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THE EPITHELIUM OF THE BRAIN CAVITIES.

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Incidentally during a recent investigation in cerebral anatomy there arose this query: "Is the endymal epithelium ciliated?" Nearly all anatomical authorities agree that it is in the fœtus and early youth, but beyond this age there is a diversity of opinion. The majority believe that cilia do not exist in the adult brain; some that they do exist in the fresh state, and others that they are found only in certain patches of the endyma. Among the last there are those who hold that some of these ciliated patches occur on the plexuses, while their opponents maintain that the epithelium covering the plexuses is pavement-like and devoid of cilia.

In a former research, which included the endyma somewhat indirectly, no cilia were visible. The interest aroused by this apparent discrepancy has been the chief incentive toward prosecuting a more thorough inquiry regarding this important question.

Believing that the morphological differences in these cells in mammals are unimportant, but nevertheless regretting the unavailability of human material, it was thought best under the circumstances to confine the work chiefly to the mesal cavities of the cat's brain, special attention being given to the diacœle, mesocœle, and epicœle. In order to give as general a description as possible of the cells, regardless of the age of the subjects, three different stages were studied: at birth, at six weeks, and the adult. Ciliated cells were found in all which resembled each other so closely in structure that the stages might easily be interchanged. For details of structure high powers should be used; nothing less than 600 diameters will give satisfactory results.

Preparations hardened by Gaules'* method show the cilia quite well, either when sectioned or after being teased.

* Heat 0.5 per cent. solution of NaCl. to the boiling point and add HgCl₂ to saturation. Cool. Put tissues in the solution cold or heated to 40° C. Leave from 10 minutes to 2 hours or longer. Then remove HgCl₂ by 70 per cent. alcohol, containing a little tincture of iodine. When the color of the iodine no longer disappears the HgCl₂ is removed. Preserve in alcohol.

The epithelium, in some places, may be stripped from the adjacent tissue, as a continuous membrane, and this after remaining a short time in some dissociating agent may be easily teased apart. Scrapings from fresh subjects are preserved almost indefinitely in a saturated aqueous solution of acetate of sodium and may be teased apart in this liquid at any convenient time.

The cells are very short, columnar in outline, and ciliated at their free ends, the long diameter of a cell, including the cilia, being about $9\ \mu$. The cilia are relatively much longer than are usually seen. They represent about one-fourth of the entire length, or $2.5\ \mu$. In hardened preparations they are not always perfectly preserved, often appearing to have been thinned out and broken off. A thorough injection of the hardening agent into the cavities will do much toward obviating this undesirable feature.

The nuclei, more or less oval in outline, nearly fill up the cell-bodies. In none of the nuclei, stained or unstained, could nucleoli be detected, although numerous clear spots could be seen, particularly in the fresh specimens. Luschka (p. 95) believes that the epithelium must have a secretory function, because the clear drops found in the cells resemble those found in the cerebro-spinal fluid. He also states that Kölliker has observed the exit of these drops from the epithelium.

The cell-bodies send off one or more roots into the adjacent tissue, the neuroglia, and by means of them are anchored in their places.

In an examination of a hardened preparation the epithelium of the paraplexus was found to be pavement in character and entirely destitute of cilia. This remarkable transition, from the columnar epithelium of the walls of the cavities to a pavement epithelium of the plexuses, is probably due to the fact that when the blood-vessels of the plexus intrude through the rima into the paracœle (lateral ventricle) the endyma, as an elastic membrane, is pushed along before them, and in accommodating itself to this intrusion the cells, originally columnar and ciliated, have become gradually flattened out and non-ciliated by the pressure. The layer of neuroglia, if present, has for the same reason become infinitesimally thin.

The neuroglia varies in thickness at different places. Under a high power it has a wavy, homogeneous and slightly fibrous appearance, in which are scattered neuroglia cells. The neuroglia passes imperceptibly into the true nervous substance as a connective medium, binding together nerve cells and fibres.

