

ON THE ABSENCE OF THE CORPUS CALLOSUM IN THE HUMAN BRAIN, WITH THE DE- SCRIPTION OF A NEW CASE.

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CASES of absence or defect of the corpus callosum are of interest, not only because of their great rarity, but because of the light which they throw on the distribution and functions of this commissure, and on the development of the mesial aspects of the cerebral hemispheres.

AUTHOR'S CASE.—The case here recorded came under my notice accidentally while examining the brain of a man who had died of pneumonia in the Edinburgh Royal Infirmary in October, 1886. During the short period of his stay in hospital, Dr. Sillars the resident physician noted nothing peculiar in his manner or mental condition. His sister whom I saw after his death, gave me the following account of him:—As a boy at school he was generally backward. He could read, was good at mental arithmetic, but never learned to write much more than to be able to sign his name. He was always somewhat "dour" (obstinate) and eccentric, but in no way vicious or revengeful. He was fond of music; always took an interest in what was going on around him. He was for thirteen years in the employment of one firm, where he earned a pound a week as light porter. On applying to the manager of this firm, I learned that he was considered "queer," though no one could say in exactly what way, but that he discharged his duties satisfactorily. Some time before his fatal illness he became careless and untidy in his habits, and indulged very freely in alcohol.

On removing the brain my attention was first directed to the absence of the corpus callosum. On separating the hemispheres, the frontal lobes of which were loosely united by the leptomeninges, it was seen that this commissure was completely absent, as was also the psalterium of the fornix. Covering the

third ventricle and the sides of the optic thalami was a thin membrane (evidently the velum interpositum), extending from the lamina terminalis in front backwards over the thalami, and having in the middle line two long antero-posterior veins. This structure had extended into the lateral ventricles, and was fringed by the choroid plexus in the usual way. It was loosely connected with the falx, but the adhesions were torn in removing the latter. The two hemispheres were separated by a mesial incision and placed in Müller's fluid; the left reserved for transverse vertical, the right for transverse longitudinal sections. Nothing abnormal was noted about the size or conformation of the cranium, but unfortunately no careful examination of this was made. The brain was not weighed, but its size seemed fairly normal. It was richly convoluted, but there was a remarkable anomaly in the formation of the various lobes (see figs. 1 and 2—drawings natural size of inner and outer surface of right hemisphere).

The outer surface of the cerebrum presented the following abnormalities:—(a) The frontal lobe is reduced in size, while the occipital and to a less degree the temporal are increased. The length of the convex margin of the great longitudinal fissure between the extreme point of the occipital and frontal lobes is $11\frac{1}{2}$ inches; the distance between the tip of the frontal lobe and the superior extremity of the fissure of Rolando (*f.r.*) is $3\frac{1}{2}$ inches; that between the fissure of Rolando and the parieto-occipital (*p.o.*) fissure is 4 inches; and that between the parieto-occipital fissure and the tip of the occipital lobe is $3\frac{1}{8}$ inches. (b) Both limbs of the fissure of Sylvius (*f.s.*) are normal, but the fissure of Rolando (*f.r.*), instead of having the normal direction downwards and forwards, passes downwards and slightly backwards. It also reaches the median surface of the hemisphere, where it extends as a deep fissure as far as the free margin of the grey matter of the gyrus fornicatus.

In the frontal lobe the sulci are all present, but the convolutions, especially the lower, are abnormally small. The præcentral sulcus (*pr.c.*) and ascending frontal convolution (*a.f.*) are normal.

The postcentral sulcus (*po.c.*) extends from $\frac{1}{8}$ inch above the horizontal limb of the fissure of Sylvius to within 1 inch of the middle line. It is not directly continuous with the intra-parietal sulcus (*i.p.*) which is unusually deep and extends backwards to within an inch of the parieto-occipital fissure. The convolutions of the occipital lobes are unusually large and numerous. In the temporal lobe the sulci are normal, and the convolutions (*t.*, *t.*, *t.*) well developed.

On the median surface (fig. 2) the calloso-marginal fissure cannot be traced. The fissure of Rolando (.*r*.), as already stated extends as a deep vertical cleft almost to the free edge of the grey matter. The parieto-occipital (*p.o*) and calcarine (*c*) fissures, both of which are well marked, do not join each other, but each passes separately into the fissura hippocampi. The parieto-occipital fissure is unusually far forward so that on its mesial aspect also the occipital lobe is unusually large.

On this aspect of the frontal lobe are several quite anomalous fissures. Their distribution is very accurately represented in the drawing (fig. 2). Specially noteworthy are two almost horizontal sulci (*f.h.*) joining the anterior upper angle to the triangular area *spt.* These probably represent the anterior end of the embryonic fissura hippocampi (fig. 31; *cf.* also figs. 11, 12, 16, 21). On the parietal lobe, between the (anomalous) fissure of Rolando and the parieto-occipital fissure (*po*), are two deep sulci which pass at a distance of about $\frac{1}{2}$ inch from each other from the free lower margin of the gyrus fornicatus almost to the vertex. They lie near the middle of the lobe and diverge slightly from each other as they pass outwards. In consequence of the absence of the calloso marginal sulcus, and of the peculiar distribution of the other fissures, the gyrus fornicatus is apparently gone, and the convolutions on this surface have a peculiar radiated arrangement (*cf.* figs. 12, 16, 21, and see Case X.).

The hippocampal (*h*) and the uncinata (*u*) gyri are normal.

The convolutions on the inferior aspect followed the normal type.

On the base of the brain, the vessels, optic nerves (*o.n.*), chiasma (*o.c.*), and tracts were normal, as were also the corpora albicantia (*c.m.*) and the peduncles.

On the mesial aspect the following structures were present and normal (see fig. 2):—(1) the anterior (*a.c.*), middle (*m.c.*), and posterior commissures (*p.c.*); (2) the optic thalamus and infundibulum; (3) the lamina terminalis (*l.t.*).

The corpus callosum was entirely absent. The septum lucidum and fornix were apparently absent; but, placed more laterally than these structures, and overhung by the grey matter of the cortex, a triangular area of white matter (which has the size represented in the drawing—*spt.* fig. 2) lay between the anterior commissure below, the free edge of the grey matter (of the gyrus fornicatus?) in front and above, and the tela choroidea (not shown) and optic thalamus behind and below. This area has several shallow longitudinal grooves. Its lower rounded

margin is formed by a structure which is undoubtedly the fornix (ascending limb). This triangular area is almost certainly the septum lucidum (see below).

Transverse vertical section of left hemisphere (fig. 3) made immediately anterior to the triangular area of white matter (*spt.* fig. 2), and through the anterior cornu of the lateral ventricle. *c.n.*, caudate nucleus; *l.n.*, lenticular nucleus; *i.c.*, internal capsule (*of quite normal size and appearance*); *c.r.*, fibres of corona radiata curving from internal capsule upwards and mostly inwards towards grey matter of convolutions, almost no fibres traceable into the dark area *spt.*; *spt.*, a dark area of fibres having mostly antero-posterior direction regarded as a forward continuation of fibres of *spt.* (fig. 2), and as belonging to septum lucidum; *l.v.*, anterior cornu of lateral ventricle; *f.*, between *l.v.* and *spt.*, white fibres running upwards and outwards, and then entering tract *spt.*, and possibly belonging to fornix system (a similar strand seen in brain of kangaroo—Beever): *e.c.*, external capsule; *cl.*, claustrum; *f.s.*, fissure of Sylvius.

Fig. 4. Transverse section at level of anterior commissure. *a.c.*, anterior commissure (of normal size); *f.*, fornix ascending limb (relation to *spt.* should be noted); *spt.*, an area of white fibres—mostly having a longitudinal direction—a few strands crossing it transversely cannot (microscopically) be traced further than a dense network at its outer edge; *c.s.*, a shallow fissure between *spt.* and gyrus fornicatus (*g.f.*), regarded as representing the callosal sulcus; *i.c.*, internal capsule—careful examination shows to be quite normal size; *c.r.*, coronal radiata—passing upwards and inwards. Many fibres traced into (*g.f.*), gyrus fornicatus. A few seemed to enter the network outside area *spt.*

Fig. 5. Transverse section, made at posterior limit of the triangular area *spt.* (fig. 2), and about the middle of optic thalamus; *r.b.*, an oval area of white fibres, mostly running longitudinally, several strands run transversely into the irregular network on its outer margin; this network passes round lateral ventricle within the internal capsule and may be connected with (*c.n.*) caudate nucleus; the strand *r.b.* is evidently the backward prolongation of strand *spt.*; *f.*, fornix—of normal size, but very lateral in position, intimately connected with the strand *r.b.*; *g.f.*, gyrus fornicatus; *c.s.*, callosal (?) sulcus—between *g.f.* and *r.b.*; *i.c.*, internal capsule—again normal in size; *c.r.*, corona radiata—many fibres again traced over the area *r.b.* into gyrus fornicatus, as well as into other convolutions at vertex; *o.t.*, optic

thalamus; *e.c.*, external capsule; *cl.*, claustrum; *i.*, island of Reil; *t.*, temporal lobe; *f.s.*, fissure of Sylvius; *o.*, optic tract.

Fig. 6. Transverse section through pulvinar of optic thalamus; *r.b.*, backward continuation of area *r.b.* (fig. 5), some of its fibres traced outwards for a short distance (see the dark shaded part) along upper wall of lateral ventricle; *f.*, fornix, body, in intimate relation to area *r.b.*; *f.*, fimbria of fornix, in intimate relation to (*g.d.*) fascia dentata, and (*c.amm.*) cornu ammonis.

