THE COMMON FROG*

VI.

The Skeleton of the Frog

IT may cause surprise to speak of the skin of the common Frog as part of its skeleton, consisting as the skin does of soft membranous structures only.

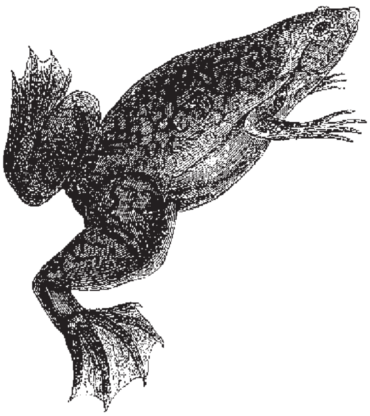

FIG. 26.—*Dactylethra capensis.*

The term "skeleton," however, should properly include all the membranous and gristly, as well as the bony struc-

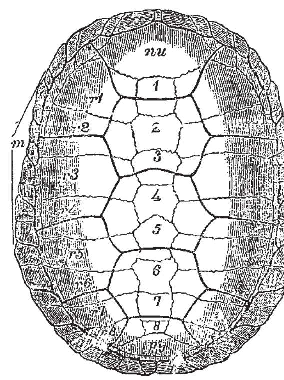

FIG. 27.—Dorsal surface of the Carapace of a Fresh-water Tortoise (Emys) 1—8, expanded neutral spines; r^1—r^8, expanded ribs; *nu*, first median (or nuchal) plate; *py*, last median (or pygal) plate; *m*, marginal scutes. The dark lines indicate the limits of the plates of the horny epidermal tortoise-shell; the thin sutures indicate the lines at the junction of the bony scutes.

tures.* Moreover, more or less of the skin may attain to so solid a condition as fully to justify its comprehension

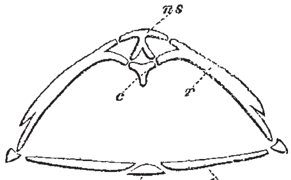

FIG. 28.—Diagram of a vertical section of both Carapace and Plastron of a Tortoise, made transversely to the long axis of the skeleton. *c*, vertebral centrum; *ns*, neural spine which expands above into a median dorsal scute; *r*, rib which forms one mass with a lateral scute and terminates at a marginal plate; *ic*, inter-clavicular scute; *hy*, hyo-sternal scute.

under the name "skeleton," even in the popular signification of that term.

* Continued from p. 69.

† See "Lessons in Elementary Anatomy," Lesson II., p. 22.

The skin of Vertebrate animals consists of two layers: an outer layer (the epidermis or *ecteron*), and an inner layer (the dermis or *enderon*). The *epidermis*, and any projections or processes developed from it when they take on a dense or hardened structure, become *horny*. Of such horny nature are hairs, feathers, nails, and scales, they are more or less dense *epidermal* appendages. The

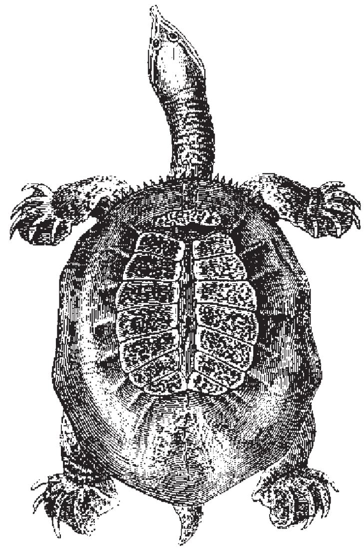

FIG. 29.—A Mud-tortoise (*Trionyx*), showing the dorsa' lates.

dermis when hardened becomes *bony*, and of such nature are the bony skin-plates or "scutes," and teeth. They are *dermal* appendages. Now both layers of the skin of the common Frog are entirely soft and utterly destitute of any

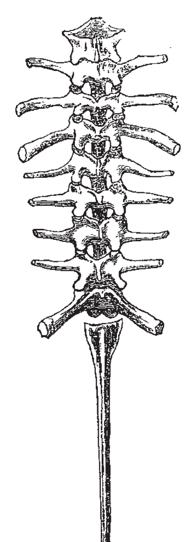

FIG. 30.

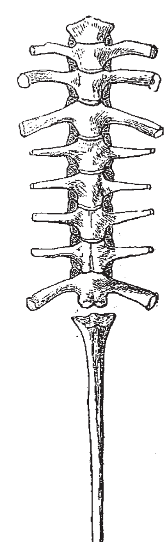

FIG. 31.

