III. "Contributions to the Anatomy of the Central Nervous System in Vertebrated Animals. Part I.—Ichthyopsida. Section I.—Pisces. Subsection III.—Dipnoi. On the Brain of the *Ceratodus Forsteri*." By ALFRED SANDERS, M.R.C.S., F.L.S. Communicated by Dr. GÜNTHER, F.R.S. Received February 23, 1888.

(Abstract.)

The brain of *Ceratodus* has the following general arrangement:—The membrane which represents the pia mater is of great thickness and toughness; there are two regions where a tela choroidea is developed: one where it covers in the fourth ventricle, and the other where it penetrates through the third ventricle and separates the lateral ventricles from each other.

The ventricles are all of large size, and the walls of the lateral ventricles are not completed by nervous tissue. The thalamencephalon and the mesencephalon are narrow, and the medulla oblongata is wide.

All the cranial nerves are present except the abducens and the hypoglossal. There is a large communicating branch between the trifacial and the vagus. The glossopharyngeal has no separate root, but is a branch of the vagus. The ganglion of the vagus is not the termination of the main trunk, but is an offshoot from the ramus lateralis; the ganglion gives off the branchial nerves and the ramus intestinalis; the ramus lateralis passing on without entering it.

In the minute structure of the dorsal part of the cerebrum there are four layers to be seen, externally a layer of finely granular neuroglia, with slight indications of radial striation; next a layer of larger sized cells; then another layer of neuroglia with fibrillæ having a tendency to a longitudinal direction; finally, a layer of rounded cells closely crowded together on the internal surface. The ventral part of the cerebrum has only two layers—the external of neuroglia and the internal of rounded cells.

The olfactory lobes resemble the cerebrum in structure; there is an internal layer of cells continuous with those of the cerebrum, and an external layer of glomeruli olfactorii, which seem as if they were the external layer of the cerebrum condensed; between the two there is a layer of longitudinal fibres on which fusiform cells are developed.

The optic lobes also consist of four layers; externally there is a layer of longitudinal fibrils derived from the optic tract; then a layer of smoothly granular neuroglia; then a layer of transverse fibrillæ which collect into a commissure in the central line at the dorsal surface; there are also fusiform and rounded cells sparingly scattered

through it; the internal layer contains cells mostly rounded. At the central line on the dorsal surface there is a ganglion of large cells resembling those of the optic lobe of the Plagiostomata.

The cerebellum is a mere bridge over the fourth ventricle, and its structure presents the usual number of layers; internally there is the fibrous layer which ultimately goes to form the crura cerebelli ad medullam; then the granular layer, the cells of which are of large size compared to those of the same layer in Teleostei and Plagiostomata; then comes a layer of Purkinje cells, the form and number of processes of which are not uniform; the external layer is the molecular, which consists of a coarsely granular network derived from the processes of the Purkinje cells, also a network of finer fibrils and many rounded cells.

In the spinal cord there are three columns of longitudinal fibres on each side in the white substance, viz., the ventral columns between the two ventral roots of the spinal nerves, the lateral columns between the dorsal and ventral roots, and the dorsal columns between the two dorsal roots; fibres of large size are scattered throughout the two former columns, but are collected principally in the ventral; the dorsal columns consist entirely of fibres of minute size.

The principal feature in the white substance is a fibre of gigantic dimensions which is situated on the summit of the ventral columns —one on each side; it consists of a common medullary sheath enclosing, where the fibre is largest, about forty to fifty axis-cylinders; these have the characteristics of the axis-cylinders of the ordinary fibres of the white substance, but have no separate medullary sheaths; this fibre is traceable throughout the spinal cord; commencing opposite the posterior end of the abdomen, it extends forward to a short distance behind the exit of the facial nerve; it varies in size and becomes of the greatest diameter near the posterior end of the medulla oblongata; its axes escape through the medullary sheath and join the longitudinal fibres of the ventral columns; near its anterior termination all the axes have escaped except one; at this point it bears a great resemblance to Mauthner's fibre in the Teleostei. This remaining fibre decussates with that of the other side a short distance behind the exit of the facial nerve and joins the root of that nerve.

In the grey substance of the spinal cord there are two series of ganglia—one in the ventral horn, which consists of multipolar cells often of very large size; they send processes into the ventral and lateral columns which often become the smaller-sized longitudinal fibres. The cells of the other series are of smaller size and are situated in the substantia gelatinosa centralis; they are smooth in outline and give off one or two processes; they probably have to do with the dorsal roots of the spinal nerves. Cells also of this kind

occur at other places as in the fibræ rectæ, and in the field of the ventral columns.

