by the agency of a leaven or ferment which is contained in the stomach-juice, and can be, like the ferment of saliva, easily separated and prepared. As so separated, it is called pepsin (the medicine called by that name is supposed to contain some of it, and indeed often does). Consequently, having the ferment, we can easily imitate digestion out of the body. For this experiment there are three things necessary—first, that our liquid should contain pepsin; secondly, that it should be slightly acid; and thirdly, that it should be kept at the temperature of incubation, *i.e.* about 97° F. We select for the experiment a substance which, although nutritious and containing nitrogen, is not easily digested—such, for example, as boiled white of egg. In water containing a small percentage of hydrochloric acid and a trace of pepsin, it is gradually dissolved; but chemical examination of the liquid shows us that it has not been destroyed, but merely transformed into a new substance, called peptone, which is afterwards absorbed, *i.e.* taken into the circulating blood.

Between this process and the digestion of the Dionæa leaf, the resemblance, as Mr. Darwin has found by a most elaborate comparative investigation, is complete. It digests exactly the same substances in exactly the same way, *i.e.* it digests the albuminous constituents of the bodies of animals just as we digest them. In both instances it is essential that the body to be digested should be steeped in a liquid, which in Dionæa is secreted by the red glands on the upper surface of the leaf; in the other case, by the glands of the mucous membrane. In both the act of secretion is excited by the presence of the substance to be digested. In the leaf, just as in the stomach, the secretion is not poured out unless there is something nutritious contained in it for it to act upon, and finally in both cases the secretion is acid. As regards the stomach, we know what the acid is: it is hydrochloric acid. As regards the leaf, we do not know precisely as yet, but Mr. Darwin has been able to arrive at very probable conclusions, the setting forth of which we look forward to in his expected work on the Droseraceæ.

(*To be continued.*)

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

IV.

IN the Teleostei the jaws attain their maximum amount of mobility, and the articulation of the lower jaw is, consequently, brought to the farthest possible distance from the skull, by the disjointing of the mandibular arch from its original attachment. This arch consists of two cartilaginous bars (see Fig. 11, Pl.Pt and Mck) corresponding to the upper and lower jaws of the shark or ray, but containing certain important ossifications. The apex of the arch, corresponding to the spiracular cartilage of the ray, is formed by the meta-pterygoid (Fig. 7, M.Pt), below which, and separated from it by a broad synchondrosis, is the quadrate (Qu) bearing a rounded articular surface for the mandible. In the pterygo-palatine cartilage are three ossifications—the palatine (Pl), pterygoid (hidden in the figure by the maxilla and jugal), and mesopterygoid (Ms.Pt). The proximal portion of the originally cartilaginous lower jaw is ossified by the articular (Art), while its distal portion remains as the comparatively slender Meckel's cartilage, running on the inner side of the dentary, almost to the symphysis.

As in the Elamobranchs, the proximal part of the hyoid arch forms the suspensory apparatus for the jaws, but unlike the corresponding cartilage in those fish, contains two ossifications, the large and massive hyo-mandibular (H.M), articulating with a cartilaginous surface afforded to it by the sphenotic and pterotic (see Fig. 9), and the symplectic (Sy) below, which, fitting into a groove in the quadrate, firmly binds together the hyoid and mandibular arches. The free portion of the hyoid articulates with the cartilaginous space between the hyo-mandibular and symplectic, through the intermediation of a small bone (shown in Fig. 7 by dotted lines, being hidden by the pre-opercular), called by Cuvier the stylo-hyal, but better named inter-hyal, as it is not the homologue of the mammalian styloid process. The hyoid cornu is segmented as in the ray, except for the fact that there is a median basal piece, usually called, from the circumstance of its giving support to the tongue, glosso-hyal (G.Hy). All these segments are ossified and separated from one another by tracts of cartilage.

The branchial arches are much smaller in proportion to the mandibular and hyoid than in the shark and ray; they also lie almost entirely within the latter, instead of in a regular series behind it. Each of the first four bars is divided into pharyngo-, epi-, cerato-, hypo-, and basi-branchial; and each segment, with the exception of the last pharyngo-branchial, is ossified. The fifth arch (inferior pharyngeal bone) is much smaller than its predecessors, and consists simply of a tooth-bearing cerato-branchial. The pharyngo-branchials (superior pharyngeal bones) are not dentigerous.