Fig. 7. *l.v.*, posterior cornu of lateral ventricle, much dilated; *o.r.*, optic radiation of Gratiolet (*cf.* figs. 20 and 25); *t.*, a thin band of fibres, between optic radiation of Gratiolet and ependyma of ventricle. Note the absence of all callosal fibres. This tract has been very carefully drawn from both naked eye and microscopic sections. *i.l.f.*, inferior longitudinal fasciculus.

Fig. 8. Transverse longitudinal section of right hemisphere above the level of the lateral ventricle. Shows the remarkable shortness of the frontal lobe; *f.r.*, fissure of Rolando; *f.r.x.*, the abnormal Rolando (fig. 2) on the mesial aspect of the hemisphere. The crowded grouping of convolutions at the bottom of the fissure should be noted. This probably explains the shortness of the frontal lobe, the gyri, which should normally have been on the mesial surface, and extended round the tip of the lobe, being compressed into this position. In the absence of evidence of constriction by any malformation of the falx or membranes, it is probably a result of repression of the forward growth of the hemisphere during its development.

Fig. 9. Transverse longitudinal section of same hemisphere above the level of the optic thalamus (seen from below, to show the arched form of the structures *spt.* and *r.b.*). *f.*, fornix.

Fig. 10. Similar section slightly lower than the fig. 9 (from above). Letters as in preceding sections. Note *spt.* as a broad strand of white fibres lying internal to the anterior horn of the ventricle (represented by a black line). Its fibres pass from below, backwards and upwards, and enter *r.b.* (fig. 9). Note that in fig. 9 *r.b.* is arched, and has the fornix along its inferior surface. *o.r.*, optic radiation of Gratiolet; *t.*, a narrow strand (drawn exactly of natural size) internal to *o.r.*, and representing the tapetum, which remains when the forceps major is removed (note absence of all callosal fibres). The disproportion in size between the structures marked *t.* and *spt.* is to be noted (see cases of Onufrowicz and Kaufmann). In fig. 10 the apparently normal relation of fimbria of fornix (*f.x.*), fascia dentata (*f.d.*), and cornu ammonis (*c.amm.*) is to be noted. In the section from

which fig. 9 was drawn the mass of the fibres of *r.b.* passed into the white investment of the cornu ammonis.

Apart from the absence of the great transverse commissure the points of special interest in the above case are the deformity of the frontal lobe, the peculiar radiated arrangement of the convolutions on the median aspect of the hemisphere, the value of the structures *spt.* and *r.b.*, the relation of the callosal fibres to the internal capsule (with reference to Hamilton's recently expressed views), and finally the light thrown on the ordinarily accepted opinions with regard to the functions of the corpus callosum.

With a view to their elucidation I have abstracted the accounts of all the recorded cases available to me. The most important papers are in the *Archiv für Psychiatrie*, vol. i. (Sander), vol. xviii. (Onufrowicz and Kaufmann), and in the *Glasgow Medical Journal*, 1875 (Knox). It is much to be regretted that the accounts are in most cases extremely meagre and evidently frequently inaccurate.

1. *Cerebrum Divided into Two Hemispheres, but Corpus Callosum completely absent.*

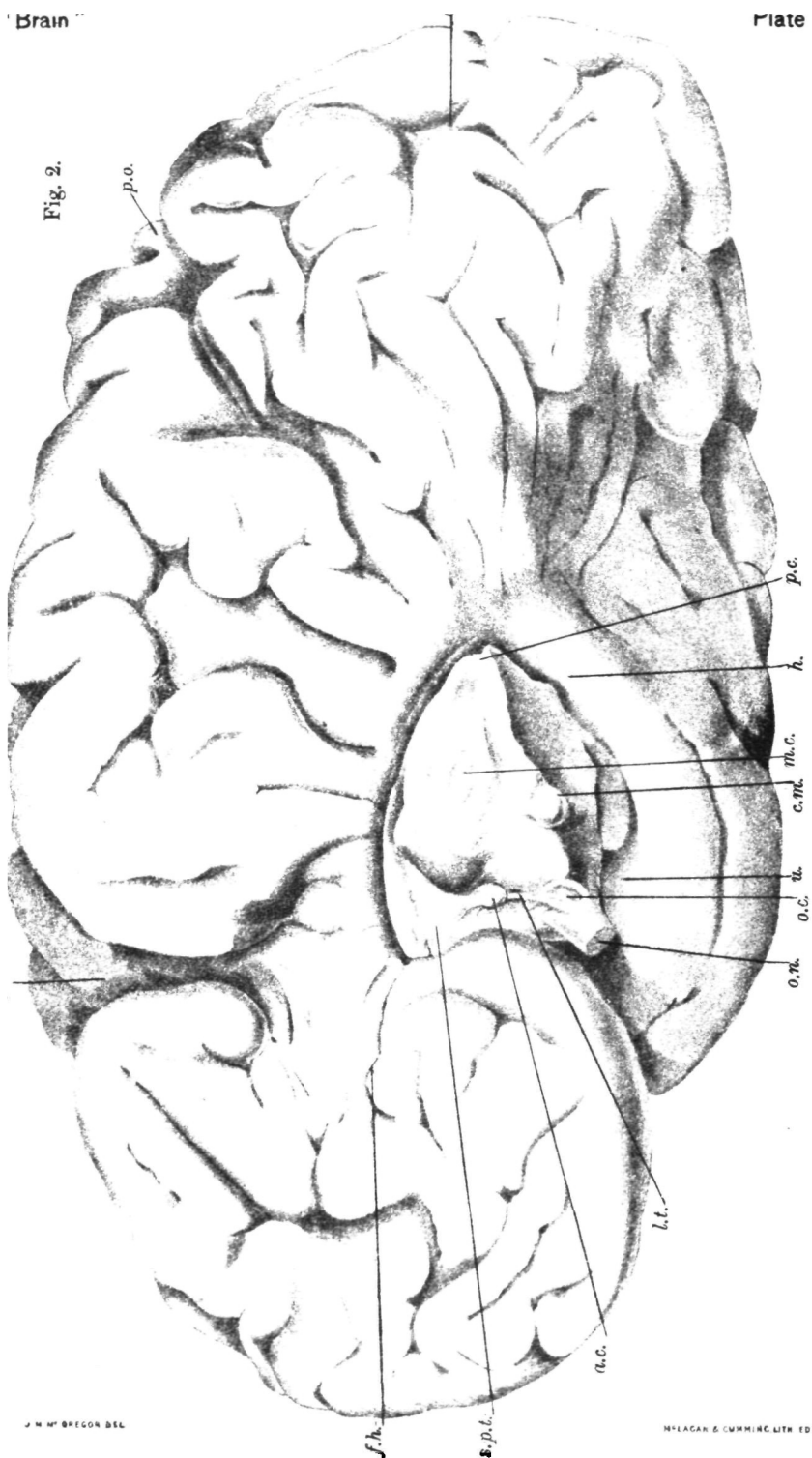
I. Reil, *Arch. f. Physiologie*, xi., 1812, p. 341, quoted by Sander, *Arch. f. Psychiatrie*, vol. i. p. 135.—Woman, aged thirty; stupid, could go messages; otherwise healthy; died suddenly from an apoplectic seizure. Ventricles moderately distended with fluid. Corpus callosum completely absent. Hemispheres held together only by anterior commissure, optic chiasma, isthmus of crura cerebri, and corpora quadrigemina. Inner surfaces of anterior lobes of hemispheres completely separated, parts of them in which the beak and knee of the corpus callosum should have been inserted covered with convolutions. Fornix arose from thalamus, formed corpora mammillaria, ascended behind anterior commissure, coalesced on both sides with that part of the roof of the cerebral ventricles which runs just under the longitudinal convolutions. and formed with it a rounded edge. It ended in a normal manner posteriorly.

II. Ward, *London Medical Gazette*, March 27, 1846; see Knox, *Glasgow Medical Journal*, April, 1875.—An illegitimate child, died at eleven months; could see and hear; gave no indication of intelligence; cried like a puppy. Skull twice normal thickness. No trace of corpus callosum, anterior, middle, or posterior commissures (of fornix and septum lucidum, no note). Frontal lobes flattened.



Fig. 1.

Fig. 2.



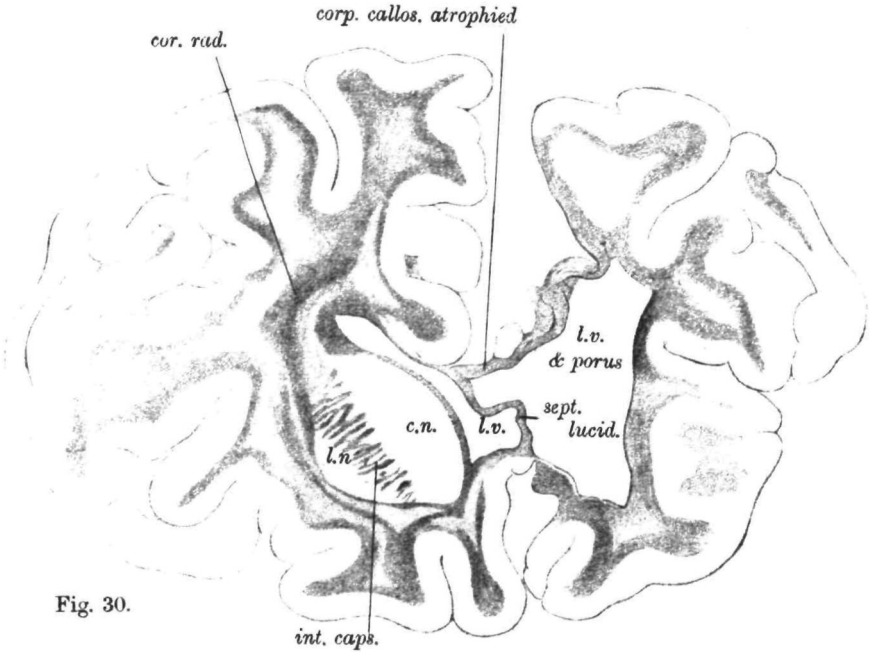


Fig. 30.

