

ON THE MORPHOLOGY OF RIBS AND THE FATE
OF THE ACTINOSTS OF THE MEDIAN
FINS IN FISHES.

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IN a paper read before the American Association for the Advancement of Science, two years ago, I reached the following conclusions on the ribs of vertebrata :¹—

“ 1. The ribs are developed *between* the myocomata ; they are therefore *intervertebral*.

2. The ribs are originally one-headed and connected with well-developed intercentra.

3. All forms and connections of the other ribs can be derived from that condition.

4. The lower arches of the caudal vertebræ are either formed by true ribs, the oldest fishes (Ganoidei, Dipnoi), or by processes of the intercentra (Teleostei, Stapedifera).

5. The connection between the Dipnoans and the Stapedifera is still missing.

6. Some remarks on the nomenclature of the elements of the vertebral column.

Owen's names, 'neurapophysis' and 'pleurapophysis,' are not correct ; the neural and pleural arches are no processes of the vertebræ, but are distinct parts.

The two elements composing the neural arch ought to be called the *neuroids* ; the two elements composing the pleural arch, the *pleuroids*.

The spines connected with the neuroids ought to be called, as before, *neural spines* ; those connected with the pleuroids, *pleural spines*.

The real centrum of the vertebra ought to be called *centrum* ; the lateral elements composing it, *hemicentra* (Albrecht), not *pleurocentra*.

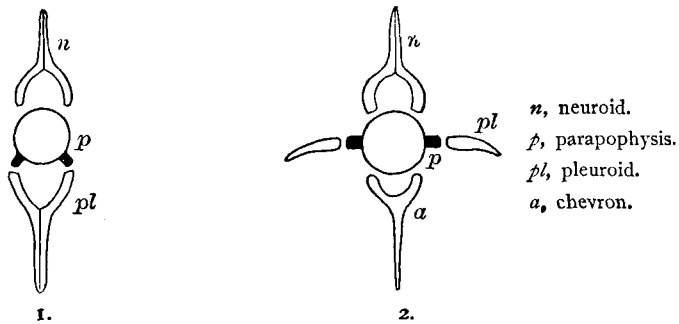
The name intercentrum ought to be preserved.”

¹ BAUR, G. On the Morphology of Ribs. *American Naturalist*, October, 1887, p. 45.

I have nothing to change in these general results, but can add some important facts relating to numbers 4 and 5.

The connection between higher vertebrates and fishes is found to be the condition represented by LEPIDOSTEUS.

Up to this time the difference in the tail of fishes and the higher vertebrates appeared to be a fundamental one. In fishes the "hæmal arches" which enclose the subcaudal blood-vessels are either formed by true ribs, or by the prolonged parapophyses to which the ribs are united. In all higher vertebrates the ribs are entirely separated from the "hæmal arches"; they are placed above these on the side of the vertebræ. The following diagrams represent the two conditions:—



1. Caudal vertebra of Fishes.
2. Caudal vertebra of higher Vertebrates.

It is evident that the "hæmal arch" of fishes, which is either composed of pleuroids, or of pleuroids and parapophyses, cannot be the homologue of the "hæmal arch" of the higher vertebrates. The question is, what elements of the fish's skeleton are used in the formation of the "hæmal arch" of the higher vertebrates; in other words, *what are the homologues of the chevron bones?*

The original condition is, that the subcaudal blood-vessels are surrounded by the pleuroids, in the same way as the neural cord is surrounded by the neuroids. In the higher vertebrates the pleuroids have moved dorsad, and have become entirely independent from the blood-vessels. In fishes the pleuroids are connected with the parapophyses ("Basalstümpfe" Goette) of the vertebra. The condition found in the higher vertebrates could be developed by two different ways: either the parapophyses

