The Brain of the Mole
Graduation Thesis.

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An Anatomical and Physiological Research

by

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Goodenir Prizeman (joinr), 1878
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The chief objects we had in view in the present research were, briefly, as follows:

1. To present a complete series of illustrations of successive transverse sections of the brain. By this means we hoped to be able to furnish such a guide to the anatomy of the brain, as would facilitate the labours of future observers.

Our own investigations have made us feel how great a need there is for some work, by reference to which it would be easy to recognize the main structures in a section. We do not here forget the works of Meynert, L. G. Clarke, and others; but, though these contain numerous drawings of sections of the medulla and pons, they contain few of the corpora quadrigemina, the optic thalami, and corpus striatum, and still fewer of the cerebrum. Nor do they deal systematically with the brain of any animal. (Since this introduction was written, we have become acquainted with Forel's elaborate article on the Segmentation...
and Regio subtalamicae, see Arch. J. Leyce. 1877. pt. iii. It contains a series of drawings illustrating the structure of these regions in man.

The drawings we have given, though as yet incomplete, will, we hope, in part meet this defect. By taking a brain so small as that of the mole, we have throughout been able to represent complete sections of the brain—a point of much importance for the correct understanding of the anatomy of the organ.

2. To trace the connections of the various strands of fibres (the fibre-anatomy of the brain).

The small size of the brain of the mole makes it comparatively easy to examine with care every section. The advantage of this, in an attempt to elucidate the course of the fibres, cannot be overestimated.

3. To study the differences in the cells of different regions (the cell-anatomy of the brain).

Here again the small size of the brain enables us, within moderate limits, to obtain a comprehensive view of the cell-structure of the whole brain.
So far, the brain of any small animal would have served equally well. The choice of the mole as the subject of research was determined by considerations of anatomical-physiological interest.

In the first place, this animal is remarkable for the large size of its fore paws, and for their corresponding functional activity; and in view of the experiments of Hitzig and Ferrier, it became interesting to determine whether the cerebral areas for the fore and hind legs are of equal size, or whether they are as in the former are larger than those in the latter; and further to determine whether there is any difference in the size or number of the cells in the two areas.

Moreover, the rudimentary condition of the sense of sight, and the great acuteness of the senses of smell, touch, and hearing, miper, by causing atrophy or excessive development of certain parts, throw light on the nucleus of origin of the corresponding nerves, or on the cerebral regions in which they are represented.

It only remains to say that the research was suggested to me by Professor Rutherford, whom I cannot thank too much for the
advice and aid he has given me throughout the investigation.

Note. This Thesis is in the main the Essay I presented a year ago in competition for the Goodair Prize, in its present form, it contains a much more complete account of the literature of the subject, our own observations being in most cases supplemented by those of the most recent writers, in particular of Egas, Meynert, Stieda, Sudmann, Forel, and Huguenin.

We repeat that the subject is yet far from completed. We have left almost untouched the anatomy of the corpora quadrigemina, the crus cerebri, the medulla oblongata, the gray substance of the cerebral cavities, the origin of the nerves, &c., and have not given from such results, as we have arrived at. Our excuse for this is, that the literature of this part of the subject is very extended and difficult, including as it does the researches of Stilling, Van der Rolk, Lochner, Claude, Meynert, Dean, Debré, Kölliker, Bente, Stieda, and Flechsig; and yet, we were loath to continue our investigations.
until we had reached the limit of the knowledge of this region, mindful of the disappointment of laboriously working at a subject that some previous investigator has already fully elucidated.
Anatomical.

In the anatomical part of this thesis we shall first give a short general description (macroscopic) of the brain of the mole, and shall then describe the chief appearances presented by successive transverse and longitudinal sections. We shall afterwards turn up the special consideration of various parts of the brain, and shall indicate their relations to surrounding parts, and their connections with other parts, by means of different systems of fibres. And finally, we shall give an account of the microscopic structure of the brain, paying chief attention to the cell-differences.

This part would become too long were we to attempt to give with any fulness the results of the older anatomists. We shall therefore as a rule confine ourselves to the results of recent authors. For the more important references up to 1870, the reader may consult Meynert's Essay on the Brain of Mammals, in Biicher's Histology, Herlitz's Nervenlehre, Haid's Papers in the Zeits. f. wissensc. Zool. Bd. 18. 20. 23., also Robens 'Centroorgan des Nervensystems des Schafield...
1877, and Fritzch's "Bau des Hirns". 1878.

Until quite recently, few, followed to any extent, in investigating the anatomy of the 
encephalon, the method of which this thesis is 
an example: we mean the method of examining 
macroscopically a series of successive transver 
and longitudinal sections, and noting the 
special characteristics of each section. The 
brain of man is of course too large for 
such a method, and yet it is to this 
brain that anatomists have chiefly directed 
their attention.

Heyrovsky describes and figures isolated 
sections only, of the brains of the 
Cercopithecus, cercopithecus (one of the smaller 
quadrumanous) and the dog.

Stieda has worked a good deal at 
this method. He has published three books 
on the 'central nervous system', in the course 
of which he describes the brains of the 
long-man, of birds, of fry, and of 
mammals. His list of mammals includes the 
mouse, and the rabbit (the brains of 
which are described at considerable length), 
the dog, the cat, and the mole. His 
figures are illustrated by many diagram 
and schematic drawings.
Where so much has been attended, minuteness of description could scarcely be expected: nevertheless, Stedaeus hopes form a valuable contribution to the comparative anatomy of the brain. It would take so long to attempt any summary of his results, but we may say generally, that he has chiefly studied the posterior parts of the brain, viz. the medulla oblongata and the brain. He also comes very briefly the structure and relations of the corpora bi- or quadrigemina, the basal ganglia, and the cerebral hemispheres. In the cerebrum he pays most attention to the layering of the cortex, and to the mode of formation of the structure of that special part of it known as the cornu Ammonis. He shall notice in the course of this essay his description of the brain of the mole, and shall then indicate the more important points in which his results agree with, or differ from, our own. We may add that he gives five drawings of the brain of the mole—three representing sections through the cornu Ammonis, two, section through the medulla oblongata. Meynert mentions Belzada's microscopic investigation of transverse sections of the body of the brain,
but I have not been able to obtain further reference to them.

Forel has published two important papers on the microscopic structure of the brain: the first (1872) was on the Nuclei Thalami and the adjacent structures; the second (1877), a very elaborate article, was on the Degeneration and the Regio Subthalamica. His papers are illustrated by numerous drawings. Full abstracts of his results are given in the course of this paper.

Finally, the method of transverse sections was used by Robson, and Fritsch in their beautiful investigation into the structure of the brain of fishes.
Literature.

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Description of Drawings.

Fig. (1) represents the upper surface of the brain of the mole. We would call attention to the large size of the olfactory bulbs, to the absence of all trace of sulcus in the cerebrum, and to the peculiar shape of the cerebral hemispheres, narrow in front, and much expanded behind, especially in the postero-external region. The cerebrum of the mole presents well-marked differences from that of the rat; the former is broad and has a flattened out appearance, the latter is narrow, and more uniform in its width, and has a rounded and thickest appearance. The corpora quadrigemina are not exposed on the upper surface of the brain. The cerebellum is well developed, particularly in its transverse diameter; it is not covered by cerebrum.

Fig. (2) gives a view of the under surface of the brain. The greatly developed bulbs' olfactorios is now still better seen; its line of junction with the rest of the brain is observed to slope backwards and inwards. (a) is the olfactory tract; the convolution to its outer side we shall call the external olfactory convolution, that to its inner side the internal olfactory
convolution. The latter forms a round bulging mass. The olfactory tract is seen to end posteriorly in the tip of a convolution, which is probably to be regarded as the representation of the uncinate gyrus. This convolution is bounded on its inner side by a sulcus, which marks it off from a somewhat hollowed-out region (c). (d) represents the under and anterior portion of the hippocampus major. In the middle line, a white band is seen, running almost transversely; this is the optic commissure; the delicate optic nerves that arise very nearly at right angles from are not represented. Immediately in front of the optic commissure is the grey matter corresponding to the lamina cinerea; in this figure it has been partly torn away, and in consequence the anterior portion of the third ventricle is exposed. It is the ganglion interpedunculae of Budden. Behind the commissure are the infundibulum, the much developed corpora olfactoria, and the grey matter which receives the name of the locus perforatus ponticus, but which here forms quite a protuberance. It is the ganglion interpedunculae of Budden. The crus (d) is seen running backwards and inwards.
(c) is the fossa, behind which are the medulla oblongata and spinal cord, and to its outside the cerebellum. The most striking feature of the base of the brain is the great development of the grey matter of the third ventricle. This, we know, is continuous with the grey matter of the central cavities, and represents, in fact, the anterior portion of the cerebro-spinal axis. As we ascend in the scale of animals, we find that, pari passu, the proportion of this grey matter to the grey matter of the basal convolutions diminishes. Taking the brains of man and male as representatives of the two extremes, the difference in the relative formation of the base comes out very distinctly.

Fig. (3) is a horizontal section through the brain. (c) is the corpus callosum; (a) the caudate nucleus; on the inner side of this is the lateral ventricle, which can be traced posteriorly into the descending cornu. (d) is the fornix, the septum lucidum being seen between this and the corpus callosum. (e) is the hippocampus major, which is seen to constitute a large part of the whole cortex cerebri. Behind the fornix is the optic thalamus and third ventricle.
With regard to the cranial nerves: the olfactory, the fifth, and the seventh, are well developed; the optic and the third only developed. I have not been able to detect the fourth and sixth nerves.

As the corpora quadrigemina have a very important relation to the second, third, and fourth nerves, I examined these ganglia in the rat and the mole, and compared their dimensions in the two cases. I found that the corpora quadrigemina of the former were considerably larger than those of the latter. The difference in size was more especially seen in the posterior tubercles, which are scarcely developed at all in the mole, while they are well developed in the rat. From this it would seem that the posterior, rather than the anterior tubercles were the centres for the optic nerves, whereas just the opposite has been concluded on anatomical and experimental grounds. Meynet, however, and lately Eugenio, have stated that the optic nerve also sends fibres to the posterior tubercles of the corpora quadrigemina.

But as the corpora quadrigemina have other functions, besides that of forming a centre for the optic nerve, conclusions, drawn
from their comparative development, as to one particular function, cannot be safely accepted; and at present we merely note the fact that it is the testes of the corpora quadrigemina which have the most dwarfed appearance.

To sum up the main points in the macroscopic anatomy of the brain of the mole: the cerebrum is remarkable for the large size of the olfactory bulb, the olfactory convolutions, and the anterior commissure, the hippocampus majus, and the fornix. The anterior tubercle of the optic thalamus is particularly well developed, and that ganglion as a whole is of large size. The corpora quadrigemina, and especially the posterior tubercles, are small.

**Description of Transverse Sections.**

Fig. 4 is a section through the olfactory bulb. The outermost layer (a) is the olfactory nerve layer; within this are the stratum glomerulosum (b), the ganglionic layer, or the stratum gelatinosum of Clarke (c), and the stratum granulosum (d). There is a special layer of ganglionic cells between the stratum gelatinosum and stratum granulosum. The
innermost or medullary layer is scarcely yet seen, but the fine network of fibres in the centre of the section is immediately in front of this layer.

**Fig. 5.** Shows the medullary layer of the olfactory bulb (a), the olfactory lobe (b), the commencement of the anterior commissure, and the enlarged extremity of the olfactory ventricle.

