; whilst in the Alligators this tooth fits into a pit instead. In very old Alligators this tooth often perforates the bone and is visible on the surface of the upper jaw.

The geographical range of the true Crocodiles is extremely wide, since they are found in Africa,

S. Asia, Malaysia, Australia, and America. Three groups may be distinguished according to the shape of the head. In the first the head is long and narrow, recalling that of the Gharials; the second is intermediate in type between the first and third, which last has the muzzle very short and broad like that of the alligator, from which, however, it may readily be distinguished by the peculiar notch in the upper jaw for the reception of the fourth tooth.

One of the best-known of the Crocodiles is the Marsh Crocodile (*Crocodilus palustis*), known in India as the "Mugger." This species inhabits the rivers and marshes of India and Ceylon, extending eastwards through Burma and Malacca into the Malay archipelago.

In India it is held in veneration by the Hindus, and is kept in a state of semi-domestication, attended by fakirs. Mr A. L. Adams has given a graphic account in his "Wanderings of a Naturalist in India," of a visit to a celebrated crocodile pond or "mugger-peer" at Karachi. This pond, some three hundred yards in circumference, and studded with small islands, was the home of hundreds of these scaly creatures of all sizes and ages. Visitors being expected by the fakirs who have charge of this pond and its inmates to pay for their entertainment by providing a feast for the scaly monsters, Mr Adams had a goat slaughtered, "during which operation," he says, "the brutes seemed to rouse themselves as if preparing for a rush. Then our guide, taking piece after piece of the flesh, dashed it on the bank, uttering a

low, growling sound, at which the whole tank became in motion, and Crocodiles, of whose existence we had been before ignorant, splashed through the shallow water, struggling which would seize the prize." The largest of these crocodiles, said to be over two hundred years old, lived by himself in a long narrow tank. By way of further distinction the fakirs had painted his forehead red; and they and the natives who worship in the neighbouring temples showed him great veneration, making a salaam whenever he showed himself above water.

According to Sir J. Emerson Tennent, the Marsh Crocodile is an arrant coward, hastening to conceal himself on the approach of man. On one occasion one of these Crocodiles which was overtaken in the jungle by a gentleman on horse-back, fled to the nearest shallow pool, and thrusting its head into the mud till it covered up its eyes, "remained motionless, in profound confidence of perfect concealment." The same habit of covering the eyes and leaving the body exposed, it will be remembered, is also a characteristic of the ostrich, thereby bringing upon itself much ridicule. As a matter of fact, however, this habit of hiding the head is not so foolish as it appears. The bodies of these and many other creatures which also adopt this habit, harmonize so perfectly with their surroundings that, but for the brightness of the eyes, they would often pass undiscovered. By hiding the head, not only are the eyes effectually concealed, but the outline of the body is most effectually disguised, inasmuch as

it harmonizes the more completely with its surroundings. It is quite possible that the narrator of this episode may have passed several crocodiles thus concealed, they having had warning of his approach before he discovered them.

That a crocodile should be susceptible to tickling seems hardly likely. Yet this is a fact. Sir Emerson Tennent gives an instance which came under his own observation. "One morning . . . we came suddenly upon a crocodile asleep under some bushes . . . several hundred yards from the water. The terror of the poor wretch was extreme when it awoke and found itself surrounded. . . . It started to its feet and turned round in a circle, hissing and clanking its bony jaws, with its ugly green eyes fixed upon us. On being struck with a stick, it lay perfectly quiet and apparently dead. Presently it looked cunningly round and made a rush towards the water, but on a second blow it lay again motionless and feigning death. We tried to rouse it, but without effect . . . nothing would induce it to move till, accidentally, my son, then a boy of twelve years old, tickled it gently under the arm, and in an instant it drew the limb close to its side, and turned to avoid a repetition of the experiment. Again it was touched under the other arm, and the same emotion was exhibited, the great monster twisting about like an infant to avoid being tickled."

During times of great drought, they, like the African mud-fish Protopterus, bury themselves in the mud and remain in a state of torpor till released by the return of the rains. Occasion-

ally, however, instead of burying themselves, they appear to migrate in a body in search of water, numbers falling by the way, either by accident, or at the hands of natives whom they encounter.

The largest and most formidable of all the crocodiles is the Estuarine Crocodile (*Crocodilus porosus*). It resembles in general appearance the foregoing species, but may be distinguished therefrom by the more elongate snout. Furthermore, it differs from the Indian Marsh Crocodile and from all other species, by the presence of a long ridge running forward from each eye towards the snout. Specimens of over twenty feet are fairly common, and one instance is on record of a specimen which had attained the enormous length of thirty-three feet. Frequenting the tidal portions of rivers, it is not surprising to find that this species frequently descends to the sea. This fact accounts for its wide geographical distribution, which extends from the Gulf of Bengal to Southern China, across the Malay Peninsula to Australia. Its ferocity makes it at once detested and feared. In India the natives of Dacca, at the mouth of the Bay of Bengal, make the hunting of this beast a profession. An account of one of these hunts, published in a native paper, tells how a boy was carried off by a man-eater of this species. The hunter having been summoned, he moored his canoe near the scene of the tragedy, knowing that having recently made a successful raid the brute would hover near the spot in the hope of obtaining fresh victims. In a short time the

quarry was descried, when the hunter, and his assistant, hid themselves in the canoe whilst the hunter's son, a boy, entered the water and commenced to splash about. At once the crocodile made for him, but the boy quickly beat a retreat, and the monster coming up at the exact spot where his intended victim had been, was struck by a couple of harpoons. After a long chase, the wounded crocodile was at last secured and despatched with an axe. When opened the stomach was found to contain several gold and silver ornaments—gruesome relics of former victims.

Perhaps one of the best-known species is the Crocodile of the Nile (*Crocodilus niloticus*). It is only slightly inferior in size to the Indian Crocodile just described, and is nearly as dangerous. The steamboat and the modern rifle have practically effected the extinction of this species in Egypt, though in the upper reaches of the Nile it is still abundant, and still exists in Palestine. From thence it extends southwards to the Cape, and northwards to Senegal. It also occurs in some numbers in Madagascar. Like others of its tribe this species has a habit of lying half-asleep on sand-banks, with its mouth wide open. At such times, the Nile Crocodile invites, or at least permits, the entrance between his huge jaws of numbers of Egyptian Plovers (*Pluvianus ægyptius*), who fearlessly enter this formidable cavern for the purpose of clearing the mouth of insects which may have intruded, attracted by the moisture of the tongue.

The boldness and ferocity of this species is well illustrated by the account narrated by a correspondent of the *Times*, of an incident which occurred during a journey to Mashonaland. One evening while crossing the Tokui River on horseback a man named Williams was seized by the leg by a crocodile and dragged from his horse into the stream. He was, however, immediately released and succeeded in swimming to a small island. But a comrade who rode in to his assistance fared almost as badly, for another crocodile sprang up between him and his horse's neck, then slipped back, and in doing so, made with its claws a dreadful wound in his side, and in the horse's neck. Williams ultimately died of his wounds. It is said, indeed, that more people are killed by crocodiles than by any other of the wild beasts of Africa.

In Madagascar this crocodile digs long subterranean passages of from thirty to forty feet in length, the passage opening below the level of the water, and rising gently terminates in a chamber large enough to allow of the creature to turn its huge body round. To admit air, the roof of this chamber is pierced by numerous holes. Into these lairs the crocodile retires to devour his prey, or to escape danger. In this last endeavour, however, they often fail, for natives, guided by the air-holes, dig them out from above.

Known as *Champsa* by the ancient Egyptians, this crocodile was held by them in great reverence, numbers being kept and tended with the

greatest care by the priests. They bedecked these hideous creatures with ornaments, hanging rings and precious stones from the fleshy flap protecting the ears, and encircling the fore-feet with bracelets. Thus adorned they were presented to the people for veneration. A crocodile among these ancient people, was one of the symbols of Typhon, the brother of Osiris, who was considered the author of all evil. One of these deities was a man with a crocodile head, named *Sarek*. When these creatures died, their bodies were embalmed, and hundreds of these mummified bodies exist till to-day. Embryos, as well as adults, seem to have shared this distinction.

One other crocodile must find mention here. This is the Long-snouted Crocodile (*C. cataphractus*) of W. Africa. In the peculiar length and slenderness of its snout this species closely resembles the Gharials. It is interesting to note that it preys on fish, frogs, aquatic reptiles, and wading birds, which it approaches by stealth. Shy and timid in its habits, this species is prosecuted by the natives for the sake of its flesh, which, in spite of its musky flavour, is much esteemed. This appreciation for crocodile flesh is widespread; the natives of other regions where crocodiles of some sort or another abound, are equally fond of it. This species is abundant in the fresh water of the interior, and thrives in the salt-water lagoons of the Guinea Coast; and in the delta of the Camerons it may be seen lying on the sandbanks bordering the mangrove swamps, from which it darts with amazing

celerity on the slightest alarm. A fully adult example measures about eighteen feet.

The slenderness of the jaws seem, as in the Gharial, to be correlated with the feeding habits. Neither the one nor the other appears, except rarely, to attack large prey. This seems to support the view that the short-snouted forms have acquired this characteristic by adaptation to the requirements for the capture of powerful prey, such as the large mammalia.

With the Caimans and Alligators we may close this chapter. Closely allied, they are to be distinguished from the Crocodiles by the fact that the fourth lower tooth is received into a socket in the upper jaw instead of a notch.

Alligators appear to have been common in Europe in past ages, for their remains occur in the pluviatile deposits of the Upper Chalk, and they survived until the Pliocene age. Possibly their extinction was due to climatic changes, for at this time the tropical types of vegetation seem to have begun their retreat southwards in the European regions, and this may have been followed by a similar retreat on the part of the animals dependent thereon. At the present day but two species of Alligators are known. One of these, strangely enough, occurs in the rivers of China, the other in the Southern States of North America.

The American species (*Alligator mississippiensis*) seems to have fallen on evil days. They are being slain by the thousand for the sake of their hide; and settlers wage unrelenting war on them for the ravages they make upon their pigs. As a con-

sequence of this persecution, it is interesting to note that as their numbers diminish in Florida the Mocassin snakes increase; whilst in Louisiana, where they are also rapidly decreasing, the musk-rats are at the same time increasing and doing much damage by their burrowing.

In the spring and early summer months, and more especially during cloudy days or in the evening, alligators make much noise, croaking like a bull-frog, but louder. On the approach of winter they retire to holes in the ground, and, passing into a state of torpor, remain till awakened by the spring. Whilst in this state of helplessness they are eagerly sought for and disinterred by negroes who esteem the tail a great delicacy.

The Caimans number five species, and are distinguished from the Alligators, among other things, by the armour-plating of scutes along the under surface of the body.

The traveller-naturalist Bates found the Caimans in myriads in the waters of the Upper Amazon. "It is scarcely exaggerating," writes Bates, "to say that the waters of the Tolimoens are as well stocked with large alligators in the dry season as a ditch in England is in summer with tadpoles."

Caimans never attack man when on his guard, but they seem to know when this may be done with impunity. Bates gives several instances in support of this view. While staying at Caiçara a large trading canoe arrived, manned by an Indian crew. These fellows, during the first two days after their arrival, spent the time, as was

their custom, in drunkenness and debauchery ashore. Whilst in this muddled condition, one of them during the hottest part of the day took it into his head to go alone to the river to bathe. "He was seen only by the Juiz de Paz, a feeble old man who was lying in his hammock, in the open verandah at the rear of his house, on the top of the bank, and who shouted to the besotted Indian to beware of the alligator. Before he could repeat his warning the man stumbled, and a pair of gaping jaws, appearing suddenly above the surface, seized him round the waist and drew him under water. A cry of agony, 'Ai Jesús' was the last sign made by the wretched victim. The village was aroused: the young men . . . seized their harpoons and hurried down to the bank, but of course it was too late; a winding track of blood on the surface of the water was all that could be seen. They embarked, however, in montarias, determined on vengeance; the monster was traced, and when, after a short lapse of time, he came up to breathe—one leg of the man sticking out from his jaws—was despatched with bitter curses." On another occasion a boy, whilst bathing, was seized by the thigh and carried under water: a cry was raised which reached the lad's father, who, rushing down to the bank, plunged in after the monster and its victim. "It seems," says Bates, "almost incredible that a man could overtake and master the large Caiman in his own element; but such was the case in this instance, for the animal was reached and forced to release his booty by the man's thrusting his thumb into

his eye. The lad showed us the marks of the alligator's teeth in his thigh."

CHAPTER IV

GECKOS, LIZARDS, AND CHAMÆLEONS

THE creatures which form the subject of the present chapter are those which, with the Snakes to be considered presently, make up the sub-class Squamata. This sub-class is divided into two orders—Lacertilia or Lizards in a wide sense, and Ophidia, or Snakes. The Lacertilia are again divided into three sub-orders—Geckos, Lizards proper, and Chamæleons. The total number of species comprising these sub-orders amounts to more than 1800.

The exact origin of the forms which belong to this sub-class is unknown, but they are probably descendants of the ancient group to which we have already referred, and of which the remarkable Tuatera Lizard is the sole representative. No fossils are known which carry us beyond the Juranic. Attaining their greatest development within the Tertiary period, they appear, says Dr Gadow, "to have a future before them, being apparently still on the increase in number and species, but certainly not in size."

Their manifold variety in shape, size, and structure give them a quite peculiar interest, inasmuch as their several variations are generally directly traceable to adaptation to their environ-

ment. Between the typical lizard and the crocodile there is an undoubtedly superficial resemblance, so much so that the former is often described as crocodile-like, whilst the latter is as often referred to as lizard-like. The likeness, however, is purely superficial, and confined to the general contour of the body.

Any one who will take the trouble to compare the skeletons of the two groups, or the organs of circulation or respiration, for example, will see at once how widely they are separated. Consequently, no further comparison between the two need be made here. If, however, the differences which distinguish the Lizards from the Crocodiles are many and wide, this is by no means the case between the Lizards and the Snakes, inasmuch as many Lizards have come to assume a snake-like form through the loss of their limbs, concerning which loss we shall have much to say later on in this chapter. Nevertheless, a little discrimination will enable even the uninitiated to tell the limbless lizard from the snake. In the first place, the two halves of the lower jaw in the lizard will be found to be closely united, and the ear is usually visible externally. In the snake the two halves of the lower jaw are connected only by a ligament, and there is no external aperture to the ear. Furthermore, the lizards, with few exceptions, have movable eyelids, the snakes never.

As a rule, the body of the lizard is covered with overlapping scales, but in some forms these become reduced to mere tubercles, whilst in others they are underlain by bony scutes recalling those on the back of the crocodiles. These scales

are shed periodically, generally in the form of large flakes, but in certain instances they are cast off in one piece, *e.g.* the Slow-worm (*Anguis*). Skin-glands, as in the birds, are conspicuous by their absence. The nearest approach to these organs are certain pores in the anal and femoral regions. Each of these pores perforates a scale, and leads into a tubular invagination, or infolding, which is lined with what are known as epidermal cells, the breaking up of which produces a yellowish debris, and by filling up the tube, eventually appears at the surface in the shape of a little cone. Their use is unknown.

The teeth present some interesting variations in the nature of their attachment to the jaws. Thus in some forms they become immovably fixed, or ankylosed, by their bases with the inside of the jaw, when the dentition is said to pleurodent; in others, they are as firmly fixed to the cutting edges of the jaws, forming then an acrodent dentition. When the teeth are lodged in sockets, as happens in the Crocodiles, the dentition is described as thecodent.

Most Lizards, like the Tuatera, are remarkable for their ability to part company with their tails at a moment's notice. When threatened, this organ, in many species, is temptingly raised as if to invite or perhaps challenge the enemy to seize it. If this be done it immediately breaks off, leaving its owner to make good his escape before his would-be captor has had time to recover from his surprise. But these tail-less lizards have no need to adopt the stratagem of the fox in the fable, to persuade their fellows to

undergo a similar amputation, for in a very short time a new tail is developed. This, however, is never so perfectly developed as the original organ. In the first place, distinct vertebræ are replaced by a simple fibrous rod; and in the second, the scales clothing the outer surface are rarely of the same regular arrangement as those of the stump or of the last portion. Sometimes, however, the more primitive ancestral arrangement of scales is reverted to, at others the arrangement is true to type, as in the Common Lizard and Slow-worm, for example. It is interesting to remark that though the bony skeleton of the regenerated organ is not replaced, the muscles of the new growth do not differ greatly from those of the old stump. The tail of the "Monitor" Lizards (*Varanus*) differs from that of their allies in that, instead of being fragile and easily detachable, it is, on the contrary, of unusual strength. Of great length and slenderness, it appears to be used as a whip, inflicting blows of considerable severity.

Another peculiarity of the Lizard-tribe is the possession of what are known as "fat bodies." These are organs of unknown function, found in both sexes, extending from the inguinal region forwards along the belly immediately beneath the skin. They are largest during the spring-time, and consist of a mass of connective tissue permeated with fat, which gives them a yellowish-white colour. Later in the year they become greatly reduced in size, forming grey or reddish flaps richly supplied with blood-vessels.

In the great number of the species, and their

extremely specialised condition, the Lizards among Reptiles occupy the place of the Passeres among Birds.

Of the senses the best developed is sight, and after this hearing. The majority of species are carnivorous, the larger kinds feeding on small mammals, birds, and the members of their own tribe; the smaller kinds mainly upon insects, worms, and so forth: a few are exclusively herbivorous. Some species of lizards never drink, others do so by lapping movements of the tongue, which varies greatly both in its length, shape, and power of movement.

Lizards are found over the whole globe, save only polar and sub-polar regions. They may be found in the most arid deserts, as well as the most fertile spots, and extend their range vertically to the regions of perpetual snow. But whilst the colder regions afford little more than a bare existence, the tropics and sub-tropical regions produce food in abundance. Consequently it is here that the greatest wealth in point of numbers, size, shape, and coloration is met with. These are the regions wherein the group has attained its maximum development. Escape from the extremes of climate appears to be necessary in all cases, since in tropical climates, during the hottest months of the year, when drought prevails, the bulk of the species fall into a state of torpor; whilst in the colder regions the species hybernate, remaining dormant for many months.

The evolution of the Lizard tribe has been marked, as we have already hinted, by a very

conspicuous diversity in the matter of adaptation to environment, and for the capture of food. Adaptations which are expressed in structural modifications, sometimes of a very profound character. In all this they differ conspicuously from the Crocodiles and Tortoises, which are peculiar, rather on account of the uniformity they display in their organisation.

In the matter of the capture of food a few examples will suffice. In the case of Lizards which feed upon living animals the prey is seized, generally, by a snapping motion of the jaws, and passed whole down the throat, not torn in pieces, as with the Crocodiles. Adaptations indeed for tearing prey are conspicuous by their absence. Some of the former, however, seize their victims by a lightning thrust of the tongue, and among these the Chamæleons come easily first. In these creatures the tongue attains a great length. Covered with a sticky secretion, this organ is expelled with a dart-like motion and unerring accuracy, so that a fly can be taken at a distance of five or six inches from the tip of the creature's snout. Only in two species of lizards belonging to the genus *Heloderma* is the prey killed by poison. This is injected, as in the case of Snakes, by means of grooved teeth, which convey the deadly secretion from the large glands in which it is formed, but whilst in the snakes the poison is transmitted through certain teeth in the upper jaw, in these lizards it is conveyed through certain teeth in the lower jaw. The herbivorous lizards of the

genus *Iguana* have the edges of the teeth finely serrated, in which particular they bear a close resemblance to the teeth of the Giant Dinosaurs, which has been named on this account Iguanodons.

In the curious Galapagos lizards, *Conolophus* and *Amblyrhynchus*, the teeth are trilobate in form, a character apparently directly connected with the creature's herbivorous diet.

When the tongue is not used for the capture of food, it appears either to become degenerate, or to become modified into an organ of touch, forked at the top, very sensitive, and capable of being protruded or withdrawn with great rapidity.

With this brief survey we must pass on to consider the peculiar characteristics of the individual groups which form the subject of the chapter, and the part they play in the economy of nature.

One of the oldest groups of the Lizard tribe is that represented by the Geckos. Of almost world-wide distribution, and numbering nearly 300 distinct species, considerable differences in habitat, as might have been expected, are met with. Many have become peculiarly modified to enable them to climb, and these are the most generally known forms. Their strange shape and weird movements have long attracted the attention of mankind, among whom they have, in many cases, engendered feelings of dread and animosity, which are totally undeserved. They are believed in some countries to be capable of emitting venom from their toes, and poisoning whatsoever they crawl over, whilst one species at least is credited with

the power of indenting steel with the teeth! In Egypt so intense is the dread in which the lobe-footed species is held, that it is known as the "father of leprosy."

The Geckos are plump in shape, mostly sombrely coloured, and flat-headed. The skin is mostly covered with small granular tubercles, but regularly arranged scales are rarely present, save in the under-surface. Two genera, however, have the upper surface of the body also invested in scales, and both these are desert-dwelling types. The skin is shed in flakes and eaten. The eyes are remarkable in that they are not protected by movable eyelids, but by a transparent shield, of the shape of a watch-glass, which is generally regarded as a modified nictitating membrane. Behind this the eye moves freely. The eyelids are reduced to fringes encircling this peculiar cover. This "window" appears to be kept clean by the tongue, which can be protruded for some considerable distance. In response to the more or less nocturnal habits of the creature the pupil of the eye contracts into a vertical slit, as in the eyes of cats, for example.

The tail presents many variations of form. Generally cylindrical, and tapering to a point, it is in some forms leaf-like, as in the fimbriated Gecko (*Uroplates-fimbriatus*) for example; or provided with lobes, as in the Fringed-Gecko (*Ptychozoum homalocephalum*); but in many desert forms the tail is long, slender, and laterally compressed. In some species it is more or less prehensile.

One of the most remarkable features of this sub-family is the peculiar modification which the foot of the climbing species has undergone. Herein the under-surface of the toes has developed a series of plates, which serve as adhesive pads, wherewith the animal is enabled to climb, not only trees, and the smooth faces of rocks, but even the polished vertical surface of a window-pane; or, stranger still, to run along the ceiling with the ease and security of a fly. The pressure of the foot causes the plates to spread out, and driving out the air between the plates, to form a vacuum. Long claws, more or less perfectly retractile, complete the armament of this remarkable organ. Dr Gadow remarks, anent the wonderful climbing powers of these creatures: "Those which take up their abode inside a house become almost domesticated. They are strange sights when hunting for flies running up and down the papered walls; but we fairly gasp when they come to the upper corner, calmly bend over, and with the next jerk slide along the whitewashed ceiling. We are accustomed to flies performing such feats, but at animals five inches long, supple and fat, we are inclined to draw the line. However, that is the way of the Geckos, and—be it confessed—the more we ponder over the mechanism of their fingers and toes, the less we comprehend how such little vacua can support or suspend such heavy creatures from a dry and often porous surface."

