Notes of researches on the intimate structure of the brain : third series / by J. Lockhart Clarke, Esq.

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Notes of Researches on the Intimate Structure of the Brain.—Third Series.

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Structure of the Valve of Vieussens.—The valve of Vieussens consists of four different kinds of layers. The most inferior layer is composed of epithelium, which is continuous with that of the fourth ventricle. The *second* layer is a stratum of longitudinal nerve-fibres, continuous with the white substance of the inferior vermiform process of the cerebellum. The *third* layer consists of a multitude of round, granular nuclei of about the 3500th of an inch in diameter, traversed by fibres derived from the subjacent layer. These nerve-fibres, in my preparations, may be seen in the most unequivocal manner to divide and subdivide into small branches, to which the nuclei are attached as by stalks. The *fourth* or *uppermost* layer is chiefly granular, but is also interspersed with nuclei of the same kind. Along its under side, where it joins the preceding layer, is a row of large multipolar cells, which are connected by their processes with the nuclei of both layers*.

Structure of the Cerebral Convolutions.—In the human brain most of the convolutions, when properly examined, may be seen to consist of no less than *eight* distinct and concentric layers. This laminated structure is most marked at the end of the posterior lobe. On cutting off the rounded point of this lobe in the human brain, by a transverse section, at about the distance of an inch, measured along the side of the longitudinal fissure, I found, at this part, that the stratified appearance was very indistinct in the *upper* and *outer* convolutions, while it was still clearly observable in the *inner* and *lower* convolutions which rest on the cerebellum. It was most conspicuous in the convolution that lies over the bottom of the posterior notch of the cerebellum, and which runs outward and upward, and then winds inward, to reach the surface at the side of the longitudinal fissure.

In vertical sections of convolutions taken from the end of the posterior lobe, where the laminated structure is most marked, the

* This description of the valve of Vieussens formed part of the manuscript of a Paper published in the 'Proceedings of the Royal Society' for June 20, 1861, but was accidentally omitted in the printing.

first or superficial layer is a comparatively thin stratum of fine and closely-packed fibres, intimately connected externally with the pia mater—with which they are very liable to be torn away—while internally they are continuous with fibres radiating from the grey substance.

The second layer is of a pale or whitish colour, and several times the thickness of the one just described. It consists, first, of fibres running parallel with the surface, both around the convolution and longitudinally; secondly, of fibres radiating across them from the grey substance beneath, and crossing each other with different degrees of obliquity; and thirdly, of a small number of scattered nuclei, which are round, oval, fusiform, or angular, and have their longer axes in different directions, but mostly within-outward.

The third layer is of a grey colour, from two to four times as thick as the one above it. It is densely crowded with cells of small size, but of different shapes, in company with nuclei like those of the preceding layer. The cells are more or less pyriform, pyramidal, triangular, round and oval, or fusiform. The pyriform and pyramidal cells—especially in the outer portions of the layer—lie for the most part with their tapering ends toward the surface; and the oval and fusiform cells have generally their longer axes and their processes in a similar direction. In the deeper portions of the layer, however, their position is more irregular, many of them lying with their longer axes parallel with the surface, and in connexion with a multitude of fibres which run in the same direction and in great number *along* the layer. They contain each a comparatively large granular nucleus, which frequently nearly fills the cell. Two, three, four, or more processes spring from the broader ends of the pyramidal cells, and run partly toward the central white substance, and partly in the plane of the layer, to be continuous with nerve-fibres in different directions.

The fourth layer is of a much paler colour. It is crossed, however, at right angles to its plane, by narrow long and vertical groups of small cells and nuclei of the same general appearance as those of the preceding lamina. These groups are separated from each other by bundles of fibres radiating toward the surface from the central white substance, and, together with them, form a beautiful and fan-like structure. This layer is distinguishable from the

one immediately above it by a tolerably sharp outline, but internally it gradually passes into, or blends with, the next one below it, or the fifth lamina.