**Fig. 6.** The cortex of the olfactory bulb has now been reduced to a strip along the inner side of the section (right in the fig.), but its medulla is seen to form a covering over the whole of the olfactory lobe. Many of the fibres of the medulla pass from both outer and inner sides to the under surface of the lobe, where they form the olfactory tract (olf. t.). The olfactory lobe (olf. l.) is now much larger; the distinction between the outermost layer of its cortex and the medulla of the olfactory bulb is well marked. The anterior commissure (a. c.) is still in immediate relation with the ventricle, which is of considerably less dimensions than in the previous section. It will be seen that at one point the anterior commissure and the olfactory bulb are in contact. The
cortex of the frontal lobe is just seen at (B). Fig. 7. The olfactory bulb is still further diminished in size. Immediately beneath it is now seen the internal olfactory mass. When this first appears, three or four rounded masses of small, very deeply stained, nuclear-like bodies are seen immersed in a fine fibrous matrix. A little more posteriorly, we have the appearances presented in the section we are examining, where (a) represents the sharply defined ground aggregations of nuclear-like cells, (b) the incomplete layer of larger and less deeply stained cells, and (c) the clusters of large, multipolar cells. This region is seen to be richly supplied with fibres from the medulla of the olfactory bulb. It also receives a few fibres from the olfactory tract of the inner root of this tract. The frontal (A) and olfactory lobes (O.L.) are separated by a layer of medulla, which is partly composed of the medulla of the olfactory bulb. The olfactory lobe now completely surrounds the anterior commissure, and cuts it off from direct communication with the bulb. The inner part of the lobe is seen to be much smaller than
Fig. 9. The last relic of the olfactory bulb is seen at (a). The cells of the olfactory lobe are no longer separated from those of the frontal lobe, though, externally, the separation of the two lobes is marked by a slight depression in the contour-line (b). But there is no difficulty in distinguishing the two lobes by the characters of the cells. Internally, the lobes are united by cells (c) having the same structural characters; and as the cells which belong to the frontal lobe in this region form the anterior part of the gyrus fomicatus (f), the connection between olfactory lobe and gyrus fomicatus is evidently very close. In the number and deep-staining of the cells (d) from a point opposite the olfactory tract to a point opposite the external junction of the frontal, and olfactory lobe, we see indications of what is afterwards a very distinct layer, coincident in extent with and related to the fibres of the external root of the olfactory tract. The anterior commissure (a.c.) is now a short distance below the ventricle; above it and to its outer side, is seen the anterior extremity of the corpus striatum (c.s.); above which
the fibres of the corpus callosum can be readily made out. Fibres of the projection system may be seen running within the corpus striatum. The change in the appearance of the internal olfactory mass (i. o. c.) will be noted. The cell layer (e) now forms a continuous zone round the multipolar cells.

**Fig. 9.** There is little to remark in this section, beyond the increase in size of the corpus striatum, and the internal olfactory mass. The latter is still separated from the anterior commissure by cells which represent the inner division of the olfactory lobe.

**Fig. 10.** The inner division of the olfactory lobe has disappeared, and the cells of the gyrus fomiticus are seen to form a well-marked group on the median surface of the hemisphere. On the outer side of the anterior commissure, two small bundles of transversely running fibres are seen; these can be traced to the external olfactory convolution, and to the anterior commissure. The internal olfactory mass extends some distance up the mesial aspect of the hemisphere. Above the cell layer (a), which is here very distinct, is seen a dark layer (b).
This chiefly consists of transversely divided fibres. Between this layer and the anterior commissure is the so-called basal region of the caput of the corpus striatum (b.o.s.). Fibres are observed to pass from this mass to the cells of the gyrus fimbriatus. The external olfactory root (e.o.o.) and the outermost cell-layer of the external olfactory convolution (e.o.e.) are well seen in this section.

Fig. 11. The caudate nucleus (a) is now for the first time clearly seen. To its outer side are the fibres of the internal capsule. It represents the anterior part of the pedunculus septi pellucidi. The longitudinal fibres which it contains may be followed superiorly into the cells of the gyrus fimbriatus, etc., inferiorly into the internal olfactory convolution (applying this term to the superficial layers of the internal olfactory mass).

Fig. 14. The two halves of the brain are united in the region of the pedunculus septi pellucidi (s). The basal ganglion forms for a short distance the inner wall of the lateral ventricle. The external root of the olfactory tract (e.o.r.) is here very thick.
At (a) between the olfactory tract and the external capsule, fibres are observed running from the external, to the internal olfactory convolution. Immediately above the corpus callosum is seen a band of transversely divided fibres, the so-called nervous Lanzieri (N. E.). (S. E.) is the septum lucidum.

Fig. 15. The corpus callosum unites the two hemispheres. The two halves of the anterior commissure have almost met; in the space between them are seen the posterior fibres of the pedunculus sephi, or, as they are better called, the precommissural fibres of the anterior pillar of the fornix (A). The base of the caudate nucleus and the septum lucidum are in contact. The three divisions of the corpus striatum are clearly indicated, viz., the caudate nucleus (a), the internal capsule, and the lenticular nucleus. To the outer side of the last is the external capsule (b). The third ventricle is seen at (c).

Fig. 16. The anterior commissure is now fully formed, its fibres crossing from one side to the other. Externally it sends fibres outwards into the external capsule, from which they pass to the external olfactory convolution. The olfactory tract is greatly
diminished in size. Above the anterior com-
missure, there is a ventricular space (v),
(part of the third ventricle), on either side
of which are fibres running downwards and
outwards; these belong to the post commis-
surral fibres of the anterior pillar of the
formic (fz).

Fig. 14. The internal olfactory convolution is
no longer seen, its place being taken by the
lamina cinerea (s.c.). The olfactory tract
has also disappeared. In this and subsequent
drawings a space has often been left between
the upper surface of the septum lucidum
and the corpus callosum. The space is,
however, so far as we know, an artificial one,
the septum lucidum and corpus callosum
being really united by a network of fine
fibres, whether nervous or connective in
nature, we cannot tell. In many of the sections
the piece of brain, septum lucidum (s. l.), bounded
above by corpus callosum, and on either side
by lateral ventricle, is separated from
the rest of the section. There is no fifth
ventricle.

Fig. 16. The cortex is divided into two regions
by the character and mode of aggregation of
the cells, especially of the second layer.
the upper or fronto-parietal region, and the
tones, or, as we may call it, the temporo-
sphenoidal region. (a) represents the second
cortical layer of the temporo-sphenoidal
lobe. The amygdaloid nucleus, a rounded
mass of darkly stained cells, is seen at (d).
Fibres of the projection system are found in
the lenticular nucleus; so that it becomes
difficult to separate it from the internal
capsule. The transversely divided fibres (c) from
what may be called either the upper part of
the crus or the lower part of the internal
capsule. The distinction between the fibres
of the crus of the crus of and the segmentum is not
very evident in the figure; but it is not
difficult to make out that the fibres of the
lower and outer part of the region (c) belong
to the crus of, those of the upper, and inner
part, to the segmentum. At (g) fibres are
seen passing outwardly from the optic
thalamus (o.t.); they are continued into the
segmental part of the internal capsule, and
leave it to join what we afterwards describe
as the upper division of the post-commissural
fibres of the fornix. The lower division of these
fibres, or the descending crus of the fornix is
seen at (f). (f) represents the anterior pillar
of the fornix; the fibres that cross from one side to the other form the lyre. The anterior extremity of the optic thalamus (a.t.) comes into view in this section. It is separated from the optic thalamus of the opposite side by a narrow band of grey substance, (m), which expands above and below, as represented in the fig. The optic thalamus proper has a much darker appearance than the grey mass just mentioned. (v) is the third ventricle; (o.c.) the optic chiasma.

Fig. 19. In this figure we would call attention to the fornix with its fibres, some running transversely, others longitudinally, to the diminished size of the septum lucidum (s.l.), to the absence of the band (m) of the previous figure, the optic thalamus being now united by the middle or grey commissure. Further, to the well-marked eructa (ca), to the now transversely divided descending crus of the fornix (fr), to the line of demarcation that has shown itself between the crus and the lower and inner part of the cerebrum, and to the first appearance of cells (a), which we shall afterwards see to belong to the hippocampal region.

Fig. 20. The space (m), which bounds the anterior surface of the rolled-in hippocampus, the decrease in the number of fibres that
pass from the cerebrum to the crus, (these present are mainly derived from the optic thalami, and merely traverse the corpus striatum), the increased size of the optic thalami, the absence of the septum lucidum, and the appearance of the anterior part of the upper hippocampus (v'), are the main things to be noticed in Fig. 20. (vab) is the ganglion habenulae; above it is the upper part of the third ventricle (v').

Fig. 21. This section shows us how large a part of the whole cerebrum the hippocampus forms. The upper and lower portions of the hippocampus are represented in this and the following drawings by k' and k. The commissures of the hippocampus (lyra) is much thinner than it was further forwards. The descending cornu of the lateral ventricle is seen at (b), bounded above by the medulla of the cerebrum proper, below by the medulla of the hippocampus. The inner limit of the ventricle, in this and other figures, is not represented, as there was always an artificial split in the sections between the lyre and the corpus callosum. For a description of the cornu ammonis, we refer the reader to page 71. The corpora mammillaria are shown at (c.m.); fibre
of the fornix are observed running from then upwards and outwards. (e') is the diverticulum of the third ventricle, which leads through the infundibulum to the cavity of the pituitary body. (a) are fibres running along the outer border of the optic thalamos upwards and inwards. The difference between the outer and inner portions of the ganglion habenulae is well marked.

**Fig. 22.** The outer division of the ganglion habenulae has disappeared; from its inner division fibres are observed running downwards and outwards.

**Fig. 23.** There is a considerable falling off in the size of the ganglion habenulae; the fibres that, in the previous section, were seen issuing from it, are now at some distance from it (f). The depth of the optic thalamos is less; it is run outwards as if were by the increased development of the tegmentum. The lower division of the third ventricle is at a higher level than in the previous figure. Fibres, running transversely, are observed on either side above the corpora mammillaria (c.m.), as yet they do not meet in the middle line. In this and other figures, the upper division of the third ventricle and the enclosed choroid plexus are very imperfectly represented. This
is due to the fact that in the sections of this region, the ventricle was destroyed by the separation of the thalamus and areas from the cerebral hemispheres. (a) represents longitudinal bundles of fibres continued backwards into the substantia reticularis.

Fig. 24. For the first time the anterior tubercles (named) of the corpora quadrigemina (c.b.) come into view, the optic thalamus being displaced outwards; the demarcation between the two is indicated by the slight furrow in the outline. (p.c) is the posterior commissure; above it is the pineal gland, connected with which on either side is the peduncle of the pineal gland, or the so-called ganglion habenula. The fibres (f) are now considerably nearer the base of the brain. The transversely running fibres, noticed in the previous section, have now met in the middle line below the third ventricle. These fibres and their equivalents are to be seen in sections down to fig. 32, arising from the inner part of the tegmentum. The change in the form and size of the upper and lower divisions of the third ventricle, and the lesser thickness of the grey commissure, are to be noted.

Fig. 25. (c) is the corpus geniculatum externum.
Since writing this, I have become acquainted with Förel's paper. In it (c) is called the corpus geniculatum internum. The corpus geniculatum externum is a small collection of grey matter at (d), fig. 22.
I am not certain whether (c) should be regarded as pulvinar or corpus geniculatum externum. But from its structure being different from that of the optic thalami, and from the fact that in the carnivora the pulvinar is almost entirely absent and the corpus geniculatum externum enormously developed, the latter view is probably correct. (s) is theSyndesmous of Sylvius, around which is seen the grey substance of the central cavities. (ca) is the crus laterale, (t) the tegmentum, and (m), between the two, the substantia nigra. (g) is a ganglion corresponding in position to the locus perforatus posterior of man; into it the fibres (f) of the previous section can be traced.

Fig. 26. Above the arching transverse fibres of the corpora quadrigemina (fillet), are seen others running longitudinally (c).

Fig. 28 is the last section in which the corpus geniculatum externum is seen. The following figures show the various forms of the Sylvian fissure as it widens out to open below into the fourth ventricle. In figs. 28 and 29, many of the fibres of the superior cerebellar peduncles (Bainearm) are observed to descend in the middle line. The ganglion (g) in which we have seen the fibres from the
ganglion lamellaceae end, is not covered by fibres of the pons (f).

Fig. 30. At (5.2) are seen fibres of the filament (that coming from the nates). These form the superficial lamina (oberflächliches schleifenzellblatt) of German writers.

Fig. 32 represents a section through the lower part of the testis of the corpora quadrigemina. (a) is the ganglion of the testis; (5.2) the superficial lamina, or that part of the filament which comes from the nates; (5.1) the deep lamina, or that part which arises from the testis. The fibres of the latter are seen to decussate in the middle line with fibres from the corresponding lamina of the opposite side. The fibres of the superficial lamina are in part cut longitudinally, as they form the outer border of the segmentum, and in part transversely (5.1), as they overlie the pons. Above (5.2)' are fibres running transversely (fibres of the deep lamina); (a) is the crusta, bounded above and below and also penetrated by fibres of the middle cerebellar peduncle (Brückenwurme); to the whole structure the name pons (f) is applicable. Cells are found in great numbers among the fibres of the crus cerebelli. (b) is the posterior longitudinal fasciculus.
(3) is the superior cerebellar peduncle (Cauda).