Yet another remarkable feature of the climbing

Geckos is the extraordinary development of that portion of the inner ear, known as the endolymphatic sac. In all animals this is concerned with the work of keeping the body informed of its position by the movement of certain hard bodies suspended in fluid, over delicate nerve-endings. In the Geckos in question this sac leaves the head, and becomes stowed away in the shape of a large pair of bags behind the ear, or on the sides of the neck.

Nearly all the Geckos appear to possess a voice, which in some species resembles the word "Gecko"—hence the name by which these creatures are known. A South African desert species is said to congregate at times in such numbers, and to produce such a din, as to make existence in the neighbourhood intolerable. The males are larger than the females.

The smaller Geckos feed chiefly on insects, but the larger forms will take anything that they can manage to overpower; the smaller species of lizards, mice, young rats, and even bats, having been recorded among their victims.

Of the climbing species the most remarkable are the Fringed and Fimbriated Geckos. The former, *Ptychozoum homalocephalum*, a native of the Malay Islands and Archipelago, has developed curious membranous expansions of skin which extend down each side of the body, limbs, and tail. By their means the animal is said to be enabled to take flying leaps, the membranes acting as a parachute.

It does not seem to be definitely known that this interpretation of the use of these folds is

correct. More probably they are only part of a general protective disguise, the folds being applied to the surface of the trees so as to effectually blend the body with its surroundings, and thus bring about invisibility. The plausibility of this view will impress every one who has had an opportunity of watching the Fimbriated Gecko (*Urovlates fimbriatus*) now living (1903) in the Gardens of the Zoological Society in London. The remarkable way in which this extraordinary creature harmonises with the branch on which it rests, is one of the first things that rivets the attention. This harmony is partly due to the coloration of the animal, which is of a dark grey, almost black, but relieved by large, irregular blotches of lichen colour; and partly to the presence of a short ragged fringe which extends along on each side of the body as far as the base of the tail, where it is replaced by broad lobes. When the animal is at rest the body is pressed flat against the bough, so that the fringe along the flanks, and the lobes of the tail completely obscure the general outline. To make the disguise more complete the hind legs are placed in what one might be pardoned for calling an unnatural position. Thus the right leg will be directed forwards, the left stretched backwards in a straight line parallel with the tail. Even in confinement, exposed in a glass case with purposely unsuitable background, and within a foot of the observer, this creature is almost invisible. Indeed, but for its remarkable eye, it is probable that its presence would be discovered only by the merest accident. This, the most conspicuous

feature of the body, is large, of a bright golden colour, relieved by curious crescentic lines of bright chestnut, ranged on either side of the pupil, which is vertical—possibly in accordance with nocturnal habits. The horns of the crescents are directed inwards, and the crescents themselves are three or four in number, one lying within the other, by fine semilunar bars of red. It is known to the natives by a name which signifies "the beast that leaps at the chest," and they believe that if any one approaches the tree on which one of these curious creatures is lying it will leap out on to his chest, and cling there so firmly that it can only be removed by shaving away the skin!

In these two species we have the highest point of specialisation for an arboreal life which has been attained in the group.

Let us now turn to the modifications which have taken place through adaptation to a desert-dwelling habitat. The best instance is that furnished by the Persian *Seratoscincus scincus*, a denizen of the desert. The digits, in place of the adhesive lamellæ, have their under surface granular, and fringed with lamellæ, resembling those which form the adhesive disc of climbing species. In this desert form the lamellæ serve for running over loose sand. Furthermore, the body differs from that of climbing species in that it is clothed with scales. On the upper surface of the tail these scales give place to large nail-like plates. Their use is remarkable, inasmuch as they can be rubbed one upon another to produce a shrill

cricket-like noise, intended apparently as a decoy for grasshoppers, on which the wily performers largely feed. Stridulating organs of this kind are rare among vertebrates.

From the Geckos we must pass now to the Lizards proper, which in numbers surpass all other orders of Reptiles, since, up to the present time, more than 1500 distinct species have been described. The general form of the body we have already indicated (p. 79), consequently we are free to proceed to discuss the various modifications which have taken place therein as a result of the struggle for existence. These take the form of adaptations to various and often widely different modes of life. In this connection it is a point of some significance and extreme interest to remark that the degree of modification varies to a surprising extent, even among reptiles living amid precisely similar surroundings; some of these creatures undergoing profound changes, obviously directly adapted to their peculiar habitat, whilst others apparently succeed in holding their own without suffering any very obvious transformation.

The common English Lizards *Lacerta vivipara* and *Lacerta agilis*, and the Giant monitors serve as admirable examples of the ground-dwelling forms which have succeeded in holding their own without undergoing any conspicuous modification of form. Both the English species are heath dwellers, the vivaparous lizard exhibiting a preference for moist places, and occasionally taking to the water, being a good swimmer. The monitors are to be met with in Africa,

Southern Asia, and Australia, and although they vary greatly both in size and habitat, some being semi-aquatic, they have yet, as we have just remarked, escaped conspicuous modification of form. As with the English species, there is nothing remarkable about the shape or covering of the body, the limbs are well developed, and bear the normal number of digits, five on each foot.

The life history of the largest of these creatures, *Varanus salvator*, which attains a length of seven feet, is extremely interesting viewed in this light. Its range is considerable, extending from Nepal to Ceylon, Cape York, and Southern China, including the Malay Islands and Philippines. Mr Annandale, who studied this species in Lower Siam, describes it as equally at home on land, in the water, or among the branches of trees. In the water it swims beneath the surface folding the legs close to the body, and using the tail both as oar and rudder.

Among the branches of the trees these great lizards find an abundance of food. In the states where the Siamese practise tree-burial, these monitors are said to eat the flesh of the corpses. Another which he met with had seized a flying squirrel. Specimens which he captured on the ground proved when dissected to have been feeding on tortoises, others on dung beetles. Eggs appear to be a delicacy much appreciated by the monitors. These are taken up with great care, and passed unbroken into the gullet lest their contents should escape. Here they are said to be crushed by the contractions of the muscles of the gullet.

Among the natives, by the way, both the flesh and eggs of the different species of monitor are highly esteemed as food. In Burma, the wretched victim, if not wanted at once, suffers the most barbarous treatment. The fore-feet are turned over the back, the toes are broken and the sinews drawn out and tied in a knot, thus rendering escape impossible. In India, they are put to a very droll use by thieves. If they desire to scale a wall too high to climb, they procure one of these lizards, tie a rope round its body, and placing it against the wall, which is of mud, release their prisoner, which at once makes for the top and jumps over to the other side bearing the rope with it. Up this the man swarms, the weight of the creature, aided by the vigorous hold which it takes of the ground, keeping the line fast!!

Though essentially ground-dwellers, the life led by the lizards we have just described is unattended, as we have already remarked, by any peculiar modification of form. Adaptation is conspicuous by its absence. Hence the versatility displayed. Quite otherwise, however, is it with the ground-dwellers which we are now to examine.

These forms, in order that they may maintain their existence, have been compelled to undergo certain more or less striking structural modifications. In some cases these are obviously adaptations to the peculiar requirements of the creature's environment; in others the interpretation is by no means so easy.

Among the more interesting of these changes we may notice the development of thorny spines

on the skin of species that frequent arid, sandy localities. In the "Horned Toad" (*Phrynosoma*), for example, of the western half of the United States and Central America, the horny scales have become transformed into a bristling armour of sharp-pointed spines of varying size. The larger of these spines closely resemble the dried husks of seeds and thus afford protection to the animal by causing it to harmonise with its surroundings. These rather forbidding looking creatures are fond of basking in the broiling sun, and in the afternoon, when the sand is heated to fever heat, they begin to retire for the night. This they do within a very short space of time, by moving the body slowly forwards in such a way that certain peculiar scales arranged like a fringe along the sides of the body turn the sand up over the back after the fashion of a plough. Soon only the head remains visible, and this looks like a little cluster of dry thorns. To prevent the sand getting into the nostrils the latter are provided with special closing valves. About a dozen species of horned toads are known, the largest of which is about eight inches in length.

Strangely enough, another spine-covered lizard occurs in Australia, and is known as the Moloch Lizard (*Moloch horridus*). But little appears to be known about this animal save that it feeds upon ants. The spines embossing the skin appear to be extremely hygroscopic. This fact was discovered by Dr Willes who, placing a live specimen in a shallow dish of water, remarked that the water was immediately sucked up as by

blotting paper. The similarity between the moloch and horned "toads," it is to be remarked, is the result, not of blood relationship, but of adaptation to a similar environment. Such parallels are not rare in Nature, and may occur whenever like structures are acted upon in like manner. Yet another spine-clad lizard is found in South and Tropical Africa and in Madagascar. Known as girdled-tailed lizards, and attaining a length of fifteen inches, it differs from the spiny forms just described in many respects. In the first place, the horny spines are backed by bony nodules so that the creature is invested in a complete armour. In the second, the spines are more symmetrical in form and arrangement, constituting, in the back, a broad shield composed of a number of transverse bands. The spines on the base of the head, the neck, and around the tail are very large. The spines of the moloch lizard and of the horned "toads" appear to serve as a disguise rather than as offensive-defensive armour. Concerning the use of the spines of the girdled-tailed lizards we have no definite information. But we have yet another group of armoured lizards to which reference must be made—the Thorny-Tailed Lizards (*Uromastix*) —and in these the armour is defensive. Desert-dwellers, like the forms just described, these creatures differ conspicuously therefrom, in that the head and trunk are quite smooth, being clothed only in small scales. The tail, however, is armed with strong spines which appear to have been developed in conjunction with the peculiar habit of these creatures of living in burrows.

These they enter head-first, and leave the tail to block the entrance thereto. These lizards are purely vegetable feeders, and have a wide distribution, occurring in North Africa, Arabia, Syria, Persia, and North-Western India.

There is nothing about the general appearance of Uromastix, to which reference has just been made, that would lead one to suppose that it was a burrowing animal. The same is true of several other lizards. Thus the members of another genus—*Liolepis*—of this family, Agamidæ, live in holes in the ground, which may run vertically downwards for as much as two feet before there is a bend in their course. Each burrow is inhabited by a pair of lizards. The same absence of any peculiar modification is true of the remarkable *Conolophus* of the Galapagos Islands. This is possibly due to the fact that burrowing is only an incident in the life-history of these species; that is to say, existence does not depend on their ability to burrow. With many other species, however, it would appear to be otherwise. Thus the eyes in many sand-burrowing lizards are protected by a transparent disc of skin on the lower eyelid, so that this can be drawn over the eye and yet leave the sight unimpaired. In the genus *Ophiops*, of North Africa and India, the lower eyelid and its window-pane is permanently fused with the upper lid so that the eye is shielded as in the Geckos, though it will be remembered in this case the protection was afforded by a different means.

A considerable number of lizards, however, belonging to widely different families have

undergone very marked changes in adaptation to burrowing habits, resulting, in extreme cases, not only in the loss of the limbs, but of the limb girdles. In these cases the length of the body becomes enormously lengthened and snake-like. So much, indeed, do they resemble snakes, that only after some experience can the one be distinguished from the other. One of the most interesting features about the loss of the limbs is that every possible gradation from fully functional limbs to mere vestiges thereof may be found. Nowhere is this gradation in the reduction of the limbs so well seen as in the Skink family.

The Skinks, it should be remarked, are a very numerous family, numbering several hundred species, and distributed nearly all over the world. Australia may perhaps be regarded as their head-quarters, but they occur also in some numbers in Africa and the Oriental region, and, sparingly, in Europe and North and South America. Dwellers in sandy regions, they seek safety from pursuit not in precipitate flight, but by burrowing, which they do with the ease and rapidity of moles, in some cases penetrating to a depth of several feet in a surprisingly short space of time. They, and the burrowing forms of other lizards, however, differ conspicuously from the moles, and similarly modified types of the mammalia, in that the burrowing habit has resulted, in the most extreme cases, in the total *loss* of the limbs; whilst in the mammalian forms in question the burrowing habit has resulted in the development of digging-limbs

of surprising power. The burrowing lizards, strangely enough, resemble instead the *non*-burrowing snakes.

The most typical skink, perhaps, is the species known as the Common Skink (*Scincus officinalis*), a thick-set, short-tailed lizard clothed in peculiarly large, smooth, overlapping scales resembling those of fishes, and forming an admirable covering for burrowing purposes. The limbs in this species are short but well developed and possess the normal number of toes. It is a small animal, not exceeding four inches in length, and in the olden time was much esteemed in medicine, being regarded as a cure for every ill that flesh is heir to. Even to-day it is greatly esteemed, both for its healing powers—which are imaginary—and as an article of food, by the Arabs. Contrasting conspicuously with this species, stands the Australian Stump-tailed Lizard (*Trachysaurus rugosus*), inasmuch as the body of this animal, which is about fourteen inches long, is clothed in a dense armour of bony nodules encased in horny scales, that give the body the appearance of a pine cone. Living in a region widely remote from that of the Common Skink, it may well be that the conditions of life demand a more durable armour; be this as may be, we know nothing at present which will account for the wide differences in the covering of the two species. Its chief food consists in worms and insects, varied by fruit and vegetables. Both the present and the foregoing species possess four limbs bearing the normal number of toes.

Let us turn now to the other members of the

family in whom reduction of the limbs is a more or less conspicuous feature. Within the limits of two genera, as may be seen in the accompanying illustration, examples may be found showing every gradation in the reduction of the toes from the full complement of five to their complete disappearance, and with them of the limb itself which is represented only by a tiny stump. The "bronze lizards," which furnish four of the five examples, are natives of the Mediterranean countries and South-West Asia. All appear to be more or less surface burrowers hiding under stones or pieces of bark. Some resort to damp places in search of food, but all seek dry and sandy spots whereon they may expose themselves to the full glare of the sun. One species of skink, by the way, occurring at Tunis and Algeria, and belonging to the genus *Euprepes*, is remarkable in that it leads a semi-aquatic life; spending much of its time on the floating leaves of the Water-lily (*Nymphea alba*), seeking safety when alarmed by diving. Its normal element, however, is the sand, and by night it retires under stones.

A considerable number of surface-burrowing forms, other than Skinks, members of widely different families, are known to science. In some of these only the hind-limbs are represented, and these often only in the males. They take the shape of fin-like flaps of skin, which, in the case of the "scale-footed" lizards, belonging to the family *Pygopodidæ*, are found on dissection to contain a degenerate five-toed foot. Generally, the limb-girdles in these legless

lizards are wanting, or reduced to the merest vestiges. The common British "slow-worm" (*Anguis fragilis*), and the curious "glass-snakes" (*Pseudopus*) represent other members whose limbs have completely disappeared. The latter are extremely interesting on account of the manner in which they kill their prey. This they do either after the fashion of poisonous snakes, by rapidly curling the body around the victim so as

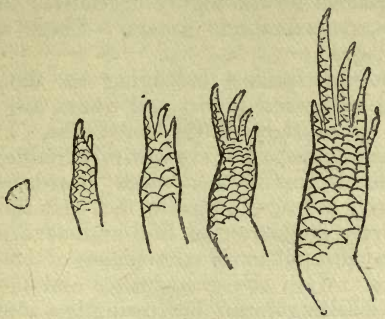


FIG. 7.—Legs of different species of lizards belonging to the Skink tribe show the gradual evolution of the limbless condition.

to crush it to death, or by shaking it till stunned. At least, when seized by man, the glass-snakes do not attempt to bite, though armed with powerful jaws. Instead, they instantly encircle the hand or arm by coiling the body around it, and then besmearing it with excrement which is said to be peculiarly offensive on account of its powerful smell.

The snake-like form of the lizards which we have just described has been slowly acquired, in

consequence of a change in its habits, the precise nature of which it is not easy to understand. The transformation seems to be due to adaptation to life in a sandy habitat, where escape from enemies is made by burrowing, and prey of a sluggish disposition or helpless character is to be captured without chase, and without the effort of climbing. By a perfectly natural transition we are led to the consideration of some yet more curious forms, highly specialised in some respects, degenerate in others. These are the amphisbænas.

Only one species, belonging to the genus *Chirotes*, possesses limbs, and these are represented by vestiges of the fore-limbs. For the rest, the amphisbænas are entirely limbless, and resemble worms rather than lizards. This peculiarity is traceable to the fact that they lead an entirely subterranean life, and have in consequence lost all external evidence of both eyes and ears. With the glass-snakes and the other surface-dwelling forms burrowing is a secondary feature in the life-history of the animal, and has in consequence involved certain minor modifications only—the protection of the eyes by a transparent window formed by the lower eyelid, closely-fitting scales, and the absence of limbs. Bearing in mind the fact that the moles, and other quite unrelated mammalian burrowing forms, have developed specially powerful and peculiarly modified limbs, it seems strange that the lizards should have acquired equal skill as burrowers by suppressing the limbs and adopting the model of the lowly earth-worm. But the

amphisbænas have become still further modified, for the body, in place of a covering of overlapping scales, is invested only in a soft skin, forming a series of worm-like rings, each of which, however, is cut up into a series of little squares—the vestiges of scales. Burrowing like earthworms, eyes, even if protected from injury, like those of the glass-snake and "blind-worms," for instance, would be not only useless but a source of danger, and consequently have disappeared. These remarkable creatures exhibit a decided preference for ant-heaps and mounds of decaying vegetable matter. Their method of progression is peculiar, inasmuch as they are able to move either backwards or forwards with equal ease, Only the lack of scales on the body renders such a form of locomotion possible. The common mole, it will be remembered, has peculiarly nodified hair, which also allows of similar forward or backward movements. The facility with which the amphisbænas move in either direction, as well as the difficulty of distinguishing the head from the tail, has led to the belief in some parts of the world that these creatures possess two heads. They feed on worms and insects, and in rare cases, apparently, on snakes. Tropical America,, the southern parts of the United States, and Africa furnish the bulk of the species; four, however, occur in the Mediterranean countries.

Although most lizards are expert swimmers, aquatic forms are rare, and only one species is entirely marine. This is the remarkable Iguanoid (*Amblyrhynchus cristatus*) — the Galapagos Sea

Lizard. This remarkable creature, as its name implies, a native of the Galapagos Islands, has been vividly described by Darwin in his "Voyage of the Beagle." It lives, he tells us, exclusively on rocky sea beaches, never venturing for more than a few yards inland. Its whole sustenance is obtained from the sea, its food consisting of a peculiar kind of sea-weed which grows on the bottom of the sea at some distance from the land. Like herbivorous mammals, this lizard appears to be gregarious, and to set out for its feeding ground in herds of considerable numbers. When swimming, the legs are pressed closely to the sides of the body, progression being effected by a serpentine movement of the body and tail. It is noteworthy that this creature has undergone comparatively little change in form, in spite of its markedly aquatic habits. The most noticeable modifications are an incipient web between the toes, and the flattening of the tail from side to side. The peculiar habits of the animal will account for the fact that, although more aquatic than terrestrial, yet its original terrestrial structural features predominate. Darwin has shown that it has an inherent dread of remaining at sea longer than necessary. So much so, that it will not even seek temporary safety in the sea when threatened on shore. "Hence," says Darwin, "it is easy to drive these lizards down to any little point overhanging the sea, where they will sooner allow a person to catch hold of their tails than jump into the water. . . . Perhaps this singular piece of apparent stupidity may be accounted for by the circumstance that this

reptile has no enemy whatever on shore, whereas at sea it must often fall a prey to the numerous sharks. Hence, probably, urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge." Darwin describes the lizard as a "hideous looking creature, of a dirty black colour, stupid and sluggish in its movements. The usual length of a full-grown one is about a yard, but there are some even four feet long; a large one weighed about twenty pounds: on the island of Albemarle they seem to grow to a greater size than elsewhere."

The American Basilisk (*Basiliscus americanus*) is another expert swimmer. It is an arboreal lizard, preferring the branches of trees which overhang the water, into which it plunges at the slightest alarm. It swims by rapid strokes of the fore-limbs, the long tail trailing behind. Both in its method of swimming and in its habit of seeking safety by taking refuge in the water, this species stands in strange contrast with the Galapagos Sea Lizard just described.

Many species of the large family of Iguanas are more or less aquatic. The Water Monitor (*Varanus salvator*), which ranges from India, through the Malayan region of China and Aus tralia, and attains a length of seven feet, is a strong swimmer, occasionally entering salt water. The Water Monitor, and probably other species of the same genus, possesses one peculiarly interesting adaptation to aquatic habits, in the shape of a pair of large cavities within the snout leading from the nostrils. When the latter are closed

these pouches serve as reservoirs of air. This seems to be the only instance of an internal structural modification due to adaptation to aquatic habits. Professor V. Ball, writing of the Indian Monitor (*V. bengalensis*), which he met with in the Nicobars, describes an attempt to capture a specimen which he did not wish to injure. "As I was pressing him into a corner he made a rush into the water, but returned, apparently not liking the surf. Just as I thought he could not escape, he made a sudden dart into the water, dived through the surf, and disappeared."

Lizards are essentially creeping animals, but some run with great swiftness. One species which has not yet apparently received any English name (*Phrynocephalus interscapularis*), is said by Dr Gadow to run so fast that scarcely anything but its shadow is seen. During this time, it is to be noted, the tail is rolled upwards, and not trailed as in crawling. It is a sand-burrowing species, and occurs in Transcaspia. But instances of extreme agility displayed by lizards could be found in plenty. Accordingly space can be found here only for such cases as call for special comment. Most lizards, in running, do so upon all four legs; a few species, however, serve to form exceptions to this rule of a somewhat remarkable character, inasmuch as for short distances at least, they do so upon the hind legs only. This curious trait was first brought to the notice of the scientific world by Mr Saville Kent, who described its occurrence in the remarkable Frilled-lizard (*Chlamydosaurus*) King of North-Western Australia.

Since then several other Australian lizards, many of the American Teguexius, and Old-World Monitors have also been shown to adopt, for short distances, the same method of escape. It has been contended that this habit has been directly inherited from those extinct giants, the Dinosaurs (chap. ix.), but of course this view cannot be seriously entertained.

Although the number of different kinds of lizards which have their abode in the tree-tops is legion, there can be no donbt but that this habitat is not to be regarded as their ancestral home. They are, as their structure shows, essentially terrestrial animals. Furthermore, it is interesting to notice that, with the vast majority of species, no special adaptation to an arboreal mode of life has taken place. Strangely enough, the struggle for existence seems to have prevented specialisation in this direction in all save a few exceptional cases. The majority of these tree-dwelling species seem, on the contrary, to be exceptionally versatile. Climbing with ease, leaping with marvellous precision, and escaping pursuit, when necessary, by daring plunges into the rivers, and thus avoiding capture, by swimming to a place of safety.