This fifth layer consists of the same kind of vertical and radiating groups of small cells and nuclei; but the groups are broader, more regular, and, together with the bundles of fibres between them, present a more distinctly fan-like arrangement.

The sixth layer is again paler, and somewhat whitish, but contains some cells and nuclei which have a general resemblance to those of the preceding layers and are arranged only in a faintly radiating manner.

The seventh layer is of a reddish-grey colour, of about the same depth as the preceding, and contains the same kind of cells and nuclei, but in much greater numbers, and mixed with some others of *rather larger* size: only here and there they are gathered into the small elongated groups which give the appearance of radiations. On its under side it gradually blends with the central white layer, into which its cells are scattered for some distance. Both this and the preceding lamina are traversed by nerve-fibres which run *along* their planes, or parallel with the surface of the convolution.

The eighth layer is the central white stem or axis of the convolution. As just stated, it contains, for some distance below its summit, a gradually diminishing number of scattered cells and nuclei, extending from the lower side of the next *upper* layer. The cells are all separate, and disposed with their longer axes at right angles to the curved surface of the convolution, and therefore in the direction of the fibres radiating from the central white stem, with which some, at least, are continuous*.

Course of the Fibres of the Central White Substance through the Convolutions.—From the central white stem bundles of fibres diverge in all directions, in a fan-like manner, toward the surface of the convolutions. As they pass between the long and vertical groups of cells (already mentioned) in the inner grey layers, some of them become continuous with the processes of the cells, and others turn round to become *horizontal*, both in a transverse and longitudinal direction

* The presence of small cells and nuclei in the white substance of the cerebrum and cerebellum, as well as of the spinal cord, was before pointed out by myself. See Phil. Trans. 1859, p. 442 (note).

as regards the convolution, and with different degrees of obliquity. While the *bundles* themselves are by this means reduced in size, their component *fibres* become finer as they approach the surface, in consequence, *apparently*, of branches which they give off, to be connected with cells in their course. When they arrive at the outer grey layer, they are reduced to the finest dimensions, and form a close network, with which the nuclei and cells are in connexion*. *Through* this layer, however, many of them pass in straight lines, and, in company with processes from some of the cells, traverse the next outer and white layer, in which part of them turn round the circumference of the convolution—part run *longitudinally* and with various degrees of obliquity, but parallel with the surface, decussating with the former—others *appear* to form loops by returning to the grey lamina from which they proceed—while the rest continue their vertical course, crossing each other at different angles, and reaching the surface, where they become continuous with the compact and thin stratum of fibres which forms the first layer of the convolution, and is in immediate connexion with the pia mater.

While the bundles of fibres diverge on all sides from the central stem of white substance, another system of fibres, springing from each side of the base of the stem, *curve inward* and form a beautiful arch over its summit, where they decussate each other, and partly constitute the *innermost* pale layer. The fibres of the stem itself are crossed transversely and obliquely by a variable number of others of different diameters; and in longitudinal sections (that is, in sections made in the length of the convolutions) these transverse and oblique fibres are frequently seen to increase in number toward the base of the white substance, where they decussate each other at every possible angle.

Such is the structure of the convolutions at the extremity of the posterior lobe, in which the laminated appearance is most marked. In almost all other convolutions, however, *eight* laminæ, although sometimes indistinct, may be brought into view by means of solution

* This network in the grey substance between the cells and fibres was, I believe, first noticed by myself in my article on the Structure of the Olfactory Bulb, &c., in Siebold and Kölliker's Zeitschrift, 1861, Bd. xi. Heft 1, plate v. fig. 6; and subsequently in my memoir "On the Development of the Spinal Cord," Phil. Trans. 1862, p. 925, *note*.