Fig. 33 is from a section through the upper part of the medulla oblongata. Patches of the epithelium, lining the floor of the fourth ventricle, are shown in two places. (3) is the superior cerebellar peduncle, (4) the middle cerebellar peduncle, (c. a. n.) the floor part of the anterior auditory nucleus, (5) the ascending root of the sensory portion of the fifth nerve. It will be observed that the transversely divided fibres of the root are arranged in the form of a crescent, in the hollow of which is the substantia gelatinosa (o.9.) The fibres (5) immediately to the inner side of the substantia gelatinosa constitute the motor root of the fifth; they are pushed inwards by the great development of the ascending root and substantia gelatinosa. The motor nucleus of the fifth is at (c). (7) is the facial division of the seventh nerve, soon after its entrance to the medulla oblongata. It is joined on its outer side by fibres which I think belong to the fifth nerve, with which some of its own fibres (7, 11) pass to the middle line; most of them, however, change their direction and run backwards, as is just indicated in the drawing. (p.5) is the anterior pyramid, (c. x.) the stratum
zonale. The cell-aggregations at (3), etc., we shall notice more particularly at a latter part of this paper.

Fig. 36 is from a section through the medulla oblongata at the level of the auditory nerve. (a.a.w) is the anterior auditory nucleus; (c.n) the outer division of the inferior cerebellar peduncle (corpus restiforme), from which radiating fibres pass to the cerebellum; (b) is the superior cerebellar peduncle; the fibres running downward from it are the fibres of the inner division of the inferior cerebellar peduncle (funiculus cuneatus and gracilis). (5) is the crescent-shaped ascending root of the fifth nerve. The auditory nerve (a.a.) is seen entering the medulla between the restiform body and the root of the fifth. (c.a.w) is the external auditory nucleus. Below the superior cerebellar peduncle are seen a few large vesicular cells, similar to those found in the corpora quadrigemina and upper part of the medulla, and generally regarded as one of the nuclei of origin of the fifth nerve. The facial nerve is seen at (3); above it is a cluster of small cells. (3) is the anterior pyramid; behind it are transversely running fibres, connecting the two halves of the medulla. (5.%) is the trunca zonale. There is a group of cells at (o).
Fig. 39 is from a section a little further back than the previous one. The cerebellum and medulla are almost completely separated from one another. (6) is the upper or upper root of the auditory nerve, (c.r.) the corpus restiforme, (f.) the funiculus cuneatus, and gracilis, (5, 2,) the stratum zonalis.

Figs. 37-40 represent the appearances presented by successive sections through the medulla of the cerebellum. They will be described particularly at a later period.

Fig. 41 (unfinished). (p.y.) anterior pyramid; (6, 2) stratum zonalis; (4) cells of origin of seventh (facial) nerve; (5) ascending root of fifth nerve; (5, 9) substantia gelatinosa, in which are bundles of transversely running fibres; (9) glossopharyngeal nerve; (c.r.) corpus restiforme.

Fig. 42. p.y., 5, z, s.g., c.r., 5', are the same as in fig. 41. (f.) represents the funiculus gracilis and cuneatus, (f.a.) the fibres arcuate, (b) the vague nerve, (m.f.) the motor field of Meynert. In the floor of the fourth ventricle are seen three or four clusters of cells (their relations to the various nerve roots are unknown to me).

(r) is the raphe. We would further call attention to the cells (a) in the region of the restiform body, to the very large multipolar cells that
are scattered among the bundles of the motor-field, to the small cells at (a), and to the group of cells (b) which corresponds in position to the olivary body of man. In this and the following figures, transversely running fibres (fibre arcuatae) ought to have been represented intervening the bundles of the motor-fields.

Fig. 423 is from a section of the lower part of the medulla. (c. c) is the upper part of the central canal, surrounded by grey matter, in which lie nerve-nuclei. Above the canal fibres are seen passing from one side of the medulla to the other. The anterior pyramid is altered in shape, and its fibres are beginning to decussate with those of the pyramid of the opposite side. To the outer side of the pyramid, between it and the bundles of the motor-field, a comparatively clear space is seen, where there are small cells and transversely running fibres. (m.f.) is the motor-field, having at its base a nucleus of large multipolar cells. (o) is the vagus (or the upper strands of the accessory). In the region of the substantia gelatinosa there are now only a few bundles of transversely divided fibres; the cellular element is strongly represented.
Description of Longitudinal Sections.

Our chief object in giving figs. 44-52 is to illustrate the mode of formation of the hippocampus major. But instead of describing the appearances of successive longitudinal sections of the region at present, we shall find it convenient to consider them at a later part of the paper, when we can compare them more readily with the appearances presented by a series of transverse sections. The sections we have figured are at too great a distance from the medial plane to be very instructive, so far as the general anatomy of the brain is concerned. It will be sufficient, therefore, to give references to two of them (figs. 44 and 47); after which, the rest will be easily understood. It will be noticed that, in several of the sections, the fore part of the under surface of the brain is incomplete.

1. f) is the frontal region, (c) the occipital region, (l) the olfactory bulb, (o. l) olfactory lobe, (i. o. c) the internal olfactory region, (o) the region of the amygdaloid ponsygdala, (e. s) corpus striatum, (e. n) caudate nucleus, (i. c) internal capsule, (l) lateral ventricle, (o. t) optic thalamus, (e. c) corpus callosum, (f) fornix, (c) crus.
Connections of the Olfactory Bulb.

We have seen that the inner fibers of the olfactory bulb form a coating over the entire external surface of the olfactory lobe. From every part of this external layer, fibers pass inwards to the cells of the olfactory lobe. The layer is not, however, of the same thickness in every part; its thickness is greatest at a point on the under surface of the lobe, where, by the convergence of fibers from all parts of the olfactory bulb, the olfactory tract is formed. It will be convenient to describe the fibers on the outer side of the tract as the outer, and those on the inner side as the inner olfactory root.

Outer Root. The outer root gives branches inwards to the external olfactory convolution. The external processes of the cortical cells of this convolution are exceedingly well marked, and contrast in this respect with the corresponding cells of the fronto-parietal region. On the inner border of the olfactory tract and outer root, there are large isolated multipolar cells. Further backwards, and to the outer side of the slight furrow (fig. 2),...
the olfactory tract rapidly diminishes in size by giving off in great abundances fibres that pass outwards to be distributed to what seems to correspond to the tip of the temporo-sphenoidal lobe.

The further connections of these regions, so far as we have been able to make out, are as follows:—The lower portions (at least) of the external olfactory convolution and of the temporo-sphenoidal lobe of the two sides are connected by fibres of the anterior commissure. Immediately above the olfactory tract, and between it and the external capsule (see fig. 14) fibres are observed to pass from the external to the internal olfactory convolution; the cells which are here elongated, have their long axes parallel to the fibres; we are ignorant of the further course of these fibres. The upper portions of the same convolutions receive association fibres, and to a less extent perhaps callosal fibres, from the fronto-parietal part of the brain.

Inner Root. Branches arise:—(1) from the gyrus fimbriatus directly. The mode of origin thus described will be understood by reference to fig. 5. It will then be seen that the cells of the gyrus fimbriatus and the inner-
most cells of the olfactory lobe form an
undivided mass. The space in contains
fibres from the olfactory bulb, the most
posterior portion of which has just dis-
appeared; and these fibres are distributed
to the gyrus fonicusus as well as to the
olfactory lobe. (2) From the internal olfactory
convolution. This is the great origin of the
damn root. Very many of the fibres issuing
from the olfactory bulb (fig. 9) immedi-
ately lose themselves amid the nucleated
masses that give this region its characteris-
appearance; but more posteriorly, fibres from
the olfactory tract pass inwards and are
distributed to the same convolution, now,
however, to its outer surface; so that it is
apparently quite enveloped by fibres from
the olfactory bulb. We cannot describe
the intimate relations of the fibres to the
various cells that are found in this region, but
it is important to observe that large
multipolar cells are found imbedded in
transversely divided fibres. It seems
probable that in these cells and fibres
the olfactory fibres end, after they have been
interrupted by the smaller cells that are
found in this region.
The further connections of the internal olfactory convolution are very difficult to make out satisfactorily. In our opinion they are as follows:

1. With the external olfactory convolution (already described).
2. With the lateral region of the caput of the corpus striatum. (We adopt here Meynert's name for the ganglionic mass that lies immediately above the internal olfactory convolution, between it and the anterior commissure.) Some of these fibres seem to pass into the anterior commissure, others pass by the inner side of the commissure to the cells of the gyrus forniciatus; but whether they belong to the internal olfactory convolution we are unable to say.
3. With the pedunculus septi lucidi, and with the septum lucidum itself. Fibres run inwards towards the middle line, and then curve upwards (fig. 14) to form the pedunculus septi. They are here interrupted in their course by large multipolar cells. Though the fibres of the two sides are adjacent, they merely run parallel to one another; they do not cross from one.
side to the other. Nevertheless, processes of cells may be distinctly seen to pass from one side to the other, so that probably a commissure of fine nerve fibres processes exists. The only indication of a septum is the presence of bloodvessels in the mesial plane.

On continuing to trace the fibres of the peduncul septi, we find that anteriorly some of the fibres are in connection with the cells of the gyrus fimbriatus, while others seem to be continuous with the fibres of the nucleus lanceolatus, that arch downwards and inwards, separated from the lateral ventricle by the corpus callosum.

Further back, the fibres, forming in part what is usually described as the pre-commissural division of the anterior pillar of the fornix, pass into the interior portion of the septum lucidum. (See fig. 14, where the outermost fibres are seen curving round the ganglionic mass, i.e., the basal region of the caudal part of the corpus striatum). The anterior part of the septum lucidum, bounded above by the corpus callosum, and on either side by the lateral ventricles, contains numerous
The anterior commissure are in contact with the innermost layer of the bulb, i.e., with the commencing olfactory tract (see fig. 5). We are unable to say definitely whether the anterior commissure receives fibres from the bulb in the way or not, but our opinion is that it does.
cells, small and rounded as a rule, but larger and multipolar in some parts, e.g., especially in the superior and external angle of the space. With these various cells the fibres probably communicate.

A little further back, fibres from the anterior portion of the septum lucidum are joined by the post-commissural branch of the anterior pillars of the fornix, and with it they run backwards to the hippocampus major.

Lastly, I think it very likely, though I have not been able definitely to make it out, that fibres pass directly into the crusta. We have already called attention to the transversely divided bundles of fibres that are found just above the internal olfactory convolution. As we trace these posteriorly, we lose them in the bundles of the crusta.

We have only to mention one more source of origin of the fibres of the olfactory bulb, and that an uncertain one, viz., directly from the anterior commissure. At the anterior extremity of the olfactory lobe, the fibres of
Literature.

According to Luys, the external olfactory root arises from the olfactory ganglion, the middle root from the olfactory ganglion of the opposite side, and the internal root from a collection of grey matter on the opposite side that is continuous with the grey matter of the central cavity. The olfactory ganglion is situated at the tip of the temporal-ethmoidal lobe and evidently corresponds to the amygdala of anatomists. In a drawing that is given of the brain of the male, what we have described as the internal olfactory convolution is figured as the olfactory ganglion, in other words as the homologue of the amygdala. We cannot accept this view, for as we have already pointed out the group of cells (d) in fig. (18) is the natural homologue of the amygdala. The development of the olfactory ganglion rests here with that of the olfactory nerve.

Meynert. In his article on the brain of mammals in Strick's Histology, Meynert does not give a very clear description of
the connections of the bulb. One of its connections however is with the occipital and temporal lobes, of the opposite sides, by the fibres of the anterior commissure, the anterior commissure being thus connected with the optic, chiasma. A case recorded by Mink would seem to favour the same view: the right olfactory tract and the left parietal, occipital, and temporoo-occipital lobes, including the tip of the uncinate gyrus, were coincidently atrophic; the left frontal convolution was relatively well developed.