The Common Iguana (*Iguana tuberculata*) may serve as a case in point. This species inhabits the forests of South and Central America, choosing those trees which border and overhang creeks and rivers. When alarmed, no matter what the height of the tree, they jump boldly down into the water below.

Travellers navigating the narrow and unfrequented creeks in the mosquito country run some considerable danger of meeting sudden death from these plunges, inasmuch as Dr Gadow assures us, on the authority of Napier Bell, that the voyager in this region "often encounters quite a shower of falling Iguanas, and runs some risk of getting his neck broken." This will readily be believed when it is known that full-grown specimens may measure as much as six feet long, and attain a weight of 30 lbs.

Arboreal and aquatic, these creatures are also burrowers, digging deep holes in the sloping sides of banks; yet neither climbing, swimming, nor digging have involved any special structural modifications. Many lizards not only climb with remarkable ease and rapidity, but are also expert leapers. The Carolina Anolis (*Anolis Carolinensis*), and the Green Gecko (*Phelesuma*) for example, leap from leaf to leaf like tree frogs. It will be remembered that another of the Geckos (*Ptychozoum homalocephalum*), was described, in the early part of this chapter, as enjoying the reputation of leaping powers of a high order, mainly, it would seem, on account of the presence of large folds of skin on each side of the body, which were regarded as serving the purpose of a parachute, affording the necessary support when in mid-air. On the whole, however, these folds appear rather to serve as masks, enabling the creature more effectively to harmonise with its surroundings.

Only in one small group amongst the Reptilia have structural modifications, which unquestionably subserve the practice of leaping, taken place,

and these are of a quite unique character. The creatures so modified are the "Flying Dragons" of the Indo-Malayan countries.

About twenty species of this remarkable genus are known. All, as may be supposed, are arboreal,

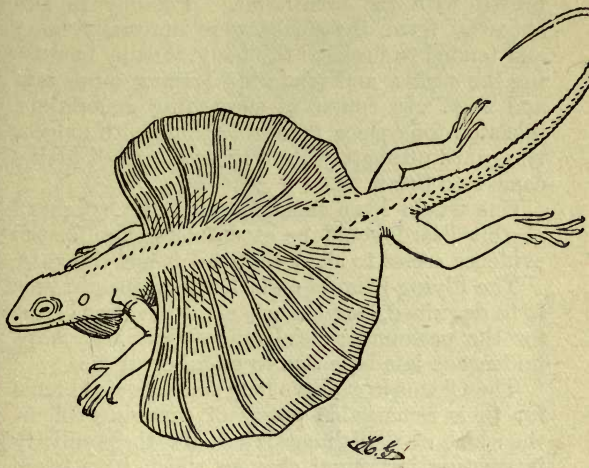


Fig. 8.—The Flying Lizard (*Draco volans*). The "flight" is performed by means of the parachute formed by skin stretched over the protruding ribs.

and, like the Anolis, move about the trees in a succession of leaps, but, unlike this species, are supported in mid-air by a relatively enormous pair of "wings." These are formed of folds of skin stretched between the hindmost ribs of the body, which for this purpose are drawn out so

as to project far beyond the body wall in the form of long slender rods. At the will of the animal these "wings" can be folded up like a fan. The ribs which take part in the formation of this strange organ are these known as "floating-ribs"—they are those whose ends are unconnected with the breastbone. Possibly in the ancestral form, these ribs were unusually long, and tended to broaden the body, thus by increasing the surface and rendering leaping more safe and easy. In course of succeeding generations selection took place, favouring those with longest ribs, until ultimately the Flying-Lizard of to-day came into being.

One would have imagined that the "flights" of this lizard would be extensive, but so far the evidence seems to show that this is not the case.

The Flying-Lizards and the Chamæleons, now to be described, stand alone among the lizard tribe for the profound specialisation which they have undergone in adaptation to an arboreal life.

The Chamæleons have long since acquired fame for their remarkable power of changing colour, the which we shall discuss later. But the peculiarly interesting structural changes which have taken place in the skeleton are by no means so familiar. To enter into details concerning this is no part of the province of the present little work, suffice it here to draw attention to the external character only. One of the first things which must attract the attention of the observer in watching these strangely sluggish creatures is the feet. In both fore and hind limbs the toes are not only remarkably short, but arranged in a perfectly unique

manner. No longer pointing directly forwards, they are bound together, as it were, into bundles. Of these, on the hand three are turned towards

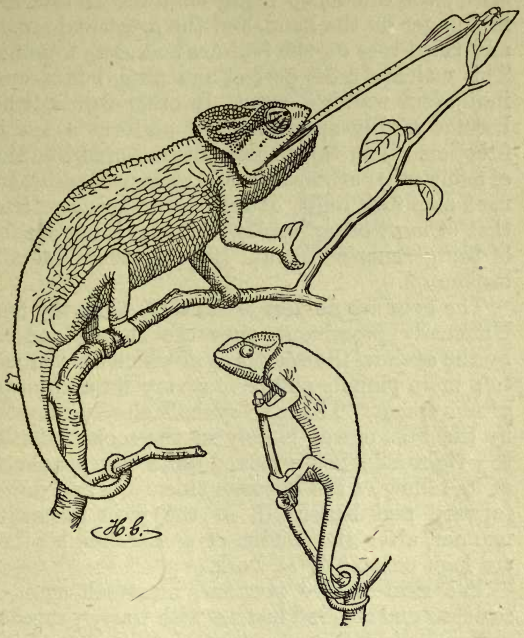


FIG. 9.—Outline drawing of Chamæleons (*Chameleon*), to show the remarkable tongue, eye, feet, and prehensile tail. From life.

the inside of the leg, and two towards the outside; in the foot two turn inwards, and three outwards. That is to say, the inner bundles are

opposed to the outer, just as the thumb is opposed to the finger in the human hand, so that the Chamæleons grasp a bough much as we grasp a stick; the difference being that the thumb and first finger on the hand, and the great and second and third toes on the foot are bound up together. This makes a most perfect grasping, but a most indifferent walking organ. In other words, it has become highly specialised to perform a special function. The tail is also peculiar, and like that of many other arboreal creatures, is prehensile, and used as a fifth limb. It differs, furthermore, from that of most other lizards, in that it is not capable of being renewed should it become accidentally broken off.

The eyes are no less remarkable than the feet. Unusually prominent, they are closely encased by the eyelids, the apertures of which are reduced to a mere pinhole and have a very limited power of movement. Thus the eyeball, closely invested by the lids, moves loosely in the socket, that of the right side being moved quite independently of its fellow of the opposite side. Up and down, forward and backward, in the most grotesque manner, after the fashion of a search-light, they are kept constantly at work.

The skin is also peculiar, inasmuch as it is scaleless and covered instead with warty granules.

Concerning the ancestors of this group, and the steps by which it has reached its present extraordinary form, we know nothing. As we have already hinted, the Chamæleons, like the Geckos, are regarded by zoologists as forming a group by themselves quite distinct from the true

lizards. This distinction, in the case of the Chamæleons, is made on account of the peculiar structure of the tongue and certain skeletal characters, of which the peculiar form of the feet is not the least important.

The home of the Chamæleons is Africa and Madagascar, and the neighbouring islands. One species, however, occurs in Europe—Andalucia. Two are found in the island of Socotra, a third in Southern Arabia, and one in India and Ceylon.

In size they vary greatly, the smallest species, which occur in Madagascar and tropical Africa, not exceeding three inches in length, while the largest, *Chamæleon parsoni*, of Madagascar, attains a length of two feet!

Adaptation to environment, so strikingly illustrated by the Chamæleons, not seldom causes animals not in the least related to assume a strong superficial resemblance. Sometimes this resemblance affects the whole body, at others only certain parts are affected; but in nearly all cases a close examination will bring out the real affinities of animals which are suspected of having fallen under the spell of "convergent evolution."

The two following instances are excellent examples of convergent evolution.

The genus *Anolis*, which is represented by more than one hundred species, is a near ally of the Iguanas, being indeed a member of the same family. But it has the curious adhesive pads found elsewhere only on the toes of the Geckos, which are a totally distinct group, belonging, as has just been remarked, to a different sub-order. The members of the genus in question, like the

Geckos, are arboreal. In this case, however, there is no possibility of mistaking any member of the genus *Anolis* for a Gecko, for though the feet have come to acquire a similar form, the rest of the body is unmistakably lizard-like.

The second case of convergent evolution, that of an arboreal lizard, *Lyriocephalus scutatus*, which represents a genus in itself, is a much more striking instance. The animal in question has come to bear a remarkably strong resemblance to a Chamæleon. The likeness, however, is confined to the general shape of the body, the feet being lizard-like and not in the least resembling the peculiarly modified feet of the Chamæleon.

CHAPTER V.

SNAKES.

FROM the point of view of evolution the Snakes are an extremely interesting group. Their near relationship to the lizards we have already referred to; indeed the differences between the two groups are comparatively slight, consisting chiefly in the structural modification of the jaws, characters which are intimately connected with the peculiar habits of feeding which characterise the snake-tribe.

The invariable absence of limbs in the Snakes constitutes one of the most obvious and striking features which these creatures possess, and it is this character alone by which they are popularly

distinguished from the lizards. Those, however, who rely on this character do so on the assumption that *all* limbless reptiles are snakes, and consequently unhesitatingly refer such forms as the common English Slow-worm (*Anguis fragilis*), the Glass-snakes (*Pseudopus gracilis*), and other limbless lizards to the members of the Snake family. Since, then, the typical lizard and the typical snake can be so readily distinguished, what are the characters by which the exceptional limbless types of the one may be distinguished from the invariably limbless forms of the other group?

The limbless lizard will be found to have a distinct external ear in the shape of a more or less well-marked pit lying behind the eye, whilst the two halves of the lower jaw are firmly united in front, and the bones of the upper jaw are firmly fixed to the skull. Further, the tongue in these degenerate forms is never withdrawn into a sheath, and the scales of the belly are not markedly different from those of the back.

In the Snake, an external ear is never present, the halves of the lower jaw are connected in front only by an elastic band, whilst those of the upper jaw are freely movable on the skull. The tongue is always withdrawn, when not in use, into a sheath, and the scales of the belly are generally very markedly different from those of the back, inasmuch as, with certain rare exceptions, they form a series of broad transverse bands lying one behind the other. These differences are largely connected with the peculiar habits of the snakes, and this significance will be dealt with presently.

It must not be supposed, however, that these are the only features which serve to distinguish the snakes. Some others we shall discuss as we proceed, but the majority are of too technical a nature to claim mention here.

Having briefly indicated the superficial differences between the lizard and the snake, we may proceed to rapidly survey the more important structural features of the latter.

The covering of the body is invariably furnished by scales, and these are never supplemented by bony plates or nodules. Symmetrically arranged on the head, in the form of shields, these scales afford useful characters for the purposes of classification. Those of the body are small in size, save only those along the under surface, which take the form of narrow bands or shields ranged in a consecutive series at right angles to the long axis of the trunk. They play an important part in locomotion.

At least once a year, generally much more frequently, the horny outer layer of the skin is shed, and this is done in such a way that not only is it turned completely inside out, but the exact shape of its late owner is preserved, even the peculiar "watch-glass" over the eye being undisturbed. These diaphanous snakes may often be picked up where snakes are common. Only in the Sea-snakes is the skin shed in flakes.

If, by any mischance, the skin is not shed, death inevitably follows; the old envelope becoming so tough and hard as to form an unyielding shell, preventing not only the further growth,

but also the breathing of the animal. This casting of the skin, furthermore, is accomplished in a very remarkable manner, inasmuch as it is forced off by the formation on the inner skin of a layer of very fine hairs, which serve the purpose of releasing the old skin by their rigidity of position. Strangely enough, a precisely similar mechanism is adopted by the crustacea for ridding themselves of the old shell when this has become too small. These hairs are known as *casting* hairs. Having performed their primary purpose, they are retained for purely decorative ends, becoming transformed into the curious, and often microscopic, stripes, ridges, or spikes which ornament the edges of the scales in the snakes and other reptiles which change the skin after this fashion, and the carapace of the crustacea.

The eye is peculiar in that, like the Gecko and certain burrowing lizards it has no eyelids. Instead, it is covered by a horny shield, which may be compared to a watch glass. This shield, as in the case of the Gecko, is probably formed by the transformation of the nictitating membrane. The snake, however, differs from the Gecko in that the eye, behind its shield, is immovable.

The nostrils are situated at the end of the snout. The sense of smell appears to be well developed, some snakes indeed, as in the common English Grass-snake (*Tropidonotus natrix*), hunting its prey by smell rather than by sight and sound.

The tongue is long, slender, forked at the top, and very sensitive, serving entirely as a delicate

organ of touch, and *not* as is so commonly supposed, as stinging or poison-injecting organ. But to this point we shall return. It is furthermore peculiar in that, when at rest, it is withdrawn into a sheath.

The skeleton is remarkable for the enormous number of the ribs, and of the bones which make up the vertebral column, in some spines as many as three hundred being present. Furthermore, these vertebrae articulate with one another by quite peculiar attachments, which, while adding considerably to the strength of the backbone, allow only of side to side movements between individual vertebrae. The ribs commence with the vertebra next behind that supporting the head, that is to say, with the axis vertebra, and extend backwards to within a short distance of the end of the body. They are long, and readily movable, and take the place of feet in locomotion. Limb girdles and breastbone are conspicuous by their absence. Only in a few cases are vestiges of limbs to be found, and these always represent the hinder pair.

Teeth are borne not only by the jaws, but by the palatine and pterygoid bones, which form the roof of the palate as well. They are lodged in shallow pits, and for greater security become fused with their respective supporting bones. Shaped like curved needles, with the points directed towards the throat, these teeth are quite useless for tearing purposes, and serve only as obstacles to prevent the escape of food from the mouth, inasmuch as this can pass in readily enough, but any backward movement thereof is

at once arrested, being caught on the needle points. Thus it is that snakes are obliged to swallow their prey whole. Broken teeth have no terrors for snakes, since provision is made by Nature for a constant renewal of those which are lost.

The lungs of snakes are peculiar in that owing to the great elongation of the body cavity, the left lung is much smaller than the right. The latter is, furthermore, remarkable in that it consists only of an exceedingly thin-walled bag, only the anterior portion of which is used for respiratory purposes, the hinder end serving merely as a reservoir of air.

Having now considered the principal characteristics of snakes, we may proceed to enquire into the factors which have given these creatures their peculiar features. Probably the most important influence at work has been the method of securing prey. Originally, like the lizards, four-footed, they seem to have been essentially hunters on the ground, taking their prey by stealth. This led, as in the case of many lizards, to the loss of the limbs and the enormous elongation of the body. Simultaneously with the disappearance of the limbs they developed new organs of locomotion, pressing the ribs into this service. The fact that every rib in the body, save only the very hindmost, takes part in this exercise, shows that this peculiar adaptation must have taken place quite early in the history of the group, before the ribs of the neck vertebræ became reduced to the dimensions which they present in the majority of other forms. The

crocodiles alone among modern reptiles, have preserved a complete series of free ribs in this region. The part which these ribs play in locomotion is briefly as follows. The free ends of each pair of ribs are attached to the ends of one of the broad shields which we have remarked running down the under surface of the body. When the creature walks the ribs are moved forward, one pair at a time, and in doing so, they move the horny shield to which these free ends are attached, so that its hinder edge projects downwards from the body and catches hold of whatsoever inequalities in the ground there may be. These inequalities serve as levers by which the body is thrust forwards. As a further aid to progress the body is thrown into a series of undulations in a horizontal plane, but never *vertical*, as is sometimes erroneously represented in pictures.

Mention has been made of limbs. These occur only as the merest vestiges, representing the hind-limbs, in certain archaic burrowing snakes and in the giants among the snakes, the Pythons and Boas. Externally, they are to be found in the shape of a pair of claw-like spurs half-concealed between the scales, at the wider end of the body. Dissection reveals further vestiges in the shape of the remains of thigh bones and hip-girdles. All trace of the fore-limbs, their girdles, and of the sternum, has absolutely vanished. The remnants of these once functional limbs are very precious links to the student of evolution, for they prove beyond doubt the fact that the modern snake has descended from limb-

bearing ancestors. Why the hind-limbs have persisted so long after the disappearance of the fore-limbs is a point which cannot be answered.

The peculiarly specialized condition of the body leaves but little room for further modification for the purpose of locomotion. Hence it is that we find more uniformity in the body than among the lizards. Yet, in spite of specialisation, snakes hold their own among the trees, on the ground, or burrowing beneath its surface, or in the water. Tree-snakes sometimes have the shields of the under surface of the body more or less markedly keeled so as to afford a safer hold, and further have a prehensile tail.

Keels of this kind are especially well developed in the Tree-Snakes of the genus *Dendrophis*, natives of South-Eastern Asia and Australia. These have the ventral scales armed with a pair of suture-like keels notched on each side. Therewith they are enabled to glide up the branches of trees in an almost straight line, instead of having to adopt an undulating motion. These snakes attain a length of six feet. Certain new-world tree-snakes of the genus *Leptophis*, when frightened or shaken out of a tree, coil up the body like a watch-spring, and let themselves drop from considerable heights. Alighting upon the ground on the spiral they escape without injury. Having a very slender body and a long whip-like tail, they are extremely graceful in form, attaining a length of six feet. They feed upon small reptiles, birds, and their eggs.

The burrowing snakes, like the burrowing lizards, show gradations of adaptation to this

peculiar mode of life. Some have undergone but little change, waylaying their unsuspecting prey, by covering themselves with earth, so as to leave only the head exposed. Others, and these are represented by four closely allied families, have undergone still further specialisation, the eyes in at least three families being reduced to mere vestiges.

In one family, the Shield-Snakes (*Uropeltidæ*) of Ceylon and Southern India, the tail terminates in a large shield, giving the body an obliquely truncated appearance. The use of this peculiar shield is unknown. They burrow in the soft earth often to a depth of several feet, and rarely appear above ground, and then only apparently during the rainy season. They appear to live solely on earth-worms.

The Cylinder Snakes (*Ilysiedæ*) of Ceylon and South-Eastern Asia, Tropical South America, like the Boas, to which they show some affinity, retain traces of the hind-limbs in the shape of claw-like spurs hidden among the scales. The most conspicuous member of this family is very beautifully coloured, and on this head we shall have more to say later (p. 161). Like their allies, the Shield-Tailed Snakes, just referred to, these snakes burrow deeply, and feed on earthworms and insects. The Coral Snake, however, appears to be a partial exception to this rule, since it is not so confirmed a burrower as the remaining members of the family.

The Blind Snakes, representing the families Typhodiæ and Glaucinidæ, are particularly interesting forms. Degraded to a worm-like

form by their burrowing habits, yet the species included in the first-named family retain traces enough of their former glories to show that they are, to quote Dr Gadow, "undoubtedly the last living descendants of formerly cosmopolitan, rather archaic snakes." Even to-day they have a wide distribution, occurring in tropical and sub-tropical countries. The mouth is exceedingly small, placed in the under surface of the head, and the jaws are capable only of the smallest dilatation. The tail, which is very short, ends in a horny spine.

The forms which make up the family Glauconidæ are interesting inasmuch as, though greatly degenerate, the pelvic girdle and hind-limbs show less reduction than in any other snakes, all the elements of the girdle being represented, as well as vestiges of femora or thigh bones. The blind snakes feed on ants and millepedes.

Just as some animals are omnivorous, whilst others have become adapted to, or specialised for, one kind of food, so others are omnimotile, if we may use such an expression; and now in one direction, now in another, become pledged to one form of locomotion only; or, as we say, are "specialised." We have already had many instances of this, and the snakes furnish no exception to the rule, though from their generally specialised conditions, further modifications are neither striking nor profound.

Instances of snakes which climb, crawl, and swim, with equal ease, have already been quoted; so also have others, in which the body has become adapted for one kind of locomotion

only, as in the case of the strictly subterranean snakes. The result of an exclusively aquatic life may now, therefore, fittingly be considered.

As might be expected, such a mode of life is approached by many gradations. The Common Ringed Snake, for example (*Tropidonotus natrix*), of Great Britain, divides its time, more or less, between the land and the water. Common in woods, heaths and hedges, it is especially abundant near water. Its chief food is frogs, but it preys also on mice, voles, young birds, eggs, and fish. When swimming, which it does with the greatest ease, the head and neck are raised above the surface of the water, a fact which shows that no special adaptation has taken place in response to the environment. The Giant Anaconda (*Eunectes murinus*) of the tropical forests of the Guianas, Brazil, and North-Eastern Peru, is still more aquatic, spending the greater part of its time in the water. Attaining a length of over thirty feet, this enormous reptile, however, is more versatile than the Ringed Snake, inasmuch as it is frequently found on shore basking on the burning sand, coiled up among the rocks, or stealthily hiding among the trees. The traveller-naturalist Bate several times encountered these enormous reptiles, and describes them as especially numerous and much detested in the country near Santarem, where it periodically visits the farm-yards, carrying off poultry, young calves, and whatever else it can lay hold of. Even man is sometimes attacked. As an instance, he quotes the case of a lad who was suddenly encircled in the terrible coils of one of these monsters at Ega.

"The father and his son," he says, "went . . . a few miles up the Teffé to gather wild fruit; landing on a sloping sandy shore, where the boy was left to mind the canoe whilst the man entered the forest. The beaches of the Teffé form groves of wild guava and myrtle trees, and during most months of the year are partly overflown by the river. Whilst the boy was playing in the water under the shade of the trees a huge reptile of this species stealthily wound its coils around him, unperceived, until it was too late to escape. His cries quickly brought the father to the rescue, who rushed quickly forward, and seizing the Anaconda boldly by the head, tore his jaws asunder." When in the trees it will often dart down its head from a considerable height to seize a passing peccary or other animal. In the water it lurks in quiet pools, or floats down with the current, but like the Grass Snake, keeps its head well above the surface.

The Javan Wart Snake (*Acrochordus javanicus*), may be taken as the representative of a family which is almost if not absolutely aquatic, frequenting rivers or estuaries, with brackish water, and occurring far out to sea. From these it is but a step to strictly marine snakes. These are represented by more than sixty species, occurring in the Indian and Western South Pacific Oceans. They are found, says M. Boulenger, "in abundance in the Persian Gulf, along the coasts of India, Burma, and the Malay Archipelago, to North Australia and New Caledonia." The coast-frequenting species ascend rivers. Between these marine forms which penetrate up the

rivers, and the fresh-water forms which occasionally wander out to sea, there is this difference, that whilst the latter show only a slight modification in the shape of a somewhat compressed body, the marine forms have acquired an eel-like form, the tail being flattened into an oar-shaped organ.