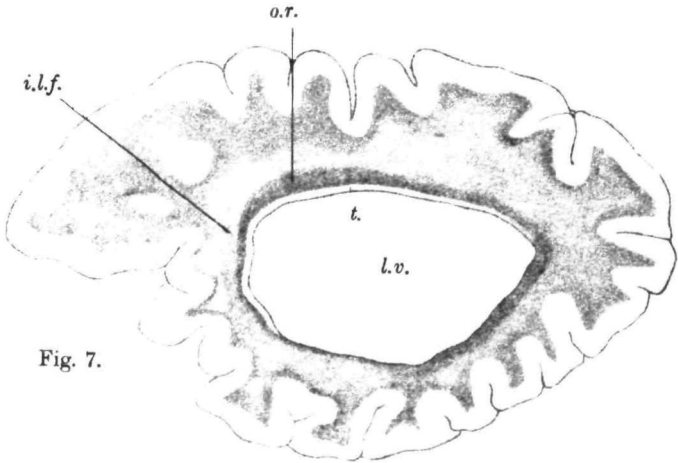


Fig. 7.

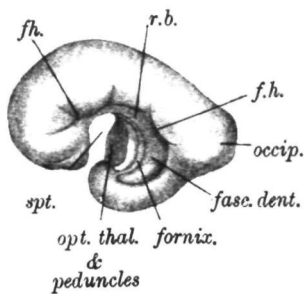


Fig. 31.

Embryo 3 1/2 months (*Mihalkovicz.*)

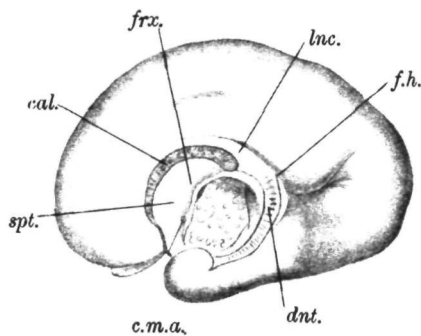


Fig. 32.

Embryo 4 1/2 months. (*Mihalkovicz.*)

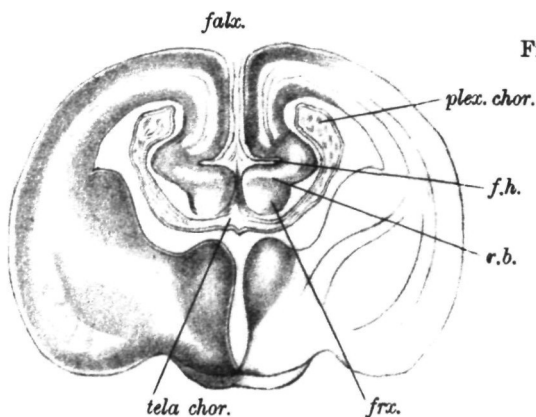


Fig. 33.

'Transverse Section of embryo rabbit. (*Mihalkovicz.*)

III. *Aertzliche Berichte der Wiener Irrenanstalt für 1853*, Wien, 1858, p. 189; see Sander, *loc. cit.*, p. 135.—Male, twenty-five years, since twenty epileptic owing to fright; ultimately imbecile. Corpus callosum entirely absent. Lateral ventricles, especially in posterior horns, much dilated. Fornix seems to have been normal (no note about commissure of the body). Anterior commissure was "ein dünner beiderseits abgerundeter, sich in ein gegenüber-stehenden Stumpf endigender Balken." Nothing said about commissura mollis.

IV. Foerg, *die Bedeutung des Balkens im menschlichen Gehirn*, München, 1855; Sander, *loc. cit.*, p. 135.—Girl, aged seventeen; extremely idiotic, muscular development very feeble. Corpus callosum absent. Psalterium of fornix absent, fornix otherwise normal. Fibres of cingulum (Zwinge) on both sides united with fornix. Presence of anterior commissure doubtful; middle commissure absent. Lateral ventricles dilated.

V. Poterin-Dumontel, *Gaz. Med. de Paris*, No. 2, 1863, pp. 36-38; see Sander, *loc. cit.*, p. 135.—Man of seventy-two years. During the twenty-five years that he was under observation he had three or four apparently slight epileptic attacks (éblouissements passagers avec pâleur de la face et résolution momentanée des membres). Very weak-minded, but could answer simple questions correctly, and could go messages. Could read and write. Moderate œdema of lepto-meninges. No trace of corpus callosum. Lateral ventricles greatly dilated (this attributed to absence of corpus callosum). Commissure anterior and mollis present, also the fornix (its psalterium absent). Brain weighed 1,078 grammes. Two hemispheres were slightly asymmetrical.

VI. Huppert, *Archiv f. Heilkunde*, 1871, heft. 3, p. 243, quoted by Knox.—An epileptic idiot, age twenty-seven. Brain weighed 1,270 grammes. Dura adherent to calvarium, which was symmetrical. Pia thickened, adherent to cortex. On removing falx 500 grammes of fluid escaped from the lateral and third ventricles, which were found greatly dilated. Corpus callosum and its radiating fibres absent. Third ventricle covered by a thin membrane. Septum lucidum apparently absent (perhaps some trace left in a lateral band of white matter). Fornix (anterior and posterior pillars) present (body and commissure absent). Other commissures present, the middle enlarged. Mental condition, entire absence of attention, memory, or judgment. Began at age of four to walk and to speak indistinctly. Never could read or write.

VII. Malinverni, *Giornal. del. R. Acad. di Torino*, 1874; also

Gazette Med. de Paris, January 16, 1875; see Knox, *l.c.*—Soldier, aged forty; of ordinary intelligence, but with a slight tendency to melancholia and taciturnity, and untidiness in his habits. Brain shows absence of corpus callosum, septum lucidum and gyrus fornicatus. (The latter two statements must be received with caution.)

VIII. Knox, *Glasgow Med. Jour.*, April 1, 1875, p. 227.—Female, aged forty; extremely idiotic, muscular system well developed. (For further details see original article.) Head of normal size, forehead low, occiput flat, brain $36\frac{1}{2}$ ounces; hemispheres nearly symmetrical. Posterior horns of ventricles dilated, ependyma thickened (fig. 12). "The corpus callosum appeared to be wholly wanting, or only represented by a very slight ridge (*rb*), which anteriorly was scarcely perceptible, but posteriorly was about one-tenth of an inch in depth. It began in front above the lamina cinerea and passed upwards and backwards attached to the side of the general cavity of the ventricle, forming the upper border of a layer of white matter, the lower border of which was part of the fornix. About half-way back it became separated from the fornix, and at last ran into the anterior and lower part of the hippocampal convolution. The lamina cinerea was divided superiorly so as to appear like a small ridge running up in front of the anterior commissure. The fornix (*f*) was completely divided in the middle line. Its anterior pillars could be traced to the corpora albicantia. Each lateral half ran upwards and backwards as a sharp well-defined border and might be traced into the descending cornu of the lateral ventricle where it ended in the usual manner. Extending between the anterior part of fornix and ridge described above as corpus callosum, was a lamina of white matter (*spt*) of considerable thickness, apparently having no attachment to corpus striatum, but bounding on the inside the entrance to the anterior horn. This was taken to represent one-half of the septum lucidum, carried away from the middle line by the divided fornix and corpus callosum. The fifth ventricle was thus opened up, and communicated (?) with the general ventricular cavity. Into this opened fifth ventricle the convolutions immediately above, and which formed part of the lateral ventricles, dipped down. The anterior and posterior commissures of the third ventricle were present and well marked." On the median aspect of the hemisphere the gyrus fornicatus absent, only the posterior part of the calloso-marginal sulcus (*c.m*) between the cuneus and præcuneus present. The parieto-occipital (*p.o*) and calcarine (*c*) fissures did not meet, but reached indepen-

dently the margin of the ventricle. This anomaly is ascribed to the absence of the gyrus fornicatus. (For convolutions and sulci on outer surface, see original. They presented slight abnormalities).

IX. Eichler, *Arch. f. Psychiatrie*, vol. viii. pt. 2, 1878, p. 355.—Labourer, forty-three, married; father of well-developed child; died of gangrene of scrotum. No mental peculiarity; a diligent, capable workman; good husband in every respect; sober, quiet, well behaved; could read and write. Cerebral hemispheres asymmetrical. Brain otherwise well developed, richly but irregularly convoluted. Gyrus fornicatus absent, or indistinguishable. Calloso-marginal, parieto-occipital, and calcarine fissures indistinguishable. No corpus callosum; in its place a thin transparent membrane with some vessels on its upper surface (the tela choroidea superior?). This was probably adherent to falx, and ruptured on removal of the latter. Of the commissures, the anterior (a) was present and enlarged; the posterior present, of normal size; the middle absent. Fornix present, its psalterium absent; septum lucidum (spt) probably present, as Eichler's figures 11 and 11a represent two laminae in the position of the triangular area (spt) in my case. Lateral ventricles dilated in their posterior horns (because corpus callosum absent.) Leptomeninges normal. On the medial surface the pia continued downwards to the margin of the fornix; the choroid plexus normal; the proper covering of the third ventricle absent, probably torn in removing the falx of the dura. Lamina terminalis present.