Yalden. Yalden's anatomical investigations have convinced him that in the rabbit the fibres of the olfactory tract are distributed only to the cortex of the lobus pyriformis; most of them to that part lying external to the tracts, very few to the internal portion. Nevertheless the lobus pyriformis is not to be regarded simply as an olfactory organ. Even its outer layer (with which the olfactory tract is more especially connected), especially under extraordinary conditions, may have its activity, called forth by other senses. In the mole rat, the mole, and the hedgehog, the lobus pyriformis and
"ganglion olfactori" (L. et al.) reach an extraordinary development. Gudden objects to the term 'ganglion olfactori', as comparatively few olfactory fibres are distributed to this part designated. He admits however that this development was parallel with that of the olfactory bulb. Gudden was unable to find evidence of the decussation of the olfactory filaments in the anterior commissure.

He supplemented his anatomical investigation by experiments on young rabbits: e.g. he destroyed the olfactory nerves or olfactory bulbs, and examined the condition of the brain after a lapse of 6 or 7 weeks. As the result of these experiments, he came to the following conclusions: 1) the olfactory bulbs are connected with the hemispheres by the olfactory tracts, and by these alone; 2) the olfactory tracts are distributed to the lateral or of the lobo hypoformis; 3) the cortical layers of the lobo hypoformis are connected by the fibres of the anterior commissure; and lastly, no fibres pass directly from the bulb to the anterior commissure, nor is there in the latter any appearance of a true chiasma.

Huguenin. Huguenin thinks that the
distribution of the olfactory tract varies a good deal in different animals. In the
hare it disappears in the cortex of the uncinate gyrus: whether it is connected with
the amygdala he cannot say. In the dog
it terminates in the uncinate gyrus and
the frontal end of the gyrus fomicatus.
In man, it is connected by the external
roor nith the gyrus uncinateus, by the
middle roor with the caudus of the corpus
striatum (Meynert), and by the internal
roor with the frontal portion of the gyrus
fomicatus. The course of the middle roor
otueiusi regards as unsettled yet.
He holds that the olfactory bulb and lobe
are quite independent of one another, the
former alone having to do with olfaction. In
support of this, he quotes Sondens observation
that, after extirpation of an olfactory bulb,
the fibres which run from the cortex of the
olfactory lobe to the commissure remain quite
intact and unaltered. Besides, he has not
been able clearly to make out the passage
of those fibres of the olfactory tract into the
olfactory lobe's lobe.
Janser. In a paper on the anterior
commissure of mammals, contributed to the
last number of the Arch. J. Psych., Ganser
gives the connections of the bulb, as made
our in the rabbit. By the olfactory tract it is
connected with the cortex of the lobe pyr-
iformis (lobe olfactorius), to which it gives
off branches along its whole course. The
author has not however been able to demon-
strate the connection of the olfactory fiber with
the cells of the cortex. And he notes that
the olfactory tract may be completely abort-
ised, and yet there be no satisfactorily or decrea-
in the number of the cells of the lobe pyr-
iformis. But this may be due to the insuffi-
ciency of the association or commissural fibers.
A small portion only of the olfactory tract
is distributed to the tip of the lateral olfac-
tory lobe: the homologue of this in man and
monkeys is the external olfactory root. The
external olfactory root does not give the
cortex to pass to the amygdala, as keys
describes: it is distributed simply to the
cortex of the gyrus unciniatus and has
quite disappeared before the plane of the
amygdala is reached.
Ganser differs from Fudden and most other
authors, in regarding the anterior olfactor
part of the anterior commissura as composed
of commissural fibres unifying the two olfactory bulbs. He was led to this conclusion by finding the olfactory part of the commissure on both sides quite abolished after destruction of the olfactory bulb. A bundle of fibres belonging to the internal capsule is very easy to be mistaken for the anterior commissure after the operation, owing to an allusion in its position. Whether the bulb receives association fibres from the hemisphere, Gaser is unable to state with certainty, but he thinks it very probable that it does. Fritsch. Fritsch's researches on the brain of fishes seem to support Meynert's view of an olfactory chiasma. For they show that a portion of the internal root of the olfactory nerve joins the anterior commissure and crosses to the opposite side.

Ferrier. Ferrier's experiments show that destructive lesions of the temporal-ethmoidal lobe on one side cause loss of smell in the nostril of the same side. In a few cases, too, there have been noticed left-sided anosmia with aphasia and right hemiplegia (see Ferrier's 'Relations of the Brain'). These last facts as far as they go oppose the idea of an olfactory chiasma.
Olfactory Lobe.

The olfactory lobe is best seen in sections through the posterior part of the bulb, as in Fig. 6, where it is seen surrounded by the bulb. It forms a considerable mass on all sides of the ventricular cavity. Further back, the inner part gradually diminishes in size as the caput of the corpus striatum and its basal mass come into view. (The olfactory ventricles can be traced posteriorly into the anterior cornu of the lateral ventricle; it swells out and forms a more expanded cavity for the anterior extent of the olfactory lobe.) In Fig. 6, the frontal lobe is first appearing; in Fig. 7, it is present, but is distinct from the olfactory lobe. In Fig. 8, the two lobes are distinct externally, but are fused internally; the cells of I and C, representing respectively the gyrus fimbriatus and the inner part of the olfactory lobe. In Fig. 9, the cells C are disappearing, and the ganglionic mass (B) is becoming more prominent; at this stage the olfactory lobe is almost entirely represented by its outer part. In Fig. 10, there is seen a great development of the parts.
In order of a better nomenclature, we shall apply the term 'olfactory lobe' only to that part, where the ventricle is entirely surrounded by the cells of the lobe (Figs. 3-9); the part behind this, we shall call the external olfactory convolution (Figs. 10-16).
between the anterior commissures, and the base of the brain, especially of the part (B. c. 2)
(we shall describe this region more particularly afterwards; see p. 87). In the following
figures, the olfactory lobe, or as we have called it, the external olfactory convolution
is easily recognizable. It is gradually continued into the temporo-ethmoidal lobe. The
structure of the olfactory lobe closely resembles that of the temporo-ethmoidal lobe,
of which in our opinion the former is to be considered the anterior prolongation.
Hippocrates however regards the olfactory lobe as a part of the frontal lobe. But there are several reasons why this view
should not be held. (1) The olfactory and frontal lobes are anteriorly quite distinct
from each other, and the junction of the two lobes is always well marked, except
for a short distance in the neighborhood
of the gyrus fimbriatus. (2) New transverse
commissural fibers are obtained from different
sources (e.g. anterior commissure and corpus
callousum). (3) The structure of the frontal
and olfactory lobes differs widely. On the
other hand, the olfactory lobe is continued
backwards into the temporo-ethmoidal lobe.
without any evident change, the structure of
the two lobes is very closely allied, and
they have similar relations with the tracts
olfactorius and the anterior commissure.
Hippocampus, Hippocampus sums up what is known
of the connections of the lobus olfactorius
as follows: It is connected with (1) the
corpus striatum of the same side by
fibres representing the corona radiata; (2) the
lobe of the opposite side by the fibres of
the anterior commissure; (3) the medulla
of the semicircular gyrius and the subiculum
of the hippocampus major by the external
olfactory convolution; (4) the claustrium
(ventromedial), also by the external olfactory
convolution; also (5) the medulla of the
frontal portion of the gyrus fomicus by
the internal olfactory convolution; and (6)
the medulla of the posterior part of the
 gyrus fomicus.

Gudder. Gunder states that central part
of the olfactory lobes (lob. pyriform) are
connected with one another by fibres of the
corpus callosum, and describes associa-
tion fibres passing from these lobes to the other
parts of the hemispheres.
Anterior Commissure.

The anterior commissure of the mole has in the main the form of a horse-shoe into the concavity forwards. Anteriorly its fibres are found at the very front of the olfactory lobe; indeed, at this point they are already so numerous, that this is one of our reasons for suspecting that some of the fibres arise directly from the olfactory bulb. In their passage backwards, the commissure gradually increases in size, by receiving fibres from the external olfactory convolution. These form at first detached masses of transversely running fibres (see Fig. 10). The fibres can be traced outwards to the external capsule, to which they help to form, and from which they pass to the posterior part of the external olfactory convolution, and the anterior part of the tenbro-ethmoidal lobe. The other portion of the latter region, as all event is supplied by fibres from the corpus callosum. These transversely running fibres are particularly abundant at the level of the evening of the anterior commissure, and they may be easily traced into the external capsule. Fibres from the basal portion of the corpus striatum
pass into the anterior commissure; but whether they are in reality derived from the internal olfactory convolution or cannot tell.

It is difficult to say whether fibers run back-wards in sections behind the plane of the crossing of the commissure, on account of the presence of the bands and cur fibers of the ans, but it may be said with certainty that if such fibers are present, they are comparatively few in number. I have not been able to trace fibers from the anterior commissure to what is apparently the occipital lobe. No corpus callosum, alone appears to supply this region.

The relations of the anterior commissure varies, at different parts of its course. Anteriorly, it is immediately beneath the olfactory ventricle, and forms the medulla of the olfactory lobe; it is always found nearer the median than the outer aspect of the brain. Further back it is separated from the ventricle by the developing corpus striatum, though still surrounded on its outer and under sides by the cells of the olfactory lobe. Further back still, it is completely cut off from the external olfactory convolution by the development of the
corpus striatum, and from the internal
olfactory convolution by the development of
the basal mass of the substance of the corpus
striatum.

As the fibres cross from one side to the
other, they are seen to lie in a channel, the
called canal of the anterior commissure
(protocere).

Viewed comparatively, the anterior commissure
in the mole is developed in a remarkable
degree; in the midline line it is more than
twice the thickness of the corpus callosum, but
its antero-posterior extent is very limited. Its
large size is explained by the great
development of the anterior part of the
temporo-sphenoidal lobe, and of the olfac-
tory lobe, and perhaps also, of the olfactory
bulb.

Then again, the concavity of the curve is
directed forwards, while in man it is directed
backwards; this also is explained by the
development of the olfactory lobes in the
mole, and its now development in man.

According to Meyrueis, the occipital lobe
is one of the chief areas of distribution of
the anterior commissure—It may be therefore
that the small development of this or absence
in the mole of fibers running posteriorly, and the large number of these fibers in man and monkey, is to be looked upon as an indication that the occipital lobes are badly developed in the mole. A comparison of longitudinal fiber sections through the brains of the rabbit and mole shows that that part of the occipital lobe which borders the first longitudinal fissure is less developed in the mole than the rabbit. We do not wish to go yet to draw any conclusions, especially as Meynert’s account of the anatomy of the anterior commissure is not accepted by some anatomists; but the development of this portion of the occipital lobe and the condition of visual sensations offer to be remembered in connection with the fact, that Meynert and Wall Ferrer have, the one from anatomical, the other from physiological, investigation, located the origin of the optic nerve in or near the occipital lobe.

Literature.

Burdach (quoted by Gauze) followed the fibers of the commissure into the temporal-sphenoidal lobes, and the tip of the
occipital lobe, and suspected that fibres also passed into the olfactory convolution, a view previously held by Malacceine, Roland, and Cavan. It is a commissure, not a chiasma. Forel thought that its fibres run from the pretectal nucleus, optic thalamus, and olfactory nerve of one side to the cortex of the whole of the gyrus fimbriatus of the opposite side. Gratiolet regarded this anterior commissure as a true commissure, which in man connects the entire hemispheres, in apes, connected the occipital extremities only, and in other animals connects merely the olfactory lobes. Arnold states that it is a commissure uniting the anterior portions of the both inferior lobes (temporal lobes). According to Seys, it is distributed exclusively to the temporal lobes.

Meynert recognises three kinds of fibres in the anterior commissure: (1) fibres from the olfactory bulb to the occipital and lateral striate lobes of the opposite side; (2) commissural fibres, connecting together both the two olfactory lobes and (and the two hemispheres; and (3) fibres proceeding from the olfactory lobe to the
corpus striatum - of the same side. He
are thus, he remarks, "all the variations
in the course of the fibres that were
ascertained by Johann Müller to the chiasma
nervorum opticorum", and "the analogy
between olfactory lobes and retina is
rendered still more close by the presence of
an olfactory chiasma corresponding to
that of the optic nerves." Meynert makes
no distinction between the medulla of
the olfactory lobes and the olfactory
part of the anterior commissure.
Gudex distinguishes between the olfactory
division of the anterior commissure and
the medulla of the olfactory lobe.
In the rabbit the commissure may be
said to be made up of two bundles: one
beginning in the olfactory bulb, and
containing besides commissuroal fibres,
fibres that pass to the corpus striatum of
the same side (or it may be through
this ganglion to other parts of the brain),
olfactory division of the
hence it is clear the anterior commissure
is smaller just in part of the crossing
of the commissure than further forwards); the
other is composed of fibres entering the
commissure laterally from the cortex of the
lobus piriformis, and is joined by a small bundle from the external capsule, and a somewhat larger bundle coming from behind. The commissure contains no crossed fibers.