That these marine forms, which are believed never to leave the water, have been derived from several distinct fresh-water types is an extremely interesting point, especially in view of the fact that, though unrelated, all have acquired the same peculiarly modified body. Here we see again the principle of convergent evolution at work—that is to say, the effect of a similar environment acting on similar structures. Just as the burrowing lizards and the burrowing snakes have come to resemble one another in the same way. Further, we have to remark a resemblance of another kind between these marine snakes, inasmuch as certain harmless kinds have come to bear so close a resemblance to poisonous species in their coloration that they can only be distinguished after careful discrimination. On this point we shall have something to say when discussing the phenomena of mimicry.

Comment has frequently been made throughout these pages on the fact that, while certain animals have preserved a remarkable versatility of locomotion, or the ability to subsist upon a varied diet, others have, by what we may call a process of concentration, acquired a peculiar facility in one direction only in the matter of movement, or a special adaptability for subsist-

ence on one kind of food. But, at the same time, in gaining these ends they have done so by a complete surrender of freedom in other directions. The development of perfection in one direction has been at the expense of efficiency in every other. In other words, it has led to specialisation. In many cases this specialisation may be traced to the pursuit of food. A pursuit dictated possibly by congenital preference, sometimes by force of circumstances. In others the interpretation is to be sought elsewhere.

The peculiar form of the body of the snake is, in part, probably to be attributed to its singular feeding habits. In the case of the blind burrowing forms this interpretation seems certainly to be well founded, but whether the pursuit of their peculiar food is the result of an ancestral preference, or of force of circumstances cannot of course be known. It is legitimate speculation to suppose that the earliest snakes were small creatures, living upon insects and the smaller members of their own class. These being easily procurable without the effort of pursuit, the limbs became less and less needful, and consequently gradually atrophied. Later, in the absence of severe competition and abundant food, the carnivorous species were evolved, ultimately developing into the giant forms of to-day —which, by the way, are not so large as certain extinct species.

The foregoing remarks will probably gain an additional interest if a brief survey is given of the different methods adopted by snakes for procuring their prey; and of the peculiar, and indeed

remarkable structural modifications which they have undergone for the purpose of swallowing their victims.

Since it is the practice, in all save a few exceptional cases, among the snakes to swallow their prey whole—and this prey is generally of large size, the circumference of the victim being much greater than that of the captor—the bones of the jaws have acquired an unusual elasticity of movement. This has been attained by substituting elastic ligaments for the usual inflexible joints between the different bones which make up the jaws. When the food is seized, the process of swallowing is not, like that of other animals, performed by forcing the prey down the mouth and into the body, but rather, the creature seems to draw itself over its prey and slowly to envelop it. The sternum and shoulder girdle being absent the ribs are free to expand to any extent, and hence the region of the chest offers no restrictions to the size of the morsel swallowed.

The work of swallowing appears to be a purely mechanical one, a fact which sometimes leads to "regrettable events." A case in point occurred some eleven years since (October 1892), in the gardens of the Zoological Society of London. Mr A. D. Bartlett relates how, on the evening of that fatal day, two pigeons were placed in the cage containing two fine specimens of Boa constrictors, one of the birds being immediately seized, the keeper left the house. Returning next morning he found that one of the snakes had disappeared. A glance at the remaining

snake showed that, from its enormously distended body, it must have swallowed its companion, which was about nine feet in length. Unable to curl itself round, it was stretched nearly full length along the floor of the cage, its body distended to bursting point, and its scales no longer forming a faultlessly overlapping series, but stretched wide apart like so many small islands. Within eight-and-twenty days not only had the gigantic meal been digested, but another pigeon introduced into the den was immediately swallowed!

"This peculiar case," says Dr Gadow, "is not one of ordinary cannibalism: it is rather an unintentional accident. When two snakes happen to get hold of the same animal . . . and begin to swallow it, the action of swallowing becomes almost mechanical, the snakes continuing to push their jaws over their prey . . . so long as they feel something in the mouth. After the original prey has been mastered, it is the turn of the opposite snake's head, and if the weaker snake does not give way it is swallowed by its stronger mate."

Some snakes kill their prey before swallowing it; others swallow it alive. The Common Grass Snake (*Tropidonotus natrix*), for example, swallows its prey after the latter fashion. Fishes and frogs form its commonest victims. The former are seized by the belly and borne to land; the latter, if seized by one hind leg, is gradually swallowed without more ado, the other three limbs being pushed forward towards the head. If seized by the middle, the hapless victim is

turned and swallowed head foremost, and for some time afterwards may be seen wriggling within the body of the captor.

Contrary to what might be expected, the unfortunate victims do not seem to suffer much injury during their passage to oblivion, for on rare occasions—and they are very rare—the captive is returned unhurt to the light of day. Dr Gadow gives an instance of one such restoration: "One very tame snake," he says, "had swallowed a frog on my table when a friend entered the room. The snake was frightened, jumped on to the ground, striking it with its full belly, and thereby hurting the frog, which squeaked loudly; whereupon the snake reversed its mechanism and the frog hopped away, none the worse for its terrible experience."

Those snakes which kill their prey before swallowing, do so by one of two methods—by crushing, or by poison.

Perhaps the best known of the crushing or constricting snakes are those of the Python tribe, which contain within their ranks the largest of living snakes. Between sixty and seventy species are known, of which the "Anaconda" of the tropical forests of South America is the largest, though the Indian Pythons, *Python molurus* and *Python reticulatus*, run it very close, attaining a length of thirty feet. These enormous creatures can crush a tiger or an ox with comparative ease, though the tales of such bulky animals being swallowed afterwards cannot be credited. The prey is apparently seized by a sudden spring and immediately encircled by coil after coil of

the lithe and powerful body, which being drawn tighter and tighter, soon reduces the victim to a crushed and mangled corpse of the shape of a sausage. By means of these constrictions the necessary shape for convenient swallowing is obtained.

The Burmese have a quaint legend about the Reticulated Python (*Python reticulatus*) which has been done into English by Mason in his book on "Burma . . . and its Productions." "According to an old Karen legend," he says, "all the poisonous serpents derive their virulence from the Python, which, though innocuous now, was originally the only one that was venomous. In these days he was perfectly white, but having seduced away a man's wife, Aunt Eu (Eve), he made her, while she was in his den, weave figures on his skin in the forms which are now seen. At that time, if he bit the footstep of a man in the road, such was the virulence of his poison that the man died, how far soever that man might have passed from the bitten track. The Python had not, however, ocular demonstration of the fact, so he said to the crow: 'Crow, go and see whether people die or not when I bite the foot-track.' So the crow went to the neighbourhood of a Karen cabin, and found the people, as is their custom at funerals, laughing, singing, dancing, jumping, and beating drums. He therefore returned to the python, and told him that, so far from his effort producing death, on the contrary they produced joy. The python was so angry when he heard this, that he ascended a tree and spit up all his venom, but other creeping

things came and swallowed it, and people die of their malignancy to this day. The tree, therefore, from which the python spat up his venom became deadly, and its juice is used to this day for the purpose of poisoning arrows. The python made the other creatures promise not to bite without provocation. The cobra said: 'If there be transgression so as to dazzle my eyes to make my tears fall seven times in one day, I will bite.' So said the tiger (whose bite the Karens esteem as virulent as a serpent's) and others, and they were allowed to retain their poison. But the water-snake and the frog said they would bite with or without cause as they liked. So the python drove them into the water, where their poison melted away and their bite became harmless."

Concerning poisonous snakes we may remark that these are not, as was at one time believed, a group of closely related forms, opposable, as a group, to the non-poisonous snakes. On the contrary, a more complete knowledge of their anatomy shows that these poisonous, together with certain non-poisonous forms, represent one of two distinct branches of a common, non-poisonous stock, the members of each branch having independently acquired their deadly powers.

It is popularly supposed that the venom of the snake is concealed in the curiously long forked tongue, which is always so much in evidence in the snakes. As in the similar organ of the lizard, this is, as a matter of fact, perfectly harmless, and used only as an organ of touch. The

poisonous weapons of these creatures are to be found in a pair of specially modified teeth in the upper jaw, and a corresponding pair of poison bags or glands. These teeth in some forms are marked by a deep furrow in front; in others, the edges of the furrow meet to form a channel open only at the point of the tooth. At the base of each tooth is the bag of poison, so placed that the opening of the mouth causes the poison fang—which has been lying folded back towards

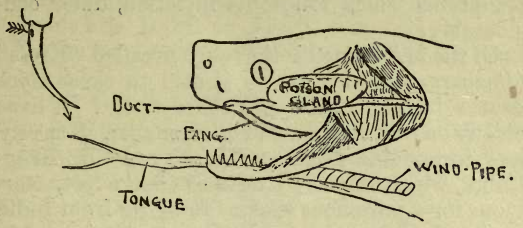


FIG. 10.—Head of a poisonous snake dissected to show the poison gland and fang through which the venom is conducted.—After GADOW.

the throat—to press upon the bag and force out of it into the groove, or tube of the tooth, a small but deadly quantity of venom, which is introduced into the body of the snake's victim as the fang buries itself in the flesh thereof.

The poison bag is formed by a modification of either of certain salivary glands known as the upper labial gland, or of the gland answering to the parotid gland. The fact that two different glands have been utilised for the same purpose, coupled with the fact that the bones bearing the fangs differ remarkably in size, is strong evidence

in favour of the view of the independent origin of the poisonous snakes.

The snakes of the genus *Doliophis*, allies of the Cobras, are remarkable for the enormous size of the poison bags, which extend far beyond the head, along each side of the body, terminating in club-shaped thickenings. Owing to their great size the heart has been shifted further backwards than in any other snake.

The virulence of snake-poisons, and the symptoms which follow its injection, differ considerably.

Of the first named is the much dreaded "Krait" (*Bungarus corulens*), which is said to cause more deaths in India than any other snake. It lives chiefly on rats, lizards, and other snakes. Scarcely less formidable is the "Hamadryad" or King-Cobra, which attains a length of twelve feet, enormous for a poisonous snake. Ranging from India to South China and the Philippines, it is held in detestation everywhere on account of its size and poisonous properties.

The African cobras have a remarkable habit of squirting the poison from the mouth when threatened, and are said to be able to throw several feet. The object of such waste is not easy to understand, since unless the venom reaches a raw surface, or is injected into the flesh by the teeth, it is powerless.

Foremost among venomous snakes stand the Vipers and Pit-vipers, inasmuch as it is among these forms that the poison apparatus has reached its highest perfection. To attain this, certain of the jaw-bones have undergone considerable modi-

fication. Thus the maxillary, in other poisonous snakes a longish bone, firmly fixed, and lodging the fangs and sometimes smaller teeth behind, is in the vipers reduced to a columnar shape and shifted forwards so as to lie in the front of the jaw. Into the lower end of this bone the long poison tooth is fixed; above, it is slung on to the neighbouring bones so as to move as by a hinge. By this means, when the mouth is closed the fang is drawn backwards so that its point looks towards the throat, but as soon as the jaws open the point is forced forwards so as to be in the best possible position for its deadly work.

As is generally the case among poisonous snakes, a series of reserve teeth are to be found packed away behind the functional fang. Every gradation is represented, from the nearly finished tooth to the merest germ.

The Viper family has succeeded in many spheres—ground-dwelling, arboreal, semi-aquatic, and burrowing types being represented.

Pages might be written on this group, but we must select for the present purpose one or two of the most conspicuously dangerous types. Such are the "Daboia" (*Vipera russelli*) and the Pit-vipers.

The "Daboia" has been described as one of the scourges of India, and is equally terrible in Ceylon, Burma, and Siam. What the "Daboia" is to India, the "Fer-de-Lance" (*Lachesis lanceolatus*)—one of the Pit-vipers—is to America, since it occurs in abundance in the sugar-plantations, and exacts therefrom a heavy toll on those

who labour there. The experiment of importing the mongoose to wage war against this terrible creature proved a failure; even this redoubtable little warrior retreating before its venom and seeking safer prey. The Pit-vipers are so-called from the presence of a pit between the nostril and the eye, supplied by branches of the trigeminal nerve. Apparently sensory, the function of the pit is unknown. Some sixty species of Pit-vipers are known, and of these probably the most remarkable are the dreaded Rattle-snakes.

We might remark that the only poisonous snake in Great Britain belongs to the Viper family. *Vipera berus*, the Common European Viper. This snake exhibits a preference for heaths, moors, and woods. Brambles, clumps of nettles, and heaps of stones are also favoured spots affording safe cover. Mice form its principal food.

The bite of the Common Viper, though attended with great pain, is rarely fatal. The bitten limb soon swells and becomes discoloured. Very shortly after the deposit of the venom the victim is overcome by great prostration, vomiting, and cold perspiration, and experiences some difficulty in breathing. In from twelve to twenty-four hours the severity of the symptoms begins to abate, but recovery may not take place for some days later, and then is rapid. Death, however, may occur from depression or the secondary effects of the wound. The remedy is to apply a ligature and bandages *above* the wound, then to open the latter still further with a clean knife and pour in Condy's fluid or bleaching powder.

Internally, before the arrival of the doctor, *small* doses of alcohol may be given.

The Common Viper may generally be distinguished from the Grass-snake by reason of the diamond-shaped pattern which runs down the back and the ∧-shaped bar on the head. The females are larger than the males.

Certain mammals and birds are immune by nature against snake-bites: such are the Hedgehog, the Pig; and the Secretary-bird, Honey-buzzard, and Stork.

It should be remembered, in justice to these dreaded and much abused creatures, that their poisonous properties are directed mainly to the capture of food. Man falls but too often a victim to their virulence because he threatens their safety, or invades their dominions.

One of the most remarkable adaptations for feeding to be found among the Vertebrata is that of the Egg-eating Snake (*Dasypeltis scabra*) of tropical and South Africa. The jaws are almost toothless, since large teeth would probably break the egg-shell and so waste the contents. The egg is accordingly swallowed whole, and, having passed the head, forms a huge swelling immediately behind. After a few slight contortions the swelling suddenly collapses, and later the shell and its inner lining, neatly rolled up, are ejected from the mouth, like the indigestible pellets of birds of prey. Dissection of the creature shows that the teeth of the jaws have been replaced by teeth in the throat formed by downwardly directed spines from the vertebral column, which, piercing the

gullet, play the part of true teeth. By breaking the egg far down the gullet, none of its precious contents are wasted.

The food of this species appears to consist chiefly of birds' eggs. Though even when full-grown and scarcely exceeding a length of two feet and a half, it is quite able to swallow an ordinary hen's egg.

CHAPTER VI.

DOMESTIC LIFE.

DOMESTICITY is not a strong point with the Reptile people. Amorous outbursts displayed in the choice of mates, and here and there proofs of some slight regard for their offspring, are all that can at present be recorded in their favour on this head. In all this they stand in strong contrast to their poor but distant relations the Frogs and Toads and their kind on the one hand, and their aristocratic cousins the Birds on the other. Indeed, in all that pertains to the emotions of this character they are almost fish-like. Laggards in love, they are still more apathetic as parents.

In so far as the affections are concerned, the Reptile is seen at its best, or worst, according to the traditions of its tribe, when seeking a mate. The advances appear always to be made by the males, and to vary greatly in the way in which they are made. Where rivals are many, some endeavour to succeed by wiles and blandish-

ment; others employ violence, the several suitors fighting viciously among themselves for the coveted prize.

But little appears to be known concerning the methods of courtship prevalent among the Tortoise tribe. The writer was therefore the more fortunate in witnessing a little love passage between two painted Terrapins (*Chrysemys picta*) in the Reptile House at the Zoological Society's Gardens in London, the date, to be quite precise, being the 21st of July 1901. The unusual activity of a male of this species was the first thing to attract attention to his movements, which appeared to be excited by some strange stimulus. Watched more closely, he was found to be dodging a female of his own species, and making most frantic efforts to swim round so as to directly oppose her path. This done, he closed up, and immediately commenced to beat a lively tattoo with his long finger-nails upon her devoted head and eyes, the movements being so rapid that nothing more than a blurred image of the nails was visible. As soon as she escaped these peculiar attentions, he set about circumventing her again, and again succeeded, and this was repeated, not once, but many times during my stay there.

Dumb for the rest of the year, some at least appear to find a voice during this time of courtship. Thus the giant Tortoise of the Galapagos (*Testudo nigra*), at this period only, utters a hoarse bellowing sound, which can be heard at a distance of more than a hundred yards. His mate is at all times voiceless, like the far-famed Cicada.

Among the Crocodiles fierce battles are apparently commonly fought by the males for the possession of some coveted female; whilst displays and caperings of a most ludicrous kind, accompanied by loud bellowings, intended for the eye and ear of his mate alone, appear to take place after the conqueror has driven off his rivals. Thus the Alligator has been described as endeavouring to ingratiate himself in the eyes of his chosen one by splashing and roaring in the midst of a lagoon, twirling round on the surface of the water with head and tail lifted up, and the body swollen out with air to bursting point. During this time, too, it should be mentioned, these creatures emit a strong odour of musk, which is secreted by glands situated in the lower jaw.

Among the lizards, as with the birds, the males are often brilliantly coloured, whilst their mates are comparatively dull. The difference between the sexes, however, is by no means as frequent as among the birds. There seems to be evidence to show that this beauty is the result of sexual selection. That is to say, the females choose as mates those which are more brightly coloured than their rivals, or at least those which combine beauty of colour with aptitude for display. Darwin, dealing with this subject, reminds us that in the genus *Sitana*, the males alone are furnished with a large throat pouch, which can be folded up like a fan, and is coloured blue, black, and red; but these splendid colours are exhibited only during the pairing season. In the female this pouch is wanting. Coloured pouches of this kind are common among the

reptiles and probably serve in all cases the same purpose.

In many species of lizards the males during the breeding season become very pugnacious, and rivals never meet without a conflict. In *Anolis carolinensis*, for example, when two males meet they face one another, bob the head up and down two or three times, expand the throat pouch, lash their tails from side to side, and then, worked up to the requisite pitch of fury, rush at one another, rolling over and over, and holding firmly with the teeth. The conflict generally ends in one of the combatants losing his tail, which is eaten by the victor!

Dr Gadow, on the authority of Mr Annandale, describes as follows the courtship of the lizard (*Calotes emma*) of the Malay Peninsula. "The males are very pugnacious and change colour as they fight. At the time of courtship a curious performance is gone through by the male, the female remaining concealed in the foliage hard by. He chooses some convenient station, such as a banana leaf or the top of a fence, and advances slowly towards the female. His colour is then pale yellowish flesh colour, with a conspicuous dark spot on each of the gular pouches, which are extended to their utmost. He stands upright, raising the fore part of the body as high as possible, and nodding his head solemnly up and down. As he does so, the mouth is rapidly repeatedly opened and shut, but no sound is emitted. When he is driven away, caught or killed, the dark spot disappears entirely from the neck."

With the Chamæleons ornament in this direction can no further go; at least it would almost seem so. Only in a few species, however, do we meet with these marked sexual differences. The most conspicuous instance is that furnished by *Chameleon bifurcus* of Madagascar. Herein the snout of the male is armed with two enormous bony projections resembling horns. Only a rudiment of these is present in the female. In Owen's Chamæleon (*Chamæleon oweni*), from the west coast of Africa, the male bears three such "horns," two of which project from the forehead and the third from the snout; but the female is weaponless. These curious projections appear to be comprised of fibrous tissue in the young animal, and to become bony later in life. Probably during a still earlier phase in the history of their development, they were quite flexible in character, as in the case of a similar appendage in one of the lizards (*Ceratophora stoddartii*). This suggests that originally the "horn" may have been of still softer tissue, erectile during excitement. From this it passed to a permanently rigid structure which now, late in life, becomes bony. At the present day, at least with the Chamæleons, these appendages appear to be used as weapons of offence by the males when fighting for the possession of mates. As in the case of horns in the mammalia, there seems to be a tendency for these structures to be transmitted to the females, and probably, in the course of ages, they will, in this sex, come to assume very nearly the proportions of those of the males, though it is improbable they will ever be quite

as large since they do not come under the influence of selection.

The snakes, like the lizards, afford instances of sexual differences in colour, but there seems to be no evidence that these creatures fight for their mates, and hence perhaps the absence of all weapons save poison, and this is only associated with the capture of food or the slaughter of foes.

On the whole, there is far less activity and intensity of feeling displayed by the reptiles in their choice of a mate than is the case with the birds, as those who may have read the Story of Bird-life will probably have remarked.

Similarly, in the care they display for their offspring, the reptiles are far behind the birds. With the latter, it may be remarked, the young are produced from eggs only after a long period of incubation, but in many reptiles the eggs are often retained within the body during the whole process of their development, so that the young are ready to leave the shell immediately after the egg is deposited, or are even born free. It is of importance to note that whilst in some reptiles the internal development of the egg is normal, in others it occurs only when for some reason laying is retarded. In this, probably, we have the clue to the origin of the normal cases of internal development.

When the development of the egg takes place outside the body, incubation by the mother rarely takes place. Instead, the eggs are buried in warm earth or decaying vegetable matter and there hatch out. It is probable that in those rare

instances where incubation of the eggs is supposed to obtain, the real object is protection, inasmuch as no appreciable increase in temperature was traceable in the case of the Indian Python (*Python molurus*), which, during the summer of 1881 remained for almost six weeks coiled around her eggs, fifteen in number, in the gardens of the Zoological Society of London.

A receptacle for the eggs in the shape of a nest appears never to be made, though the Nile Monitor (*Varanus niloticus*), is said to build itself a nest among the bushes on the banks of streams, especially those which dry up in summer. It may happen, that further investigation will show that this is used also for the eggs.

That the progress of embryonic development may be arrested and suspended for a relatively long period of time is probably a fact not generally known. Thus the eggs of one of the northern Pond-tortoises (*Emys orbicularis*), laid in the autumn, do not hatch out till the following spring, withstanding the severe winters of North Germany and Russia, though only a few inches below the surface. Similarly, in the "Tuatera" (*Sphenodon punctatus*), the eggs are laid from November to January or February—the southern summer—and by August contain nearly ripe embryos. These, however, do not hatch out till the following February, or till the embryos are some thirteen months old. During a large part of this time they seem to undergo a sort of summer sleep, or œstivation, akin to the winter sleep, or hybernation, of the tortoise embryo.

The egg-shell among the reptiles varies greatly in its texture, being of great hardness in some forms, as in some tortoises and in crocodiles for example, and soft and leathery or parchment-like in others, as in most lizards and in snakes. In these cases, where the shell is of sufficient density to require this, the snout of the embryo is provided with a sharp conical "tooth" wherewith the shell is cut, just as among the birds. In colour the shell is white or yellowish, but without markings as in birds, save in the Tuatera lizard, the egg-shell of which may bear a zone of reddish spots.

Eggs which have only a parchment-like shell, be it noted, sometimes exhibit the strange feature of growing after they have been laid. This growth is due to the stretching of the shell by the developing embryo, which in addition to feeding on the contained food material, takes in air and moisture through the shell.