of potash or soda. Sometimes, as in certain parts of the posterior lobe itself, one can scarcely make out more than seven layers, there being only one broad layer of arciform fibres running *along* the grey layer outside the white central stem. It is an error to call the layers containing these *arciform* fibres (for I shall so name them) the white layers of the convolution, for they are always interspersed with numerous cells, with processes of which they are continuous. In some parts of the brain (on the vertex for instance) the second (from the centre) of the arciform bands of fibres is very broad and strong, and thickly interspersed with large and small cells of different shapes. These arciform fibres of the convolutions run in different planes, transversely, obliquely, and longitudinally. Where a convolution bends round upon itself at a right angle, a section made at the angle contains them in abundance; but here the separate fibres forming the arciform bands are very short, being cut in their passage. The curved arciform fibres, then, establish an infinite number of communications in all directions between different parts of each convolution, between different convolutions, and between these and the central white substance. I have already shown that the more superficial layer of grey substance contains numerous arciform fibres, but finer and less strongly marked.

But the convolutions at the extremity of the posterior lobe differ from the rest, not only in the greater distinctness of their several laminæ, but also in the appearance of some of their cells. On advancing forward, the convolutions contain a great number of cells of a *much larger* kind. In a section, for instance, taken from a convolution at the vertex, and in a vertical line passing through the optic thalamus, the *greater number* of the cells differ but little from those at the extremity of the posterior lobe; but amongst these cells, in the two inner bands of arciform fibres, and the grey layer between them, I found a number of *much larger*, triangular, oval, and pyramidal cells scattered about at variable intervals. The pyramidal cells are very peculiar. Their bases are quadrangular, directed toward the central white substance, and give off four or more processes, which run partly toward the centre to be continuous with fibres radiating from the central stem, and partly parallel with the surface of the convolution, to be continuous with *arciform* fibres. The processes may frequently be seen to subdivide into minute

branches which form part of the intervening network, as I have described on former occasions. The opposite end of each pyramidal cell tapers gradually into a straight process which runs directly towards the surface of the convolution, and may be traced to a surprising distance, giving off minute branches in its course, and becoming lost in the surrounding network. Many of these cells, as well as those of a triangular, oval, and pyriform shape, are as large as those of the anterior grey substance of the spinal cord.

In other convolutions I again found the vesicular structure somewhat modified. In the surface convolution, for instance, at the side of the longitudinal fissure, on a level with the *anterior* extremity of the corpus callosum, all the three inner laminæ are *thronged* with pyramidal, triangular, and oval cells, of considerable size, and in much greater number than in the situation last mentioned. Between these, as usual, is a multitude of the smaller cells.

The cells of the convolutions in man certainly differ in some respects from those of the larger mammalia—from those, for instance, of the ox, sheep, and cat.

In the early fœtal brain of mammalia and man the structure consists of one uninterrupted nucleated network. As development advances, separate layers may be distinguished. In a fœtal sheep $2\frac{1}{2}$ inches long, for instance, I distinguished six layers in a transverse section of the brain, extending from the vertex to the interior of the lateral ventricle. The first, second, and third corresponded to those which I have described in the convolutions of the adult human brain, and still consisted of roundish nuclei connected by a network of fibres. The third of these layers consisted chiefly of a dark and dense stratum of nuclei, exactly similar to that which the caput cornu posterioris of the spinal cord presents at the same period of development. The fourth layer consisted chiefly of elongated and radiating groups of nuclei. The fifth layer was dark, containing nuclei and a dense stratum of transverse fibres. The sixth layer was composed of epithelium, uninterruptedly connected with the network of the preceding layers, and having precisely the same appearance as the epithelium of the cord at the same period of development.

On the Structure of the Cerebellum.—The observations of Gerlach on the minute structure of the cerebellum are in the main confirmed by my own. I must state, however, that the outer grey layer con-

sists of an exceedingly fine *network* of fibres interspersed and connected with nuclei. This network is partly formed by the minute ramifications of the processes which proceed from the large nucleated cells along its inner border, and which completely reach the surface, communicating with each other in their course. In my preparations this arrangement is very distinctly seen.

The facts contained in these notes will be illustrated, as soon as possible, by appropriate drawings.