It is uncertain whether the anterius commissure simply as a commissure. Its fibers end in the lobus olfactorius and in the occipital and tentorio-ethmoidal lobes. The convolutions to which they may be traced are the uncinus gyrus, the gyrus hippocampi and fusiformis, and the first, second, and third tentorial and convolution. It is undecided whether they go to the region of the insula or not.

Gasser divides the anterius commissure into a pars olfactoria and a pars temporalis.

The pars olfactoria is readily demonstrable in most mammals, but in man and monkey it is so small that it has often been overlooked by author. It arises from the olfactory bulb, not from the olfactory lobes as generally described.

The pars temporalis is distributed solely to the temporal lobes; no trace of it is found in the occipital lobes.
Ganser believes that the anterior commissure is a commissure, and not a chiasma, basing this belief on the contention that the parsolf. and pars ten. are quite distinct from one another. In support of this view he adduces the following: 1) in horizontal sections of various brains (dog, cat, hedgehog, mole), the pars olfactoria and pars temporalis can generally be distinguished from one another. Owing to their being cut at a different angles the two parts have different shades, the parsolf. being lighter than the pars ten. 2) In an experiment on a rabbit after the method of Gudsen, the most anterior part of the hemispheres and lobus pyramidiformis (including the olfactory tract) had been removed—after death there was found no trace of the pars olfactoria on either sides, while the pars temporalis was intact on both sides. 

Fritsch An interesting light is thrown on the division of the anterior commissure by Fritsch's recent investigations into the brain of fish. Here the two divisions of the anterior commissure, instead of lying in contact, are quite separate, the greatest in the comm. interlobulares of Gottsch connec.
In concluding this part of our subject we may add an observation of Ganser.

A priori we should expect that animals with large teniro-olfactory lobes will have a large pars temporalis; an animal with small teniro-olfactory lobes, a small pars temporalis. This is not the case; however, for the size of the teniro-olfactory lobe affords scarcely any clue to the size of the pars temporalis, as the following table will show:

<table>
<thead>
<tr>
<th>Relative Volume of Proxin.</th>
<th>Relative Size of Pars Temporalis</th>
<th>Development of Temp. olf. lobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog.</td>
<td>1</td>
<td>Large</td>
</tr>
<tr>
<td>Hedgehog.</td>
<td>4/15</td>
<td>Small</td>
</tr>
<tr>
<td>Rabbit.</td>
<td>4/7</td>
<td>Small</td>
</tr>
</tbody>
</table>
Corpus Callosum.

The corpus callosum extends in the median plane from section 74 to section 124, it cannot therefore be said to be remarkably short, though this is given as the general character of the corpus callosum in the sectionum. There is no genu. At the level of section 84, the depth of the corpus callosum in the middle line is greater than at any other part, if we except the recurved sphenium. The sphenium is very much developed. As we shall afterwards see, it is identical with the lyre of the fornix. Quite posteriorly, as in section 131, the fibers of the corpus callosum over, and of its hippocampal portion, are seen to form a single band, which is soon split into two by the intervening lateral ventricles. Still further forwards, as the posterior limit of the sphenium, the fibers of the corpus callosum and the hippocampal commissures are still seen in contact, and in this relation they continue until the development of the septum lucidum separates them.
As regards the distribution of the fibers of the corpus callosum: The fibers that pass forwards to supply the anterior part of the frontal lobe are scanty, considering the amount of brain substance in this region.

Opposite the anterior extremity of the corpus callosum, the fibers curve gently upwards and inwards, and are apparently chiefly distributed to the lower part of the outer surface of the brain: the temporal lobe and the lower part of the inner surface of the hemisphere (gyrus foenalis) are very poorly, if at all, supplied with callosal fibers.

Still more posteriorly (see fig. 22, et seq.), the fibers of the corpus callosum penetrate much further outwards and downwards, and are distributed in abundance to the subjacent cortex.

Those parts of the brain that are most supplied with callosal fibers are the external surfaces of what may be called the frontal, parietal, and occipital lobes (with the exception of the tip of the frontal lobe) and the posterior portion of the base of the brain. Though the
gyrus fimbriatus is not directly supplied with callosal fibres, these may yet find their way to the gyrus through the nervous fascicles, as shortly to be described. The fibres of this corpus callosum, as they cross the middle line do not run parallel to one another, but diverge in various directions.

Touilla thought that the corpus callosum was composed of fibres arching from one crus to the other; Gratiolet, that it was composed of fibres passing from the crus of one side to the hemispheres of the opposite side. Reil, Arnold, and others looked on it as simply a commissure between the corresponding portions of the hemispheres, and this view is now generally held by anatomists. Broadbent thinks that the corpus callosum is not exclusively a hemispherical commissure, as some of its fibres seem to pass into the radiating crura. Various descriptions have been given of the mode of termination of the corpus callosum in the hemispheres. Burdach believed that its fibres were distributed to certain special convolutions. This, Meynert denies, affirming
that they are distributed to all the convolutions.

The most anterior part of the tentorium sphenoidal lobe is most sparingly supplied with calla-
osal fibers, but that it receives fibers from
the anterior commissure. Broadbent observes
that the convolutions to which the collateral
and radiating fibers go are chiefly those
along the margins of the great longitudinal
fissure and the Sylvian fissure, and
also to the ascending frontal and parietal, and the second frontal convolution.

The fibers are distributed most abundantly
to the convolutions along the margins of the
longitudinal fissure. Broadbent describes
a connection of the corpus callosum, that
so far as we are aware has not yet been
described or confirmed: it is that the fibers
on the under surface of the body of the
sphenium take a curved direction forward,
across the mass of fibers arching back
from the thalamus to the occipital region
of the hemisphere, and terminate (like a
larger proportion of them at any rate) in
the internal gray nucleus of the corpus
striatum.
Medulla of Hemisphere.

The appearances that the medulla presents in section vary a good deal with the position of the section examined, but it will be sufficient to describe two or three sections chosen so as to show the greatest divergence in structure and relations.

We may mention that the three face systems of fibres are here met with: the projection system represented by the fibres of the corona radiata, the commissural system by the corpus callosum, and the association system, according to Meynert by the axial band that underlies the gyrus fimbriatus (the nucleus tancini), and by other fibres not recited, made out in the brain of the mole.

If we examine a section above the level of the anterior commissure, the corpus callosum is seen to form on either side of the midline, a distinct band of transversely running fibres. A little further outwards, the uppermost fibres of the corpus callosum are seen to spread out and pass into a bundle composed mainly of longitudinally running fibres (the nucleus tancini); while the
remaining fibres as they pass onwards are almost immediately met by fibres from the internal capsule. Turning to the general decussation at this point, it is difficult to distinguish between callosal and projection fibres; the most internal fibres of the latter may however generally be distinguished among the callosal fibres by the obliquity of their course, as they pass downwards and forwards. Taking this distinguishing feature as our guide, we have never been able to trace fibres running from the corpus striatum of one side to the hemisphere of the opposite side. These internal fibres of the projection system intermingle with the fibres of the nerves lenticuli as they pass onwards to be distributed to the overlying cortex; some of them however alter their course and actually form part of the asial system.

Above the decussating callosal and projection systems fibres is seen the inner layer of the cortex, made up in the most part of fibres running essentially with the surface of the cortex, and of cells with their long rases in the same direction. This layer probably represents the associative system.
In a section made through the hinder portion of the corpus striatum (e.g. Fig 29), the point of emergence of the projection fibres from the internal capsule into the medulla of the hemisphere is considerably further removed from the middle line than the same point in the section just described. The nucleus lenticuli, on the contrary, is considerably nearer the middle line: so that now a wide interval separates the nucleus lenticuli and the upper and outer fibres of the internal capsule.

In a section still further back, behind the posterior limit of the corpus striatum, three layers can be recognised without any difficulty, and often a fourth is interposed. From within outwards, the layers are: (1) the transversely running fibres of the corpus callosum; (2) the a layer generally of lipar appearance, made up of oblique or longitudinal fibres, generally loosely arranged; above this layer there is further a dark compact layer (3) of transversely divided fibres in connexion anteriorly with the nucleus lenticuli, which it resembles; and (4) the deepest layer of the cortex, which
From the arrangement of the fibers and cells has a cubiform appearance. The layers mentioned under C1 seem to be especially related to the posterior fibers of the lateral capsule; for they are most developed where these fibers enter the medulla.

The various laminae appear to be mainly a magnified form of layers C1 and C2. Its relations will be understood on reference to the Jigs. Anteriorly we have traced it to cells of the gyrus fimbriatus, which are in intimate connection with fibers from the internal olfactory convolution. It is chiefly distributed however to the cortex of the tip of the frontal lobe. Posteriorly, in addition to supplying the cortex of the occipital lobe, it also sends fibers to that portion of the gyrus fimbriatus which lies on the under surface of the corpus callosum, whence they pass to the infero-campana major. The axonal band these connections we have thus shorty described, is considered by Meynert one of the most important constituents of the association system of fibers. But, though this may be its chief function, we would lay stress on
the part it bears as the conductor of the projection fibers that are destined for the upper and inner aspect of parts of the brain other than those that are immediately opposite the point of emergence of the fibers of the internal capsule.

Hüfner states that in man the longitudinal system of fibers under the gyrus prolocus (mark der Zwinge) runs backwards above the corpus callosum, turns round the splenium, and enters the gyrus ventralis terminatus in the tip of the temporo-ethmoidal lobe in the vicinity of the amygdala. Its relations to this ganglion are uncertain. It contains association fibers that connect the mesial surface of the frontal part of the brain with the tip of the temporo-ethmoidal lobe, and also fibers that connect part of the brain situated between these extremes. In mammals, the bundle receives entering fibers from the middle of the olfactory lobe, and callosal fibers pierce it as they pass forwards to the cortex. Whether it contains also fibers of the corona radiata is doubtful.

Immediately above the corpus callosum (see fig. 24 a). This band has not been represented in
all the figures) and on the outer and under surface of the cortex of the gyrus fimbriatus, there is an eithe sides a longitudinal system of fibres that reminds one of the fascial band (nervus Laciniei) just described. Posteriorly, it is continuous with the substance reticularis of the hippocampus major; anteriorly it seems gradually to lose itself in the cortex of the gyrus fimbriatus. In some sections there is an appearance as if this band and the nervus Laciniei were connected by a thin layer of transversely divided fibres. Meynert regards this band as belonging to the association system, and if this there can be little doubt; but we cannot agree with him when he describes it as losing its origin anteriorly in the inner olfactory convolution. For, as we have seen, it has ceased to exist as an independent mass long before it is near the olfactory convolution.
Hippocampus Major

The cornu ammonis or hippocampus major, we know, is formed by an involution of the Cerebrum; and keeping this in view the explanation of its structure in the Mole complicated though it be becomes comparatively easy.

In the Mole the cornu is very highly developed and the involution carried to a great extent. We shall describe at some length the appearances presented by a series of longitudinal, and transverse vertical sections.

Longitudinal Sections. In fig. (41) we see at the posterior part of the brain, and both above and below the S-like involution of the Cortex, there being formed as it were two cornua. The fornix, the pyramidal layer, and the layer of reticular substance correspond respectively to the medulla, the middle layer of the cortex, and the outermost so-called cell-less layer, of the hemispheres generally.

At the terminal part of the S we notice in addition another layer consisting of closely packed small cells, which we may term the nuclear layer and which we shall afterwards see to correspond to the small cells that form Meynert's second layer.

In a section still further removed from the middle line (fig. 45) we find that two Cornua enlarged and less widely separated from one another, and the intervening optic thalamus and crus diminished...
In fig. (46) we have got beyond the lateral limits of the optic thalamus, the nuclear layers have united, and the fornix is seen running backwards between the convoluted pyramidal layers, which it thus supplies. In fig. (48) the pyramidal layers, of what for purposes of description we have called the two Cornua, are in contact at h. Still further outwards, the Cells at this point disappearing, we find (see fig. 49) the pyramidal layer separated into two portions p and p'.