The number of the eggs varies, among the tortoises, for example, some species laying from three to five, others as many as one hundred and twenty. Among the birds, it may be remembered, there are many species which lay but a single egg, and more in which the number does not exceed three.

That the reptiles' eggs are invariably white is to be explained by the fact that they are never exposed, but laid either in holes of trees, or burrows, or buried in the ground.

With many reptiles great care is displayed in the disposal of the eggs. Thus the European Pond-tortoise first prepares the ground by water-

ing it from the bladder and the peculiar anal water sacs to which we have already referred. Then it stiffens the tail and bores it a hole with it, enlarging this by the aid of the hind feet till it is about five inches deep. The eggs are then laid at the bottom and distributed by the feet. Then the soil is put in again and beaten down flat, and the spot concealed by scratching the surface a little with the claws. This done, no further interest in the nest is displayed.

The eggs of some species of tortoises, by the way, are highly esteemed as food, or eagerly sought for on account of the oil they yield. The vast quantities that are destroyed by man every year for this purpose is almost incredible. The naturalist Bates, describing the scenes which took place on the breeding ground of the "Arran-Turtle" (*Podocnemis expansa*) of Tropical South America some fifty years ago, gives us an idea of the magnitude of this destruction. "The turtles," he says, "lay their eggs by night, leaving the water . . . in vast crowds, and crawling to the central and highest part of the praia." They "excavate with their broad webbed paws deep holes in the fine sand: the first comer, in each case, making a pit about three feet deep, laying its eggs (about one hundred and twenty in number), and covering them with sand; the next making its deposit at the top of its predecessor, and so on until every pit is full. The laying season over, which lasts about fifteen days, the natives commence the work of collecting the eggs. This is done in a very methodical manner.

"Placards," says Bates, "were posted up on the church doors at Ega, announcing that the excavation on Shimuní would commence on the 17th of October, and on Catesá . . . on the 25th. We set out on the 16th, and passed on the road . . . a large number of people, men, women, and children in canoes of all sizes, wending their way as if to a great holiday gathering. By the morning of the 17th, some four hundred people were assembled on the borders of the sand-bank, each family having erected a rude temporary shed of poles and palm leaves to protect themselves from the sun and rain. Large copper kettles to prepare the oil, and hundreds of red earthenware jars were scattered about on the sand. The excavation of the taboleiro, collecting the eggs, and purifying the oil, occupied four days. All was done on a system established by the old Portuguese governors, probably more than a century ago. The commandante first took down the names of all the masters of households, with the number of persons each intended to employ in digging; he then exacted a payment of one hundred and forty reis (about fourpence) a head towards defraying the expenses of sentinels. The whole were then allowed to go to the taboleiro. They ranged themselves round the circle, each person armed with a paddle, to be used as a spade, and all began simultaneously to dig, on a signal being given—the roll of drums. . . . It was an animating sight to behold the circle of rival diggers throwing up clouds of sand in their energetic labours and working gradually towards the centre of the ring. . . . By the end

of the second day the taboleiro was exhausted; large mounds of eggs, some of them four to five feet in height, were then seen by the side of each hut, the produce of the labours of the family."

"When no more eggs are to be found, the mashing process begins. . . . The whole heap is thrown into an empty canoe and mashed with wooden prongs; but sometimes naked Indians and children jump into the mass and tread it down, besmearing themselves with yolk and making about as filthy a scene as can well be imagined. This being finished, water is poured into the canoe, and the fatty mass left for a few hours to be heated by the sun, on which the oil separates and rises to the surface. The floating oil is afterwards skimmed off with long spoons, made by tying large mussel-shells to the end of rods, and purified over the fire in copper kettles.

The destruction of turtle eggs every year by these proceedings is enormous. At least 6000 jars, holding each three gallons, are exported annually from the Upper Amazons and the Madeira to Pará, where it is used for lighting, frying fish, and other purposes. It may be estimated that at least 2000 more jarfuls are consumed by the inhabitants of the villages on the river. Now it takes at least twelve basketfuls of eggs, or about 6000 by the wasteful process followed, to make one jar of oil. The total number of eggs annually destroyed amounts therefore to 48,000,000, As each turtle lays 120, it follows that the offspring of 400,000 turtles is thus annihilated. A vast number,

nevertheless, remain undetected, and these would probably be sufficient to keep the turtle population of the rivers up to the mark, if the people did not follow the wasteful practice of lying in wait for the newly-hatched young, and collecting them by thousands for eating, their tender flesh and the remains of the yolk in their entrails being considered a great delicacy. The chief natural enemies of the turtle are vultures and alligators, which devour the newly-hatched young as they descend in shoals to the water. These must have destroyed an immensely greater number before European settlers began to appropriate the eggs than they do now. It is almost doubtful if this natural persecution did not act as effectively in checking the increase of the turtle as the artificial destruction now does. If we are to believe the tradition of the Indians, however, it had not this result, for they say that formerly the waters teemed as thickly with turtles as the air does now with mosquitoes. The universal opinion of the settlers on the Upper Amazon is, that the turtle has very greatly decreased in numbers and is still annually decreasing."

But this is a digression, though it is hoped a pardonable one. Let us return to our subject —the Care for the Young.

Among the Crocodiles, a veritable nest is built, although in its simplest form this differs but little from the hole dug by the majority of reptiles. The Common Crocodile, for example (*Crocodilus niloticus*), has been observed in Madagascar to dig a hole in the sand of from eighteen inches to two feet deep, so contrived that the bottom

of the nest is wider than the top, and has its centre in the form of a mound. Thus, when the eggs, some twenty to thirty in number, are laid, they roll down the slope into the circular trench. When the hole is filled up the mother takes up her station on top when sleeping, and thus betrays what she had taken so much pains to conceal. In about twelve weeks the eggs are hatched. The mother, when the time of hatching is at hand, repairs to the nest to liberate her young ones and conduct them to the water. The reality of the mother's regard for her young was proved by the naturalist Voeltzkow, who built a fence about a nest near hatching time. Several times she returned and partly destroyed it during the night, and each time it was replaced by a stronger. At last the nest was found deserted, and then it was discovered that the mother had dug a hole beneath the fence through which her offspring escaped.

It seems that the mother is warned of the approaching escape from the shell by a peculiar hiccough-like noise made by the young when she returns for her nightly slumbers. Young birds, it will be remembered, also signal their approaching appearance by "cheeping" whilst within the shell. Like the birds, the Crocodile breaks the shell by means of an egg-tooth placed on the top of the snout. The nest of the Alligator (*Alligator missisippiensis*) is a much more portentous structure, resembling that of the mound birds. It is a large structure, built by the female, and formed of dead leaves and twigs, together with fine earth heaped up into a mound about three

feet high, and as much as eight feet in diameter. On the top of this mound, some eight inches from the surface, some twenty to thirty white, hard-shelled eggs are laid, and left to incubate by the heat generated by the decaying vegetable matter. As soon as the young escape from the shell they make their way out of the nest and run to the water without any aid or further care from the parents. During the time that incubation is going on, however, the eggs appear to be jealously guarded; the mother digging a cave in the river bank, immediately below the nest, and there lies in wait for possible marauders.

Sea-snakes appear to guard their young for some time after birth, inasmuch as the naturalist Semper once found a large female coiled up among the rocks, and between her folds were at least twenty young, two feet in length.

That the Common British Viper accompanies its young for some time appears to be very probable, but the very prevalent belief that they take refuge in the mother's throat when threatened by danger, is wholly without foundation in fact.

Among the lizards very little care appears to be taken of the eggs, and of the young none at all. Thus, for example, the Common English Lizard (*Lacerta vivipara*) retains the eggs, some six to twelve in number, within the body until they are ripe, sometimes even the young escape from the shell before leaving the body of the parent. But once free they are left to their fate. For some days they lie motionless among the leaves or in crevices of the ground, being

nourished by the remains of the food yolk of the egg. Not until this is absorbed do they commence to feed, their first meal consisting of aphides, and similar tiny creatures. At birth it should be mentioned, they are less than an inch in length.

We may pass now to a brief survey of another side of reptile domestic life—their sociability. Reptiles are far less frequently found dwelling in colonies or living in large herds than birds or mammals. Perhaps the most remarkable instances are the great "warrens" of the Sand Iguana of the Galapagos (*Conolophus subcristatus*), and the enormous herds of an allied form living on the same islands, *Amblyrhynchus cristatus*. The former Darwin found to be so numerous on James Island that "we could not for some time find a spot free from their burrows on which to pitch one single tent." The latter are still abundant, and may be seen swarming in masses of thousands on the rocks fringing the sea. Similarly the Crocodilia and certain species of sea-snakes consort together in enormous numbers; as also did the Tortoises of the Galapagos a couple of centuries ago. These huge crowds, however, are not gathered together for mutual protection or love of their kind; they are simply the result of unchecked increase, there being room and food enough for all, and no enemies sufficiently powerful to keep down their numbers.

In other cases, however, mutual advantage is evidently the inciting cause to the gathering together of large numbers of the same specie.

Thus the Common British Grass-Snake (*Tropidonotus natrix*) and the Viper (*Vipera berus*) on the approach of winter seeks out some sheltered hole in a bank, or under the roots of trees, and in a state of torpor await the spring. Though commonly they retire singly, they are not unfrequently found huddled together in masses of considerable numbers. With the Common Rattle-snake (*Crotalus horridus*) of North America, this custom of hybernation in large masses is apparently the rule rather than the exception. Assembling, it is said, in thousands from a radius of twenty or thirty miles they meet, in the ancestral den, to pass the winter in a state of torpor, huddled together for the sake of warmth. This "homing" instinct is, of course, of the same nature as that which guides the swallow back to its old nest, or the salmon back to the same river, for nesting purposes.

Among the Crocodilia extremes of climate are avoided in one of three ways — hybernation, æstivation, and migration. Thus the Alligator (*A. missisippiensis*) passes the cold season in a state of torpor in holes in the ground; whilst the Marsh Crocodile (*C. palustris*) of India and Ceylon passes periods of drought buried in the mud, remaining there, in a torpid condition, till the rains. The large Caiman (*Caiman jacar*) of South America, apparently disapproving of this waste of time, avoids unpleasant extremes by migrating, retreating to the flooded forests in the wet season, and returning to the rivers in the dry season.

The Lizards and Tortoise-tribe also hybernate

when the winter is cold, but they do so singly and not in colonies as in the foregoing instance.

CHAPTER VII.

REPTILIAN LIVERIES.

"THE existence of colour, as such," remarks Professor Poulton, "is not necessarily of any value to an organism." Colour is the incidental result of chemical or physical structure which causes certain light-waves to be absorbed; or the elements of the tissues may be so arranged that the light is scattered, causing what are known as interference colours, such as the metallic colours of birds' feathers. The red colour of blood is an instance of non-significant colour, since, hidden away in the tissues of the body, its redness ceases to exist, and only becomes apparent when drawn from the animal. The often beautiful colours of non-living bodies again serve as instances of non-significant colour.

Nevertheless, the coloration of the vast bulk of living animals is fraught with a deep significance, and represents the results of a long process of selection. From the wide range of variation offered by the inevitable production of non-significant colours, the innumerable patterns which form the characteristic liveries of the different species of animals have been formed. Animals which, by their conspicuous coloration, either drew upon themselves the attention of their

enemies, or advertised their presence to their prey, were gradually exterminated. In yet other cases, strangely enough, the development of strangely contrasting colours proved of the greatest benefit to the possessors, in consequence they became yet more conspicuous, and survived on account of this advantage over their more sombre relatives. It is by these means that the different types of animal coloration of to-day have been arrived at. The nature of these types, and the part they play in the Story of Reptile Life, we may now proceed to discuss.

The Reptiles rank among the most gorgeously coloured of animals, and the several types of coloration which they display may be grouped under three main heads:—Resemblance colours; Warning colours; and the colours induced by courtship.

Closely allied as the Reptiles undoubtedly are to the birds, yet in the matter of coloration they more nearly resemble the naked amphibia—the much despised frogs, and toads and their allies. Among the birds, seasonal changes and sexual differences in coloration are common. Changes according to season are almost unknown among the Reptiles, and sexual differences are the exception, not the rule. With the birds, fleeting changes of colour are restricted to naked areas of the skin on the head and neck in some few species; and even then are rare, the colour being for the most part fixed. The Reptiles afford numerous examples wherein the most rapid changes of colour, all over the body, take place. The interpretation of this is not far to seek; it is due

chiefly to the very different nature of the covering of the body. In the feathers of the bird, changes of colour can take place only with extreme slowness; whereas, in the scaly skin of the Reptile, or fish, or the smooth skin of the frog, a fleeting play of colour is possible. It is brought about in this wise. The horny outermost layer of the skin is colourless; in the layer beneath this are embedded iridescent cells with striated surfaces. Below this, in the deepest layer of the skin, cutis, are a large number of cells filled with highly refractive granules, chiefly guanin-crystals. These cause white colour by diffuse reflection of direct light. Nearer the surface are cells filled with oil-drops, and these give a yellow colour. In the granular mass are embedded numerous colour-bearing branching sacks or chromatophores containing, for the most part, blackish-brown or reddish pigment. The branches of these sacks being contractile, the contained granules of colour are drawn away from or towards the surface of the skin, and thus, combining with the stationary colour, effect a corresponding change in the coloration of the animal.

The marvellously vivid hues which bedeck so many Reptiles are all produced by a very limited palette—black, red, yellow, and white, with the combinations grey and brown. The white pigment, as we have already remarked, is due to guanin-crystals; blue and green are structural or optical colours. The former appears, at least in birds, to be associated with a dark-coloured pigment; the latter with a yellow pigment, in

combination with a modification of the outer horny and colourless layer of the epidermis. The green colour of some tree snakes, however, appears to be due to a pigment, inasmuch as Mr Boulenger, one of our greatest authorities on Reptiles, observes that green tree-snakes give the colour of the alcohol in which they are preserved a green tinge.

Wholly white Reptiles, it is interesting to note, are unknown in an adult state, though it must be remarked the newly-born chamæleon is snow-white; uniformly green, or blue, and black are common. As a rule, however, the colours are varied so as to produce a well-marked pattern.

The "resemblance colours," to which reference was made at the beginning of this chapter, are so called because they enable the wearers to conceal themselves, by reason of their likeness to the general surroundings. By this means they are enabled either to escape their enemies or to approach their prey unobserved. Since the same type of coloration is adopted to gain two very different ends, we can only tell whether the livery of any particular reptile is assumed for protective or aggressive purposes after a careful examination of each case. Thus, the green tree-frog is obviously protectively coloured, whilst the green tree-snake is to be regarded as aggressively coloured. Incidentally, of course, the aggressively coloured reptile is also protectively coloured.

Though the real significance of the colours of animals was not really grasped until within this

last few years, its meaning was vaguely realised long since. As witness of this we quote the following lines:—

"The deadliest snakes are those which, twined 'mongst flowers,
Blend their bright colouring with varied blossoms,
Their fierce eyes glittering like the spankled dewdrop;
In all so like what nature has most harmless,
That sportive innocence, which dreads no danger,
Is poisoned unawares."—*Old Play.*

The absence of white coloration among Reptiles is easily understood. Save amid snow, such an investment would be extremely conspicuous, therefore the wearer would need either to be sufficiently strong to bid defiance to all enemies, or to be independent of colour for its food. Amid snow a white dress might be essential, as among birds and mammals, but as reptiles which live in regions where snow falls hybernate during the winter months, no such adaptation to their environment is needed.

The Lizards, Grass-snake, and Viper of the British Islands are admirable examples of resemblance colours. Harmonizing perfectly with their immediate surroundings, the lizards are to be regarded as illustrating protective resemblance, acquiring by their disguise escape from their enemies the snakes. Whilst the latter from their equally perfect covering illustrate aggressive resemblance whereby they are enabled to steal unawares upon their prey. It may be objected that this theory of coloration proves too much, inasmuch as, if the lizards are effectually concealed, and with their other prey

similarly protected, the snakes would starve. As a matter of fact, in the first place, this particular form of coloration, with both hunter and hunted, is not absolutely perfect. In the second, lizards have enemies other than snakes, and snakes have prey other than lizards. The protective coloration affords both a measure of protection sufficiently great to ensure the survival of the device. Many times in the life of an individual death must have been escaped solely on account of this coloration; and so with the snakes, conspicuously where their chances of approaching prey unawares would be infinitely small. The khaki uniform of our soldiers does not prevent many from falling victims to the more sharp-sighted of the enemy; but clad in red the mortality would be many times as great.

Protective "resemblance colours" are of two kinds among the Reptiles—those which are relatively permanent and fixed, and those which are variable and fleeting, though no sharp line can be drawn between the two, inasmuch as, by reason of the contractile powers of the chromatophores under the stimulus of changes in the environment, even relatively permanent types of coloration may change.

One of the best of all examples of permanent protective coloration among the Reptiles is probably that of the Fimbriated Gecko (*Uroplates fimbriatus*) of Madagascar (see frontispiece).

The general colour of the body may be described as that of a piece of bark, blotched irregularly with patches of lichen-colour. Judging

from a specimen now (1903) living in the Gardens of the Zoological Society, it would seem, from the large size of the eyes, and its custom of lying absolutely motionless along a branch, that this creature is crepuscular in its habits.

In a wild state, doubtless, the day is passed stretched motionless along a bough, and absolutely secure from detection. The resemblance to the bough is still further enhanced partly by the curious disposition of the limbs, which are thrust out at odd angles from the body, and partly owing to narrow fringes of skin, extending from the side of the lower jaw backwards to the tail, where they suddenly expand into broad folds. By this means the outline of the body is obliterated passing insensibly into that of the bough.

Contrasting in the strangest possible manner with this is another Gecko (*Phelesuma Madagascariensis*) also hailing from Madagascar. This animal is of a rich, verdigris green, enlivened with bright vermilion red spots in the middle of the back, and a V-shaped red bar on the crown of the head. Little appears to be known about the habits of this animal, but there can be no doubt but that, unlike its relative, it hunts by day. Its small eyes and green colour proclaim this. These eyes, by the way, differ remarkably from those of the species just described, inasmuch as they are red in colour, and have a round pupil. In the Fimbriated Gecko they are of a beautiful golden yellow, streaked with vertical lines of chestnut, and the pupil is vertical, by day appear-

ing only as a barely perceptible slit. As the shadows of evening grow the slit widens, till at last the pupil becomes perfectly round.

Both these Geckos are instances of permanent, protective coloration. Variable protective coloration occurs in some Geckos and many Lizards, but is apparently not met with among Snakes. One of the best examples afforded by the Lizards is that of the variable.

Calotis mystaceus, of Burma. Mr Mason thus describes it: "The male . . . is sometimes a beauty. He may be often seen jerking his head up and down, with the head, pouch, and whole front of the body a glowing ultramarine blue, contrasting beautifully with the reddish-brown of the hinder part of the body and tail. From the nose to the shoulders below the eye, is a broad white band, which is interrupted by those reddish-brown patches, in line with the white band, before reaching the uniform reddish-brown of the hinder part of the body. Occasionally the white band below the eye assumes a brownish colour, and the animal appears to have a broad band down each side. He does not always, however, appear in this gay dress. While I am writing, I see him coming down the trunk of one of the trees in a very faded garment. His skin suggests a bright calico after it has been washed, whose colours succumb to soap. The blue is there, but it is no longer the bright blue of yesterday. It has changed to a dull, light indigo colour. He runs across the grass to the foot of another tree, and stops on the bare ground at its base, where for a minute or more

he bites with great energy at a struggling grasshopper, and while thus exercising himself the blue fades out from his body altogether, and his whole body takes the colour of the brown earth on which he stands. After tarrying a minute or two he ran up the other tree, and the dull light blue colour seemed to return to him." Since the female of this species is similarly coloured, it may be that this naturally variable coloration has been increased by sexual selection.

Equally vivid are the changes displayed by the red Agama.

Agama sanguinolenta. Dr Gadow, on the authority of a German naturalist, Zandes, thus describes the many changes of colour displayed by this lizard: "The usual garb is earthy brown above, with somewhat darker and indistinct markings. The under parts are whitish. Sometimes the creature changes to dirty white, at other times into blackish or grey brown. Bluish-red stripes may appear on the sides of the body; blue lines begin to show on the throat, and alternately the whole belly, originally white, may become ultramarine blue. When the general tone happens to be sulphurous yellow, blue often appears on the tail and limbs. Brick red appears on four longitudinal rows of patches on the sides of the body. Sometimes the whole animal assumes a vinous tinge, or it is at first greenish before turning into blue. The change begins on the tail and limbs, extends over the head, and at length reaches the back. Red appears in both sexes, more frequently in the female; blue almost entirely in the male. Sunlight and warmth only

intensify the colour." The change of fleeting colours from behind forwards is interesting, because Eimer has noticed that the change in permanent pattern of many reptiles also takes place from behind forwards.

It is the Chamæleon which is popularly supposed to be the past master in the art of colour changes, and certainly their reputation is justified. The colour of the Common Chamæleon (*Chamæleon vulgaris*), Dr Gadow reminds us, is impossible to describe, since the same specimen may appear in half a dozen garbs in as many days. After careful study for many months, when every possible change and combination of colour seems to have been exhausted, it will suddenly develop a quite new combination. Individuals vary, some change but slowly and seldom, others frequently and rapidly. Some are much speckled, others patched or streaked. In the dark they appear generally to fade to a cream colour, but this is not always the case; light focussed on one side only, it is interesting to note, causes that side to change in response, while the opposite side of the body remains unchanged. Adaptation to their immediate surroundings appear to take place only to a modified extent, though, as a rule, they appear to be brightest when amidst bright green foliage.

Some animals have acquired the mantle of protective coloration, not so much for the shelter it affords as for the purpose of approaching their prey unobserved, like wolves in sheep's clothing. This device is known as "aggressive resemblance." It is practised, it will be remembered,

by the Mata-mata Tortoise (p. 42), the Crocodiles and Alligators (p. 59), who, by their resemblance to logs, are enabled to creep up to, or be approached by, their prey without creating suspicion. The Grass-snake and the Viper of the British Islands, and the green tree-snakes, and the sand-coloured desert forms are all instances of aggressive resemblance. The giant arboreal Boas and Anacondas have also to be regarded under this head. Their enormous bodies, if uniformly coloured, would be too conspicuous, consequently the surface is broken up, in the case of the Boas (*e.g. Python molurus*) by a net-work of black and yellow, and by the Anacondas by blotches of the same tints. Thus the effect of strong light and shade, as of sunlight breaking through a dense mass of leaves, is produced. Instances of reptiles which resort to what are known as adventitious colours for protective or aggressive purposes are rare. The Mata-mata, and a few other fresh-water Tortoises, are cases in point.

