cumference of the earth, we may assume that the longitude of the major axis is constantly changing and progressing from west to east within certain limits, and then returning from east to west; in other words, oscillating through a determinable space.

I have ventured to bring this interesting subject under the notice of the readers of NATURE in the hope that it may receive the attention which it appears to merit, and that satisfactory illustrations will be forthcoming to show that the differences between the equatorial major and minor axes of the earth are competent to explain or throw light on many disputed points in geological inquiry, and to lead to a rational solution of some difficult problems. On the other hand, it does not appear unreasonable to suppose that known geological facts may serve to point out a line of investigation which may lead to a more correct knowledge than we appear to possess at present of the figure of the earth, the probable changes which are slowly taking place, and the relation which these bear to geological inquiry.

HENRY Y. HIND

Windsor, Nova Scotia

REPORT OF PROF. PARKER'S HUNTERIAN LECTURES "ON THE STRUCTURE AND DEVELOPMENT OF THE VERTEBRATE SKULL" *

V.

WHEN the investing bones, mentioned in the last paper, are removed, the chondro-cranium of the axolotl is seen to have a far lower structure than that of the salmon. The hinder part of the skull-floor is constituted by a flat plate of cartilage (Fig. 13, B.O) formed from the investing mass, and answering to the basi-occipital, but unossified. From this rises up on each side a narrow cartilaginous pedicle, which, uniting above with its fellow, forms the occipital ring inclosing the foramen magnum. An ossification—the exoccipital—is formed on each side of this arch where it bears the occipital condyles; but, as in all amphibia, the supra-occipital, like the basi-occipital region, remains cartilaginous.

From the front edge of the basilar plate proceed two cartilaginous rods, uniting between the nose capsules as an expanded inter-nasal plate (I.N) and rising up to form the walls of the brain-case, but leaving its floor and roof to be covered in by the investing bones—the parietals and frontals above and the para-sphenoid below. These rods are, clearly, the very slightly altered trabeculæ; they bear a single pair of ossifications, placed considerably in front of the optic foramen, and answering to the lateral elements of the "os en ceinture" or "girdle-bone" of the frog. The nasal capsules, situated immediately outside the expanded cornua trabeculæ (hypo-trabeculars), are as far apart as in the ray.

The auditory capsules are largely cartilaginous, but contain three bones—the prootic, the epiotic, and a small ossicle nearly filling up a membranous space in the capsule between the prootic and opisthotic regions; the space is the first appearance of a *fenestra ovalis*, the bone of a *stapes*, so that in the tailed Amphibians is seen the earliest foreshadowing of the delicate apparatus by means of which vibrations of the air are communicated to the membranous labyrinth. The apparatus is, however, in a very rudimentary condition, there being neither tympanic membrane nor external meatus, and the stapes being connected, not with a chain of ear-bones, but with a band of fibres, the stapedio-suspensorial ligament (s.s.l), which unite it with the hinder part of the suspensorium.

The upper end of the mandibular arch is not let down to a considerable distance from the skull like that of the salmon, but forms the whole of the suspensory apparatus of the lower jaw, thus taking on the function performed in the fish by the proximal portion of the hyoid arch. The suspensorium is a stout cartilage sloping downwards and forwards, rounded below into an articular surface for the jaw, and divided above into three processes, the pedicle (p) or true apex of the arch, the ascending process (a), and the otic process (o). The two former are coalesced with the hinder ends of the trabecula, the latter with the auditory capsule; the first division of the fifth nerve passes out between the pedicle and the ascending process. A granular deposit of calcific matter (Qu) in the lower part of the suspensorium is the only representative of the bony quadrate of the fish, the meta-pterygoid region remains wholly unossified.

The pterygo-palatine arcade is very rudimentary, being represented only by a thin bar of cartilage (Pl.Pt) passing forwards from the front edge of the suspensorium, but not coming into contact with the ethmoidal region. Two bones are, however, developed in connection with this cartilage—the small tooth-bearing palatine, and the enormous triangular pterygoid.

As in the salmon, the lower jaw, stripped of its investing bones, consists of an articular and Meckel's cartilage; the latter, however, is large and stout, and not reduced to a more slender root on the inner side of the dentary.