In fig. (50), the process of involution being carried still further, the fissures (a) and (a') meet and completely shut off a rounded portion from the rest of the brain. The opposite horns of the nuclear layer (see preceding fig.) have united, and enclosed the Cells (p) belonging to the pyramidal layer.

In fig. (51) we are so far from the middle line that the hippocampus is surrounded posteriorly by the ordinary cerebral cortex; and finally, a little further outwards, the included portion of the pyramidal layer disappears, and the circular outline of the nuclear layer (see previous figure) is represented by a rounded aggregation of cells.

Transverse sections. The hippocampus first makes its appearance in fig. (20) (see also fig. 19. a), where the Cells p and p', superiorly and inferiorly,
represent the anterior limits of the pyramidal layer, the cells (n), inferiorly, the nuclear layer. The two portions of the hippocampus are separated, as was also seen in the longitudinal sections, by fibres proceeding from the optic thalamiæ to the hemispheres (A' and A'). In fig (21) the two cornua, upper and lower, are well seen; each has its subiculum (s), its covering of substantia reticularis (s.r.), not represented in the drawing, its fasciculi dentata (f.d.), and its alveus (a), and between the two are interposed the fibres (F).

By the disappearance of these intervening fibres of the fornix, their place being taken by a mass of pyramidal cells, the pyramidal layers of the two cornua are united at b (fig 22).

Fig (23) shows how, by the extension of the clefts a and a' (due to a continuous process of involution) until they have met, the mass of cells just mentioned is divided, and an outer and inner lamina of pyramidal cells formed. We would remark too, that the lower nuclear layer has considerably increased in size; that inferiorly it is already beginning to have a forked appearance, and that it is surrounded on its outer side by fibres representing the substantia reticularis.

In fig (24) the forking of the lower nuclear
layer is carried much further; and within the bay thus formed are seen Cells (p) that are continuous with the Cells of the inner pyramidal layer. In fig. (25) the inner arm of the lower nuclear layer, and its corresponding substantia reticularis, have almost disappeared. In fig. (26) the upper and lower nuclear laminae have united. By the development of the inner arm of the superior nuclear layer (see fig. 27), the Cells (p), which are the representatives of the inner pyramidal layer, are completely encircled. The lower and inner part (n of prev. fig.) of the inferior nuclear layer seems to have very little to do with this result. In fig. (27) the ring of nuclear cells is completed; at its lower margin a rounded mass of cells is seen (h), which is almost separate from the main body, just described. It will have been noticed that the upper and the lower nuclear layers, and the layers of substantia reticularis that are related to them do not undergo parallel changes.

The remaining figures (28-31) show little more than the gradual diminution of the parts as the sections approach the posterior limits of the cerebrum.

It will be easy to understand from the description we have given in what way fibres are able,
even in such sections as those represented in figs. 29 and (50) to reach the inner surface of the inner pyramidal layer (p).

Having now described at some length the appearances presented by the Cornu Ammonis, we shall briefly notice the variations in its developmental condition in other animals. We would first draw attention to the enormous development of the hippocampus in the Mole as compared with Man. On comparing representations of sections of the Hippocampus of various animals (Mouse, guinea-pig, Cat, Dog, Monkey), given by Broca and Meynet, it is easy to see that in the Mole the Hippocampus is developed to an extraordinary extent. In this respect the only brain comparable with it is that of the bat, an animal which in many ways, as in the relative development of fore and hind limbs, the impaired state of the sense of sight, and the great acuteness of the senses of smell, hearing and touch, closely resembles the Mole. What the special physiological import of the great development of the Cornua in these animals is, we can do little more than guess; but several considerations render it probable that the Cornua are the sensory-motor centres.
for tactile sensation. For example, it would seem that in the Mole and the Cat, where visual sensation, and consequently the great number of reflex muscular combinations usually dependent on it, are defective; amends are made by the greater development of the sense of touch, which in these animals becomes a great determining source of reflex actions. We should therefore expect coincidentally, a great development of the cerebral centre for tactile sensation, a condition which is satisfied if the hippocampus be the sought for centre. Further the experiments of Ferrier, in which the Cornu Ammonis was destroyed, the facts of hemianesthesia, and cases of loss of tactile sensation with lesion of the hippocampal region, are all in accord with this theory. It must be admitted however that the evidence as yet is very incomplete and inconclusive. With regard to the connection of the Cornua of opposite sides — in the Mole this takes place simply by the commissural fibres of the fornix, but in the Mouse Städeli describes and figures in addition, a union in the middle line of the superior lamelle (outer layers) of the pyramidal layers, and also a union of the inferior lamelle and nuclear layers, these having previously united on either side to form one
layer. In the rabbit the cells of the outer pyramidal layer, and, for a short distance, those of the nuclear layer meet in the middle line. In the dog and cat the pyramidal layers of the two sides approximate more nearly than in the Mole, but they do not touch.
Connections of the Cornu Ammonis

We shall first describe the relations of the medulla (fornix) and afterwards those of the cortex (Substantia reticularis) of the hippocampus. We shall apply the term fornix to all the fibres of the medulla of the hippocampus, in other words to all the fibres in relation to the pyramidal layer, as well as to the fibres of the lyra and of the anterior columns of the fornix.

Fornix

The cornu Ammonis being a modified portion of the cortex, we have to look in it for fibres belonging to the projection, the commissural, and the association-systems, and these we shall now show are actually represented in it.

1) Commissural fibres. We need add little to what we have already said of the transverse fibres of the fornix, the so-called lyra or psalterium. They are first observed in section 350 where they are separated from the Corpus Callosum by the anterior pillars of the fornix and by the septum lucidum. It is very interesting to observe that in section 349, we do not see the last traces of the commissural fibres of the anterior commissure.
is very well marked. (My sections of this part of the brain are somewhat imperfect owing to their tendency to separate into pieces, mapped out by the ventricles, commissures etc.). I have not been able to make out the actual contact of the fibres of the anterior commissure and of the anterior fibres of the lyra, but I cannot say they are not in contact; at all events they are very near to each other. We thus see the close relations of the three great commissures; instead of forming three disconnected systems, they would seem to be merely different portions of one continuous system: the reflected corpus callosum forming the lyra, which again is almost traceable into the anterior commissure. **Association fibres.** We have already stated that fibres of the nervous Lancisi pass posteriorly to the under surface of the corpus callosum, and thence to the hippocampus. Other fibres of the N. Lancisi, more anteriorly, pierce the corpus callosum and so reach the upper surface of the corne; while other fibres pass from the hemisphere to the corne in the neighbourhood of the involuted part. The precommissural fibres of the anterior plicae of the fornix (see p. 41) also come under this head.
We may remark that in the fornix posteriorly there is not that distinction between fibres of the commissural and association systems, which we find in the medulla of the hemisphere, as for example the distinction between the corpus callosum and the nerve fasciculus. According to Meynert, the fornix receives fibres from the posterior parts of the gyrus fornix, which run forwards from part of the precommisural fibres of the anterior pillar of the fornix, and spread out over the lower half of the septum lucidum. He also describes (and figures in the guinea pig) fibres which arise from the inner olfactory convolution, and underlie in its whole extent the corpus callosum, the body and splenium of which they traverse to enter every part of the course of the gyrus fornix. No mention is made of the distribution of any of these fibres to the hippocampus major. The association fibres of this body are said to be derived from the nerve fasciculus by its being continuous with the substantia reticularis.

Projection fibres. The projection fibres are contained in the post-commissural fibres of the anterior pillar of the fornix. They enter the grey matter that bounds the optic...
thalamus on its antero-external surface. They are directed obliquely downwards and outwards, and may be divided into two portions, of which the lower is the more marked (see fig. 18).

(1) The lower fibres continue to descend towards the basal grey matter (lateraleminence), passing at the same time slightly backwards. They always keep to the outside of the optic thalamus. Arrived at the base, they change their course and run backwards, and are finally lost in the corpora mammillaria and the surrounding grey matter: so far they form the so-called "descending crus of the fornix". We did not make out the loop arrangement that is generally described, by which the fibres of the fornix are directly continuous with the fibres that ascend from the corpora mammillaria to the anterior tubercle of the optic thalamus. The "ascending crura of the fornix" to the fibres themselves were seen.

(2) The upper fibres run downwards and outwards to the upper part of the crus, where they pass into a bundle of fibres, which is situated to the inner side of the crus, and which represents the tegmentum. The cells at this part are very numerous. We would also describe a connection between the fornix and
the outer surface of the optic thalamus, at a region posterior to that of which we have hitherto been speaking:—Fibres, that run downwards and outwards along the margins of the optic thalamus, appear to be continuous with adjacent fibres of the fornix, which have a similar direction. Without more extended examination we would not however speak positively on this point.

Projection fibres also arise from the inner surface of the base of the caudate nucleus. These join the fornix as it lies in the deep hollow between the caudate nucleus and the optic thalamus. Their direction varies: anteriorly, they run inwards and somewhat downwards, more posteriorly they run inwards, and inwards and upwards. We cannot say whether they all arise from the corpus striatum or whether some may not arise directly from the Cereba; nor can we affirm that they all pass into the fornix, as some appear to connect the caudate nucleus with the optic thalamus.

We are inclined to regard the last named fibres (i.e. those arising from the Caudate nucleus) as the representative of the stria cornea, here much developed in comparison with its condition in Man, and united with what is ordinarily termed the fornix.
(which is also much developed), to form a single band.

We are not aware that the fibres we have described as arising directly from the tegmentum have been previously noticed. Meynert describes only fibres that arise from the corpus albicans, from which a few fibres pass into the tegmentum, but the great majority of the fibres pass to the optic thalamus. Broadbent states that the post-commissural fibres of the anterior pillar of the fornix proceed "mainly to the corpus albicans, thalamus and crus." Should our description be correct considerable light will be thrown on the relations and functions of the fornix. Heretofore the hippocampus has been supposed to receive its supply of projection fibres solely from the optic thalamus, by way of the descending crus, the corpus albicans, and the ascending crus, and from the tegmentum by a few fibres that first pass to the corpus albicans. Now apart from the unusually round method of supply, which this view supposes, it is inconceivable that so large an organ as the hippocampus in the Mole should be supplied by so few projection fibres as seem to compose the descending crus (see fig 19 for). Besides this view limits the supply of the
hippocampus to fibres from the optic thalamus (or tegmentum), whereas all other great portions of
the brain are supplied as well by fibres from
the corpus striatum (or crista). All these dif-
ficulties are resolved by the description we have
just given of the projection system of the corne.
In its fibre supply then, the hippocampus is seen
to be easily referable to the general cerebral type;
and as we shall afterwards have occasion to show
the same holds in regard to the structure of
its cortex.

Substantia reticularis

We have already pointed out that the substantia
reticularis is connected with the bundle of longitu-
dinal fibres that lie in the cortex of the gyrus
fornicatus. We think that both formations are
to be regarded simply as modifications of the
ordinary structure of the outer so-called cellless
layer of the Cortex. In other parts of the
brain, a similar development of fibres in this
outermost layer is seen but it is carried to a
less extent. (We may remark that a mo-
dification of the first layer is found at all
the points of transition from the cortex of the
hippocampus to the cortex of the general hemi-
pheric surface)
According to Meynert, the substantia reticularis of the cornu Ammonis is continued with the nervous lancioli; the substantia reticularis of the uncinate gyrius, with the superficial medulla of the external olfactory convolution. In the former case, it will be observed, that fibres in one part of their course belong to the medulla, in another, to the outer layer of the cortex; and that therefore according to this, the relative positions of the cerebral medulla and cortex are not to be looked upon as constant. We merely note this at present, as a condition of matter, which a priori we should most scarcely have expected. We need hardly remind the reader that the fibres of the substantia reticularis are generally regarded as association fibres (For a further description of the substantia reticularis, see microscopic account of hippocampus, p. 126). Our preparations show that the 'amygdaloid nucleus' is subsisted directly by fibres from the internal capsule.
Corpus striatum.

We shall describe the corpus striatum under the heads of (1) candata nucleus, (2) internal capsule, (3) lenticular nucleus, and (4) basal ganglia (the basal region of the caput of the corpus striatum of Meynert).