Protective coloration, however, is sometimes assumed for its own sake, and not for aggressive purposes, as in the case of those snakes which frequent rocky or desert places. But for their harmony with their surroundings, they would be in constant danger of being pounced upon by snake-eating hawks and other enemies with a liking for snake-flesh.

Certain lizards, and some snakes, have adopted a system of what is known as "warning coloration," whereby the creature, by exhibiting certain conspicuously coloured areas, endeavours to make

itself appear more formidable than it really is, or save itself the trouble and expense of carrying out its threat in those cases where the ability to do this exists. That is to say, it adopts the policy of "bluffing," which, as in human affairs, is very often effective.

Among the lizards a very good instance is furnished by the Moustached lizard (*Phrynocephalus mystaceus*). This is an inhabitant of Transcaspia and Southern Russia, and when threatened becomes violently excited, raises itself upon its hind limbs, curls and uncurls its tail, and opens its mouth to its widest extent; with the result that it assumes a quite fearsome aspect. This effect is largely enhanced by the fact that the corners of the mouth are provided with flaps of skin, which, in excitement, swell up into half-moon shaped plates, the inner surfaces of which pass gradually into the rosy lining of the mouth, thereby causing it to appear much larger than it really is.

The frilled-lizard, a native of Northern and North-Western Australia, can assume an even more formidable aspect when threatened by a superior force. This is done by means of an enormous frill encircling the head. This frill is supported by the horns of the tongue-bones, which are extraordinarily elongated, projecting from the throat, on either side of the head, into the frill like the ribs of an umbrella. When brought to bay, the red-lined mouth, armed with teeth, is opened to its fullest extent, and the frill is spread so as to stand out like two huge wings on either side of the head, with the result

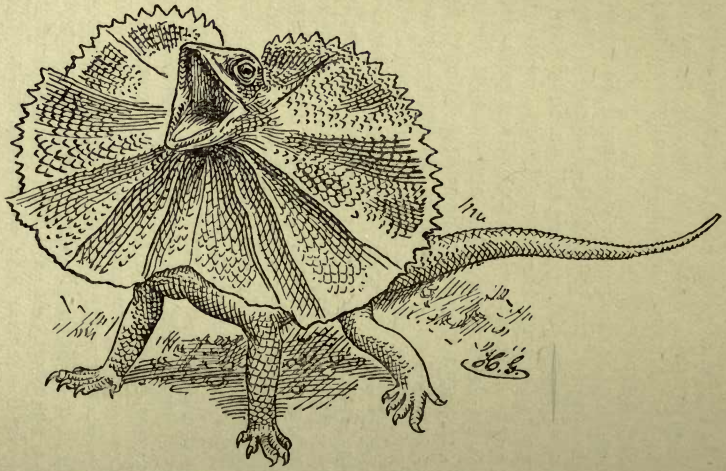


FIG. 11.—The frilled-lizard, *Chlamydosaurus kingi*, in a threatening attitude.

that a truly terrible aspect is assumed, calculated, especially when backed by the very serviceable looking teeth, to make most foes deliberate before pressing attack further.

That signs other than colour are sometimes adopted for warning purposes we have just seen in the case of the frilled lizard. The deadly Rattle-snakes (*Crotalus*) and the equally poisonous Cobra (*Naja*), are further cases in point. Protective coloration has been adopted, as in the foregoing instances, as a first-line of defence, and when this is broken through, they fall back upon the second—warning tactics. The device of the rattle-snake is the production of peculiar shrill sounds produced by a number of horny "bells" loosely jointed and fitting closely one into the other. These bells, which may be as many as twelve in number, have a curious origin. "The oldest terminal bell," says Dr Gadow, "is in reality the horny covering or tip of the tail, and with each moult or shedding of the skin the youngest bell becomes loose, but is held by the new covering which has been developed in the meantime. There is thus produced an ever-increasing number of loosely jointed bells, but every now and then most or all the bells break off, probably when they are worn out, and a new set is developed." The noise made by this rattle, when the weather is dry is very considerable; so much so that in a room a vigorous snake can make conversation almost impossible for half an hour or more. During this time the rattle is kept in such rapid vibrations that it shows only as a blurred image. By this means possible

enemies are warned off, and thereby the snake is saved the expenditure of poison which is used only for the slaughter of victims for food, or the purposes of self-defence when hard pressed.

The Cobras effect the same end by dilating the neck. This is done through the agency of the ribs in this region, which are raised so as to expand the skin into a broad shield, sometimes described as a "hood," and thereby giving a terribly formidable appearance to the infuriated animal. In some species the back of this shield is adorned with a curious pattern described by some as "spectacle pattern," by others as "eye-like markings," and these are supposed to add to the terrifying aspect. It is difficult to see, however, how this can be, since they are, from their position, hidden from the view of the creature for whose benefit the display is made.

In the foregoing cases the animals when at rest are quite inconspicuously coloured, and in no way court attention: but the North American lizard known as the Gila-monster (*Heloderma suspectum*) behaves in a quite different manner. About two feet long, and clad in what may be likened to a "blazer" of black and orange arranged in rings, this creature, though more or less careful to conceal its very obtrusively coloured carcase, makes no effort, when discovered, to escape danger by flight. This insolent confidence is apparently begotten by the consciousness of power in the possession of poison fangs. It is the only known poisonous lizard. Like the poisonous snake, the death-dealing fangs are grooved, and down these the

poison, secreted by large glands, is conveyed into the wound inflicted by the bite. It feeds on worms, centipedes, frogs and lizards' eggs. The frogs are paralysed by the poison, before swallowing, as is the case with snakes. Though not so powerful as that of many snakes, the bite of the lizard has been known to produce death in people whom they have bitten.

A precisely similar plan of warning coloration, rings of black and red, or black and yellow, has been adopted by certain South American snakes of the genus *Elaps*, whilst the poisonous sea-snakes of the genus *Hydrophis* and *Enhydris*, for example, though less brilliant, have adopted a like device —dark bands on a lighter ground. *Hydrophis obscura* has black bars on a yellowish ground; *Enhydra bengalensis*, black bars on a grey or olive ground.

That this warning coloration is of use only as a protection against their immediate enemies, there can be no doubt. Indeed, Dr Alcock, F.R.S., of the India Museum, Calcutta, tells me that the sea-eagles seize and devour these snakes with impunity; so that the shore around the coast of Malabar is strewn with the skeletons. This means that the peculiar coloration can have no significance for the eagles, which evidently find this creature neither unpalatable nor dangerous.

Imitation is said to be the sincerest form of flattery. Sometimes, however, a different motive must be attributed to the imitators. In the cases we are now about to consider, for example, certain perfectly harmless snakes have adopted the livery of the obnoxious species which have just been

described. These snakes live in the same regions as the obnoxious forms, and thus it is easy to see that, disguised as dangerous, they participate in whatever advantages the obnoxious forms have acquired, and in consequence, live in peace, instead of perpetual molestation and persecution. This assumption of the coloration of alien and obnoxious forms is known as "Mimicry." Thus, the deadly snakes of the genus *Elaps*, have many imitators. The poisonous *Elaps fulvius* of Guatemala is imitated by the harmless *Pliocerus equalis: Elaps corallinus* of Mexico by the harmless *Homalocranium semicinctum*; whilst in other parts of South America similar cases occur. The poisonous water-snakes are likewise mimicked by harmless forms.

Another interesting form of mimicry is that wherein not so much the colours, as the actions of the mimicked form are copied. A case in point is that of the harmless and toothless Egg-eating Snake (*Dasypeltis*), which mimics the poisonous Bug Adder (*Clothos atropos*). Both are protectively coloured, but the harmless form when alarmed, renders itself practically indistinguishable from the poisonous, by flattening out its head and darting forward with a hiss as if to strike. It may well happen, of course, that this disguise may cost the mimic its life, and so completely defeat the object of the mimicry. But this would only occur when the subject to be terrified chanced to be a man, who naturally kills at sight all venomous reptiles he may come across, and it must be remembered that the disguise of this snake is

not an adaptation to defeat the wiles and higher powers of discrimination of its arch-enemies.

The origin of the "warning colours" of poisonous reptiles is probably a device lately adopted and following on the success attained by creatures which, unarmed, developed distasteful properties—rendering them unpalatable to such animals as attempted to prey upon them—and then advertised their unpalatability by the display of conspicuous colours. This device by no means assured *absolute* immunity, since a certain percentage of these conspicuous forms, constantly fell, and still fall, victims to young and inexperienced animals who probably seize them *on account* of their gaudy colours, just as a child would do. Finding them unpalatable they for ever after leave *all* animals so coloured severely alone. The general truth of this has been proved by experiment. Though the subjects of the experiments die, only a small percentage are sacrificed, whilst the vast body of survivors have their safety assured. Distastefulness in itself, without colour, is obviously no protection since it makes no difference to the distasteful animal whether it is tasted and rejected, or tasted and swallowed, whether it die from injuries received, or whether it die from ingestion; inasmuch as the taster is left to go on repeating the experiment throughout its life from inability to distinguish distasteful from palatable forms.

For similar reasons, poisonous properties, in themselves, are no protection—where protection is required. If the poisonous animal be attacked

by a hungry animal, its superior in size, it will succumb, and its death will fail to benefit its surviving relatives inasmuch as the poison renders the body neither unpalatable nor dangerous to the animal which eats it. Consequently then, its poison is unrealized by the swallower, and therefore could never have served as a deterrent for future remembrance. As soon, however, as the device of unpalatable animals was adopted, immunity from experiment resulted, and with it, the consequent gain to the species. This being so, the warning-colours of reptiles, themselves now mimicked, originated in mimicry, they being palatable, by their colours are mistaken for unpalatable.

Although the coloration of reptiles can, for the most part be accounted for, with more or less probability, there are some instances which are not so easily to be explained. Thus, it is a fact that the young of many reptiles are often much more brilliantly coloured than their parents. Why this should be is not clear, unless this more brilliant livery was too conspicuous, and so was exchanged for one of a more sombre type, and now only reappears in the course of development like other rejected characters.

Again, some snakes, though practically blind, are most beautifully coloured, as in some of the burrowing-snakes belonging to the family Uropeltidæ. What is the use of colour here?

How the coloration of reptiles has been affected by courtship, we shall discuss in another chapter.

CHAPTER VIII.

FLYING-DRAGONS.

SURELY no phase in the story of Reptile-life is more pregnant with interest than that which concerns the creatures which form the subject of the present chapter.

Relics of an ancient past, appearing and disappearing with a mysterious suddenness, much of their history is hid in mist that can never be penetrated. They are a contradiction in themselves, for a flying reptile is an anomaly. The *raison d'etre* of their existence seems to have been to point a moral and adorn a tale, the moral being the unwisdom of dogmatising as to what Nature can or cannot do. Inasmuch as, but for the fortunate accident of the preservation of their remains, the existence of creatures so strangely made, and from a stock so proverbially earth-bound, would have been deemed, by those who affect the gift of prophesy, an impossibility.

If, familiarly, we may speak of them as "flying-dragons," thereby investing them with a species of eerieness to which they may well be entitled, we must, when recalling their peculiar features, do so in more severe language, using the Christian and surname, so to speak, whereby they have been made members of the kingdom of animals.

The Pterodactyles, then, are so called on account of the structure of the fore-limb, which had become modified, by the extraordinary elon-

gation of one of the fingers, into a support for a membrane or thin fold of skin, thereby converting this limb into a wing, hence the name Pterodactyle, or wing-fingered.

In accordance with its powers of flight, we find the bones of the shoulder-girdle very strongly developed, whilst the bones of the hip-girdle and the hind-limbs were weak. The sternum, or breast-bone, forming the base of attachment for the shoulder-girdle, was well developed, and furthermore bore a large keel projecting from its anterior border, for the attachment of the powerful muscles needed to move the wings. The position of this keel, it may be noted, agrees closely with that of the Gannet among birds, it being placed at the extreme anterior end of the sternal plate. This resemblance is extremely interesting, as it suggests that the method of flight was gannet-like. And this in turn lends colour to the view that these strange creatures fed upon fish which they picked up from amongst the shoals swimming at the surface of the sea. The method of capture pursued by these old Reptiles, however, probably resembled that of the Terns rather than that of the Gannet, which seizes its victim by plunging, like a bolt from the blue, beneath the surface of the water.

The bones of the skeleton generally, and of the wings in particular, were hollow, and during the life of the creature contained air, as in birds. They are furthermore remarkable for their thinness, a point of considerable importance in the larger flying forms.

The head, which was very bird-like in many

respects, varied greatly in size and shape among the different groups. The jaws were either armed with teeth lodged in sockets, and apparently adapted for holding slippery prey, such as fish; or were toothless and ensheathed in horn, or in thin leathery skin, as in birds.

The tail was in some species exceedingly short, in others of great length.

In size these creatures varied greatly, the smallest species not exceeding that of a sparrow. the largest having an expanse of wing of over twenty feet, these reaching the highest maximum ever attained by any flying animal.

During life the body was probably invested in a covering of scales, and it is quite probable, especially having regard to the extreme activity of these creatures, that these scales were brilliantly coloured, as in many Reptiles of to-day. When at rest, it is supposed that they passed the time clinging to the surfaces of rock-cliffs by the large claws on the short digits immediately in front of the wing-finger.

Concerning the origin of this group of extraordinary creatures we know nothing. They appear suddenly, fully developed, in the Lower Lias, *e.g. Dimorphodon*, and vanished from the face of the earth quite as suddenly in the Cretaceous period. It is instructive to notice that the earliest forms to appear were small, the huge bulk ultimately attained by certain species in the Cretaceous epoch being reached by slow stages.

Since the wing is the most important feature in these creatures we may profitably revert to

this organ, in order that we may study it a little more closely.

As in the rest of the skeleton, this organ shows signs of increasing complexity when traced from the earliest known specimens onwards to the time when they finally disappeared; though these changes are not of a very marked character. Of its origin we know nothing; but of the five digits which we may justly assume this limb originally possessed, only four remain. The missing digit is that answering to our little finger. The first, second, and third fingers were short, and armed with claws, which served probably to suspend the animal when at rest, whilst the fourth was enormously elongated. This served, during life, for the attachment of a large fold of skin extending outwards from the body, and backwards, to include the hind-limbs and tail. It differs fundamentally from the wings of the bat and bird. In the former, all the fingers are preserved, the thumb is free, and the remaining four are enormously elongated and extremely slender, serving to support a thin skin-fold much as the ribs of an umbrella support its covering. In the bird, three fingers remain, the thumb, which is short, is free, whilst the second and third digits are closely bound together, forming a rod for the support of ribbon-shaped organs known as the quill-feathers. Further details of this wing, compared with that of the bat and pterodactyle, by the way, will be found in the "Story of Bird Life."

As in the bird and bat, there extended along the front of the wing, from the shoulder to the

wrist, a fold of membrane, like the large fold which served the purposes of flight. This membrane was probably bounded in front by a strong tendon which, before it reached the wrist, passed into, or was attached to, a long, slender bone known as the "pteroid." This bone has been the cause of much speculation, and by some authorities is regarded as answering to the thumb. Probably, however, it corresponds to a similar but smaller bone found in a precisely similar position in the bird, and known as the *os prominens*. The development of bones in tendons subjected to considerable strain is a common feature. When nodular in form they are known as sesamoids.

The wrist bones, as in the bird, were considerably reduced in number. In the earlier pterodactyles there were two distinct rows, made up of several distinct bones; but in the later Cretaceous types, these became merged one into another, so that those of each of the two originally distinct rows became fused, each row into a single bone.

The bones of the middle-hand, or metacarpus, are seen also to undergo modifications. In some species they were very short, whilst in others, as in the species of the genera *Cynorhamphus* and *Ptenodracon*, they were extremely long, thus giving an extra joint to the wing, comparable to that formed by the elongation of certain ankle-bones in the Frog, for example. What purpose this elongation may have served is unknown; but it is interesting to note that those species in which those middle-hand bones were elongated

the fore-arm was relatively shorter than in those with shorter hands.

Here this examination of the wing must stop, lest we become wearisome.

The method of locomotion when on the ground has given rise to much speculation. According to Professor Seeley, these creatures walked on all fours on upright legs, the wing-finger and its membrane being folded and turned upwards like a pair of umbrellas, to allow the palm of the hand to reach the ground. Though it savours of presumption to question the verdict of one so versed in all that concerns these creatures, we venture to doubt whether this was possible. Rather, we believe, they scrambled along the ground after the fashion of a bat.

Whilst the majority of these creatures hunted their prey by daylight, others would appear to have been crepuscular in habit, inasmuch as the eyes in these forms are of great size. Whether these nocturnal species were also fish-eaters we do not know.

In general appearance, as we have already remarked, the *Pterodactyles* varied considerably, at least when extreme types are compared. The earliest known species, *Dimorphodon macronyx*, from the Lower Lias of Dorsetshire, had a relatively enormous head and a relatively small brain. Its jaws were armed with large teeth, and the tail was extremely long. This species was, by the way, by no means a pigmy in point of size, having a skull of some eight inches in length and an expanse of wing of four feet. The Pterodactyles of the genus *Rhamphorhynchus*, of

the Lithographic Stone of Bavaria, differed from Dimorphodon chiefly in that the head was long and pointed, and that the tail, which was of great length, terminated in a leaf-like expansion.

Side by side with these long-tailed, tooth-bearing forms there lived numerous short-tailed types, which exhibit evidences of increasing specialisation in the gradual decline of the teeth and the evolution of toothless types, whose jaws were either encased in horn or a thin leathery skin as in birds. These new types are represented by the species of the genus *Pterodactylus*. In *Pterodactylus antiquus*, for example, we find only a few small teeth confined to the anterior end of the jaws, whilst in *P. spectabilis* they have completely disappeared. Curiosity is naturally stimulated to account for this loss of the teeth, but so far, no explanation appears to be forthcoming. Assuming them to have preyed upon fish, as is generally believed, the advantage of such weapons seems obvious, for fish are proverbially slippery creatures. Nevertheless, we find indubitable evidence, if we turn to the birds, that toothless jaws are by no means incompatible with a fish diet, as witness the Cormorants and Kingfishers, Herons, Divers and Grebes, and Penguins, for example. Among the fish-eating birds, however, we must not forget that some seem to have had to make shift to replace the lost teeth of their ancestors by developing tooth-like processes on the edges of the horny jaws, as in the case of the Mergausers among the Drakes, and in the Darters, allies of the Cormorants.

Further evidence of specialisation in the form

of increased size, and in the development of ornament, appear in the Pterodactyles of the Cretaceous or Chalk age, some of the largest of which attained a gigantic size, having an expanse of wing of twenty feet, and a skull a yard in length. Whilst some species were tooth-bearing, others were entirely toothless. But with or without teeth they must have been formidable creatures — flying-dragons, indeed! Animals of such enormous size, would, one would have imagined, have become incapable of flight, as in the case of the Ostrich-tribe among birds. As a matter of fact, however, the bodies of these flying monsters were remarkable for their lightness, partly owing to the extreme thinness of the bones, which were almost paper-like in thickness. Furthermore, the trunk, in proportion to the size of the head and wings, was really extremely small. In one genus at least, the bones of the shoulder-girdle underwent a peculiar modification on account of the great size of these wings; inasmuch as the shoulder-blade, instead of running backwards parallel with the spine, and over the ribs, turned directly inwards so as to lie parallel with the ribs and at right angles to the spine with one of the neural-arches of which it is articulated by a special joint. This gave rigidity to the girdle. Among the birds this very necessary stay is provided by the merrythought, a bone conspicuous by its absence in the pterodactyle.

The question of ornament is a delicate one, inasmuch as this is for the most part an entirely superficial character, and therefore leaves no

record after death. As we have already remarked, the general coloration of the body may have been extremely brilliant. The play of colour over the wing-like expansions of the Flying-Lizard of to-day (*Draco volans*), is at times wondrously vivid, and there is certainly no reason why the wings of these old-world creatures should not have been equally beautiful. The only evidence, however, that we can produce

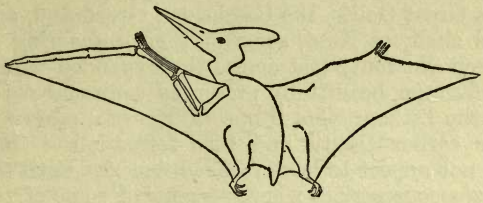


FIG. 12.—Outline restoration of an extinct Flying-dragon (*Pteranodon*). By the author.

in support of this hypothesis, is of an indirect character. This is afforded by the giant *Pteranodon longiceps*, of the Cretaceous of North America, wherein the hinder regions of the skull was produced backwards and upwards into an enormous bony crest, comparable to that of the Cassowaries among living birds, which is certainly an ornamental feature. We may conceive that this ancient flying-dragon, then, was one of the beaus of his kind. His great toothless stork-like beak — a yard long — and cranial crest ensheathed in a gaily-coloured case, and his body made resplendent with all the

colours of the rainbow, glistening with iridescence, as only the scales of a reptile can, he used these charms, perchance, to overcome the indifference of a much-exacting mate; wheeling and turning in the sunlight, in amorous flights, till finally he conquered.

During the time that these creatures lived they appear to have spread themselves almost over the whole world. Their remains occur in abundance in the British Islands, in the Lias, the Great Oolite, the Cambridge Greensand, and the chalk of Kent, some of them measuring as much as twenty feet across the expanded wings. In Europe, beautifully preserved examples occur in the Lithographic Stone of Bavaria, others in the earlier Oolitic and Lias formation. They do not appear to have reached America until the Cretaceous period, where remains of some of the very largest examples have been obtained from the chalk of Kansas. That they occurred elsewhere on the earth's surface, and both earlier and later in time than present records show, is highly probable, and proof of this may at any time be produced. The preservation, as well as the discovery, of the remains hitherto unearthed is the result of a series of those accidents by which the world has benefited; although the list appears now to be practically exhausted, we may live in hope that this will not prove to be so. In any case, enough remains to form one of the most striking and impressive chapters in the history of the animal life of this wonderful world of ours yet pieced together. To the Story of Reptile Life, these creatures

have contributed much, for their mysterious origin, sudden extinction, and wonderful organisation, has caused their much-despised cousins of to-day to shine with a kind of reflected glory!

CHAPTER IX.

EARTH DRAGONS.

WHILST the creatures described in the last chapter mark but an episode in the story we are endeavouring to tell, the history of those which we are immediately to consider, marks an epoch of the greatest magnitude in the development of animal life upon the earth. In this same chapter we shall also deal with creatures of brobdignagian proportions, and the question of their ancestry. Our survey, however, must necessarily be brief, for these themes bristle with difficulties, and can only be rightly understood by those qualified by a life study of such questions, to discern the value and true perspective of the evidence so far collected.