FIG. 30.—Backbone of the Frog (dorsal aspect). FIG. 31.—Backbone of the Frog (ventral aspect).

of these appendages. Allied forms, however, present us with examples of some interesting epidermal conditions. Thus in old male Toads, in *Dactylethra* and in one of the Japanese efts, the epidermis of some of the finger-tips becomes hardened and horny, in other words we begin to meet with incipient "nails." "Incipient" because, in ascending from the lowest vertebrates, "nails" are first met with in the Frog's class, and these only very rarely and in an imperfectly developed condition.

As has been mentioned, in two kinds of Frog (*Ceratophrys* and *Ephippifer*) the skin of the back is furnished with bony plates. These are found in the deeper layer or dermis, and are therefore "scutes."

The remarkable circumstance, however, is that we have here a lower stage (as it were an *incipient* condition) of that more developed dermal skeleton which exists in tortoises and turtles. In most of these reptiles both the back and the belly are protected by bony plates which adjoin one another, and together form a solid box in which the body is enclosed. Moreover the bony plates of tortoises and turtles are invested by large horny epidermal scales ("tortoise-shell"), which scales do not agree in either size or number with the bony plates on which they are superimposed.

Again, the middle series of bony plates of the back are continuous with the subjacent joints of the backbones, and the lateral series of dorsal plates are continuous with the ribs beneath them.

There are certain Chelonians, however—"mud-tortoises"—(of the genus *Trionyx*), which have the dorsal plates

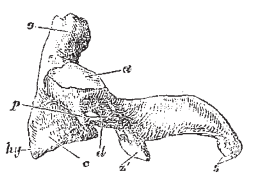

FIG. 32.

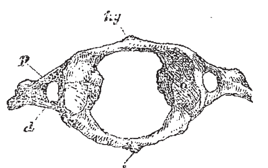

FIG. 33.

FIG. 32.—The Axis Vertebra. *c*, centrum; *s*, neural spine; *d*, tubercular process; *p*, capitular process; *a*, anterior articular surface for atlas; *z'*, postzygapophysis; *o*, odontoid process; *hy*, median vertical ridge beneath centrum. FIG. 33.—The Atlas Vertebra. *s*, rudiment of neural spine; *d*, tubercular process; *p*, capitular process; *a*, articular surface for skull; *hy*, plate of bone holding the place of a cranium, and articulating with the odontoid process of the axis vertebra.

much less developed and not connected with the ventral plates save by means of soft structures.

Here then we have in reptiles an interesting approximation to the condition we have seen to exist in those exceptional Anourans, *Ceratophrys* and *Ephippifer*. Moreover this resemblance is still further increased by the fact that in *Trionyx* the bony plates are not covered with any tortoise-shell, but are merely invested by soft skin as in the genera of dorsally-shielded Batrachians.

Have we then here a true sign of genetic affinity? Are these tortoises to be deemed the more specially modified descendants of shielded frogs or of some as yet unknown slightly-shielded animals which were the common ancestors both of frogs and tortoises?

Certainly tortoises cannot be the direct descendants of frogs, they agree with all reptiles in characters which are both too numerous and too important to allow such an opinion to be entertained for a moment.

The other opinion is hardly less untenable; for if all the multitudinous species of frogs (together with a number of reptilian forms more closely allied to the tortoise than any frogs are) descended from slightly shielded animals, how comes it that all frogs and toads, save one or two species in no other way peculiar, have every one of them lost every trace of such shielded structure which nevertheless cannot easily be conceived to have been in any way *prejudicial* to their existence and survival?

On the other hand, it cannot but strike us with surprise that structures so similar—extending even to the continuity of the dorsal plates with the subjacent joints of the backbone—should have arisen twice in nature spontaneously. Here we seem to have a remarkable example of the independent origin of closely similar structures; and if so, what caution is not necessary before concluding that *any* given similarity of structure are undoubted marks of genetic affinity!

