

## NOTE ON "THORNS," AND A THEORY OF THE CONSTITUTION OF GREY MATTER.

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THE minute lateral branches born by the dendrites of all classes of nerve cells in the central nervous system were termed "thorns" by Ramón y Cajal. In their typical form they appear, in preparations made with the chrome-silver method, as minute stalks, each bearing at its end a black bead. Hence they have been called "gemmules," and the bead at the end (the "contact granule") has been supposed to be a dot of naked protoplasm, by means of which the dendrite establishes contact with nerve fibres which run parallel to itself.

Semi Meyer<sup>1</sup> has questioned the existence of thorns as real structures on the ground that he could not find them in preparations made by subcutaneous injection of methylene-blue. Kölliker<sup>2</sup> regards them as embryonic structures not to be found in the adult unless they appear as artifacts. Ramon y Cajal<sup>3</sup> has, however, shown that they can be displayed by methylene-blue staining both in the young animal and in the adult. He concludes that, since they are displayed by three such diverse methods as those of Golgi, of Cox, and of Ehrlich, there can be no doubt as to their existence.

<sup>1</sup> S. Meyer. Die subcutane Methylenblauinjection, ein Mittel zur Darstellung der Elemente des Centralnervensystems. *Archiv f. mikr. Anat.*, xlv., 1895; und über eine Verbindungsweise der Neuronen *ibid.*, xlvii., 1896.

<sup>2</sup> Kölliker. Handbuch der Gewebelehre des Menschen. Sixth edit., vol. ii., pp. 647, 755, &c., 1896.

<sup>3</sup> Ramón y Cajal. Las Espinas Colaterales de las Células del Cerebro teñidas por el Azul de Metileno. *Revista Trimestral Micrográfica*, vol. i., p. 129.

I also find them in their typical form in nine preparations out of every ten, but I have nevertheless come to the conclusion that they are structures which are only partially revealed by either the chrome-silver or the methylene-blue, and that the typical form of a rod with a dot at the end is due to *post-mortem* change in the tissue.

I have examined the thorns in the brains of a large number of animals, young and old, all healthy, and all killed with chloroform, but hardened in various ways; and I find



FIG. 4.

Protoplasmic processes of pyramids of cortex cerebri showing thorns prolonged into filaments. Adult hedgehog. Blood vessels washed out with salt solution, dilated with 1 per. cent. lactic acid, and then injected with 4 per cent. formaline. Hardened in bichromate of potassium and formaline.

so great a variation in their appearance that I have come to the conclusion that they are organic structures which are not shown in their entirety by the chrome-silver method.

(1) They may be totally absent. I first noticed this in a brain injected through the aorta with warm bichromate of potassium and osmic acid solution, after washing out the blood-vessels with salt solution, and their dilation with 1 per cent. of lactic acid. They are present in certain other preparations injected in this way. I cannot, therefore, attribute their absence to the method. It is, however, very difficult to make sure that the irritating osmic mixture has penetrated all parts of the brain.

(2) When present they vary much in length, from less than  $1\ \mu$  to 8 or 10  $\mu$ . The longest are found on the granules of the olfactory bulb.

(3) They present a considerable variety in form, the typical stalk and dot giving place to a filament with two or three dots on its course, or the filaments being invisible and



FIG. 5.

Cell of nucleus lenticularis. Dendrites bearing filaments in place of thorns. Adult hedgehog. Blood vessels washed out with normal salt-solution, dilated with 1 per cent. lactic acid, and then injected with 4 per cent. formaline. Hardened in bichromate of potassium and osmic acid.

the dots appearing alone, in a parallel row on each side of the dendrite.

(4) In certain specimens, as shown in figs. 4, 5 and 6, the thorns are replaced by filaments of varying length, which appear to be in direct continuity with the cell or its dendrites.

It is the main trunk and the large branches of the dendrites which usually carry lateral filaments in place of

thorns. The filaments are best seen (*a*) on the apical dendrites of large cortical pyramids, near to the cell, or (*b*) on the centripetal (or apical) dendrites of the double pyramids (giant pyramids) of the subiculum cornu ammonis. Two difficulties at once present themselves. (1) When the lateral filaments are not seen the trunk of the dendrite usually appears smooth and devoid of thorns. (2) In both the situations named (*a* and *b*) a vast quantity of tangential fibres cross the dendrites—in the cortex, the fibres of the laminæ

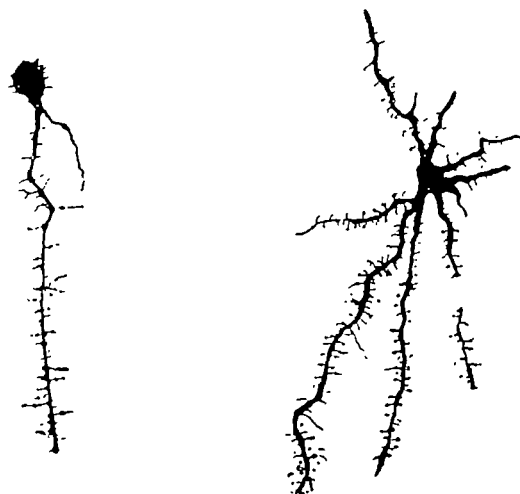


FIG. 6.