X. Urquhart, *Brain*, Oct. 1880.—Female, idiot, with deficiency of co-ordinating power over muscles. Attention, imitation, ideation, the moral sense feebly developed. Calvarium thin, extremely irregular in shape, shortened antero-posteriorly, nearly circular. Right side of skull flattened posteriorly, bulged slightly anteriorly, so that the hemisphere of that side was, as it were, pushed forward. Dura mater non-adherent. Cerebral hemisphere small. Convolutions small and simple, especially in the frontal and occipital lobes. Corpus callosum represented by a rudimentary ridge on each hemisphere. (From a drawing of the brain kindly sent me by Dr. Urquhart, I take this to closely resemble the ridge at the upper part of the white septum lucidum in my own case.) Gyrus fornicatus absent, numerous radiating convolutions taking its place. Fornix and septum lucidum absent. A thin pellucid extension of pia mater seemed to connect the hemispheres.

XI. Anton, *Zeitschrift f. Heilkunde*, vii. Bd. i. pp. 53-64, 1886. (fig. 13).—Fœtus, female. Born at seventh month; lived six hours. Skull normal in size and configuration. Falx major normal. Lepto-meninges not thickened. Both hemispheres nearly symmetrical. Poorly convoluted. Corpus callosum and psalterium of fornix quite absent. Anterior commissure also absent. Only trace of septum lucidum (*spt*) present. Fornix system (*f*) well developed; the lepto-meninges came into direct contact with it. Middle commissure of normal size. Gyrus fornicatus (*g.f.*) small. Calloso-marginal sulcus (*c.m.*) only present in its posterior vertical part. Nervus lancisi (*n.l.*) fused with the fornix, and passes into the fascia dentata (*f.d.*). Parieto-occipital (*p.o.*) and calcarine (*f.c.*) fissures do not unite. The lateral ventricles so dilated that Anton considers hydrocephalus to be the cause of the condition, and to have acted before the fourth month.

XII. Onufrowicz, *Arch. f. Psychiatrie*, xviii., 1887, p. 306, figs. 16, 17, 18, 19, 20.—Male, aged thirty-five. Died of pneumonia; extremely idiotic. (The very full description in the original article should be read.) Brain very small; convolutions on median surface show the apparent absence of the gyrus fornicatus (fig. 16, *g.f.*); the calloso-marginal fissure (*c.m.*) present only in its posterior part; parieto-occipital (*p.o.*) and calcarine (*c*) fissures do not meet; gyrus hippocampi (*h*) and gyrus uncinatus (*u*) well developed. (There are other abnormalities not of special interest here.) Corpus callosum absent; in its place a thin membrane (*l.t.*), which must be considered as the representative of the lamina terminalis (the tela choroidea superior). Psalterium of fornix absent; fornix (*f*) and septum lucidum (*spt*) displaced laterally. Anterior commissure (*a.c.*) present; middle absent; posterior cornu of latter ventricle (*l.v.*) dilated. On transverse sections a structure (see figs. 17, 18, 19, 20, *aof*) similar to that marked *spt* and *rb* in my case, and lying between grey matter and fornix, and considered to pass backwards into tapetum (*t*, fig. 20). Onufrowicz considers this strand the fronto-occipital association bundle, rendered prominent owing to the absence of the corpus callosum.

XIII. Kaufmann, *Arch. f. Psych.*, xviii. and xix. p. 769, figs. 21, 22, 23, 24, 25.—Female, twenty-four. After an accident at four years of age, her mental development was retarded and her general health impaired. When in hospital she showed feeble mental capacity without any very marked psychical change. Died of chronic parenchymatous nephritis. Skull symmetrical; dura mater normal; pia mater œdematous, and slightly thickened.

Two frontal lobes with included dura and pia united together. Corpus callosum absent; in its place a thin fold of pia mater continuous in front with that lying between the two frontal lobes. Commissura media absent; commissura anterior and fornix (*f*) present; choroid plexus and lateral ventricle present. The fornix runs along the inferior margin of a strand of white fibres (*aof*), running mostly in an antero-posterior direction. This is considered as the association system of frontal and occipital lobes, (the superior longitudinal fasciculus of Burdach), which has become prominent owing to the absence of the corpus callosum (the view of Onufrowicz). Gyrus fornicatus absent or rolled inwards towards the association bundle, but *separated from it by a deep fissure*. Calloso-marginal sulcus (*c.m.*) abnormally far forward (?). Parieto-occipital (*p.o.*) and calcarine (*c*) fissures do not unite. A series of transverse sections are figured (see figs. 22, 23, 24, 25), showing the relation of the so-called occipito frontal association system to the fornix and gyrus fornicatus, and to the tapetum of the posterior cornu of the lateral ventricle. He quotes from Wernicke (Lehrbuch) to show that this system passes in the substance of the white fibres of the gyrus fornicatus along its whole length round the splenium of the corpus callosum into the gyrus uncinatus. Here, *loc. cit.* p. 231, he traces this bundle outwards over the lateral ventricle into the tapetum. How it gets back from there to the gyrus uncinatus is not very easy to understand. The cause of the lesion is supposed to be early hydrocephalus.

XIV. Christie, *Proceedings of Roy. Med. Chir. Soc.*, 1868, ref. in *Lancet*, 1868, p. 436.—Male, aged twenty; idiotic, and without power of speech from birth. Brain weight, 28½ oz.; corpus callosum completely absent.

XV. A. Virchow, Berlin, *Gesellschaft f. Psychiatrie und Nerven.*, 9th May, 1887, quoted by Kaufmann, *loc. cit.*, p. 236.—Child died at six weeks with convulsions. Marked hydrocephalus; no corpus callosum, no anterior commissure, no septum lucidum (no note of fornix). Many other developmental defects, and changes of inflammatory origin, such as thickening of pia, and adhesion to brain substance.

2. Primary Partial Development of Corpus Callosum.

XVI. Sander, *loc. cit.*, p. 128; *Archiv f. Psychiatrie*, vol. i., p. 128.—Cretin, brain abnormally small, corpus callosum present, but splenium reduced to ¼ centimetre, while genu is ⅔ centimetre

in thickness; psalterium of fornix present; fornix, pes hippocampi, calcar avis, normal; posterior of cornu of ventricle abnormally wide, forceps of corpus callosum quite absent.

XVII. Sander, *loc. cit.*, p. 299.—Microcephalic boy, five months old. Corpus callosum present, but splenium too thin; forceps present; anterior commissure present, middle commissure absent; fornix present, small; septum lucidum normal, lateral ventricle not dilated.

XVIII. Sander, *loc. cit.*, p. 303.—Microcephalic brain. Corpus callosum short, splenium thin; no further examination allowed.

XIX. Paget, *Med. Chir. Trans.*, 1846, p. 55, fig. 15.—Girl twenty-one; mental condition fairly normal; showed merely want of forethought, some flightiness of manner, but had a good memory, was trusty and competent, and of good character. Convolutions normal, corpus callosum 1·4 inch long, anterior margin 1·9 inch from tip of frontal lobe, posterior 3·7 inches from occipital lobe; length 1 inch in middle line, increases in length as it proceeds outwardly. Fibres of anterior part continued into frontal lobes fibres of middle part—a few fibres pass transversely from one hemisphere to another; most pass with varying degrees of obliquity, most of the oblique bands pass from left to right—these in the left side being thicker. There is not, in their usual position, a trace of the septum lucidum or middle part of the fornix. The tapetum present, psalterium of fornix absent; fornix, anterior and posterior commissure normal, middle commissure very large (fig. 15).

XX. Jolly, *Zeitschrift f. rationelle Medicin*, Bd. xxxvi., 1869. (The same case is described by Nobiling, *Baier. Aertz. Intelligenzbl.*, 24, or *Jahresbericht für Medicin*, 1859, p. 153, quoted by Knox, *loc. cit.*)—Railway servant, died fifty-eight, of cancer of stomach. Mental power normal, brain of normal size, convolutions of both hemispheres well developed; corpus callosum length 2·8 cm. (about 1 inch); knee is 1·9 cm. thick; the body varied from 1·1 to 12 cm. thick; the posterior rudiment of the splenium 0·6 cm.; distance of knee from tip of frontal lobe 4·7 cm., of posterior margin from tip of occipital lobe is 8·5 cm. Psalterium of fornix absent, fornix present (rudimentary), ventricle dilated, ependyma thickened; anterior commissure apparently present, middle commissure absent, cornu ammonis normal. (It would have been interesting to know how far forwards it extended, and what was the condition of the fascicula dentata and nerve of Lancisi.)

XXI. Chatto, *London Med. Gazette*, i., 1845.—Child, year

old : epileptic (daily fits) ; in all its life manifested no sign whatever of recognising persons or objects. Corpus callosum represented by two thin strands, a few lines broad, uniting the anterior parts of the hemispheres ; psalterium of fornix absent, septum lucidum also absent (fornix itself presumably present). No note of condition of other commissures. A small hyatid cyst, size of hazel-nut, lying anterior to corpora quadrigemina, with smaller ones adhering to it, containing gelatinous fluid ; small quantity of fluid in ventricles ; brain firm.