The development of the salmon was described at far greater length than that of the shark or ray, the metamorphoses gone through being much more complex, and exhibiting in a most instructive manner the endless modifications which the facial arches may undergo in their modes of segmentation and coalescence.

Besides the adult, seven arbitrary stages of the skull were described; in the first three of which the embryo was still unhatched, and lying as a flat tape-like band about $\frac{3}{4}$ of an inch long coiled round the yelk-sac; in the fourth the head was just emerging from the chorion; the fifth consisted of salmon fry at the second week after hatching; those of the sixth stage were at the sixth week; and those of the seventh young salmon of the first summer, varying in length from $1\frac{1}{2}$ to $2\frac{1}{4}$ inches, and having in all essential respects the cranial characters of the adult. The earliest stages are remarkable for their want of symmetry, the head being so twisted that only one eye is visible in an upper view.

The head of an embryo at the first of these stages is shown in Fig. 10; it resembles very closely the earliest conditions in the shark and ray (Figs. 3 and 6, vol. ix. p. 467), having, like them, prominent sense-capsules, a widely-open mouth, and simple, unsegmented facial arches, which latter, however, present very important differences to the homologous structures in the lower types. The trabeculæ (Tr) are seen in the roof of the mouth, where they lie, enclosing the pituitary body (Pty) like a pair of forceps, in the same plane as the investing mass and notochord, and not at right angles to them like the post-oral arches. Curving under the eye is a bar of somewhat thickened indifferent tissue (Pl.Pt) representing the pterygo-palatine arcade, but, even in this extremely early stage, so entirely distinct from the mandibular arch proper (Mn) as to have the appearance of a true, separate face-bar. It long remains, however, in a rudimentary state as regards histological development, not being converted into true hyaline cartilage until the fourth stage, when it unites with the main part of the mandibular arch.

In the second stage, a most noticeable change has taken place with regard to the hyoid. A lozenge-shaped basal piece, the glosso-hyal, has appeared between the bars of opposite sides, and the whole arch has split lengthwise from top to bottom, becoming divided into an anterior and posterior division, the former of which becomes the fixed hyo-mandibular and symplectic, the latter the free epi- and cerato-hyals.

In the third stage, this process has gone farther: the two divisions of the hyoid have become separated from

* Continued from p. 10.

one another below, and have grafted themselves above to the auditory capsule, thus approximating very closely to the state of things found in the ray, where, as in this early stage of the salmon, the two parts of the hyoid are nearly equal in size. The pterygo-palatine has not yet united to the mandibular arch, although it has joined anteriorly with a "conjugational process" sent out from the now flattened trabecula. Meckel's cartilage is entirely separated from the quadrate.

The chief point to be noted in the fourth stage is the assumption of an undoubted Teleostean character, by the slipping down of the posterior bar of the

Fig. 10.

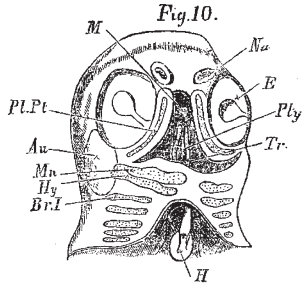

FIG. 10.—Head of Embryo Salmon, about ¾ inch long (× 10 diam.). H, heart.

hyoid, which is now attached, not to the upper angle of the anterior bar, but to about its middle, a small nodule of cartilage, the inter-hyal, appearing between the two. This important change has advanced still farther in the fifth stage (Fig. 11), in which also the palato-pterygoid has united with the quadrate, and the membranous roof of the brain-case, beginning to chondrify, has formed the anterior part of the tegmen cranii (T.Cr), and sent back a supra-orbital bar (S.Or) to meet the ear capsule, leaving, however, a large membranous space or fontanelle (Fo) in the roof of the cranium. The trabeculæ, although flattened out and united in front, are completely separated behind, both from one another and from the investing mass, which

Fig. 11.

