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I. Wissenschaftliche Mittheilungen.

1. Some additional points on the Primitive Segmentation of the Vertebrate Brain.

By Bertram H. Waters B.A., E.M. Fellow in Biology, Princeton College, U. S. A.
eingeg. 25. März 1891.

The following is a brief abstract of some investigations, which were undertaken in the Morphological Laboratory, at Princeton, under the direction of Dr. Henry F. Osborn, during the winter of 1889—90, pursuant upon those of Mr. C. F. W. McClure, the results of which were published in this journal in number 314, 1889.

It was intended, by the study of still lower forms than have been investigated by him, to confirm results already obtained and to show that the symmetrical folds or constrictions which have been first shown to exist in the lateral walls of the embryonic hind-brain and which were believed to be remains of a general primitive neural segmentation, extended into and involved the fore and mid-brain also.

These folds have frequently excited the interest and comment of investigators, but not until recently have they been regarded as having segmental value. As early as 1828 von Baer observed them in the medulla, and since then they have been noted and commented upon, more or less at length by Remak, Dursy, Dohrn, Foster and Balfour, Beranek, Kupffer, Orr, McClure and others¹.

¹ Vide bibliography in »The Primitive Segmentation of the Vertebrate Brain«, by Charles F. W. McClure. Zoologischer Anzeiger No. 314, 1889 and Journal of Morphology, Vol. IV, No. I.

The investigations of Orr and McClure are not only the most recent but the most definite and exhaustive and have well established the following points:

1. The hind-brain is made up of five or six symmetrical constrictions (neuromeres) from the crests of which the cranial nerves of the corresponding region take origin, with the exception of the VIII. nerve.

2. The fore-brain contains neuromeres corresponding in every characteristic of structure to those of the hind-brain, the number being doubtful.

3. The spinal cord also consists of neuromeres similar to those of the medulla from which the sensory roots of the spinal nerves originate.

4. All these segmentations whether giving origin to nerves or not degenerate rapidly and early.

It will be seen that these investigations left the primitive condition of the fore-brain very doubtful and that of the mid-brain even more so. I have attempted by the study of fish and amphibian embryos to establish the points already made and to add some new ones, regarding especially the fore- and mid-brain. The forms used were *Gadus morrhua* and *Amblystoma punctatum* embryos. The following is a brief review of Part I.

I have found that in general the neuromeric segmentation appears at a relatively late period in the Cod. Sections of early stages (6 to 9 days) show the neuron as a perfectly straight and narrow tube, the walls of which are in apposition along the median line but not fused and in which there is no proper lumen anterior to the 4th ventricle. A few of the sections (9 days) show some of the characteristic hind-brain segmentations but none appear in the other regions.

In embryos of about 10 days incubation, cranial flexure is quite marked and individual sections of the entire brain area are not obtainable. However the ventral portion still preserves its simple tubular character, the walls being narrow and uniform in thickness, but enclosing between them a considerable lumen. In embryos of this age the neuromeres of the anterior regions first appear.

Fore-brain.

This area has a peculiar club-shaped or trefoil appearance. Directly in front of the eyes and almost in apposition with the forward end of the primitive fore-brain lie the olfactory vesicles. These I find are connected with the brain by a short thick mass of cells on either side, the I. pair of nerves, which even in late stages have no connection with

the Prosencephalon, there being no olfactory lobe, while the nerves themselves agree closely in histological structure and relation with the other cranial nerves. The region thus giving origin to the I. pair of nerves shows markedly the characteristics of a true neuromere. Immediately behind the (neuromere I.) are the remnants of the optic diverticulum. Young *Amblystoma* sections show that the brain walls on either side immediately beneath these, are symmetrically constricted thus proving the existence of an optic neuromere with which the II. pair of nerves were probably at one time in connection. This I. have considered the second neuromere.

A short distance behind it lie the white transversely arranged fibres of the posterior commissure. In this area the Cod brain shows little or no segmentation, but from the fact that it nearly corresponds in extent to neuromere II. and that its existence is quite evident in *Amblystoma*, it seems probable that this space is occupied by the IIIrd and last of the fore-brain neuromeres.

Mid-brain.

Cod sections of about 11 or 12 days exhibit a region extending from the posterior commissure to a point about midway between it and the auditory vesicles. Within these limits there appear two well-marked convolutions of the brain wall, which are slightly smaller than those of the fore-brain and rather more semicircular than oval in form. The characteristic radial arrangement of cells is present. From the first in the Cod at a low level some fibres are given off and from the second in *Amblystoma*, near its dorsal surface some cells are proliferated, but I have not been able to satisfy myself, that they represent the corresponding nerves of this region. I feel confident however from the theoretical evidence derived from the character of the fibres of the II. and IV. nerves, that transverse sections and more specific methods of staining will determine more definitely their existence.

Hind-brain.

I have little to add to the investigations of McClure for this region. In the Cod 6 neuromeres are to be found corresponding to the number observed by him in the lizard and chick. In *Amblystoma* only 5 are found, the VI. or abducent, being absent. In other forms the neuromeres exhibit closely the general characters described by Orr and McClure.

General summary.

From the above considerations it seems probable that the total number of primitive encephalomeres was eleven, divided as follows:

Fore-brain 3.

Mid-brain 2.

Hind-brain 6 or 5.

The following points I think are fairly well established in the embryos of *Gadus morrhua*.

1. The neuromeres appear at a late period in the ontogeny and soon degenerate, thus disproving the supposition of their mechanical formation and strengthening that of their phylogenetic importance.

2. The olfactory pits develop early in connection with the I. pair of nerves, which arise from the fore-brain and seem to have no connection with the Prosencephalon, there being no trace of an olfactory lobe.

3. The fore-brain contains three neuromeres. From the first, the roots of the olfactory nerves arise; at a point somewhat above the second the optic diverticula are formed; from the third no nerve seems to arise.

4. The mid-brain is composed of two well marked neuromeres slightly smaller and more semicircular than those of the fore-brain.

5. The hind-brain neuromeres of the Cod correspond in number and character to those described by Orr and McClure for that region in the Amphibia and Sauropsida. In *Amblystoma* but five are to be seen, as these authors have pointed out.

The following were less definitely observed.

6. Evidence of the origin of the III. and IV. nerves from the two neuromeres of the mid-brain is unsatisfactory. The first one in the Cod seems to give origin to some fibres which may correspond to the III., and from the second, in *Amblystoma*, at a high level. some cells are proliferated which may represent the IV.

7. There seems to be no doubt as to the origin of the hind-brain nerves as described by Orr and McClure. I think however I am able to confirm Orr's statement which McClure considered doubtful, viz. that the VI. nerve arises from the ventral portion of the second neuromere, at least in all forms in which six neuromeres are present in the hind-brain.

Princeton, March 10, 1891.

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Autor(en)/Author(s): Waters Bertram H.

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