It will be remembered that at the very commencement of our story we showed that the origin of the Reptile people is to be traced from the lowly stock to which the Frogs, Toads and Newts belong. But we then made no mention of the fact that simultaneously there arose from this same stock a second group, which, developing along different lines to those followed by the main branch, terminated in a coterie of forms

known collectively as the Anomodontia, or, according to some, as the Theriodontia, in reference to the form of the teeth. These creatures have excited the most profound interest, not only because they present so many important differences from the members of the other branch, but also, and chiefly, because it is from their ranks that we are enabled to trace, with no small degree of certainty, the origin of the mammalia, the highest of all the Vertibrates; though we can, at present, point to no known form as the actual ancestor thereof. The close resemblance, sometimes most striking, between certain species of these ancestral reptiles and the Carnivora among the mammalia, is to be put down to the fact that both trace their descent from the same source, and leading similar lives have developed similar organs.

As a sample of the rarity of this likeness let us take a single instance, that furnished by the species known as *Cynognathus crateronotus* of the Karoo formation (Permian or Triassic) of South Africa—the source from which most of these remarkable forms have been obtained. The skull of this beast presents a quite astonishing similarity, especially in regard to the teeth, to that of a dog or wolf. The component elements of the skull, however, and the character of the vertebrae, reveal the reptilian nature of these remains. The teeth of another species (*Trity-lodon*) were of the type adapted for grinding purposes, and for a long time were actually believed to be those of a mammal. Further pursuit of this subject would be a departure

from the legitimate object of this book, and must accordingly be left for another volume which we propose to devote to Mammal Life.

But, as we have already hinted, besides these singularly mammalian types yet other types existed which, somewhat differently constituted to the forms which gave birth to such distinguished progeny, developed and intensified

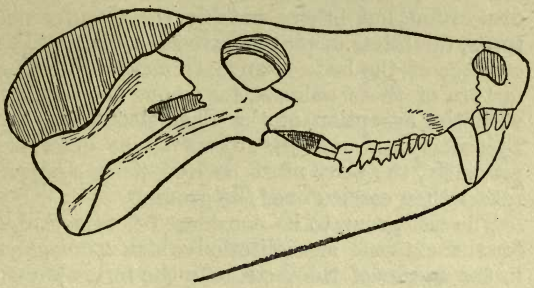


FIG. 13.—Outline restoration of the skull of an Extinct Mammal-like Reptile *Cynognathus*. Note the general dog-like shape of the skull.—After Smith Woodward.

their several peculiarities, so that they eventually died out unmistakable reptiles. Since they too present traces of distinct mammalian leanings, we may regard them as creatures striving after an unattainable ideal, achieved, however, by people of their own blood.

The forms in question constitute three distinct groups. The most primitive of these, that is to say, the nearest to the ancient giant Salamanders or Labyrinthodonts, the ancestral stock just referred to, is that represented by an anomalous

looking beast known as Pariesaurus. This was a heavy, clumsily built animal, with a short, massive head, and short tail and legs. The limbs, however, were sufficiently long to carry the body well above the ground. The jaws were armed with teeth having serrated edges. But in addition to these, small teeth occurred also on the palate. From the heavy build of this beast, we may infer that it was of a sluggish disposition, but others, notably the Carnivorous types, doubtless displayed extreme agility. The carriage of the body is an extremely interesting feature of these animals, for among the reptiles, with the exception of the Chameleons and the Pterodactyles, and the forms to be described presently, the body must be said to be dragged rather than carried over the ground.

The last group to be considered is remarkable for the extreme specialisation which it displays in the matter of the teeth. In the forms known as the Dicynodontia, or double dog-toothed, the jaws were either toothless or encased in horn, as in the Tortoises, or were armed with a single pair of tusk-like teeth which projected downwards from the upper jaw. It is from the presence of these teeth that the group takes its name.

Whether the remains of certain large Reptiles which have been found in Texas really belong to this group or not is uncertain. But the genera known as *Dimetrodon* and *Naosaurus* are remarkable, indeed unique, on account of the enormous development of the spines of the anterior trunk vertebræ, which projected above their case of

attachment, some *two feet*, and probably formed an immovable but fin-like crest along the back. In Naosaurus these spines acquire a still more eccentric character developing some half dozen cross-pieces, like the yards of a ship's mast. What part these could have played is a mystery!

We must turn now to a very different group of Reptiles, long celebrated both on account of their bizarre shape, as well as for the colossal size which many of them attained. It has been suggested indeed that the numerous legends of dragons handed down to us from remote times are founded upon remains of these creatures, which may have been unearthed by unsophisticated people with a love for the marvellous. Mythical these stories undoubtedly are, in so far as they affect to record the conflicts which have taken place between men and beasts of this kind, inasmuch as the advent of man took place some millions of years after the last of these monsters had ceased to exist, nevertheless the author of the first fable may have been inspired by the discovery of the remains of some unusually well-preserved fossil. But whether or no, they are the dragons indicated in the title chosen for this chapter. To the serious student they are known as Dinosaurs—terrible Reptiles—an appropriate name enough!

As touching their origin, we may remark that they arose during the Triassic period, as Dr Smith Woodward reminds us, as a race of land reptiles, "at first so generalised that it is difficult to separate them from the Rhyncocephalia (p. 11) and Crocodilia, but afterwards constituting

at least one distinct order." An alliance with the Anomodonts has recently been suggested, but this is not likely to receive much favour. They reached the dignity of a dominant race during the Jurassic and Cretaceous periods, succeeding the Anomodontia, and disappearing as the Mammalia commenced their era of ascendancy.

These singular creatures, like other notorious groups which preceded and followed them, make their first appearance on the stage in a comparatively humble guise, the earliest known forms being small carnivorous types, having the jaws well armed with cutting teeth lodged in sockets, and hollow bones, like those of birds. In the course of the evolution of the group we find specialisation taking place in many directions. Originally quadrupedal, some became bipedal, developing enormous hind-limbs, and reducing the size of the fore-limbs, a method of progression which, at different times and in various places, during the history of this group, developed into leaping, as in the Kangaroo and Jerboa of to-day. Witnesses to this we have in the remains of *Hallopus*, from the Jurassic of Colorado, and *Compsognathus*, a beast about the size of a fowl, from the Lithographic Stone of Solenhofen in Bavaria. As the body increased in size, attaining that enormous bulk which has made these creatures famous, such agility became impossible. Indeed, it is now generally believed that the huge size of the very largest species made life on land almost impossible. But to this we shall return. There is good evidence to show that the larger species at least of these

bipedal types when at rest supported the body on the downwardly directed branches of the hip-girdle, known as the pules, and it is probable that the skin immediately covering these developed a thick callous pad like that on the breast of the Ostrich, which serves a similar purpose.

One of the earliest known of these carnivorous forms was a beast named *Anchisaurus colurus*. Measured by the standards of to-day, he would have been called large, standing about four feet high. But he was a veritable pygmy compared with some of the forms which arose during the later Jurassic era. By way of illustration, we will select the species known as *Ceratosaurus nasicornis*, since this lived in what is now North America, its remains having been found in the Upper Jurassic of Colorado. Standing, when erect, some twelve feet high, this monster was probably capable of considerable activity, since its bones were hollow. With an enormous head, armed with powerful and pointed teeth, and a formidable horn on its snout resembling that of a Rhinoceros, it preyed, in all probability, upon equally huge herbivorous species of its own kind. But earlier than this, there lived in our own islands similar bipedal carnivorous types, quite as huge as the Ceratosaurus. The remains of one such, known as *Megalosaurus bucklandi*, having been found in the Great Oolite of Stonesfield, near Oxford. The teeth of this animal were more than three inches long, and had finely serrated edges, therein differing in this respect from the teeth of *Ceratosaurus*.

The development of the herbivorous types, to

which reference has been made, proceeded simultaneously with that of the carnivorous, and it would appear attained even more striking results in the matter of bulk, some species having reached a quite colossal size.

In the course of their evolution many changes, other than mere increase in size, are to be remarked. Thus in some we find more or fewer of the teeth suppressed, and their place taken by horny plates; in others, we meet with the development of heavy armour, intended to serve the purposes either of offence or defence. Again, it is to be noted that bipedal and quadrupedal forms alike competed in the race for size, and though in the end victory rested with the quadruped types the race was keen and close.

The huge beast known as *Brontosaurus excelcus* from the Jurassic of Colorado may be taken as a type of the quadrupedal group. Attaining a length of between 50 and 60 feet, this creature was remarkable for the small size of its skull, which was smaller in proportion to the size of its body than in any other known Reptile. The jaws were armed with blunt-pointed teeth. The neck and tail were of great length, whilst the trunk was comparatively short. The weight of such an enormous body was greatly reduced by the hollowness of the bones, which were, throughout the skeleton, permeated by large air cavities. In another closely allied contemporary, *Diplodocus longus*, we see the effect of specialisation in regard to feeding habits reflected in the dentition, which was of a very curious type. Only the front of the jaws bore teeth, and these were extremely

feeble, long and slender in character: longest in the middle of the jaws and decreasing and finally disappearing on each side, so that by far the greater part of the jaws were quite toothless. The suggestion that this peculiar dentition is due to adaptation to feeding on succulent aquatic vegetation is borne out by several features in the skeleton. Chiefest of these is the fact that there was but a single external bony nostril, and this opened on the middle of the top of the skull, as in whales and porpoises. From this we may gather that the creature led a more or less completely aquatic life, the position of the nostril allowing it to come to the surface to breathe without exposing the rest of the body. But hugest of all these giants was the great *Atlantosaurus*, with a length of 80 feet, and a height of thirty feet! Mere figures will not convey any idea of the real proportions of this living mountain of flesh. This can only be done by comparing it with some of the giants of to-day. An elephant beside this monster becomes a pygmy: only some of the largest whales equal it in length, but they do not approach it in height, being to all intents and purposes legless.

As we have before remarked, some are inclined to believe that the great size of these monsters was incompatible with a life on land, and that accordingly they must have lived in the water. Bodies of such huge size, it is argued, could scarcely be moved on land, but, buoyed up by water locomotion would be easy. That many species were indeed aquatic, obtaining their sustenance by browsing on aquatic vegetation, there is good reason to believe; indeed, in the remains

of the *Diplodocus* just described we have almost convincing proof of this. The limbs of this species, it is interesting to note, were of the same type as those of the *Atlantosaurus* and *Brontosaurus*, pillar-shaped and short-toed, that is to say, they resembled the limbs of the Elephant, Hippopotamus and Rhinoceros in the main features, and these, it is to be noticed, all have extremely heavy bodies. Accordingly this type of limb has been adopted as most suited to bear the strains imposed thereon.

The existence of limbs of this type in an exclusively aquatic animal is an extremely interesting feature, and shows that this mode of life was adopted long after the limbs had become adapted to the requirements of a terrestrial life, as in the case of the Hippopotamus among the Mammalia. The latter, it is to be remarked, is an expert swimmer, though we would not gather as much from the shape of the legs! Possibly, like the Hippopotamus, these ancient reptiles passed a certain amount of time on shore, and hence the need of preserving the terrestrial form of the limbs.

Among the bipedal types we have equally gigantic species. As an example we may select the celebrated *Iguanodon bernissartensis*, represented as in life opposite. Like the four-footed types, some of these huge bipeds are believed to have been aquatic, on account of their great size. Although there is much to be said in support of this view, there yet seems room for doubt as to whether this aquatic habit was as universal as the hypothesis de-

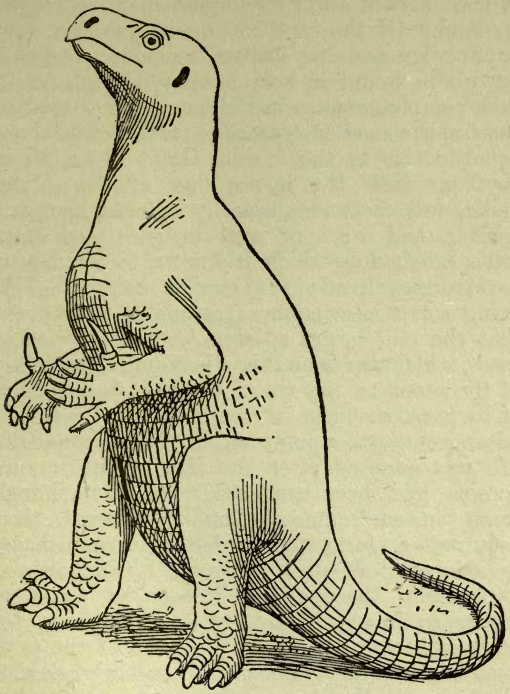


FIG. 14.—Restoration of land-dragon—*Iguanodon bernissartensis*. The thumb of this huge monster was armed with a powerful spur, which was probably used as a weapon of defence.—By the Author.

mands. The Iguanodons seem to show that at least all but the very largest may have lived on land. Of the reptiles now in question, four or five species are known, remains of which have been found in this country, though not in such completeness as in Belgium. Of these two species, the smaller *Iguanodon mantelli* was about equal in size to the extinct Giant Sloth, *Megatherium*. Now the latter, one of the Mammalia, was most emphatically a forest-haunting species, and we may well imagine that Mantell's Iguanodon, which is known to have been herbivorous, lived in a similar habitat. This being so, it seems more reasonable to suppose that the still larger species, *Iguanodon bernissartensis*, which was some thirty feet long from the tip of the snout to the tip of the tail, was, in spite of its great size, also a dweller on land. Otherwise, we must suppose either that the aquatic life was adopted after the size of the smaller species had been surpassed, or that, though living in environments totally different, they acquired a form practically indistinguishable save in point of size. Between Iguanodon and Diplodocus there is an interesting point of difference in the matter of the dentition, for whereas in the latter only the front of the jaws bear teeth, and these of a peculiarly slender character, in the former the front of the jaws were toothless and ensheathed in horn, whilst the sides of the jaws bore teeth in closely serried ranks. From their close resemblance to the teeth of the living Iguanas this giant derives its name, which being translated means Iguana toothed.

The general appearance of this monster can be seen from the accompanying illustration. As we have already remarked, remains of these huge reptiles occur in the British Islands, but complete skeletons have been found in Belgium. Indeed, the manner of their discovery surpasses all similar records, inasmuch as no less than twenty-nine were found in one spot during mining operations for coal at Bernissart, in Belgium. Probably they were overwhelmed by some great flood, swept into the river, and their bodies borne down by the stream and deposited at the estuary, where they were slowly covered up in the mud which always collects at this point.

Among the armoured types were some very formidable creatures, in every way worthy of the name of Dragons. One of the most striking forms is that known as Triceratops, he of the three horns. The head of this beast was five feet long, being longer than in any other known land animal. From the roof of the skull there arose three formidable horns, one above each eye and one on the snout, whilst the bones of the back of the skull were expanded to form an enormous frill overlapping the neck. Like the Iguana, the front of the jaws were toothless and ensheathed in horn, so as to form a sharp cutting beak. That the trunk was heavily armoured with bony plates is probable, though we have no positive evidence on this point as yet. The total length of this brute exceeded twenty-five feet. Whether these weapons were worn by the males only, and whether they were used offensively by

rival males when fighting for the females of their choice, as is the case among the horned ruminants of the present day, or whether they were used defensively against their giant carnivorous relatives, we, of course, shall never know. Be this as it may, their presence seems to argue considerable activity on the part of the wearers thereof. A fight between a couple of infuriated

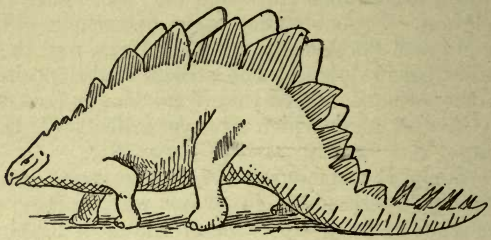


FIG. 15.—Outline restoration of an extinct gigantic Land-dragon (*Stegosaurus*). Note the remarkable double row of plates running down the back, and the huge spines on the tail.—After a drawing by C. E. Knight.

beasts of this description would have been an exciting scene to witness!

Still more remarkable animals in many respects were the Stegosaurs, from the Upper Jurassic of Colorado. The largest of these was about twenty feet long. The head, unlike that of Triceratops, was remarkably small, whilst the brain seems to have been smaller, in proportion to the size of the animal, than in any other land animal. The armature consisted of a double row of enormous bony plates running along the back, from the neck to the base of the tail, in the form

of a double crest. The largest of these plates is two feet high, and this probably does not represent their full size since they were almost certainly invested in a horny sheath. The tail, some ten feet long, was armed with a formidable array of spines, forked at the top, and some of them as much as three feet in length, with a diameter of six inches at the base! Whether the sides of the body were also protected by bony plates we do not know; neither can any hazard a guess as to the use or probable need of such an extraordinary armour as that which surmounted the back.

In not a few instances these wonderful reptiles have left their mark upon the world in the shape of footprints. *Anchisaurus colurus*, the carnivorous beast mentioned earlier in this chapter, is one of the species which has impressed the world in this fashion! For a long while these footprints were believed to be those of birds, inasmuch as the marks of two feet only were discernible, and they had apparently but three toes apiece. Undoubtedly these impressions bear an unmistakable resemblance to those made by birds, and as the Dinosaurs were then unknown, the obvious inference was that birds had made them.

We now know their true origin, and there is the less room for doubt since, at that period of the world's history, birds had not appeared. These "footprints on the sands of time" were apparently made in soft, clayey soil, probably near the margin of some pool or shelving river bank, and then covered at high tide with turbid

water, which filled up the impress with fine mud. In some other cases where these footprints of bipedal dinosaurs are preserved, the smaller prints of the fore-limbs are also visible, showing where the creature had progressed on all fours, just as kangaroos do when feeding. The feet of the gigantic Brontosaurus made an imprint covering an area of a square yard! In England, footprints ascribed to Dinosaurs have also been found. As Mr Lucas remarks, "oddly enough, these numerous tracks all run one way, from west to east, as if the animals were migrating, or were pursuing well-known and customary routes to their feeding-grounds."

Whether these huge creatures laid eggs or produced their young alive is a legitimate subject for speculation. The probability is that they were viviparous. In one species, indeed (*Compsognathus longipes*), what appears to be the remains of an embryo have been traced.

In the matter of brains they seem to have been singularly deficient, those of the very hugest species not exceeding a weight of two pounds. Much the same holds good with the giants among the Mammalia, Really, however, there is no need that the size of the brain should increase in the same ratio as the size of the body. The amount of intelligence required of these giants is no greater than that demanded of their relatively pygmy relations, and of co-ordination of movement much the same may be said. It is only when creatures of low intelligence come into contact with more highly gifted competitors that brain power tells, as witness the results

which have followed the advent of man in competition with the lower animals.

These huge reptiles lived in an age of reptiles, when the Mammalia were at most only just emerging. They were the dominant type, and therefore had just as much intelligence as the times required and no more. They do not owe their structure to lack of reasoning powers, but to other causes which we shall discuss later.

As touching the relationship which has long been held to exist between the dinosaurs and the birds, those who have read the "Story of Bird Life," may remember that certain striking points of resemblance were pointed out between the hip-girdle and hind-limbs, in the bipedal dinosaurs and birds. These resemblances, it was suggested, were to be attributed rather to a derivation from a common stock, than to parallel development due to a similar mode of locomotion. This view, first promulgated by Huxley, has been widely accepted. Nevertheless, it is now being as widely discarded, and we think rightly so. This is not the place wherein to discuss the question of the bird's ancestry, but we may perhaps be fairly expected to offer some justification for the rejection of an association apparently so well-founded and commonly believed in. The view advanced by Dr Gadow, that those dinosaurs which most resemble Archæopteryx, the oldest known bird, were its contemporaries, and therefore cannot be regarded as ancestral forms, has this objection, that it does not take into consideration the fact that though Archæopteryx is the

oldest *known* bird, it is certainly not the *first* bird. Whether their remains are ever found or not, there can be no doubt but that yet more primitive types than Archæopteryx must have existed, and similarly there must have lived more primitive types than the most primitive *known* dinosaurs—*Anchisaurus* and *Zanclodon*, cf the Upper Trias. Consequently there is no reason why the bird and the dinosaur should not, after all, have been derived from the same incipient stock. That is to say, the mere fact that the oldest-known bird and the most bird-like dinosaurs were contemporaries, or that the wing of the bird is totally different from the fore-limb of these contemporaries, is no proof that the two forms must be of totally distinct origin. The real objection to such an alliance seems to lie in the structural plan of the skull. The dinosaurs exhibit the same wing-like expansions of the hinder-end of the parietal, and splint-like squamosal that is found to obtain in all the members of that great branch of the reptilia, which apparently derive their origin from the Rhyncocephalian stock. Whilst this region of the skull in the birds rather resembles that of the Anomodonts and Chelonia, whether the latter really derive their origin from this stock or not, is a moot point. But there is good reason to believe that the Anomodonts, as we have already pointed out, are direct descendants from the ancient Amphibia. The birds then, perchance, may have arisen from a stem quite distinct from the dinosaurs, though we are as yet in ignorance of the precise nature

of the creatures which may have given them birth. The geological record is notoriously incomplete, but nevertheless there is no reason why many types totally undreamed of to-day should not in the near future come to light, and among these we may find the links we require.

CHAPTER X.

DRAGONS OF THE DEEP.

NOWHERE perhaps are

> "The steps of Time—the shocks of Chance—
> The blows of Death . . ."

more luridly manifested than in the history of the rocks, and the creatures entombed therein. They show, furthermore, that history repeats itself, and that the world we live in, though strangely changing in the nature of its inhabitants, is in respect of its physical laws, a world of monotonous uniformity.

We have seen in earlier chapters of this little book, how creatures originally fashioned to live on land, have, by slow degrees, become shaped anew to enable them to dwell in the great deep. This transformation, effected by imperceptible degrees, on creatures strangely unlike, results in a singular uniformity of type. But having regard to the uniformity of their environment, this is only what one should expect. The

subjects of these transformations, probably in all cases, began by haunting streams, then became amphibious, and finally drifted out to sea, where the final stages of their evolution were worked out. Thus has the sluggish tortoise passed into the ocean-dwelling turtle; and similarly, the scaly crocodiles and the ponderous dinosaurs have furnished colonists to Neptune's domain.

The creatures we are now to discuss bear further witness of this strange migration.

Known as the Sauropterygia, the earliest members of this group are represented by certain primitive types, which dwelt probably in the streams and estuaries of the old Triassic rivers. Their descendants, strangely modified, lived on until the Cretaceous. One of the best-known of the ancestral forms, was a beast known as *Lariosaurus*, a lizard-like animal some four feet long. This represents the amphibious phase of development, as is shown by the peculiar form of the limbs, which are obviously more adapted for swimming than walking. Indeed, it is doubtful whether anything more dignified than a shuffle was ever possible on land. We have, indeed, in these legs, an intermediate stage between the walking limbs of an earlier period, and the swimming paddles which ultimately succeeded them. Without describing them in detail we may say that the hinder pair were the longer, that the bones of the fore-arm and shank were moderately long, though shorter than the arm and thigh, that the wrist bones were small, and the hands and feet were

of moderate size. The fingers, indeed, might be described as short. The head was small, and the neck and tail only moderately long, the length of each being, roughly, about the same as that of the trunk. Judging by what are known as the transverse processes of the base of the tail, this organ was much used in swimming. The typical species (*Lariosaurus balsami*), is known by nearly complete skeletons from the Triassic shales of Pelerdo, on the shores of Lake Como.