The pleonastic term *ependyma** has been made by most anatomists to include both the neuroglia and epithelium. Hirschfeld restricts the use of it to the epithelium; Quain, to the thin layer of neuroglia between the epithelium and the nervous matter.

The function of cilia is evidently to propel fluids or particles along the cavities which they line. In most instances they line ducts opening externally, and clearly have an excretory function. The adult brain cavities are entirely circumscribed by the endyma in mammals, except in those which are said to possess the metapore (foramen of Magendie). Among these (man at least) it is said that cilia do not exist in the adult stage, as a rule. Except in very rare instances, the human brain is not treated immediately after death and while perfectly fresh, but is allowed to remain uncared for from twelve to twenty-four hours—a delay which may be a more potent factor than is generally imagined in promoting decomposition and thereby obliterating these delicate structures.

The propulsion of the cerebro-spinal fluid through the brain cavities, if cilia are absent, may be accounted for by the brain movements, stimulated by psychical, circulatory, and respiratory influences. In the embryonic stage, where these influences are not yet or only about to be developed, cilia abound.

Summary.

This investigation has demonstrated the existence of ciliated epithelium in the endyma of the adult, as well as earlier stages in the cat. If psychical phenomena are not incompatible with the presence of endymal cilia and if the brain is treated while perfectly fresh, there seems to be no good reason, from a morphological standpoint, why cilia should not likewise exist in the endyma of the human adult.

Bibliography.

1. Gage, S. H. Notes on Histological Methods, 1885-6.
2. Gegenbaur, C. Lehrbuch der Anatomie des Menschen, 1883, pp. 801-2. Believes that the epithelium of the human brain cavities is ciliated in youth.
3. Gray, H. Anatomy, Descriptive and Surgical, 1887, p. 692.
 "The lateral cavities are lined by a thin diaphanous lining membrane covered by nucleated epithelium (*ependyma*), with cilia scattered here and there in patches."

*The more preferable term, *enayma*, is sanctioned by Hyrtl, Wilder, and Spitzka.

4. Heitzmann, C. *Microscopical Morphology of the Animal Body*, 1883, p. 321.

In this work it is stated that cilia are met with in the investment of the ventricles of the brain and their continuation—the central canal of the spinal cord, and also on the choroid plexuses. Furthermore, that in children their presence is invariable, but in adults they are not found in every case.

5. Henle. *Anatomie des Menschen*, 1876, p. 367.

The statement is made that ciliated epithelium persists as a rule in the aqueduct, and that the epithelium of the choroid plexus is pavement.

6. Hirschfeld, L. *Système Nerveux*, 1866, p. 29–30.

Defines ependyma as a single layer of ciliated pavement epithelium, not ciliated on the plexuses.

7. Lee, A. B. *The Microtome's vade mecum*, 1890.

A handbook of the methods of microscopic anatomy.

8. Leidy, J. *An Elementary Treatise on Human Anatomy*, 1889, p. 769.

Uses the term *endothelium*; says that it consists chiefly of short columnar ciliated cells; though the cilia mostly disappear by adult age, except in the ventricular aqueduct.

9. Leydig, Dr. Franz. *Traité d'histologie*, 1866, p. 201.

Is convinced of ciliary movement in the brain epithelium of young cats. He believes that it also exists in birds, amphibia, and fishes. The cilia are very fine but quite visible.

10. Luschka, Dr. Hubert. *Adergeflechte des Gehirnes*, 1855, pp. 90, 121, and 169.

The epithelium of the ependyma shows essential differences according to age. In the foetus and newly-born it is ciliated. In a four-year-old child a mixed epithelium was found in all the ventricles. Normally the epithelium of the plexus of the adult man shows no cilia. Besides man, this author examined epithelium from the brain of the horse, calf, dog, and rabbit, and cilia were found in all.

11. Quain. *Elements of Anatomy*, 1882, II, pp. 302 and 324.

Defines ependyma as a layer of gelatinous substance (neuroglia) free from nerve cells underneath the lining epithelium.