3. Cases of Absence of Anterior Part of the Corpus Callosum.

XXII.—Mitchell (Henry), *Med. Chir. Trans.*, xxxi. p. 239, fig. 14.—Boy, fifteen ; civil and well conducted ; slow in acquiring knowledge at school ; could read and write, but in doing so had tendency to fall asleep ; had difficulty in learning his trade, but was very shrewd in money matters ; generally mentally sluggish. Injury to head from cricket ball three years before death (confined to hospital for twelve months). Brain and convolutions of normal size, skull and dura normal, anterior part of body of c.c. absent exposing ventricles, velum interpositum probably torn through, posterior $\frac{1}{2}$ of c.c. present, measuring $1\frac{1}{2}$ inch long, from anterior border to tip of frontal lobe = $3\frac{1}{2}$; posterior margin 2 inches from tip of posterior lobe ; at side of cavity the corpus callosum persists as a thin rounded margin. The septa lucida, fifth ventricle, and most of the anterior pillars of the fornix were absent ; anterior commissure and small part of the anterior pillars of the fornix, and most of the posterior part of the fornix were present. The radiating fibres from all parts of the corpus callosum seemed normal. Query ? Was this not a case of dropsy of the fifth ventricle which had caused destruction of the anterior part of the c.c., the septa lucida, and the corresponding parts of the fornix ? (fig. 14).

XXIII.—Langdon Down, *Med. Chi. Trans.*, xlv. p. 219.—Boy, aged nine ; idiotic, could not stand, or feed himself, or speak ; fond of music. Calvarium thick, somewhat unsymmetrical ; brain weighed 2 lbs. 8 ozs. Membrane normal, velum interpositum present, posterior cornu of ventricles enlarged, positive absence of any septum lucidum ; fornix present—its pillars widely separated ; no commissure of body ; anterior commissure present ; two lines above it a transverse band (perhaps a rudiment of the corpus callosum) not more than $\frac{1}{8}$ in thickness ; middle soft commissure absent.

XXIV. Langdon Down, *Med. Chir. Trans.*, vol. xlix., 1886, p. 195.—Male, forty. Could read easy words, learning to write a little, answer simple questions, fond of music, memory defective, fond of children, otherwise passionate. Died of pleuro-pneumonia. Calvarium unsymmetrical and dense, shelving anteriorly. On separating the two hemispheres the almost entire absence of the corpus callosum was apparent, and the velum interpositum exposed to view. A small cartilaginous-like band $\frac{7}{32}$ inch broad and $\frac{1}{4}$ inch thick, situated opposite the corpora striata, was the only representative of the great commissure. The fornix was represented by two thin posterior pillars; the body of the fornix and its anterior pillars absent. Right optic thalamus much larger than left; posterior cornu of lateral ventricles was distended with straw-coloured serum; pineal gland size of a wild cherry; middle commissure absent.

4. *Cases where Absence of Corpus Callosum (or part of it) probably Secondary (to Hydrocephalus, Hydatids, or Tumours).*

XXV. Gausser, *Wiener Zeitschrift*, xi., 5th June, 1845.—Epileptic, twenty-six; central part of anterior half of the corpus callosum, also septum lucidum and anterior and middle parts of fornix, absent. Dropsy of fifth ventricle.

XXVI. Birch-Hirschfeld, *Arch. f. Heilkunde*, viii. p. 481.—Man, forty-one; of ordinary intelligence. Anterior half of corpus callosum absent; dropsy of third ventricle (and evidently the fifth) separating the two septa lucida; a cavity containing fluid in the left frontal lobe communicating with the third ventricle.

XXVII. Foerg, *loc. cit.*, pp. 17-25; see Sander, *loc. cit.*, p. 136.—Middle part of corpus callosum and body of fornix absent; otherwise everything normal.

XXVIII. Solly, specimen in St. Thomas's Hospital Museum.—Boy, sixteen; died seven days after fracture of skull. Mother says "he was never right from his birth" and supposed that his weakness of intellect was due to a difficult labour. He had always difficulty in controlling and regulating the action of his muscles so as to maintain the erect position, and was always stumbling and rolling about; he generally appeared drowsy; he was fond of reading (religious books being his favourites), but was unable to give a clear account of anything he had seen or read; childish in his amusements; he sometimes talked naturally, but was generally "boobyfied." Corpus callosum completely absent. A pale membranous bag protruded from left side, which on being

cut into was found to be a cyst 2 inches in length and 1 in breadth, containing a serous fluid, and lined by a firm membrane. This formed roof of lateral ventricle on left side; the body and most of posterior pillar of fornix were absent; a portion of anterior column present. On velum interpositum was a small hydatid, and a considerable quantity of fluid in left and third ventricle. In the right ventricle everything was normal. Anterior commissure probably present; middle abnormally thick.

XXIX. Meierzejevski, *Revue d'Anthropologie*, 1876, No. 17; see Onufrowicz, *loc. cit.*, 313.—Corpus callosum thin, anterior commissure absent.

XXX. Maclaren, *Ed. Med. Jour.*, 1879.—Female, aged thirty-two; imbecile, epileptic, deaf and dumb. Pia mater adherent along margins of longitudinal fissure; convolutions thin; white matter reduced; ventricles greatly dilated; septum lucidum absent; c.c. represented by two narrow belts—one at posterior, one at anterior extremity. Body of fornix absent; anterior and posterior pillars represented. Anterior, middle, and posterior commissures intact.

It is evident that the majority of the preceding cases are due to a primary arrest of growth and are only to be properly interpreted by the study of the development of the cerebrum. We learn from the work more especially of His and Mihalkovicz, that the anterior cerebral vesicle, which is primarily single, becomes at a very early period (about the eighteenth day) constricted in the middle line by the primitive *falx cerebri*, a process of vascular connective tissue. The two hemispheres thus formed grow up on either side of the *falx*, with their median walls at first plane and parallel to the latter; but during the second month there appear on them two curved fissures almost concentric with the free margin of the hemisphere (fig. 31, from Mihalkovicz). These fissures are termed respectively the *fissura hippocampi* (*f.h.*) (*ammons-furche*) and *fissura choroidea* (*adergeflechts-furche*). They begin anterior to the foramen of Monro, describe almost a semicircle over the corpora striata, and end near the tip of the temporo-sphenoidal lobe. The superior fissure forms a projection of the cerebral wall into the lateral ventricle, known as the *pes hippocampi major*, of which only the posterior part, that which projects into the posterior cornu, remains as a permanent structure. The inferior fissure, the *fissura choroidea*, is formed by the lateral outgrowth from the lower margins of the *falx cerebri* of the *tela choroidea superior* (velum interpositum) with its fringe of vessels, the choroid plexus. (See fig. 33, *falx*,

tel. chor., and *plex. chor.*) The cerebral wall covering this plexus becomes gradually reduced to the layer of epithelium, which forms its investment in the adult. The two fissures include between them a portion of the cortex (fig. 31, *r.b.* and *fasc. dent.*), which from its position and form is termed the convolution of the marginal arch (the *randbogen* of German authors). This convolution is continuous in front with that part of the cortex (*spt*) which forms the septum lucidum, and posteriorly it passes into the gyrus uncinatus. Along with the septum lucidum it becomes the seat of the following series of important changes:—

About the middle of the third month of intra-uterine life the triangular areas of the cortex which correspond to the two septa lucida (*spt*) become fused together and unite along their margins (thus including the cavity of the fifth ventricle between them).

In the beginning of the fourth month the lower borders of the fused septa lucida and of the as yet ununited marginal arches become differentiated into the anterior pillars, body, and fimbria (and commissure?) of the fornix (fig. 31). About the same time (probably at a slightly later date) the anterior commissure appears in the lower angle of the septa lucida. Towards the end of the fourth month, along the anterior and upper periphery of the septa lucida, the rostrum and knee of the corpus callosum (fig. 32, *cal*) are developed. During this month also the two marginal arches become gradually united as far back as the posterior extremity of the optic thalamus.

During the fifth and sixth months the fused portion of the marginal arches becomes gradually differentiated from before backwards into the corpus collosum. With the exception of a small portion of grey matter (the *induseum griseum*), and the *nervus Lancisii* (*inc.* fig. 32) above and of the fornix below the corpus callosum, the whole of this part of the marginal arch becomes modified into callosal fibres. In many mammalia the upper portion of the arch becomes collosal, while the underlying part becomes *cornu ammonis*, which thus extends much farther forwards than in man. The fusion of septa lucida and marginal arches necessarily causes the intercepted portion of the primitive *falx* to atrophy (fig. 33), so that the *falx* (*flx*) and *tela choroidea superior* (*tel. chor.*) become apparently two quite independent structures.

The portion of the marginal arches behind the point of fusion gives origin to the fornix (*fornix*), the fascia dentata (*fasc. dent.*), and the *nervus Lancisii* (*inc.*). On its outer border is the *fissura hippocampi* (*f.h.*) proper; while the anterior part of this fissure

now lying above the corpus callosum becomes the callosal sulcus (see Milhalkovicz. *Entwicklungsgeschichte des Gehirns*, pp. 120-130).

If we apply these facts to the study of the recorded cases of absence or partial defect of the corpus callosum, we find that the majority of these cases can be explained on the hypothesis of arrest of development, and that they may be classified according to the period at which this arrest takes place, the appearance of the brain varying accordingly.

1. *The Falx may constrict the Anterior Cerebral Vesicle, either not at all, or insufficiently.*—(Lesion occurs during first three weeks.) The cerebrum will consist of a single vesicle or of two imperfectly divided hemispheres, united by an unthinned septum (of grey matter). There will be one ventricular chamber, no tela choroidea superior, no convolution of the marginal arch, and therefore no fornix, no anterior commissure, and no corpus callosum. See cases recorded by Turner, *Journal of Anatomy and Physiology*, xii. p. 241 (fig. 29); Bianchi, *Storica del Monstri del Duo Corpi*, Torino, 1749, p. 100; Förster, *Missbildungen des Menschen*, 1861, p. 87, cases of Cyclopia; Hadlich, *Arch. f. Psychiatrie*, x. p. 99 (figs. 26, 26a, 27, 27a); and Wille, same volume, p. 597 (fig. 28).