Candata Nucleus. The candata nucleus (c.n.) is remarkably well developed. In sections as far back as section 275° (see Fig. 20) it is still of considerable size. Anteriorly it is quite cut off from the septum lucidum by the lateral ventricle, and the anterior commissure which lies immediately below the ventricle. In Fig. (15) the grey matter of the base of the nucleus is continuous with the grey matter of the septum lucidum. Still further back, the fibres of the stria comea arise from it as already described. Fibres pass to its base from the internal capsule and to its upper part from the internal capsule and the adjoining medulla of the ceruleum.

Internal Capsule. Though the internal capsule may be described as situated between the candata and lenticular nuclei, it must not be supposed that they are
two separate ganglia: anteriorly, they form one mass. In Fig. (16) it is easy to distinguish the internal capsule (i.e.) from the lenticular nucleus (i.e.); but further back in Figs. 18-20, it is difficult to do this owing to the fact that radiating fibres are found as abundantly in the latter as in the former. The internal capsule nowhere forms a continuous fibreous band between caudate and lenticular nuclei.

Lenticular nucleus. Posteriorly the nucleus has a striate appearance, due to its being pierced by radiating fibres of the crus; anteriorly these fibres are rarely found.

Basal ganglion. We have already given the main relations of this ganglion. It is so fused with the corpus striatum, that it is difficult to define its upper and outer limits, but a line from the anterior commissure to the olfactory tract may be taken as a rough guide in this matter. The ganglion is seen in Fig. (9) separated from the anterior commissure by the cells of the internal division of the olfactory lobe. It rapidly increases in size, being in Figs. (10) and (11) quite as large as the corpus striatum. In Fig. (14), it has become smaller. More latterly
It is continuous, at one part with the septum lucidum, and is soon lost sight of as an independent structure (Fig. 16). Sections through this ganglion are so rapidly figured, that it is difficult to speak with any certainty of its comparative development in the mole. But judging from the figures of Huguenin (loc. cit. p. 106) and Stieda (loc. cit. vol. IV), it seems relatively much larger in the mole than in the dog or mouse.

Meynert regards this ganglion as the anterior recurved extremity of the corpora mammillaria—evidence of its formation which can scarcely be accepted as the true structures are anteriorly separated by the cortex of the olfactory lobe. There is little doubt however that it is allied in structure to the corpus striatum and is not a modification of the cortex. We may also safely say that it is very specially related to the olfactory nerve.

In regard to the passage of projection fibers through the corpus striatum, we have only to state that anteriorly, the fibers, chiefly arising from the vermis, are intercalated in their course through this ganglion, while
posteriorly the fibers, mainly derived from the
tegmentum, are continued uninterruptedly through
the ganglion.

For an account of the connections of the
tabula ganglia and crus with the cortex
cerebri, we refer the reader to a paper by us
on the Localisation of the Function of the
Brain (Journ. Anat. & Phys. XI. 636). We shall
merely give here an abstract of Flechsig's
recent results in regard to the anatomy of
the internal capsule of man.

Flechsig has distinguished at least three
different systems of fibers in the internal
capsule of the pes tois or full time. One
lies to the outer side of the optic thalamus
and derives its fibers chiefly from the parietal
lobe. Another lies to the inner side of
the lentilar nucleus, forming the arc of
the inner segment of the lentilar nucleus.
Its fibers spring from the lamiina medullaris
and pass downwards, in part above and
below the 'body of tegus' (see p. 111) and
in part this 'body, to reach the
regio subthalamica of Forel, The look of
the lentilar nucleus associates itself
with these fibers. A third system of fibers is
found as the hinder third of the internal
capsule; it is continued inferiorly into the outer part (from within outward) of the third quarter of the crus tæ and thence into the pyramids, anteriorly into the medulla of the central convolutions (ascending frontal and parietal convolutions). These fibers form the pyramidal tracts.

Two other groups of fibers, not yet (in full time Julius) medullated, are found. The larger group, placed in front of the pyramidal strand, passes in part to the inner half of the crus tæ; the smaller, passes into the outermost fourth of the crus tæ; its fibers can be traced inferiorly only as far as the pons.
Optic Thalamus.

We are not yet able to give a detailed description of this ganglion and its connections from our own investigations. We shall therefore merely give an account of its anatomy as set forth in the papers of recent writers. It will be convenient to state preliminarily that Burdach recognized in the optic thalamus (excluding the pulvinar) three nuclei: an internal, external, and superior nucleus. In what follows we shall use Burdach's nomenclature with the exception that we shall call his superior nucleus the anterior nucleus.

Lüys, following Arnold in the main, distinguishes four sharply circumscribed nuclei of grey matter in the optic thalamus. From before backwards they are as follows: (1) anterior, or olfactory nucleus (nuc. anterior), most developed in animals whose olfactory nerves are large; (2) middle or optic nucleus (nuc. moyen), largest in man, scarcely perceptible in the mole; (3) median or sensory nucleus (nuc. moyen médian); and (4) posterior or auditory nucleus (nuc. moyen postérieur). Some confusion has arisen from Lüys's imperfect description of the anterior nucleus in his
first work (Recherches sur le système nerveux).

Thus, as Forel points out, Meynert uses the term 'centre médian' as if it corresponded to the internal nucleus of Burdach, whereas the 'centre moyen' is the equivalent of this nucleus. (See Iconographie photographique des centres moteurs nerveux. Paris: 1873.) What is named 'centre médian', for instance, in fig. 248 of Meynert's article in Stricker's History should be 'centre moyen'. The 'couches optiques' of Luns, or the optic thalamus proper, is the equivalent to the external nucleus of Burdach: his 'centre antérieur' to Burdach's superior nucleus. Luns's chief service in this field has been to describe the relation of the 'centre médian'. It is situated between the red nucleus of the tegmentum, the 'centre moyen', and the 'couches optiques'. Meynert states that there is only partial justification for admitting the existence of special nuclei in the optic thalamus, as the whole of its grey matter really forms a continuous mass. For Meynert, account of the anatomy of the optic thalamus we refer the reader to his article in Stricker's History.

Forel, too, abandons the idea of distinct nuclei. The nuclei of the optic thalamus
run into one another in man and monkey, and in the lower mammalia no nuclei are found, or at most only a superior nucleus. Forix does not admit the separate existence of Luys' posterior nucleus, which, he says, has only been called into existence to harmonize with Luys' peculiar views of the function of the thalamus. The limits of the anterior nucleus are sharply defined in man, less so in monkey, and still less defined in the lower mammalia. The varying distinction of limitation of the nucleus depends chiefly on the varying mode of termination of the ascending rami of the fornix. The central median is bounded above and below by two laminae medullares, laterally it passes imperceptibly into the lateral nucleus.

Ford, describes the constitution and relations of the stratum reticulatum (Gitterschicht), and accounts for the apparent absence of the medulla and lower mammalia of the laminae medullares. The innermost lamina medullaris of man is not represented in other mammalia, or becomes lost in the central gray matter of the third ventricle. He names a bundle of fibers that passes inwards from
the inner border of the stratum articulatum and lies on the upper surface of the tegmentum, the lamina medullaris externa (see a in Fig. 20). It is the lamina corona of older authors. It is very constant in the mammalia, and in some of the lower forms it is the only representative of the laminae medullares. In the mole and the bat it is diffuse and badly defined. It can be identified in man. It is connected with the dorsal layers of the regio subthalamica of Forel.

*Pulvinar and Cerebrous Geniculata.*

Forel gives a full account of the comparative anatomy of the pulvinar, the most posterior ganglion of the optic thalamus. In man it is the broader part of the whole optic thalamus; in other species it is very small and narrow; in other mammals it is either quite absent (cat) or about (mole), its place being in part occupied by the corpora geniculata extrema. He describes the variations in the development and relative position of the pulvinar, corpora geniculata, and inter. in the mammalia, and points out that only in man and monkey are the corpora geniculata actually external and internal; in the cat, they are superior and inferior; in the
lower mammalia, anterior and posterior, and in the ungulata, they occupy positions intermediate between the two last named.

The corn. genic. tenuum of the mole is much smaller, relatively, than that of the mouse, the porpoise, or even the bat, while the corn. genic. tenuum, compared with that of the same animals is highly developed. In the lower mammalia, the corn. genic. tenuum has no longer a laminated structure; indeed in the cat this is already less evident than in man and monkey, and is sometimes not to be observed.

Ganglia Habenulæ.

On peduncle of the penial gland. The penial gland and its peduncle are represented in figs. 20-24, in which their general relations may be seen. There is undoubtedly a connection between the penial gland, and its so-called peduncle, but not so important as one as the same would imply. For, starting from the penial gland and tracing the peduncle forwards, we find it increasing instead of diminishing in size. Intensely diffuse spread out in the anterior tubercles of
the optic thalamus.

The ganglion habenulae gives off (see Fig. 23, etc.) from its under and inner surface a small bundle of fibres, which in their course to the base of the brain bend at first outwards, and then run downwards and inwards and slightly backwards. The fibres on either side can be followed to the ganglion g. in Fig. (25) etc., in which they disappear. Their further course is not known to me. As is shown in Fig. (29) the ganglion is cut off posteriorly from the base of the brain by the fibres of the pons. Behind this, it rapidly diminishes in size and becomes lost. Whether the fibres from ultimately pass to the tegmentum or to the underlying hyla, we are unable to say.

Maynard describes the fasciculus sinuopticus as proceeding from the ganglion habenulae in a sigmoid curve towards the red nucleus of the tegmentum, and then arching rectangually behind the substantia nigra to run downwards as the m. anterior and innermost fasciculus of the tegmentum. He states an adhesiveness may occur in the posterior commissure between it and the zona limitans of its ganglion. He states that the ganglion
The fibres Meynert describes as turning downwards to the tegmentum do not belong to the fasciculus from the ganglion habenulae; they meet this at a very acute oblique angle, and are to be found running upwards between the fasciculus and the third ventricle, and then turning afterwards to be distributed to the other part of the optic thalamus. Other fibres evidently of the same system are seen on the outer side of the fasciculus habenulae, running to the thalamus opticus.
habenulae is larger in brutes than in man. Since our own description was penned, we have read Forel's article on the anatomy of the Habenae (Arch. f. Psych. 1877. part III). We give, an abstract of his description of the ganglion habenulae and of the bundle that descends from it to the ganglion interprenunciale, or according to Meynert to the tegmentum — for which he prefers the name Meynert's bundle. Forel finds three points of difference between
the ganglion habenulae and ganglion inter-
premunculare, the two ganglia which are crossed by Meynert's bundle: The former is (1) a bilateral organ, (2) contains no dark, nestlike structure, (3) tases stains less distinctly. The cells of
the two ganglia resemble each other pretty closely. The ganglion habenulae is the nodal
point, as it were, for three sets of fibers: (1) for Meynert's bundle; (2) for the taenia thalam
toptici, Meynert's stratum zonale; (2) for the
habenula, peduncle of the thalamic gland. The
more intimate connections of these fibers with one
another in the ganglion habenulae are not yet
known; but in rodents it is probable that one
part of the taenia optica thalami is continued
into the habenula, while another part into
Meynert's bundle. The ganglion is of large size in the mouse, bat, porcupine, and mole. The peduncle of the ganglion is in relation with the descending crus of the anterior pillar of the fornix, the loop of the crus cæli, and the stratum reticulatum.

Meynert's bundle.

Forsl points out the large development of this bundle in the porcupine, and bat. Superiorly, it terminates chiefly in the cells of the ganglion habenulae. Inferiorly, it terminates more in the tegmentum, as Meynert describes, but in a collection of grey matter which lies at the base of the brain between the corpora mammillaria and thalamus, and answers to the lamina perforata postica of human anatomists. In the lower mammalia, as in the dog, mole, and bar, and in rodents, this grey matter extends into a large ganglion, the ganglion of the lam. perf. postica, or better the ganglion interpedunc. lare (Lysholm). The termination of the Meynert bundle in this ganglion was described years ago by Lysholm. Forsl describes the conformation and structure of the ganglion in various mammals.
Stieda describes, and figures a bundle at the mouse, which is evidently the same as that just described. Ventrally it is stated to arise in the substantia cinerea media (equivalent to the lam. perf. post.) ; dorsally it spreads out in the thalamus.