The hyoid apparatus (Fig. 12) is a strong bar of cartilage connected by ligament with the suspensorium and mandible; it is divided into cerato- and hypo-hyal, but is entirely unossified, and never comes into relation with the auditory capsule. The branchial arches are four in number; the two hinder are split up into a long epi-branchial, a short cerato-branchial, and a small wedge-shaped basi-branchial.

One of the most important points to be noted in the development of the skull is the formation of the stapes; this was formerly believed to be the apex of the hyoid arch, but its true nature—as a separated portion of the wall of the ear capsule—has been demonstrated in the frog, and confirmed in the newt, axolotl, and other forms. In the axolotl of about an inch long a crescentic slit is seen in the auditory capsule, formed by the degeneration of its cartilage into fibrous tissue; the ends of this slit extend and meet, and thus cut off a circular plug of cartilage set in a ring of fibre, producing at once the stapes and the fenestra ovalis.

The investing mass remains long in the condition of indifferent tissue, and even after chondrification has set in the two halves remain separate until a very late period, thus approximating to the state of things found in Menobranchus and Proteus, in which the two parachordals are permanently united only by fibre.

The trabeculæ are at first parallel with the post-oral arches, and only at a comparatively advanced stage come to lie almost at right angles to them, as in the first stage of the salmon. The pterygo-palatine process is very late in its development, arising as a bud from the mandibular arch, and growing forwards towards the trabeculæ, with which, however, it never actually unites. The minor changes which the arches undergo will not be described here, as they have been worked out at far greater length in the frog.

VI. *Skull of the Frog* (Rana temporaria).—As far as its general aspect is concerned, the skull of this well-known Batrachian is by no means unlike that of the axolotl: it presents, however, many important differences, and shows a marked advance towards the sauropsidan and mammalian type.

Among the most important of these characters may be mentioned the backward slope of the suspensorium (see Fig. 14), the large size of the maxilla and its connection, through the intermediation of a small separate bone (the quadrato-jugal, Q.Ju), with the quadrate, the union of the palato-pterygoid cartilage with the ethmoidal region, the disappearance in adult life of the branchial arches, and, most important of all, the separation of the upper end

* Continued from p. 108.

of the hyoid arch as a chain of auditory ossicles, for the purpose of communicating the vibration of the tympanic membrane to the stapes.

Certain noteworthy peculiarities may be mentioned, with regard to the investing bones, the chief being the fusion of the parietal and frontal into a single bone (Fr.Pa), the dagger-like form of the para-sphenoid, and the addition of a horizontal bar to the upper end of the squamosal which

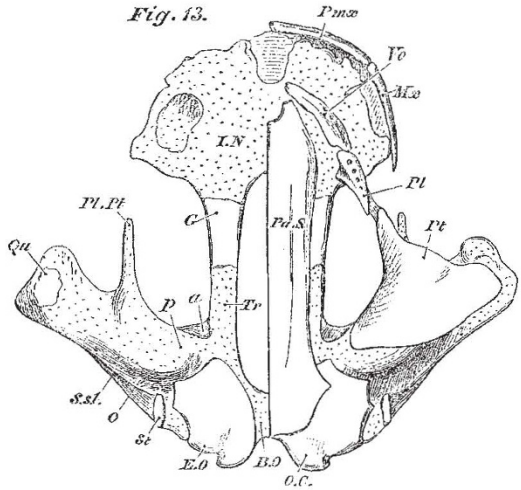

FIG. 13.—Skull of fully adult Axolotl, under view (× 2 diam.), the investing bones being removed from the right side. I.N, inter-nasal plate; p, pedicle, a, ascending process, and o, otic process of the suspensorium.

seems to answer to one of the bony plates developed in ganoids in the temporal region, while the vertical portion is clearly the homologue of the pre-opercular. An extremely small membrane-bone is also developed in connection with the external nasal opening: this is the septo-maxillary (S.Mx), which is interesting from its reappearance in lizards, snakes, and birds.