2. *The two Hemispheres perfectly divided, but Septum Lucidum and Marginal Arch, if developed, fail to unite.*—There will be no anterior commissure, no corpus callosum, no psalterium of fornix. Tela choroidea superior continuous with falx cerebri. (Fornix present if marginal arch developed.) Development arrested before the fourth month. Cases II. (Ward), III. (?), IV. (?) (Foerg), XI., XV.

3. *Hemispheres formed, but Septa Lucida united only by Antero-Inferior Angle.*—Anterior commissure present. Other structures as in Class II. (Development arrested during fourth month.) Cases (several imperfectly recorded) I., V., VI., VII. (?), VIII., IX., X. (?), XII., XIII., and my case.

4. *Hemispheres formed; Fusion of Septa Lucida and Marginal Arches more extensive, but still incomplete.*—(a) Fusion limited to septa lucida. (Arrest of development at end of fourth month.) Anterior commissure and knee of corpus callosum present. Fornix present, but its psalterium absent (Case XXI.). (b) Union of septa lucida complete; but of marginal arches limited more or less to anterior part. Corpus callosum present anteriorly, but generally thin (as in lower mammalia). Splenium absent or thin. Psalterium of fornix present, if fusion has extended sufficiently far back. Cases XVI., XVII., XVIII., XIX., XX.

The destination of the septum lucidum and marginal arch in Series 3 (and in those cases of Series 2 in which they have been developed) remains to be examined. We have seen that these structures lie between the (embryonic) fissura hippocampi and the fissura choroidea, and that the fornix is developed along their inferior margin. If now we find a structure having the same relation or position to the fissura choroidea, the fornix and the fissura hippocampi, we may fairly conclude that it represents the septum lucidum and marginal arch. There seems little difficulty in identifying the area (*spt*) in my case (fig. 2), and in Onufrowicz (*spt*, fig. 16), Kaufmann (fig. 28), Anton (fig. 13), Eichler (fig. 11), and Knox (fig. 12), as the septum lucidum.

The marginal arch presents greater difficulty. Onufrowicz and Kaufmann consider that the fibres occupying its position belong to the system of fronto-occipital association fibres, and pass to the outer side of the posterior cornu of the lateral ventricle into the tapetum—a structure usually held to be composed of callosal fibres; that they are in fact the fibres of the cingulum of Burdach, no longer concealed by the fibres of the corpus callosum. This view I consider to be untenable, for the following reasons:—

The cingulum lies in the substance of the gyrus fornicatus, separated by part of its grey matter from the corpus callosum (see Meynert, *Psychiatry*, p. 40, and fig. 18). The structure under consideration, however, is separated by a fissure from the gyrus fornicatus. In my case, its fibres certainly do not pass into the so-called tapetum, but seem rather to end in the investment of the cornu ammonis posteriorly (at least in their greatest part). And lastly, it does not become prominent in a brain in which the corpus callosum has atrophied (see fig 30, drawn from the brain sent me by Dr. Ruxton, pathologist of Wadsley Asylum, in which the anterior two-thirds of the corpus callosum had completely atrophied in consequence of a lesion affecting the centrum of ovale of the frontal and part of the parietal lobes). Had this fronto-occipital association system been merely concealed by the corpus callosum, it should now be as prominent as in the cases of congenital callosal defect. It need not I think surprise us that this structure does not contain grey matter. We find what is undoubtedly septum lucidum contains only white longitudinal fibres, and in the fornix and nervus Lancisii we see the tendency to the formation of the marginal arch into longitudinal fibres. The causes of the arrested growth are very various, and must act at different stages of development. The principal factors concerned are the primitive falx and the septa lucida. Unfortunately, few

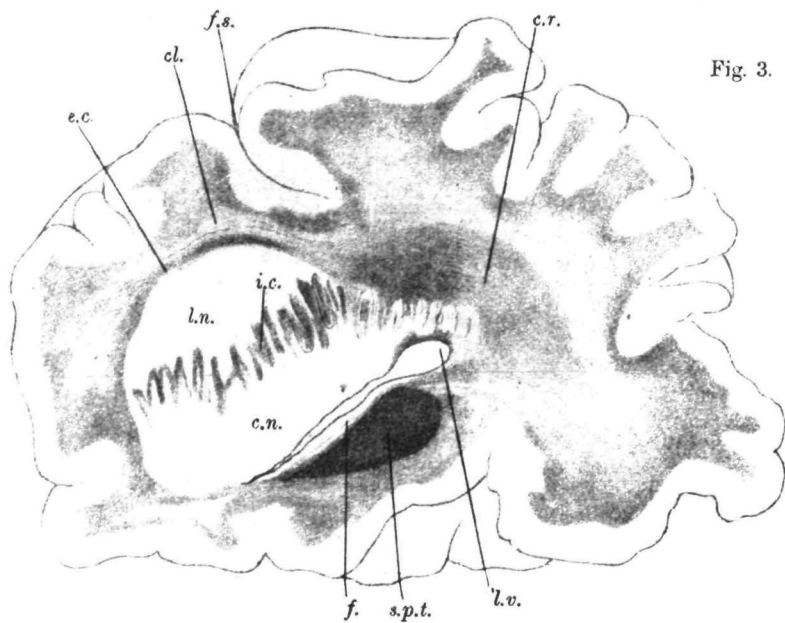


Fig. 3.

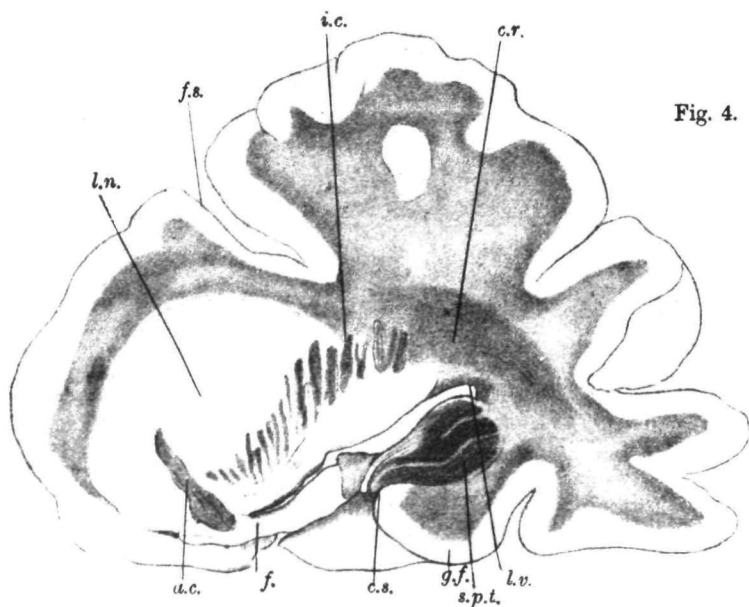


Fig. 4.

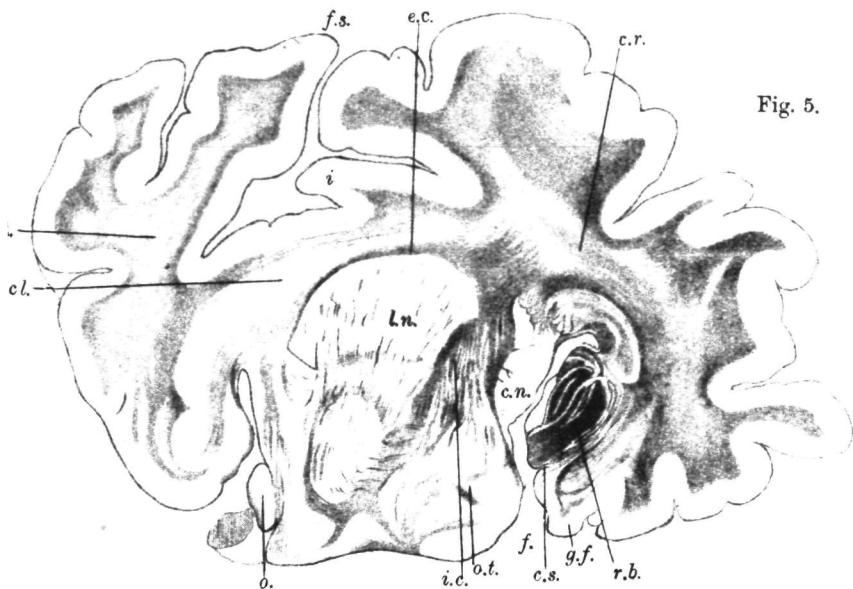


Fig. 5.