12. Ranney, A. L. *Applied Anatomy of the Nervous System*, 1888, p. 308.

"Each lateral ventricle is lined with a delicate layer, called the '*ependyma*,' that is covered with cilia in the foetus."

13. Satterthwaite, T. E. *Manual of Histology*, 1881, p. 320.

"The ependyma consists, first, of a finely granular layer covering all the nervous matter bounding the ventricles. Besides the minute granules, this layer contains a few small nuclei here and there, but no fibers. On its free surface rests a single layer of cylindrical epithelium. The cells of this layer have square free ends, while they are anchored by one or more delicate processes which emerge from the attached end and pierce the subjacent granular matrix. These epithelia, in the fresh state, undoubtedly have cilia."

14. Schwalbe. *Lehrbuch der Neurologie*, 1881, p. 797.

The cilia appear in mammalian embryos, but are absent in the adults.

15. Spitzka, E. C. Article, Histology of Brain. Reference Handbook of the Medical Sciences, vol. VIII, 1889. p. 177.

"On its (endymal) surface it is lined by cylindrical epithelia ciliated at their free ends and rooted in the underlying supporting substance by fine radial fibers. Where the endymal expanse is reflected to cover the various choroid plexuses the epithelium becomes more pavement-like."

16. Wilder, B. G. Article, Gross Anatomy of the Brain. Reference Handbook of the Medical Sciences, vol. VIII, 1889.

Description of Plate.

All of the figures were drawn from the specimens with the aid of Abbe's camera lucida. Some of the details were filled in free-hand.

Zeiss' 8 mm. apochromatic objective was used for figs. 1 and 2. His 2 mm. apochromatic, homogeneous immersion objective, for figs. 3 and 4.

FIG. 1 shows the relation of the epithelial cells to the subjacent neuroglia.

The preparation was hardened by Gaule's method and imbedded in collodion. The section was cut across the mesencephal. *a*, layer of endymal cells showing cilia and nuclei, cilia more or less thinned and broken off. *b*, subjacent layer of neuroglia with nuclei imbedded toward the periphery.

Magnified about 700 diameters.

FIG. 2. Prepared as fig. 1.

The layer of cells is partially detached from the neuroglia, showing their root-like processes.

Magnified about 700 diameters.

FIG. 3. An isolated cell from the diacœle of a fresh specimen. *c*, cilia; *n*, nucleus, showing the clear spots; *r*, root-like process broken off at its end.

Magnified about 2,100 diameters.

FIG. 4. Cells from the epicœle with a portion of the neuroglia (*b*), other letters as in fig. 3.

Magnified about 2,100 diameters.

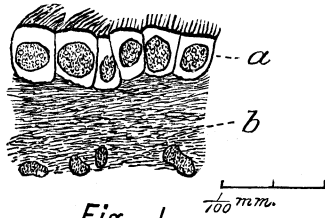


Fig. 1

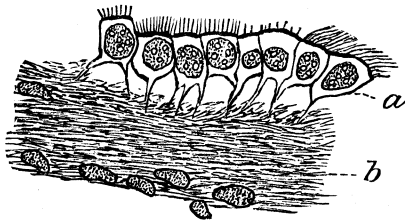


Fig. 2

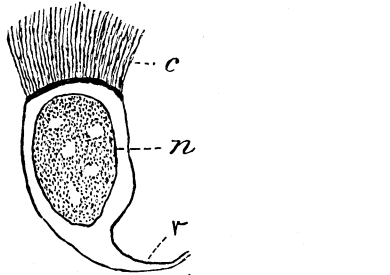


Fig. 3

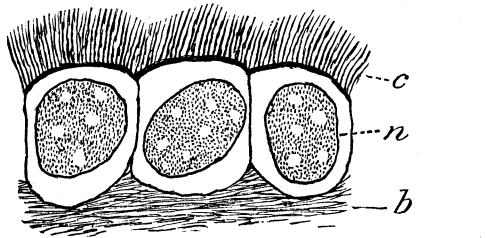


Fig. 4