The skin of the frog is also interesting from a physiological point of view. Our own skin is by no means popularly credited with the great importance really due to it. "Only the skin!" is an exclamation not unfrequently heard, and wonder is very often felt when death supervenes after a burn which has injured but a comparatively small surface of the body. Yet our skin is

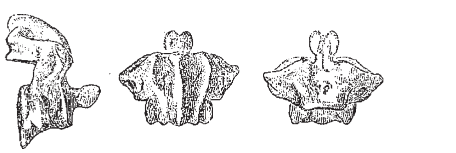

FIG. 34.—Lateral, Dorsal, and Ventral view of first Vertebra of *Amphiuma*.

really one of our most important organs, and is able to supplement, and to a very slight extent even to replace, the respective actions of the kidneys, the liver, and the lungs.*

In the frog we have this cutaneous activity developed in a much higher degree. Not only does its *perspiratory* action take place to such an extreme degree that a frog tied where it cannot escape the rays of a summer's sun speedily dies—nay, more, is soon perfectly dried up—but its *respiratory* action is both constant and important. This has been experimentally demonstrated by the detection of the carbonic acid given out in water by a frog over the head of which a bladder had been so tightly tied as to prevent the possibility of the escape of any exhalation from the lungs. The fact of cutaneous respiration has also been proved by the experiment of confining frogs in cages under water for more than two months and a half, and by the cutting out of the lungs, the creature continuing to live without them for forty days. Indeed it is now certain that the skin is so important an agent in the frog's breathing that the lungs do not suffice for the maintenance of life without its aid.

It is no less true that in Batrachians which breathe by means of permanent gills—as, *e.g.* the Axolotl—such gills are not necessary to life, as the late M. Aug. Duméril and Dr. Günther have established by cutting them away without inducing any apparent injurious effects. In the whole class of Batrachians skin respiration seems, then, to be of very great importance.

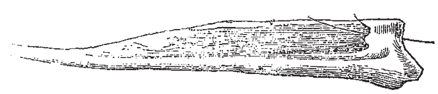

FIG. 35.

FIG. 36.

FIG. 35.—Coccyx of Frog, lateral view, a black line indicates the course of the sciatic nerve. FIG. 36.—Anterior aspect of Coccyx, showing the double articular concavities placed side by side beneath the neural arch.

The *internal* skeleton (or the skeleton commonly so called) of the frog presents some points of considerable interest, especially as exhibiting its intermediate position between fishes on the one hand, and higher vertebrates on the other. First, as regards the *backbone*, it may be remembered that it is made up of distinct bony joints (or *vertebræ*), in which it agrees with all animals above fishes and with bony fishes; its hinder termination, however, is essentially fish-like. It is fish-like, because the terminal piece, as it is called, or "*coccyx*" (unlike the coccyx in man or in birds) is not formed of rudimentary vertebræ which subsequently blend and anchylose together, but is formed by the ossification continuously of the membrane investing (or *sheath* of) the hindermost part of that primitive continuous rod, or notochord, which, as has been said,

* See "Elementary Physiology," Lesson V., § 19.
† From Νῶτος, back, and Χορδη, chord.

precedes, in all vertebrate animals, the development of the backbone, making its appearance beneath the primitive groove.

The vertebræ are shaped like rings, and enclose within their circuit the spinal marrow upon which, as it were, these rings are strung. From the side of each ring (except at the two ends of the backbone) there juts out a bony prominence called a "transverse process," and to a certain number of these a bony "rib" is in most vertebrate animals attached (though there are none in the frog), often extending round to join the breast-bone in front, and being capable of more or less motion, so as (by their simultaneous movement) to be able to enlarge or to contract the cavity of the chest, which they thus enclose and protect.

That part of each vertebra which is placed next the body cavity is generally the thickest part, and is called the "body," or "centrum." The series of bodies (or centra) occupy the position which was at first filled by the primitive notochord, the rest of the vertebral rings having been formed in the sides and roof of the canal formed by the upgrowth and union of the two sides of the primitive groove of the embryo.

The frog order is distinguished amongst vetebrates as that which has the absolutely smallest number of joints in the backbone. In the frog there are but nine in the front of the coccyx. In the Pipa toad there are but seven, the eighth vertebra (to the transverse processes of which the haunch bones are attached) having become solidly joined in one bone with the coccyx.

In all higher vertebrates, *i.e.* in all beasts, birds, and reptiles, the head is supported on an especially ring-like vertebra which—because it so supports—is called the *atlas*, and this (in almost all) can turn upon a peculiar vertebra termed (from this circumstance) the *axis*, and provided with a toothlike (*odontoid*)* process, round which, as round a pivot, the "atlas" works. Nothing of the kind exists in any fish.

In the frog (and in all its class) we find but a single vertebra representing these two, but in some allied forms, *e.g.* in *Amphiuma*, this vertebra develops a median process, reminding us of the odontoid process of the axis.

