THE TEETH OF THE MYXINOID FISHES.

IN the course of my work upon the morphology of the Vertebrata, it has occurred to me to ascertain how far the generally accepted account of the structure of the teeth in Cyclostomata exhausts the facts at our disposal. The inquiry is one of extreme interest in relation to the disputed affinities of this group with the other fishes. It is well known that Balfour regarded the Myxinoids as the survivors of a very primitive group which had never possessed true jaws. Dohrn, on the other hand, while holding that these fishes retain very many primitive characters, has always asserted their degenerate nature as a canon of his doctrine of the ancestry of Vertebrates. He has endeavoured to produce evidence of this in several of his "Studien," but so far as I am aware, the secondary character of the sucking mouth of the group has never yet been fully proved.

In Balfour's "Comparative Embryology" (vol. ii. p. 264), we read, "I am acquainted with no evidence, embryological or otherwise, that they (the Myxinoid fishes) are degraded gnathostomatous forms."

As the nature of the mouth in this group was one of Balfour's arguments against Dohrn's gill-cleft origin of the mouth of all Vertebrates,[1] and as my own views of the nature of the hypophysis cerebri are also affected by Balfour's reasoning, I may perhaps be allowed to state why I attach great importance to the structure of the teeth in the Myxinoids. With the exception of these animals and Amphioxus, all Vertebrates are known to possess true teeth and true jaws; but it appears to me that if it can be shown that the Myxinoids present traces of true teeth, it must be assumed that they once had true biting jaws. For true teeth are necessary appendages of biting jaws, while they are never found except when true jaws are present. It is important to note that Huxley long ago insisted upon the presence, in the lamprey, of a true mandibular jaw-apparatus, homologous with that of the gnathostomata.

All previous investigators of the group, from Johannes Müller to Parker, have described only the horny nature of the teeth, and that simply because no one has till now made microscopical sections of them. It must here suffice to point out that the current view is correct only so far as the Petromyzontidæ are concerned. They alone possess only horny teeth. In *Petromyzon marinus*, these are curiously complicated, in that they are represented by three horny cusps or thimble-like bodies lying one upon the other, and each arising in a special groove at the base of the tooth. (Prof. Howes writes me that he has long known of this fact.)

Myxine and Bdellostoma, which retain many more primitive characters than the Petromyzontidæ, possess true teeth in the sense of those of other Vertebrates. These are hidden by the aforenamed horny cones, which are formed above them, and, in fact, each horny tooth in these two genera has a true odontoblastic pulp underlying it. The following is a brief description of the appearance of such a tooth in longitudinal section, as exemplified in Bdellostoma. Outside all is the bright yellow horny layer, formed from a "horn groove" at the base of the tooth. Within this is a stratified epithelium, which extends inwards as far as the true tooth; I am unable, however, to find any modified layer of epidermic cells which might represent the so-called enamel organ of other developing teeth. The true tooth is mainly composed of a very hard conical cellular mass, which is probably calcified (I have not yet tested it chemically). It possesses a true pulp-cavity with blood-vessels, &c., while it is made up of cellular elements, which are arranged in a somewhat radiate fashion. The cells are hard, possessed each of a large nucleus longitudinally striated, especially at the apex of the tooth and near the surface.

The apex of the cone is surmounted by a small cap of bright transparent structureless matter, which is either dentine or enamel; from its appearance, and from the fact that the pulp is very hard and obviously calcified, I am inclined to regard it as an enamel structure. While as yet it is not possible to follow the development of this cap, it appears to me to be a secretion of the pulp-cells; and, should it turn out to be enamel, we shall have striking confirmation of the enderonic origin of that layer, advanced by Huxley more than thirty years ago. I, for one, do not believe his view to be so improbable as is generally supposed.

The teeth of Myxine present essentially the same structure as those of Bdellostoma; they are, however, smaller, weaker, and more degenerate, for the cap of enamel (or dentine) is, in them, reduced almost to nothing—indeed, it can only be found after very careful search, and I think that from some of the teeth it is entirely absent.

With this discovery, true teeth come to be characteristic of all the lowest Vertebrates except the outcast Amphioxus, and thus the gulf separating the latter from the former becomes widened. Some zoologists explain the absence of spinal ganglia in Amphioxus by assuming that they are still within the spinal cord: might one hint that they can now also suppose that the teeth of Amphioxus are still within the gums?

In view of the facts here stated it becomes an interesting question for the palæontologist as to how far the "Conodonts" really are the remains of Myxinoid teeth. Zittel's view that they are really Annelidan teeth seems to me the more probable one (*Handbuch der Palæontologie*, Bd. iii. p. 38).

J. BEARD.

Anatomisches Institut, Freiburg i/B.

[1] Amphioxus is here left entirely out of account. Personally, I do not intend to commit myself in seeking to compare any organs of Amphioxus with those of the higher Vertebrates. I would rather leave Amphioxus alone, but I may at least remark the possibility that the mouth in Amphioxus may turn out to be the homologue of the hypophysis—gut passage in Myxine and Bdellostoma. The fact that no hypophysis has yet been discovered in this animal is only in accordance with other negative comparisons between it and other fishes.

MODELS ILLUSTRATING THE MODIFICATION OF THE ARTERIAL ARCHES IN VERTEBRATES.

HAVING recently, with the help of my assistant, made some simple and inexpensive models illustrating the modifications of the arterial arches in Vertebrates, which I find very useful for purposes of demonstration, I send a short description of them to NATURE. Students, as a rule, find it difficult to understand figures of these structures, and a model, in three dimensions, gives a much more accurate idea of their general relations than any drawing can do.

My models are founded mainly on the figures given by Boas, in his paper "Ueber die Arterienbogen der Wirbelthiere" (*Morphol. Jahrbuch*, Band xiii. Heft 1).

The various vessels are represented by stout brass wires (about $\frac{1}{8}$-inch in diameter), bent to the proper form and soldered together; and each model is made, in the first place, to represent six arches. In the case of the fish, the ventral aorta and lower half of each arch (representing the afferent branchial trunk) is painted blue, to indicate that the blood contained therein is venous; the upper half of each arch (representing the efferent trunk), together with the epibranchials and dorsal aorta, are coloured red, to show that they contain arterial blood. The heart is modelled out of modellers' clay, and fixed on to the ventral aorta before being dried; it shows the typical parts of the fish-heart, and is painted blue.

At present I have only made two other models, representing these structures in air-breathing Vertebrates, the types taken being the frog and the mammal. In these, similar colouring is used, but those parts which disappear in the adult are painted *white*. The various parts of the heart are also coloured red or blue, according to the nature of the blood contained in them.

Thus, in the frog the left auricle is red, the right auricle and sinus venosus blue, and the ventricle purple, to show the mixed character of the blood. The first, second, and fifth arches, the portion of the epibranchial between the third and fourth arches, and the ductus Botalli of the sixth arch, are white; the third arch (carotid and lingual artery), red; the fourth (aortic) arch and dorsal aorta, purple; and the lower part of the sixth (pulmonary), blue. In the mammal, the left side of the heart, the left aortic arch, dorsal aorta, and carotids, are red; the right side of the heart, and the pulmonary artery, blue; and the remaining parts, which disappear in the adult, white.

The paint I have used is Aspinall's oxidized enamel.

As this method of illustrating blood-vessels is also particularly useful for lecture-purposes, I intend, later on, to model whole vascular systems in the same way.

W. N. PARKER.

University College, Cardiff.