(1) A pyramid. (2) A cell of the nucleus lenticularis. Same animal and same method of preparation as 5.

medullares; in the cornu ammonis, the remarkable deep layer of "mossy" or rosette fibres. It is open to us, therefore, to reject the continuity of the dendrites and the lateral filaments on the plea that it is a delusive appearance, an instance of attractive staining, the colouration of heterologous and completely detached structures in the neighbourhood of coloured elements—a phenomenon with which we are not unacquainted when working with the chrome-silver method. On the other hand, the continuity is unmistakable, if we may trust

the method and the microscope, although we have to bear the reflection constantly in mind that it is impossible, when examining block structures, to distinguish between continuity and juxtaposition. It seems reasonable, however, to put the most obvious interpretation upon the preparations, and to accept their evidence that under certain conditions of staining the thorns may be replaced by filaments. As throwing light upon the connection of the thorn filaments with the trunk of the dendrite, it may be pointed out, that although this part of the dendrite is usually thornless, it has frequently a warty appearance. It may be that the filaments connected with the trunk of the dendrite are coarser than those connected with its twigs. Possibly they are derived from tangential fibres. The mossy fibres appear to be non-medullated. What becomes of the group of filaments given off at each rosette? No method of colouration has, as yet, shown their destination. They are usually figured as thick, short, and blunt, but often they are filamentous. Probably this is another illustration of the varicose accumulation of cell plasm, about to be given as an explanation of the dots at the ends of thorns.

These variations in form—taken in conjunction with the fact that in many mis-stained specimens the cell outline is invisible, owing to the mycelium of filaments by which it is surrounded, which makes it resemble a burr on a rose bush rather than the ordinarily well-defined nerve cell—lead me to believe that A THORN IS REALLY THE CELL-END OF AN UNSTAINABLE NERVE-FILAMENT SURROUNDED BY A FILM OF STAINING CELL-PLASM.

Nerve cells appear to me to consist, anatomically, of two substances, (1) the non-staining filaments and (2) the soft cell substance in which the filaments are embedded. This was the view of Max Schultze. It has been recently endorsed by Flemming, Rohde, and others. For the purposes of this paper, I will term the two constituents simply nerve fibrils and cell plasm, since at the present time I desire to express no opinion as to whether the fibrils are hollow or solid, or as to the constitution of the cell plasm. In the axis-cylinder the nerve fibrils are embedded in cell

plasm which is invested by some kind of sheath, hence the sharp outline of the axis-cylinder, by which it is always distinguished. The protoplasmic processes of the cell are naked.

Nerve fibrils brought to the association fields in grey matter are invested for a certain distance with the axis-cylinder sheath. Eventually the fibrils separate from one another, lose their sheaths, and, since they are not stained (by the chrome-silver or by the methylene-blue method), they become invisible in preparations made with the aid of these methods. They again come into view when they join the dendrites of nerve cells, owing to the overflow of the cell-plasm from the naked dendrite along the fibril. This portion of the fibril to which cell plasm adheres is the "thorn." Within the cell they are to be seen as filaments which traverse its substance on their road to its axis-cylinder process, by which they are collected into a bundle. It goes without saying that this transference of nerve fibrils occurs between heterologous, and not between homologous, neurons.

Cell bodies are often seen to give off filaments. It appears that the fibrils of afferent nerves enter the body of the cell as well as its processes. Probably the appearance of many forms of "basket" endings, described by Cajal, Held, Meyer and others, in which a cell body is grasped by thick, blunt, irregular fingers, is due to the varicose accumulation of cell plasm upon the brush of terminal fibrils into which the last branches of afferent nerves divide.

If my interpretation of the thorns is the right one, we are brought back to the theory of Gerlach, with certain modifications introduced by recent discoveries. It is tempting to speculate as to the mode of working of a central nervous system thus constituted, but in the present state of our knowledge, all hypotheses are mere speculations. It appears to me probable that the presence around the fibril of a film of cell plasm is necessary for the conduction of impulses. Possibly, the opening or closing of a nerve path depends upon the greater or less extension of this plasm film around the filament; an open reflex path being one in

which the film of cell plasm is permanently extended ; inhibition being due to the withdrawal of the plasm into the cell.

The need which the psychologist constantly observes of a condition of "attention" on the part of an association field, if an afferent impulse is to produce its full effect, would appear to be due to the fact that the impulse (or rather sequence of impulses, for I imagine that all impulses are vibratory) has, on reaching the cell, to induce the overflow along the fibril of the cell plasm which favours its passage. One who adopts this theory of continuity, might easily amuse himself in formulating hypotheses which would constitute a complete system of nerve physiology ; but it is hardly worth while until the anatomical basis of the theory has been established.