The transverse commissures are—one in the spinal cord which passes through the substantia gelatinosa centralis over the central canal; another occurs on the ventral side of the anterior part of the medulla oblongata and corresponds to the commissura ansulata of Teleostei; it is connected with the commissure in the dorsal part of the optic lobes. Two other commissures are present corresponding respectively to the anterior and posterior commissures of the third ventricle of Mammalia.

There is no chiasma of the optic nerve visible externally; what there is of it is situated in the substance of the thalamencephalon.

The anterior root of the fifth nerve arises from a ganglion occupying a broad swelling in the lateral part of the grey matter of the floor of the fourth ventricle. The posterior root arises from the summit of the restiform bodies.

The facial passes backwards in a small tubercle at the junction of the floor of the fourth ventricle with the restiform bodies.

The acusticus arises from a bundle of fibres which are situated on the summits of the ventral columns, and appears to be a continuation forward of that part of the multiaxial fibre which has not decussated.

The vagus has five roots; they pass backward and enter in succession the same tubercle as, and to the outside of, the facial nerve; the three posterior roots are double, so that the vagus is equivalent to eight nerves, and consists entirely of dorsal roots.

Two nerves are given off from the ventral side of the medulla oblongata, each of which has two roots; they do not join the vagus but pass back some distance in the vertebral canal and emerge on a level with the exit of the dorsal roots of the spinal nerves.

The second and third spinal nerves supply the pectoral fin and pursue the course usually followed by the hypoglossal when that nerve is present in Teleostei.

The fibres of the ventral roots of the spinal nerves enter in a direction upward and forward toward the inner edge of the multiaxial fibre, between it and the central canal, and then passing over the dorsal edge of the same, are either lost in the grey substance of the ventral horn, join a process of one of the multipolar cells, or become one of the longitudinal fibres of the ventral column.

The brain of *Ceratodus* presents an embryonic condition in three respects, viz., first in the extreme size of the ventricles and in the tenuity of the substance of their walls; second, in the alternating origins of the dorsal and ventral roots; third, in the fact that the origins of the dorsal roots are close to the central line.

Compared to *Protopterus* it differs in the shape and the imperfection of the cerebral lobes, and in the fact of its having a well-deve-

loped rhinencephalon, but it agrees in the narrowness of the thalamencephalon and mesencephalon and in the breadth of the medulla oblongata, as also in the rudimentary character of the cerebellum.

Ceratodus agrees also with the Ganoids in the comparative narrowness of the mesencephalon and in the proportions of the cerebellum.

With the Plagiostomata it agrees in the structure of the optic lobes, both orders presenting a ganglion of large cells in the dorsal part. With the Teleostei it agrees in the multiaxial fibres which, a short distance anterior to its termination, resemble the Mauthner's fibres, also in the position and the fact of their decussation.

With *Petromyzon* it agrees in the structure of the tela choroidea which covers the fourth ventricle.

Presents, March 8, 1888.

Transactions.

Calcutta:—Indian Museum. A Catalogue of the Moths of India by E. C. Cotes and Col. C. Swinhoe. Part 2. 8vo. *Calcutta* 1887. The Trustees.

Cambridge:—Philosophical Society. Proceedings. Vol. II. Part 3. 8vo. *Cambridge* 1888. The Society.

Cambridge, Mass.:—Harvard University. Bulletin. No. 39. 8vo. 1888; Annual Report, Harvard College. 1886–87. 8vo. *Cambridge* 1888. The University.

Charleston:—Elliott Society of Science and Art. Proceedings. August 26, 1886, to July 28, 1887. 8vo. [*Charleston.*] The Society

Essex Naturalists' Field Club:—The Essex Naturalist. 1888. No. 1 and 2. 8vo. *Buckhurst Hill* 1888. The Club.

London:—Entomological Society. Transactions. 1887. Part 5. 8vo. *London* 1888. The Society.

Royal Institute of British Architects. Journal of Proceedings. Vol. IV. No. 9. 4to. *London* 1888. The Institute.

Marlborough:—Marlborough College Natural History Society. Report. No. 36. 8vo. *Marlborough* 1888. The College.

Paris:—École Normale Supérieure. Annales. Tome V. Nos. 1–2. 4to. *Paris* 1888. The School.

Sociéte de Géographie. Bulletin. Tome VIII. Trim. 4. 8vo. *Paris* 1887. The Society.

Rome:—Reale Accademia dei Lincei. Annuario. 1888. 12mo. *Roma.* The Academy.

St. Petersburg:—Comité Géologique. Bulletin. (Russian.) Tome VI. No. 1. 8vo. *St. Petersburg* 1887. The Comité.

Vienna:—K. Akademie der Wissenschaften. Anzeiger. Jahrg. 1888. Nr. 1–3. 8vo. *Wien.* The Academy.