The frog, as has been said, has no ribs, in spite of the long "transverse processes" which project out on each side of the backbone. Ribs are not necessary to it, for it could apply them to none of the purposes to which ribs are ever applied.

In all beasts ribs aid importantly in respiration, serving by their motions alternately to inflate or empty the lungs by enlarging or contracting the cavity of the chest in the way before mentioned. The frog, however, breathes exclusively, as regards the lungs, by *swallowing* air by a mechanism which will be described shortly.

In serpents the ribs are the organs of locomotion, as also in the Flying Dragon before referred to ; but in frogs locomotion is effected exclusively by the limbs. In the very aberrant species, *Pipa* and *Dactylethra* there are on each side of the anterior parts of the body two enormously long transverse processes, each process bearing at its extremity a short flattened, straight osseous or cartilaginous rib. These little ribs can, however, take no part in such functions as those just referred to.

Ribs, moreover, are found in the other existing orders of the frog's class, *i.e.* both in the *Urodela* and *Ophiomorpha*. In none, however, do they join a breast-bone, or sternum, another character in which *Batrachians* agree with fishes, though they differ from fishes in that they have a sternum at all. In ascending from fishes through the vertebrate sub-kingdom, a sternum first appears in the class *Bratrachia*.

In a certain North African Salamander named *Pleurodeles* the ribs are not only elongated, but their apices, if they do not actually perforate the skin, are so prominent as to seem to do so when the finger is drawn from behind forwards along the side of the animal's body.

* From ὀδούς, a tooth, and εἶδος, form.

The several joints of the backbone are connected together by surfaces which are not the same on both the anterior and posterior sides of the centrum, or body, of the same vertebra. Each of the first seven vertebræ is furnished with a round prominence, or head, on the hinder side of its centrum, and each of the precoccygeal vertebræ, except the first and last, has the anterior surface of its centrum excavated as a cup for the reception of the ball of the hinder surface of the vertebra next in front. The first vertebra has in front two concavities, side by side, to articulate with the skull. The eighth vertebra has a concavity at each end of its "body." The ninth vertebra has a body provided with a single convexity in front and a double convexity behind, to articulate with the concavities placed side by side on the front end of the coccyx.

These arrangements are not constant in the frog's order, still less in its class. In *Bombinater* and *Pipa* the vertebræ are concave behind each centrum, instead of in front : and the same is the case in *Salamandra*. In many tailed Batrachians the vertebræ are biconcave, as *e.g.* in *Spelerpes*, *Amphiuma*, *Proteus* and *Siren*.

The biconcave shape is an approximation towards the condition which is almost universal in bony fishes, though not quite universal, since the bony pike (*Lepidosteus*) has a ball at one end of each vertebra and a cup at the other. Moreover, even in some reptiles (*e.g.* the lizards called *Geckoes*) the vertebræ are biconcave, and the same was the case with the majority of those species of crocodiles the remains of which are found in strata older than the chalk, and even in existing crocodiles the first vertebra of the tail is biconcave.

Vertebræ with a cavity in front of the centrum and a ball behind it are found in the crocodiles now living as well as in the frog, while vertebræ with a ball in front and a concavity behind are found even amongst beasts, as in the joints of the neck of Ruminants, *e.g.* the sheep. Thus though the vertebræ of the frog's class exhibit no very decided signs of affinity, they show more resemblance to those of fishes than to those of any other non-batrachian class.

The transverse processes of the ninth or last vertebra in front of the coccyx, articulate with the haunch bones, but are not very remarkable in shape. In some frogs and toads the transverse processes of this vertebra become enormously expanded, and the expanded or non-expanded condition of this part is a character made use of in zoological classification. The coccyx is made up mainly, as has been said, of a continuous ossification of the sheath of the notochord, and never consists of distinct vertebra. Nevertheless, the small bony arches which are at first distinct coalesce with it. These arches are called "neural" because they arch over the hinder part of the spinal marrow. The great nerve of the leg (the sciatic nerve) proceeds outwards on each side through a foramen situated at the anterior end of the coccyx from the spinal marrow—the spinal marrow being that structure which gives origin to the great mass of the nerves pervading the entire frame.

St. George Mivart

(*To be continued.*)

[The author sincerely regrets, that by an inadvertence for which he is exclusively answerable, two cuts introduced into the second of these articles, namely, the figures representing *Rina esculenta* and *Bufo vulgaris*, were copied, without sanction, from two illustrations in Professor Bell's "History of British Reptiles," published by Mr. Van Voorst, to whom, therefore, this apology is due.]