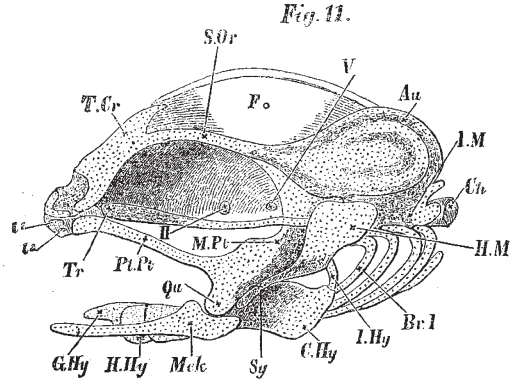

FIG. 11.—Skull of Young Salmon, the second week after hatching. (× 12 diam.) Fo, fontanelle; I.Hy, inter-hyal.

is merely overlapped by their slender inturned posterior ends (pharyngo-trabeculars). The jaws are constituted exclusively by the palato-pterygoid and Meckelian cartilages, and in many other points the skull now bears a very close resemblance to that of the shark or ray, and still more to that of certain recent Ganoids, such as Polypterus.

The sixth stage shows ossification to have set in at several points, and exhibits in an interesting manner the formation of the inter-orbital septum. The cartilage between the nasal sacs (mesethmoid) has sent backwards a triangular plate towards the orbito-sphenoidal region, another plate has risen up from the middle line of the skull-floor or coalesced trabeculæ; and by the subsequent union of these two elements the partition so characteristic of bony fishes, as well as of reptiles and birds, is produced. It is the fissure left by the incomplete union of these elements which is shown at e.t.f in Fig 8 (p. 10). In the seventh stage all the ossifications have appeared, and the skull is fast taking on adult characters.

V. *Skull of the Axolotl* (Siredon pisciforme). The group of tailed Amphibia or Saurobratrachia is one of the most interesting in a craniological point of view, presenting, as it does, so great a variety of types, that while the highest, such as the salamander, approach nearly to the frogs and toads, the lowest, such as Proteus and Menobranchus, have a chondro-cranium actually lower than that of the lamprey. As a rule, indeed, the skulls of those Saurobratrachia which, like the Axolotl and the two genera mentioned above, retain their gills throughout life, have, when once the investing bones are removed, a simpler and more embryonic structure than that of any other adult animal.

The two chief roofing-bones of the brain-case—the parietals and frontals—are far more normal in their relative size than in the salmon, the parietals uniting in the mid-line, and sending off an unusually long anterior process to the ethmoidal region. The nasals are sepa-

Fig. 12.

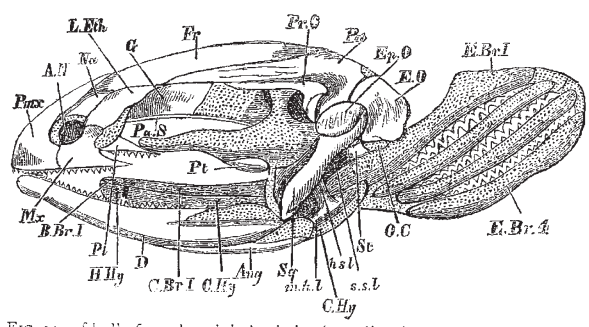

FIG. 12.—Skull of nearly adult Axolotl. (× 2 diam.) A.N, anterior nares; s.s.l, stapedio-suspensorial ligament; h s l, hyo-suspensorial ligament; m h.l, mandibalo-hyoid ligament; St, stapes; G, girdle-bone; Sq, squamosal.

rated from one another by the long ascending processes of the pre-maxilla: the supra-ethmoid of the salmon is absent, but the lateral ethmoid is represented by a membrane-bone (Fig. 12, L.Eth) evidently corresponding with the pre-frontal of reptiles, which overlies the cartilage behind the nasal sac and extends backwards to meet the anterior process of the parietal. The maxilla is considerably smaller than the pre-maxilla, and is free behind, there being no jugal or quadrato-jugal to unite it with the quadrate. On the under-surface of the skull is the large oblong para-sphenoid, and in front of it, bounding the inner side of the posterior nares, the well-developed tooth-bearing vomers, which together represent the single bone of that name in the salmon. All the opercular bones of the fish are absent, except the pre-opercular, now, as in all the high vertebrata, known as the squamosal (Sq), a flat ossification clamping the suspensory apparatus of the jaw, and extending upwards and backwards to the auditory region.

In the mandible three membrane-bones are developed, the two first of which bear teeth; the dentary has the same relations as in the salmon, the splenial lies as a flat splint on the inner side of each ramus, and the angular is also chiefly visible within, a small portion of it only (Ang) being seen externally.

The remaining bones will be described with the chondro-cranium, of which they are ossifications.

(*To be continued.*)