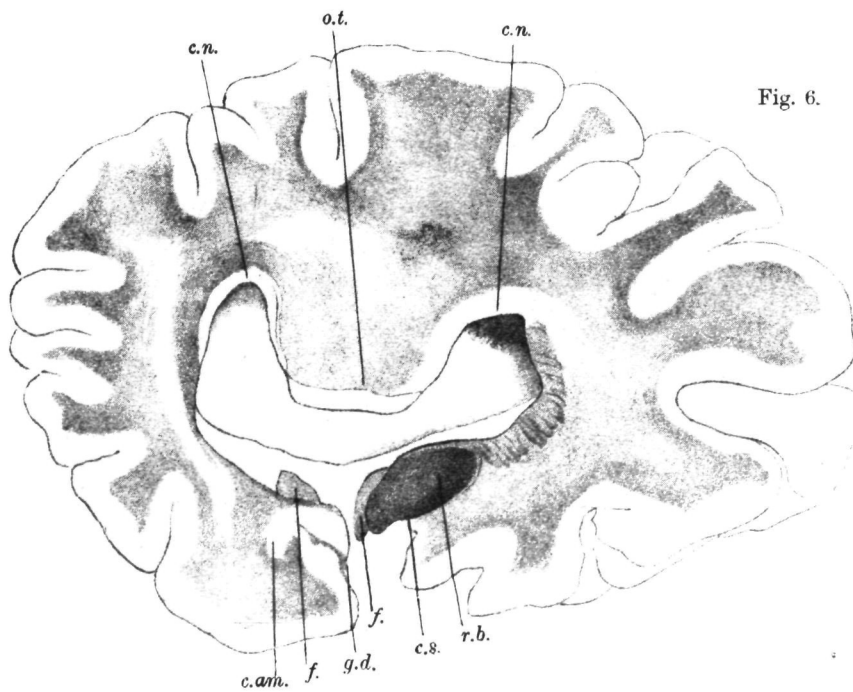
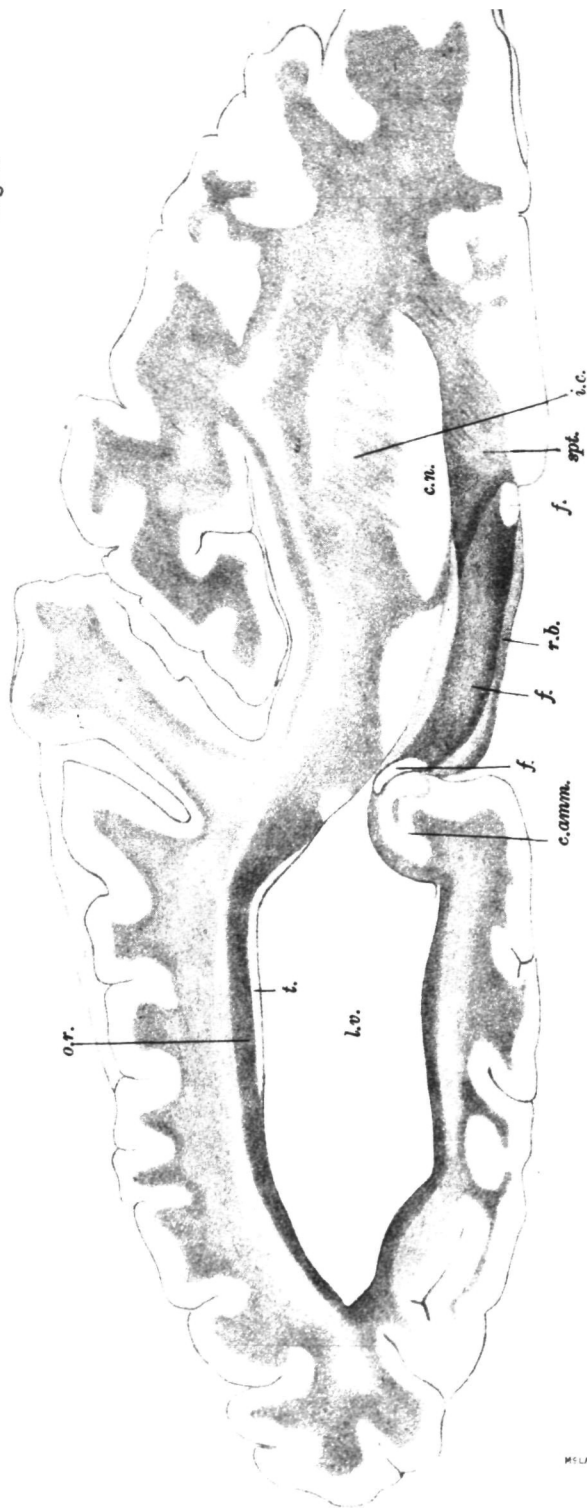


Fig. 6.

Fig. 8.



Fig. 9.



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Fig. 10.

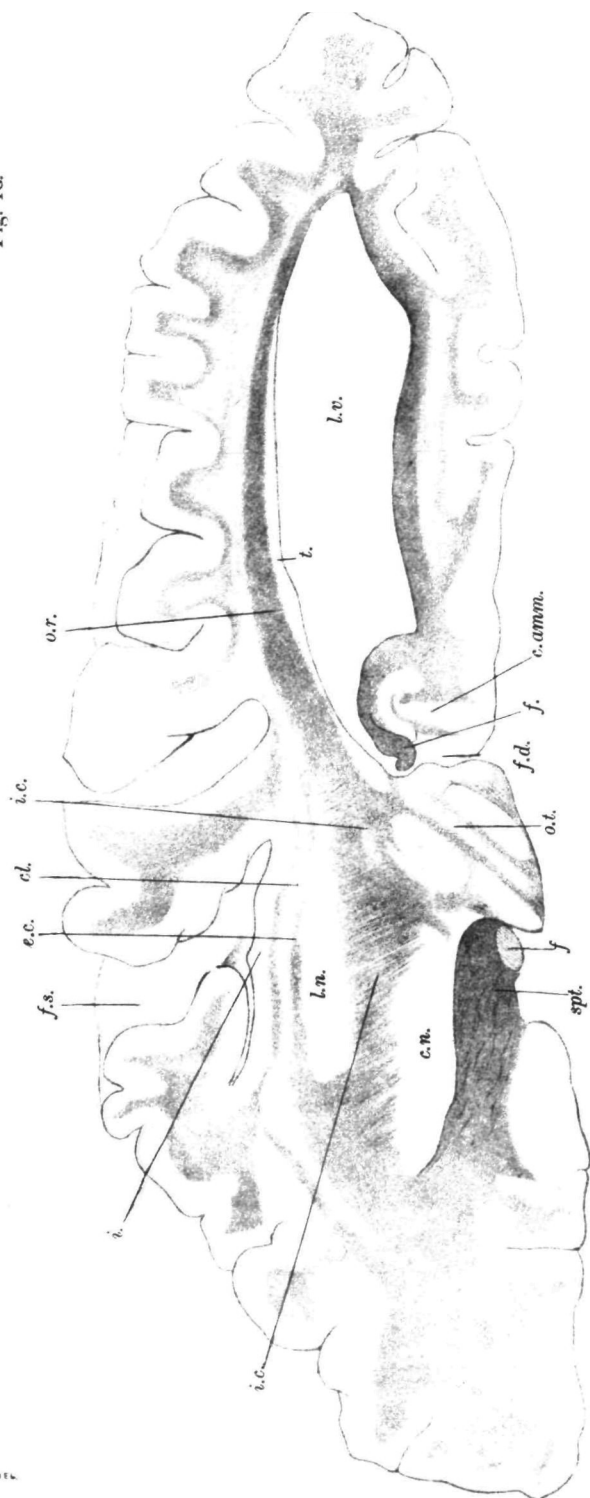


Fig. 11.

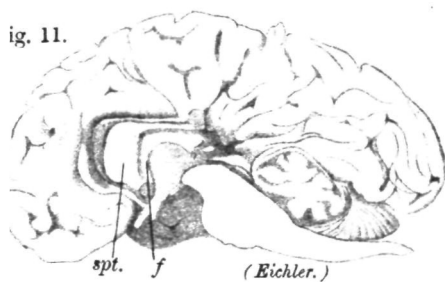


Fig. 11a.

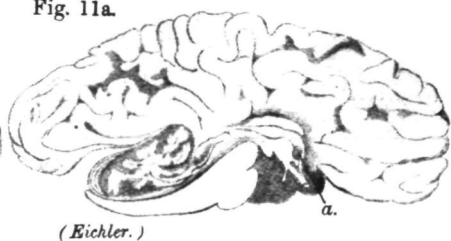


Fig. 14.

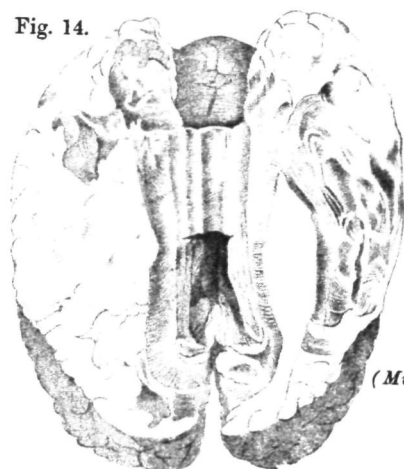


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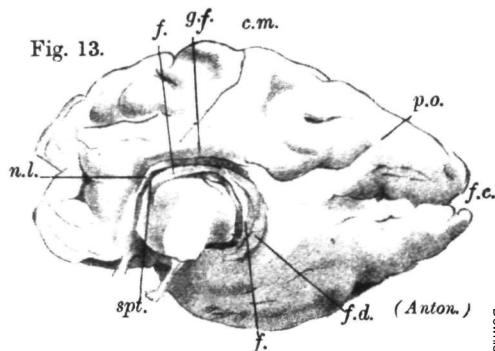


Fig. 12.

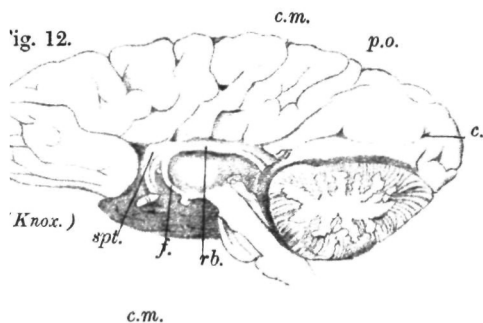


Fig. 15.