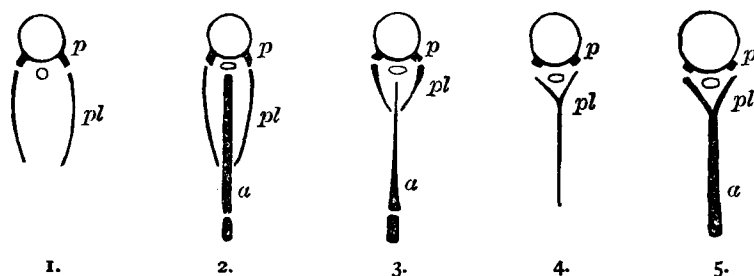
physes move dorsad together with the pleuroids (in this case the chevrons cannot represent parapophyses), or the pleuroids alone begin to move, separating from the parapophyses, which would form the chevrons. The latter opinion was held by me until now. The examination of *Lepidosteus* shows that this view is incorrect. There are forty præ-anal vertebra in a skeleton of *Lepidosteus osseus* L. before me. From the second we find well-developed parapophyses to which strong pleuroids are articulated. In the most posterior vertebræ the pleuroids begin to bend downwards and the parapophyses become a little smaller. The 41st vertebra shows the following conditions: The pleuroids are connected with parapophyses and are directed downwards; *between the two pleuroids a strong element is placed which nearly touches the centrum of the vertebra, and which supports the subcaudal blood-vessels; this strong element is the first well-developed actinost of the anal fin.* It is very strong proximally, differing from the actinosts of other fishes in this regard. In the 42d vertebra we have similar conditions. The second well-developed actinost is below the vertebra supporting the subcaudal blood-vessels, but it is not so strong proximally as the first; the ribs are not directed downwards, but backwards, and are entirely separated from each other. We have about the same characters in the next four vertebræ. In the 43d and 44th the pleuroids are turned backwards. The 43d is connected with one actinost, the 44th with two; the actinosts become very thin proximally, resembling the free actinosts in other fishes. The relation of actinosts and vertebræ becomes loose. There are in all eight well-developed actinosts of the anal fin; the anterior and posterior ones are rudimentary; these eight actinosts are in relation to six vertebræ. In the 45th and 46th vertebræ the ribs begin to turn downwards again, touching each other distally, at the same time they enclose the subcaudal blood-vessels. The same condition we have in all the following vertebræ, in which the distal parts of the pleuroids co-ossify and become very strong. These distal parts contain also the actinosts of the caudal fin.

The anterior part of the post-anal portion of the tail in Lepidosteus shows the condition of the higher vertebrates, the posterior part that of fishes.

The Batrachia (Amphibia) developed from forms in which the process, which begins at the anterior part of the post-anal

portion of the tail in *Lepidosteus*, had been carried through the whole tail. The form from which the Batrachia started must have had a continuous anal and caudal fin, with well-developed actinosts free from the ribs. *The chevron bones are the actinosts of this continuous fin.*

The following diagrams show different vertebræ from the posterior part of the vertebral column in *Lepidosteus*:—



1.

2.

3.

4.

5.

p, parapophysis. *pl*, pleuroid. *a*, actinost.

1. 40th vertebra of *Lepidosteus*.

2. 41st vertebra of *Lepidosteus*.

3. 43d vertebra of *Lepidosteus*.

4. 48th vertebra of *Lepidosteus*.

5. 53d vertebra of *Lepidosteus*.

So far it has been the opinion that the elements of the anal and caudal fins of fishes had disappeared entirely in the higher vertebrates; but now we have shown that the elements of these fins do not disappear, but are represented by the chevron bones of the tail vertebræ, which are the partial homologues of the actinosts.¹ The actinosts of the dorsal fin and the upper part of the caudal fin became probably united with the neuroids, and have undergone reduction afterwards. That the anterior and posterior paired fins of fishes, the anterior and posterior limbs of vertebrates in general, are the result of fusion of actinosts of a continuous lateral fin, there seems to be little doubt.

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¹ The proximal part of the chevron above the subcaudal blood-vessels represents the intercentrum, the distal part the actinost. In all higher vertebrates the intercentrum and the actinost are united.