In the cartilaginous brain-case the form of the trabeculæ is entirely lost by the complete union of those arches below, so as to form a solid floor of cartilage within the para-sphenoid, and by the formation of a roof of like character beneath the fronto-parietals: the latter is interrupted by a large anterior and a pair of small posterior fontanelles. Just behind the inter-nasal plate a stout dice-box-shaped ossification is developed (G) overlaid above

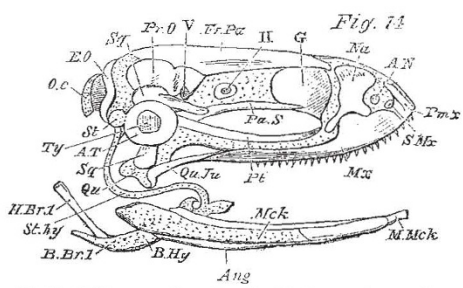

FIG. 14.—Skull of Common Frog (× 2). Ty, tympanic membrane; A.T, annulus tympanicus; M.Mck, mento-meckelian.

by the frontals and below by the para-sphenoid; this is the girdle-bone ("os en ceinture" of Cuvier), and answers to the hinder part of the ethmoid, the fore part of the pre- and orbito-sphenoids, and the pre-frontals. In its posterior half this bone contains a single cavity, in which are lodged the olfactory lobes of the brain, but in its anterior moiety a vertical partition (mesethmoid) divides it into two chambers, through which the nerves of smell pass to the nasal sacs.

Only a single bone occurs in the auditory capsule—the prootic, which extends backwards, so as almost to meet the exoccipital; the opisthotic, epiotic, and stapes remain entirely cartilaginous.

The palatine (Fig. 15, Pl) is a slender bone not provided with teeth; the pterygoid is 3-ranged, having an anterior process coming into relation with the palatine, a posterior articulating with the auditory capsule, and a descending bar which runs along the inner side of the suspensorial cartilage; the two latter help to inclose the eustachian opening (Eu). The suspensorium does not present that clear

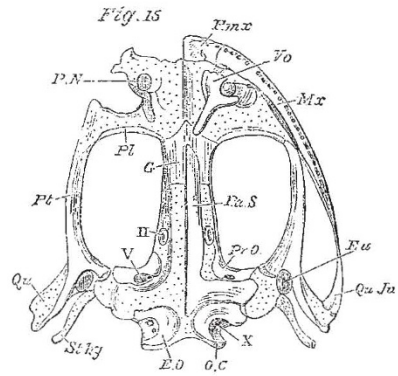

FIG. 15.—Skull of Frog, under view (× 2). the investing bones removed from the right side. P.N, posterior nares; Eu, aperture of eustachian tube.

division into pedicle, ascending process, and otic process which is observable in the axolotl; the second of these is, in fact, represented only by fibrous tissue, while the pedicle and the otic process are completely fused with the auditory capsule.

There is no articular bone in the mandible, but an interesting ossification (M.Mck) of Meckel's cartilage takes place at the point of union of the two rami. This is the symphysial ossification or "mento-meckelian" bone; it has been found in the sturgeon and also in early stages of the human subject.

The hyoid arch is divided into two portions, an upper, which subserves the function of hearing, and a lower, which supports the tongue. The first of these (Fig. 16) is a hammer-shaped apparatus, partly cartilaginous, and partly bony, the handle of which articulates with the stapes (St), while the head is fitted into the drum-membrane (Fig. 14, Ty).* The parts of this ossiculum auditûs have been named by Prof. Huxley, in their relation to the stapes, inter-, medio-, extra-, and supra-stapedial; taken together they answer to the hyo-mandibular and symplectic of a fish. The medio-stapedial (M.St) is ossified; the other portions of the apparatus are

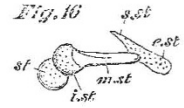

FIG. 16.—Ear-bones of Frog (× 4). i,st, inter-stapedial; m.st, medio-stapedial; e.st, extra-stapedial; s.st, supra-stapedial.

cartilaginous. The tongue-cartilage is a shield-shaped plate consisting of basi-hyal in its anterior and basi-branchial in its posterior part, and connected with the skull by two slender, spring-like rods, the stylo-hyals (St.Hy), which are fused with the auditory capsule; these answer to the anterior or lesser horns of the hyoid bone of man, the greater horns being represented by the ossified first hypo-branchials or thyro-hyals (H.Br. 1) which embrace the larynx.

* The annulus tympanicus (A.T), or ring of cartilage which supports the drum-membrane, would seem to answer rather to the external ear of a mammal than to the tympanic bone.