From this we must pass, with a jump, to the

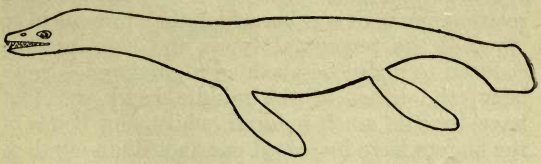


FIG. 16.—Outline restoration of an extinct long-necked Sea-dragon (*Plesiosaurus*).

well-known *Plesiosaurus*, whose remains have been found in comparative abundance in the Lias limestone of England. If size alone can qualify for the distinction of dragonhood, then the Plesiosaurus number, in their ranks, some undoubted dragons, the largest species being nearly forty feet long. Monsters of this size, however, do not appear till late in the history of this group, the culmination being reached in the chalk period, as is shown by remains found both in Europe and North America.

Compared with the Lariosaurus the Plesio saurs and their allies will be found to have

undergone very profound changes, indicating an exclusively aquatic, probably marine, life. The neck and tail have increased enormously, the former containing between thirty and forty vertebræ, that is to say, more than double the number of the more primitive type. The tail contained about the same number of vertebræ as the neck. But it is in the limbs that we note the greatest transformation. These have assumed the peculiar paddle-shape so characteristic of the extremely specialised aquatic types. The bones of the fore-arm have become extremely shortened, whilst the wrist and ankle bones have lost the intimate relation one with another which they present in so many of the terrestrial types, and have become reduced to nodules imbedded in cartilage. Similarly, the bones of the middle hand and foot have become much reduced, whilst the bones of the fingers have increased enormously in number, to form long tapering fingers, of which the third and fourth were the longest. One can picture this animal, when alive, as a huge beast having a swan-like neck in point of length, surmounted by a relatively small head and jaws armed with formidable teeth, a body like an attenuated barrel, and a tail in many species rivalling the neck in length, and provided with a broad fin at the end. Locomotion was apparently effected by the tail, whilst the paddles served as balancers. Carnivorous in habit, this beast probably chased and captured the curious armour-clad fishes which abounded in the seas of that date, as well as the smaller members of its own species. Concerning the covering of the body we know nothing.

As touching the scientific name of these creatures, we may remark that it is derived from two Greek words, *plesios*, nearer, *sauros*, a lizard, apparently on account of the structure of the paddles, for these, though strangely different from the feet of the lizard, are still structurally nearer this type than are the paddles of the "Fish-lizards," to which we now pass.

Returning for a moment to the Lariosaurus, we may remark that these creatures are regarded as the connecting links between the "Sea-dragons" just described and certain equally remarkable fresh-water and terrestrial animals forming a group known as the *Nothosauria*, among the most remarkable of which were the "Placodonts," or Plate-toothed Reptiles. These were singularly flat-headed creatures, and have become notorious on account of their teeth, which were unique among reptiles, though closely resembling those of many fishes.

One of the best known of the Placodonts is *Cyamodus laticeps*. Herein the teeth have the form of large flattened knobs, and are borne not only by the edges of the jaws, but on the palate as well, the largest of all being a pair on the back of the roof of the mouth. From their shape it is supposed that these teeth were used for crushing the shells of molluscs, and hence it is assumed that the beast frequented the sea-shore. Only recently parts of the skeleton of the trunk have come to light, and these show that the body was armour-clad.

The exact opposite of the Plesiosaurs, inasmuch as the head passed imperceptibly into the

trunk, as in the whales and porpoises of to-day, these "Fish-lizards" nevertheless bear a sufficiently close structural resemblance to the long-necked "Sea-lizards" or Plesiosaurs to justify the older naturalists in regarding them as closely allied forms. A more complete knowledge of their anatomy, however, has since shown that in reality they are probably not in any way related. What their origin may have been, however, we do not know. That they were derived from terrestrial creatures there can be no doubt, though no such terrestrial types such as lead up to the Plesiosaurs are known. Instead, these strange creatures appear suddenly in time with all their specialised features in full development. In shape, we may repeat they were strangely whale-like, at least these are the forms which they are considered to-day to most nearly resemble. The older naturalists, however, seem to have considered them more fish-like, hence the name by which they are scientifically known—*Ichthyosaurs*, "Fish-lizards." The earliest known species occur at the very base of the secondary system of zoological deposits, occurring in what is known as the New Red Sandstone of the Triassic era. But it is in the Lias that their remains are best preserved, though they lived on till the end of the Cretaceous system. It is a point of extreme interest to note that, as with many other types described in earlier chapters of this book, we have evidence of specialisation having taken place among these singular creatures in response to a change in the character of the food. For whilst the earlier species invariably have the

jaws well armed with teeth, and fed, as we know from the remains of prey found in the bodies of the fossils, on the mail-clad fishes which abounded in the seas of that time, and on the young of their own kind, many of the later members of this tribe were entirely toothless. These toothless forms occur in the Upper Jurassic rocks. They probably lived on cuttle-fish and similar boneless creatures. Furthermore, we may trace other phases in the evolution and

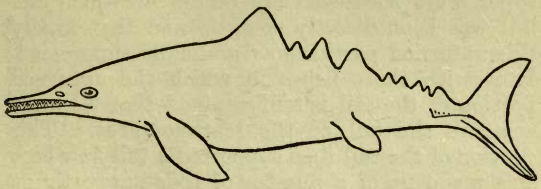


FIG. 17.—Outline restoration of an extinct Fish-lizard (*Ichthyosaurus*). Note the downwardly directed tail seen through the lower lobe of the tail fin.—After Fraas.

decline of the teeth. In the members of the Triassic age the teeth were irregular in size; during the Liassic times they became uniform in size; and finally in the Jurassic and Cretaceous we find almost a quite toothless species. But to this question of the teeth we must return later.

The general form of the body of these creatures, as will be seen in Fig. 16, was remarkably whale-like, but a little scrutiny will quickly reveal many points wherein they are peculiar. In the first place, the back was provided with several fin-like structures, which served as

balancers. These resemble the single back fin of certain whales, in that they were unsupported by a bony skeleton as in fishes. Then the tail differed in a very important particular, in a way, indeed, which makes it unique among animals, inasmuch as it turned sharply *downwards*. In the whales and other allies this organ is perfectly straight, just as in the primitive fishes. In the "Story of Fish-life," it may be remembered, it was pointed out that these primitive types were succeeded by others in which the tail was bent directly *upwards*, and that finally this upturned portion was gradually suppressed. It is with those fishes in which the upturned portion of the tail is still retained that we must compare the tail of the Ichthyosaurus. This portion of the tail then supported a tail *fin* which was made up of a number of rods supporting a membrane. In the Ichthyosaurus the correspondingly downwardly directed tail also supported a fin, but this again resembles the back fin in that it was entirely fleshy and had no supports. Inasmuch as this fin was *vertical* in position, it resembled the fin of fishes, and differed conspicuously from the huge tail fin of the whales and their allies, which is *horizontal* in position. This is a point of some importance. The horizontal position of the tail fin is peculiar to the aquatic mammalia, such as the whales and their immediate allies, and the manatees and dugongs, and has apparently been evolved to suit the need of these creatures for a constant and frequent supply of fresh air; the up and down motion of the tail driving the animal either up to the

surface for air or down into the deep for food. The vertical tail of the Reptiles now in question shows that the need for fresh supplies of air was not of such importance; they could exist for a much longer time without inconvenience. Consequently a vertical tail would be advantageous, since its undulations would serve to drive the body forward through the water, as in the fish, and thus facilitate the capture of prey.

Turning to the limbs, we note again a difference from the whale, inasmuch as all four were present instead of the fore-limbs only, though the hind-limbs were in many cases extremely reduced. From the walking limbs from which they were evolved, they differ profoundly, being now reduced to the condition of paddles, effective as swimming organs, but of little use on land. The skeleton of these paddles will well repay brief study, for whilst they resemble the similar organs of the whale tribe, and that ancient crocodile the *Geosaurus*, they still more closely approach those of the Plesiosaurs. The paddles of these old Fish-lizards, however, differ from all others, in the greater specialisation which they display: they appear indeed to have reached the maximum development ever attained by a paddle. In the earliest known members of the tribe—the species of the genus *Mixosaurus* from the Triassic formations, we find the simplest form of the Ichthyosaurian paddle. Herein the humerus or arm bone and the bones of the forearm were relatively long, the latter being readily distinguished from the first row of wrist-bones. But in the later forms, as will be seen in

the figure, these became much shortened, so that the forearm bones differ but little in size from the wrist-bones in question. Still more noteworthy is the relation of the digits one to another, for they no longer remain separate fingers and toes, but are so closely pressed together that the separate joints have become squeezed into a series of more or less hexagonal plates interlocked to form a perfect mosaic—an arrangement unknown elsewhere among animals. By a considerable addition to the number of the finger bones or phalanges the length of the hand has been greatly increased, whilst additional width has been gained partly by adding a row of bony nodules down the free border of the innermost digits, and partly by a fold of skin, which formed a kind of fringe around the paddle. The fold along the hinder margin of the front paddles at least was especially wide, and impressions in the rocks of some of the best preserved species show that in many cases it was stiffened by a series of little rods resembling the fin spines of fishes, like those supporting the fin running round the plaice or sole, for example. In yet other cases, additional width was gained by increasing the number of the digits from five to six. This was accomplished by splitting the third digit. In some of the species which appeared later in time, as in *Ophthalmosaurus*, we find a considerable modification in the form of these paddles. In the first place, the number of the digits was reduced to four, whilst the finger bones or phalanges exchanged their hexagonal for an oval shape, and thus, becoming

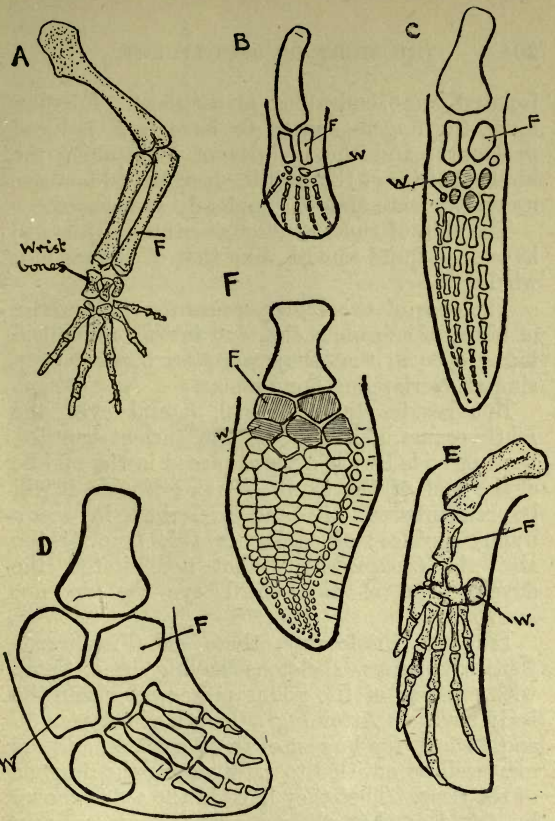


FIG. 18.—A. Left-arm of Crocodile, showing the normal form of the walking limb in Reptiles. B. The arm of an extinct ally of the long-necked Lizards (Plesiosaurs), showing the conversion of the limb into a paddle. C. The arm of the Plesiosaur, showing further evolution of the paddle. D. The arm of the extinct Crocodile *Geosaurus*, showing its transformation into a paddle. E. The arm of the Hawksbill Turtle, showing the same modification. F. The paddle of the old Fish-lizard *Ichthyosaurus*, showing the most extreme point reached in the evolution of the paddle.

A = Humerus or arm bone. F = Fore-arm. W = Wrist-bones. D = Digits.

isolated, were embedded in cartilage. Furthermore, the fingers appear to have been reduced in length, and the nodules of bone along the hinder border of the paddle, designed to increase its width, were almost completely suppressed.

The skin of these strange creatures appears to have been quite smooth, like that of the modern whale.

The eyes of the Ichthyosaurs were, like those of birds, of enormous size, and further resembled birds' eyes in that they were surrounded by a ring of overlapping bony plates.

But besides these normal, lateral eyes, the Ichthyosaurs, like most of the ancient reptiles, were provided with a third placed in the middle of the roof of the skull. Traces of this, it will be remembered, are still preserved in many living reptiles; especially is this true of the Hatteria (*Sphenodon*). What necessitated the development of this third eye we do not know.

Like the Plesiosaurs, these old Fish-lizards were viviparous, skeletons having been found with remains of the young preserved within the body cavity. Attaining a length of between 30 and 40 feet, the largest of these marine monsters may well be entitled to rank among the dragons of the deep. That they lived in the sea is shown by the fact that their remains occur only in marine deposits; but there is nothing improbable in the supposition that they occasionally ventured ashore, perchance to bask on the beach. Walking would of course have been impossible; at most they could but shuffle. What their origin

may have been we do not know, but the structure of the teeth seems to point to a descent from the giant Salamanders or Labyrinthodonts, and for the reason that these teeth present the remarkably complicated infoldings of enamel so wonderfully developed, and so characteristic of the ancient amphibians.

Remembering that both Ichthyosaurs and Plesiosaurs were not only contemporaries but probably lived side by side, one cannot help suspecting that conflicts between members of the two rival houses were not unusual. They were indeed the

> "Dragons of the prime,
> That tare each other in the slime."

perchance rending the air the while with hoarse bellowings, like the crocodiles of to-day. With but a slight effort of the imagination, one can picture some such contest, can see the water lashed into foam as the combatants writhe and twist about, whilst overhead those dragons of the air, the Pterodactyles, flutter in the hope of picking up some newly-swallowed fish disgorged by the excited and infuriated monsters. Suddenly the fray is over. The bull-necked Ichthyosaur has seized his neighbour by that long neck of his and dragged him down to die!

Whether studied individually as separate groups, or collectively, the creatures described in this chapter present us with a series of peculiarly instructive object lessons in evolution and adaptation to environment. The simultaneous development of monsters like the Plesiosaurs and Ichthyosaurs, from totally distinct

stocks with walking limbs, and the transformation of these limbs into paddles, so similar, yet so different, is in itself a revelation. But the marvel and the interest of this convergent evolution, as it is called, becomes intensified when we remember that it has been repeated with variations several times in the history of animals. The last to undergo these structural alterations were members of the warm-blooded mammals—the whales and their allies, and the manatees, whilst a close approximation thereto is going on among the seal-tribe. The uniform environment has produced a marvellously uniform result, moulding reptile, bird and mammal into creatures strangely alike; and just as they have come more and more to resemble one another, so they have come to differ more and more from the stock which gave them birth. Surveyed as separate groups, we remark that the earliest known examples of each tribe are the smallest, and least perfectly adapted to their environment. As we follow their development, we find not only an increase of specialisation, which means perfection of function, taking place, but also an increase in bulk. Finally, just before extinction takes place, we find the most highly specialised of all. Toothlessness is one of the commonest of these last phases of development, and bespeaks adaptation to a very special kind of food. Any disturbance in the balance of nature, whereby this food supply became seriously lessened, would necessarily bring about extinction of these highly specialised forms, for variation in new directions would be impossible. The Ptero-

dactyles and the Dinosaurs, as well as the creatures described in the present chapter, are all originally tooth-bearing forms, but each of these groups presents at least a considerable number of toothless types. At the same time, we would make it perfectly clear that it is not to be supposed that extinction was in any case actually due to the loss of the teeth; we only wish to indicate how easily extinction may be brought about among highly specialised types from their inability to vary further to meet new demands. The fact that the tooth-bearing forms suffered extinction equally with the toothless types, shows the fallacy of such a supposition.

Some extremely valuable suggestions on the causes of extinction, recently made by Mr C. B. Crampton and Dr C. W. Andrews, may fittingly be reviewed here. According to the first-mentioned author, the possible variations of an organism become less and less as specialisation advances; on this account any change in the environment threatens the life of the species, since only a very few individuals will have chanced to vary in a direction favourable to the changed circumstances. As a consequence of this process of weeding out, the stock becomes more and more highly specialised, and therefore more and more physiologically similar, "until at length the same results as arise from close inter-breeding — weakening of the stock, and finally extinction. Yet another possible factor in the process of extermination is that suggested by Dr Andrews. Discussing the evolution of the elephants he pointed out, another possible cause

TURNBULL AND SPEARS, PRINTERS, EDINBURGH.

WORKS OF REFERENCE

THE SURVEY GAZETTEER OF THE BRITISH ISLES. Edited by J. G. Bartholomew, F.R.S.E. With numerous Statistical Appendices and 64 Special Maps in Chromo-Lithography. Imperial 8vo, cloth, **17. 6d.** net; half-morocco, **21s.** net. Deals with nearly 50,000 different places, and is the only up-to-date and complete Gazetteer of the British Isles.

"One of the most comprehensive and accurate works of its kind."—*Pall Mall Gazette.*

THE TWENTIETH CENTURY CITIZEN'S ATLAS. By J. G. Bartholomew, F.R.G.S. 156 Maps. Introductory Text, Statistical Tables, Descriptive Gazetteer, and General Index. Extra crown folio, art canvas, **21s.** net; half morocco, **25s.** net.

"A splendid atlas. The very best atlas which can be purchased at the price."—*Daily Express.*

THE INTERNATIONAL STUDENT'S ATLAS OF MODERN GEOGRAPHY. A Series of 105 Physical, Political, and Statistical Maps, compiled from British and Foreign Surveys and the latest results of International Research. Under the direction of J. G. Bartholomew, F.R.S.E., F.R.G.S., etc. Royal 4to, cloth, **6s.** net.

"A boon to all students of the world's contemporary history."—*Daily Telegraph.*

THE HANDY ATLAS OF THE BRITISH EMPIRE. By J. G. Bartholomew, F.R.S.E. A Series of 120 Maps and Plans illustrating the Geography of the Colonies. with Statistical Notes and Tables. Cloth, **1s.** net; limp lambskin, **2s.** net.

THE HANDY TOURING ATLAS OF THE BRITISH ISLES. By J. G. Bartholomew, F.R.G.S. Being the Ordnance Survey of Great Britain and Ireland in miniature, contained in 120 Coloured Maps. Size, 6 in. by 4 in.; cloth, **1s.** net; limp lambskin, **2s.** net.

THE HANDY SHILLING ATLAS OF THE WORLD. Containing 120 pages of Fully Coloured Maps, by J. G. Bartholomew, and a Gazetteer with 10,000 entries. Size, 6 in. by 4 in.; cloth, **1s.** net.

THE INTERNATIONAL GEOGRAPHY. By Seventy Authors. Edited by Hugh Robert Mill, D.Sc., F.R.S.E. With 488 Illustrations. Third Edition, Revised. Demy 8vo, cloth, **15s.**

GEORGE NEWNES, LIMITED

3 TO 12 SOUTHAMPTON STREET, STRAND, LONDON, W.C.

NEWNES' ART LIBRARY.

Each volume contains about 64 full pages in monochrome, and Frontispiece in photogravure. These are in many cases made from works which have not previously been reproduced. Each Volume also contains a list of the principal works of the Artist. **3s. 6d.** net.

BOTTICELLI. By RICHARD DAVEY.
SIR JOSHUA REYNOLDS. By A. L. BALDRY.
CONSTABLE'S SKETCHES. By Sir JAMES D. LINTON, R.I.
VELASQUEZ. By A. L. BALDRY. **GOZZOLI.** By H. STOKES.
RAPHAEL. By EDGCUMBE STALEY.
VAN DYCK. By H. STOKES. **G. F. WATTS.** By Dr R. PANTINI.
TINTORETTO. By Mrs ARTHUR BELL.
PAOLO VERONESE. By Mrs ARTHUR BELL.
BURNE-JONES. By MALCOLM BELL.
TITIAN (Early Work of). By MALCOLM BELL.
PUVIS DE CHAVANNES. By ARSENE ALEXANDRE.
FILIPPINO LIPPI. By P. J. KONODY.
DANTE GABRIEL ROSSETTI. By ERNEST RADFORD.
FRA ANGELICO. By EDGCUMBE STALEY.

Studio.—"Messrs Newnes' now celebrated series devoted to the Great Masters . . . excellently reproduced, and apparently considerable trouble has been taken to secure reproductions of some of the least known and less accessible of the painters' chief works."

DRAWINGS BY GREAT MASTERS.

The Drawings in this new series are reproduced on a large scale on a page 11¾ in. by 8¾ in. The volumes each contain Forty-eight Reproductions, many of them printed in tints, and of these four or five are mounted on a coloured paper in harmony with the tint in which the Illustration is printed. The volumes are bound in delicately tinted paper boards with vellum backs, with a beautiful Design printed in Three Colours. Quarto, **7s. 6d.** net each.

HOLBEIN. By A. LYS BALDRY. **REMBRANDT.** By M. BELL.
ALBRECHT DÜRER. By Dr HANS SINGER.

Manchester Guardian—"Is sure of a welcome. The reproductions are printed with unusual care."

MODERN MASTER DRAUGHTSMEN.

Uniform with "Drawings by Great Masters." **7s. 6d.** net each.

DRAWINGS OF BURNE-JONES. By T. MARTIN WOOD.
DRAWINGS by SIR E. J. POYNTER, P.R.A. By MALCOLM BELL.
DRAWINGS OF DAVID COX. By A. J. FINBERG.
DRAWINGS OF ROSSETTI. By T. MARTIN WOOD.

NEWNES' LIBRARY OF THE APPLIED ARTS.

A series of Volumes for those interested in the Applied Arts of the past, providing information of really practical value to collectors and students. Particular attention has been paid to the Illustrations, which are both numerous and of the highest quality, and include both Monochromes and Subjects in Colour. Crown 8vo, cloth, gilt top, **7s. 6d.** net.

DUTCH POTTERY & PORCELAIN. By W. PITCAIRN KNOWLES.
OLD ENGLISH FURNITURE. By FREDERICK FENN.
ENGLISH TABLE GLASS. By PERCY BATE.
OLD PEWTER. By MALCOLM BELL.
ENGLISH EMBROIDERY. By A. F. KENDRICK.
FRENCH POTTERY AND PORCELAIN. By HENRI FRANTZ.

Bystander.—"From beginning to end it is always companionable, sincere, and instructive; we can imagine no more useful and agreeable volume."

GEORGE NEWNES, LIMITED
3 TO 12 SOUTHAMPTON STREET, STRAND, LONDON, W.C.