XI.—*Further Notes on the Osteology of the Shad, (Alosa sapidissima).*

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In a paper[1] on the cartilage plates which are developed in the region of the lateral line of shad, I called attention to the evidence of the concrescence of the anterior body segments, and the following notes are an outline of some of the results obtained while studying the effect of such concrescence on the internal skeleton.

Beginning with the anterior vertebral elements we find that the epipleurals have disappeared, the ribs and epicentrals of the same segments have coalesced, and passing forward are crowded closely together in the region of the exoccipitals and opisthotics; while the epineurals are similarly crowded against the posterior part of the exoccipitals and the supraoccipital, upon the epiotics and the pterotics, and against the parieto-frontal ridge.

The centra of the corresponding vertebræ have either entirely disappeared, or have united with the basioccipital. The lateral walls of the skull, which are formed by the bones of the ear capsules, are very thick, as is also the supraoccipital.

The parietal bones are wanting, and in place of them is seen on each side of the skull a large foramen which opens directly into the brain cavity. On top of the skull on each side is a deep depression extending laterally into the supraoccipital, epiotic and pterotic bones. The outer lateral and posterior part of the depression deepens, forming a pit which burrows down into the exoccipital bone. In some specimens I could pass a bristle down through this pit into the brain cavity, though in most of the specimens examined there was no connection.

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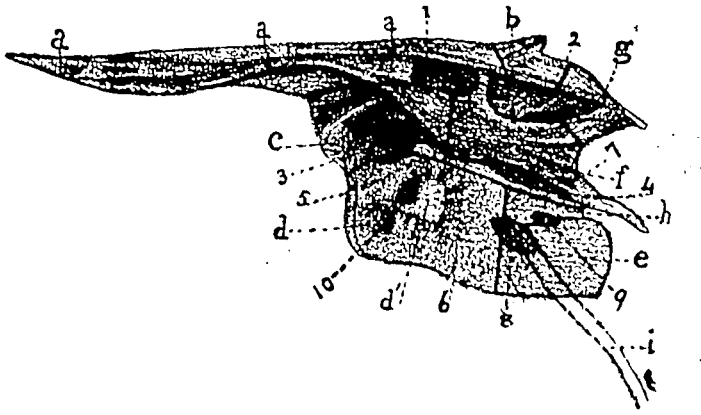
[1] "Preliminary Paper on the Structure of *Alosa Sapidissima*," (abstract), Proc. Amer. Assoc. Adv. Sci. 1887, p. 259.



PORTION OF BRAIN CASE OF ALOSA SAPIDISSIMA.

a. Frontal.
b. Supraoccipital.
c. Sphenotic.
d. Prootic.
d^1 Auditory Capsule.
e. Basioccipital.
f. Pterotic and Opisthotic
g. Epiotic.
h. Exoccipital.
i. Cartilaginous rib-like rod, attached to membraneous wall of cavity in basi-occipital
1. Parietal foramen.
2. Depression reaching down into exoccipital.
3. Facet for anterior head of the hyomandibular.
4. Facet for posterior head of hyomandibular.
5. Foramen leading into anterior auditory chamber.
6. Small foramen leading into same chamber (not described in text).
7. Foramen in pterotic, leading into same chamber.
8. Cavity in basioccipital.
9. Exit for vagus.
10. Exit for seventh nerves.

The hyomandibular articulates with the skull by two heads, widely separated, the posterior being much elongated and in some specimens showing a division into two parts. A small

membrane bone[1] lying between the heads of the hyomandibular, contains a canal which communicates with a foramen lying partly in the sphenotic, and partly in the pterotic and opisthotic.

This foramen opens into a large chamber lying in the prootic, the sphenotic, pterotic, and opisthotic, and opening below into the brain cavity. It contains a large membraneous sac, which receives a branch from the eighth nerve. In the pterotic, just beneath the post-temporal is a large foramen opening into this chamber, and communicating also with a canal in the membrane bones of the pectoral arch. The prootics are co-ossified in the median line and form the anterior part of the floor of the cranium. In the centre of each bone is a large osseous capsule containing a membraneous sac, which receives a branch from the eighth nerve, the branch passing through an oblong slit in the capsule. This slit is the only opening that I could find communicating with the interior of the capsule. This capsule and the chamber described above, with their contents, I shall designate as the *anterior* auditory apparatus.

Covering the capsule nearly, if not entirely, is a plate of cartilage which extends backward on the floor of the cranium to the occipital foramen. It is perforated for the passage of the cranial nerves, and gives off, processes in the shape of cartilaginous rods, which pass into the bones of the ear capsule with the exception of the prootic and sphenotic, with which they have no connection. Similar processes completely surround the occipital foramen.

To the base of the cartilage plate on each side is attached a membraneous sac, containing an otolith. The sac is lodged in a cavity in the basioccipital. The external lateral wall of the cavity is, in most of the specimens, of membrane only, and closely applied to it, on the outer side, is a rib-like rod of cartilage which passes downward and backward, meeting its fellow below

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[1] This bone probably represents the squamosal of higher types. The membrane bones of the pectoral arch in the Teleosts, and probably in all fish, may be derived from lateral line scales. The opercular apparatus is probably derived from similar scales.

the dorsal aorta in front of the anterior extremity of the air bladder, with which it is connected.[3]

The cartilaginous processes which pass out from the cartilage plate on the cranial floor, are occasionally continuous with it, but in most cases they articulate with it, and with each other in some instances. Some of the process are double, others are rudimentary. When removed from the bones in which they are imbedded, they present, with some modifications, the form of the membraneous labyrinth of other fish, and in consequence, I have designated them, with the membraneous sac attached to the cartilage plate as the *posterior* auditory apparatus. By careful examination, I am satisfied that the cartilage plate and its processes represent neural arches and epicentrals, and that the crowding together of the anterior body segments has resulted in a coalescence of the anterior vertebral elements with the posterior cranial bones, and a consequent modification of the original auditory apparatus and the formation of a secondary one on the primitive type.

The absorption or non-development of cartilage in the processes above described would give us a membraneous labyrinth of the usual type, and the manner in which such a structure could be formed is thus strongly indicated. Such an origin would give good reason for regarding the auditory apparatus of the Cyclostomata as the most primitive known among vertebrates.

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[3] The connection between the air bladder and the auditory apparatus seems to be very primitive in the Shad, and is very interesting, The modification of the auditory apparatus will be dealt with in greater detail in connection with a description of the nervous system now in preparation.