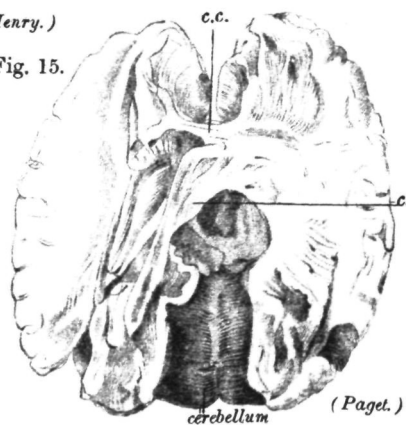


Fig. 21.

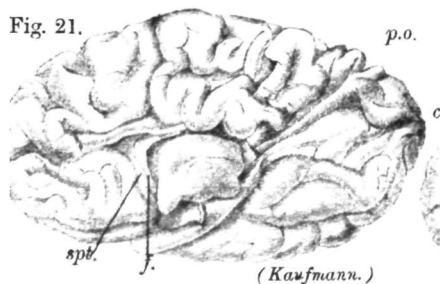


Fig. 16.

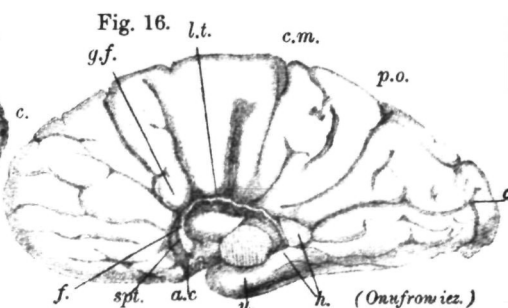


Fig. 17.



Fig. 18.

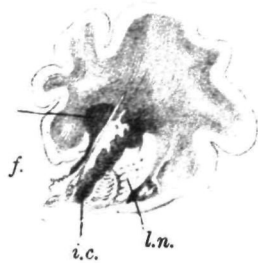


Fig. 19.

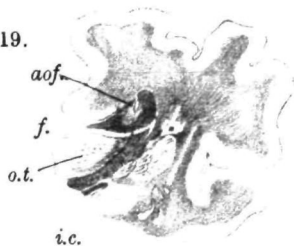


Fig. 20.

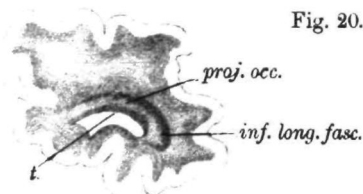


Fig. 22.

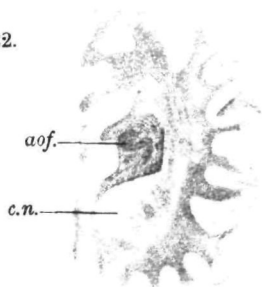


Fig. 23.

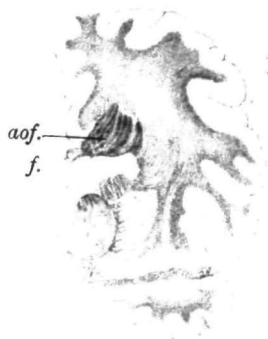


Fig. 24.

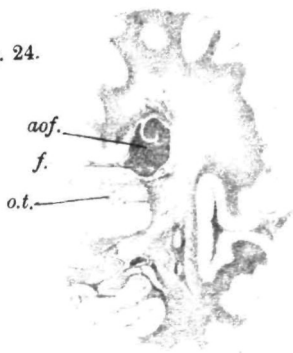


Fig. 25.

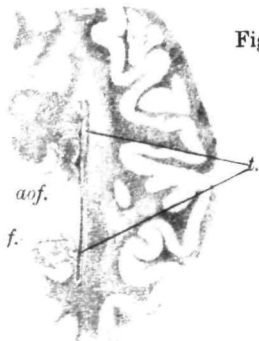




Fig. 26. (*Hadlich.*)

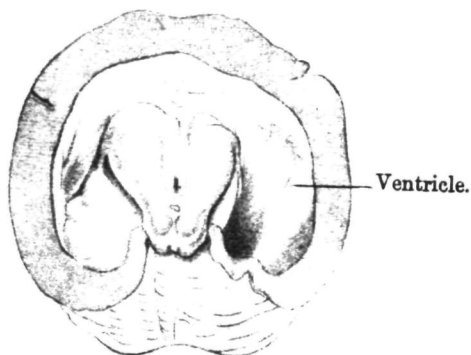


Fig. 26a. (*Hadlich.*)



Fig. 27. (*Hadlich.*)

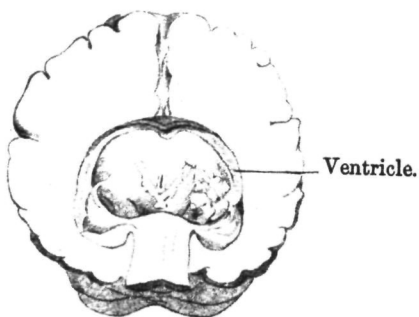


Fig. 27a. (*Hadlich.*)

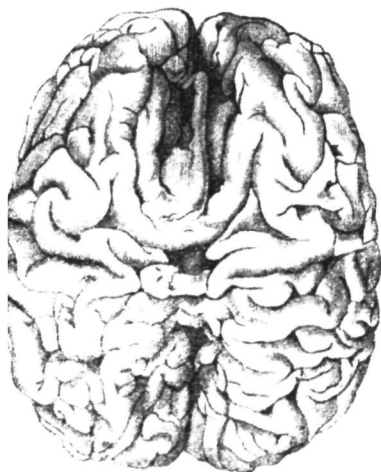


Fig. 28. (*Turner.*)



Fig. 28a. (*Willé.*)

of the records permit of our determining the cause in any given case, so that the hypotheses stated below are intended principally to aid future investigators. The causes may depend on—

1. The primitive falx cerebri—(a) its non-development during the first three weeks of life; (b) after its formation, its excessive resistance to atrophy, such as might result from intra-uterine leptomeningitis; (c) a permanently too deep position of the falx, such as might result from cranial deformity (Richter, *Virchow's Archiv*, 106). Richter considers that premature ossification of the basis cranii increases the angle between the two petrous temporal bones, and by thus stretching the tentorium cerebelli so depresses the free border of the falx that it divides the corpus callosum as it grows up against it.

2. Irregular distribution of the anterior cerebral arteries (Sander) passing between the septa lucida, and preventing their union.

3. Asymmetry of the hemispheres (resulting from asymmetry of cranium), so that the two septa lucida are not opposite each other.

4. Abnormal growths in the falx.

5. Nutritional disturbance in septa lucida, such as early hydrocephalus.

As causes of secondary defect are dropsy of the fifth ventricle (Mitchell Henry), hydatids, lesions in callosal arteries (Kaufmann and Eichler), in vessels of centrum ovale.

Several authors imagine that the area *rb* represents the stump of the corpus callosum, which has succeeded in growing so far toward the middle line. Von Gudden's law of the complete atrophy of a divided embryonic system seems to decide against this view.

The view of Professor Hamilton of Aberdeen with regard to the distribution of the callosal fibres, seems to be completely negatived by the appearance in my case and in those recorded by Onufrowicz and Kaufmann. It is obvious that if in the normal brain the corpus callosum is the main constituent of the internal capsule, the latter structure should almost disappear when the corpus callosum is absent. This however does not occur. In my case it was not possible to detect any abnormality in it; and Onufrowicz and Kaufmann make similar statements. Hamilton (*Proc. Roy. Soc.*, 1887), endeavours to explain this by the theory that the corpus callosum is present, but does not decussate—that it ascends to the cortex of the same hemisphere. Were that so the normal appearance of the tapetum should be present in the occipital lobe in my case. It is unquestionably absent. Further, in Buxton's case, fig. 80, where the anterior

part of the corpus callosum is atrophied completely, sections taken at all levels show that the internal capsule is not in the least diminished. Ruxton's case further serves to explain the apparent curving downwards of the corpus callosum into the internal capsule. The arched fibres remain though the corpus callosum is gone, but they are seen on naked eye and microscopic examination to come in very great measure from the gyrus fornicatus. It is no doubt the intermingling of the callosal and capsular systems that produces the appearance described by Hamilton. As further evidence of the separateness of those two systems may be mentioned the fact that in the mature human foetus and infant up to three months, the callosal system is non-medullated; while in the mature foetus the whole posterior limb, and in the three-months' child almost the whole of both limbs of the internal capsule are medullated. And further, in some of the lower mammalia the strand from the capsule to the gyrus fornicatus can be traced as quite distinct from the callosal system.

Lastly, the case is instructive with regard to the supposed functions of the corpus callosum. A great deal has been written as to its supposed function of co-ordinating the corresponding convolutions of the opposite hemispheres—a view which seems to date from Meynert's theory of its anatomical connections. It is right to state that Meynert's opinion is based on no proof whatever and the physiological view is equally speculative. It was supposed to account satisfactorily for the idiocy or imbecility of most of the cases. But examination of the literature shows that where there has been imbecility there has always been some other grave brain defect. On the other hand, the cases of Eichler, Paget, Malinverni, Jolly, and that recorded by me, and the second case of Kaufmann, and that of Erb (*Virch. Arch.*, 96), show that where the brain is otherwise well developed there may be “no disturbance of mobility, co-ordination, general or special sensibility, reflexes, speech, or intelligence, whether the defect of the corpus callosum be primary or secondary.

The radiated convolutionary arrangement is very difficult to explain. It may be due to the mechanical resistance offered by the ring-like marginal arch to the growth of the grey matter of the gyri. This will thus become furrowed much as a bag made of cloth when a string is tied tightly round its neck. In this case too, the furrows radiate outwards from the string. The abnormal mesial fissure of Rolando is not found in other cases. I am at a loss to account for it except on the view that the forward growth of the brain has surpassed that of the cranium, and that a duplication of the inner surface was thus produced.”