3. Real Commissural Systems.

At various parts of the base of the brain, fibres are observed to cross the median line and connect the two halves of the brain. Optic chiasma and commissura inferior. Thus anteriorly (fig. 18) there is the chiasma of the optic nerves, and immediately above it the commissura inferior. In the node it is impossible to distinguish between the two. But taking into account the small size of the optic nerves compared with the size of the white matter at the base of the brain (fig. 2), this would seem to rule out much more of a nature of a commissure than of an optic chiasma.

Gudron was able to demonstrate the existence of the commissura inferior, and to show its independence of the optic nerves by a series of experiments of which the following is a brief account.

In a rabbit in which the retina had been
destroyed on one side, the optic nerve of the same side was abroathed, and gray instead of white in appearance. The nerve was seen to pass completely to the opposite side. Above the optic chasms a thin, inferotriangularis was seen to be prominent, neither abroathed nor degenerated. In other experiments in which one or both eyes were removed, the cm. inferior was found un-affect ed. That the cm. inferior is independent of the optic tract is confirmed by comparative anatomy. In animals which have the sense of sight, as the mole and rat-mole, have a well marked, cm. inferior. In the pole cat, cat, and fox, the cm. inferior is distinct from the optic chasmas. The cm. inf. is essentially a thalamus commissure, a branch of it however goes to the corpora geniculata.

**Origin of optic nerves.**

We may say this point conveniently give the results we have arrived at, as regards the origin of the optic nerves, that from their rudimentary condition in the mole we do not attach much importance to their origin.
supplemented by other observations.

Two main origins may be described: (1) Directly from the lenticular nucleus, or very probably from the corticopontine chiasm. These fibers form the sustentacular strands of the projection fibers that penetrate the lenticular nucleus. They can be traced without break into the grey matter that immediately underlies the central medulla, and there is every evidence of their being continued uninterruptedly into the cerebral cortex. We may mention that in the brain of the monkey Meynert has described fibers, which, arising from the occipital lobes, pass through the more posterior part of the lenticular nucleus, and form the outermost strands of the crus and anterior pyramids. It is not improbable we think that these fibers are the same as those we have just described, as forming one of the roots of the optic tract.

(2) From the optic thalamus. Fibers pass inward between the crus and the post-nodis of the hippocampus, bend round the outer border of the former, and are distributed to the optic thalamus. This further course we have not been able to make out.
Literature.

Leyg describes three ganglia of origin for the optic tract: a) the tuber cinereum; b) the corpus geniculatum; and b) the corpus geniculatum internum. From the two latter fibers pass to the gray substance of the corpora quadri gemina (those from the corp. gen. ext. going to the infer. corp. quad., those from the corp. gen. int. to the sub. corp. quad., and to the cent. mogen or cent. d'olique Meynert. According to Meynert the optic tract derives its fibers from the pulvinar, the corpora geniculata, externum and internum, and the optic basal ganglion. This last place of origin is equivalent to Leyg's from tuber cinereum. Meynert contradicts Leyg's statement that the fibers from the optic ganglionic decussate. They are clearly non-decussating. The corpora geniculata are connected into the occipital and temporal lobes. The corp. gen. internum is further, connected into the superior and inferior ganglia of the corpora quadrigemina. The most internal fasciculi of the optic tract in part encircle the crista of the crus, in part intervene with the most external fasciculi. Then ultima
distribution is unknown.

Nieda remarks that the mode of origin of the optic tract in the mole is exactly parallel to that in the mouse, viz.: a superficial root lies on the surface of the anterior part of the corpora quadrigemina, springing from the longitudinal fibers in the upper part of the ganglion; a deep root arises from the gray substance at the limit between the corpora quadrigemina and optic thalamus. Hence the power of function of the two roots is a collection of cells homologous with the 'corpus geniculatum.'

... after extirpation of an eye, it is found, Proceeding of the superior ganglion of the corpora quadrigemina, the posterior part of the optic thalamus, and the corpora geniculata interna, of the opposite side. The corpora geniculata interna and the inferior ganglion of the corpora quadrigemina into its arm, were intact. In the former ganglia, accordingly, he places the origin of the optic nerve. He thinks that fibers also proceed from the back into the outermost bundle of the pedunculus cerebri, and thence to the central hemispheres. And yet, in rabbit and dogs, destruction of an optic nerve was never followed...
by marked difference in the cerebral hemispheres. In pigeons, however, in which both eyes have been destroyed, the hemispheres are markedly affected. Thus the relative weight of the brain in three doses of the same

blood was as follows: in uninjured dove, 1.84 gms; in dove, blind of one eye, 1.73; in dove, blind of both eyes, 1.39 gms.

Gudde concludes that in rabbits the anterior lobules of the corpora quadrigemina are the primary centres of the optic nerves; and the same probably holds good for the other mammals. The Scirrhines (Seichtörnchen) which have very large optic nerves have correct, roundish, large, corpora quadrigemina anteriores and mastens, polecat, rat, hedgehog, mole, and mole. Rat, whose eyes are little developed nor nor at all, have small cor. quad. ant. We may mention here that, after extirpation of the optic bulbs of Gudde found that tractus transversus pedunculi atrophied. Forl was able to deliver this tract in all these mammals he examined, except the mole. The tract is from the anterior border of the central tubercle of the cor. quad. to the inferior surface of the crista in the neighborhood of the place of exit from the brain of the third nerve.
Huegnerius. We may summarize Huegnerius's description of the termination of the optic fibers in man as follows:

Fibres pass to (1) stratum zonale (this is connected with the cortex by the corona radiata and inferior peduncles of optic thalamus); (2) pulvinar (connected with occipital lobe by optic radiation and mitral spine and by fibers of tegmentum); (3) corpora geniculata extrema (connected with cortex of occipital lobe by fibers of corona radiata); (4) corpus geniculatum laterale and thence to the anterior ganglion of the cor. quadrigemini. Some of the fibers terminate in the cells of the cor. geniculatum laterale; it is connected with the cortex cerebelli by fibers of the corona radiata. Huegnerius thinks that the fibers, which Meynert describes as passing by the arm of the inferior ganglion of the cor. quadrigemini to this ganglion belong not to the optic tract, but to the tegmentum. (We believe that Huegnerius has referred to Meynert's description, Cereb. J., 1841.)

The eye's brain presents great similarity to man's in the distribution and development of the optic roots and ganglia. In the brain of common mammals the cor. genic. later. reach an extraordinary size, and the cor. genic. interna are considerably
For the same reason he cannot accept Meyen's teaching that the other Jibes are
ad distribut to the ref. corp. loading.
developed. In the sheep and horse, too, their 
ganglia are relatively well developed. On the 
other hand, the pulvinar is rudimentary in 
carnivora and in the sheep and horse is absent.
These changes are still more marked in the 
lower mammals. In the carnivora, fibers of 
the optic tract, can be traced to the 

eventual zone of the thalamus, the thalamus 
itself, the corh. genic. extrems, the corh. genic. 
terneum (to this very few fibers go), and the 

termin ganglion of the corh. fudafjenica.

Now fibers proceed to the last named ganglia 

forel agrees with gylder that the optic 

nerves are distributed to the superior corh. 

med., the corh. genic. extrems, and habenar 

part of the thalamus, because (1) after 

destruction of the eyes or is these parts that are 

atrophied, the corh. genic. intern. and inferior 

corh. quadrig. remaining intact, and (2) in 

the mole where the eyes are scarcely developed 

their same parts are dwarfed, while the 

corh. genic. intern. and inf. corh. quadrig. with 

its arm are well developed. The corh. genic. 
terneum of the mole is much smaller, the corh. 

genic. internum, considerably larger, relatively, 

than the same ganglia in the mouse, boarzine, 

and even the cat. The corpus optimun of birds
is equivalent to the subjacent layer, and that, in the experimental conditions, as Lysaght has found out, the column supports Stedman's statements that the optic fibres proceed to the subjacent medullary lamina of the anterior ganglion of the corpora amylacea. The connexion may be easily traced anatomically, but it is confirmed by the fact that in the mole, where the optic nucleus is wanting, the subjacent medullary lamina is also wanting. The layer of grey matter that generally covers this surface of the lamina is also wanting. Ford has been unable to determine whether the optic fibres go to the subjacent medullary lamina of the same side only, or cross to the opposite. Physiological experiments support the former view. Even if there be a crossing, it can only be a partial one, as the fibres that appear to cross are not very numerous, and Stilling's is a preliminary communication to the Centralblatt, 1878, no. 22. Stilling describes a new origin of the optic nerve. He states that a considerable number of optic fibres arise from a large almond-shaped nucleus in the crusta alba plane lower than the substantia nigra. Are there any fibres that according to Burdach are connected with the substantia nigra?}
to resume the consideration of the basal
commissures—Some distance behind the
commissure (see Fig. 24) the tegmenta
are connected by fibers which cross the middle
line between the corpus mamillaris and
the lower part of the third ventricle. It is
difficult to know whether these fibers are
crossing, decussating fibers, or merely commissiornal,
linking together the cells of the tegmenta.
Certainly, some of the fibers have the latter
function, for they may be traced, arching
round the convex border of the corpus allatii,
from the cells that are situated between it
and the crus.
The system of the median transverse fibers
can be followed, constantly increasing in
importance with the increased size of the
tegmentum, continuously backwards as far
as the lower part of the tegmenta, where the
fibers of the superior cerebellar peduncles
decussate.

Meynert describes a commissure situated in
the tuber cinereum immediately behind the
basal optic ganglion. Its fibers turn backwards
within the central gray substance of the third
ventricle, but their ultimate destination is unknown.
Forel has found this commissure in the cat, cow, and porpoise. It can be traced outward between the optic tracts and the loop of the lenticular nucleus to the substantia innominata in whose fibres it is lost. In the mole he has not been able to detect it, owing perhaps to the smallness of the animal and the fineness of the fibres.

Schröpfhagen describes a commissure which is apparently homologous with that just mentioned. It consists of three layers: the superior layer consists of fibres from the posterior longitudinal fasciculus; the middle layer, of fibres from Meynert's bodies; and the inferior layer, of fibres belonging to the loop of the crus cerebri.

Forel describes a bundle of fibres in the mole which seems to correspond to that we have just noticed (see p. 108). It runs transversely from one side to the other between the inferior division of the third ventricle and the anterior part of the corpora mammillaria. Some of the fibres appear to bend upwards towards the descending arms of the fornix, and the inferior part of the crus. A similar bundle is seen in the mouse. Whether it forms a commissure strictly so called, or a chiasma, is uncertain.
This bundle is represented in man by commissural fibres in the region of the lamina perforata postica, giving below the ventral division of the third ventricle.

Regio Subthalamica (Forel).

This name was proposed by Forel for a region bounded dorsally by the lamina medullaris externa and diencephalon, ventrally by the lamina perforata posterior, corpora mammillaria, substantia nigra, and crus, medially by the grey matter of the third ventricle and the two curvæ of the anterior pillar of the fornix, and laterally by the internal capsule and stratum reticulatum. Inferiorly, it is bounded by Meynert's bundle and by the red nucleus of the tegmentum; superiorly, it merges into the substantia innominata of Reil, and into the region of the lam. perfor. and the basal part of the corpus striatum. By the aid of this description it will be easy to identify this region in our frogs. (See pages 20-24. We have not distinguished between it and the tegmentum.) Forel divides this region into three layers: (1) the co. ventral, corpus nigric., (2) the
The corpus tegreii was described by Lugo under the bad name of 'bandelette accessoire de l'olive supérieure.' It is lentiform in shape, and lies on the upper surface of the upper and outer part of the crusta. It consists of a very fine network of capillaries, nerve-fibres, and cells. It gives off fibres which pass upwards above and below the cornua mammillaria into the lamina perforata, and disappearing before they reach the middle line. Other fibres pass to the crusta and the lower part of the internal capsule, cutting the coronal suture at right angles; their ultimate distribution is unknown, some apparently end in the inner segment of the lentiform nucleus. Lugo thinks the corpus receives fibres from the superior vermicular peduncle and distributes them to the laminae medullares of the lentiform nucleus, and whence they proceed to the cells of the nucleus itself. The corpus tegreii is between its mamry and monkey in the dog, rabbit, mole, and definitely localized corpus tegreii is to be seen.

Zona incerta. The connections of the zona incerta are unknown, but it probably receives fibres from the red nucleus of the tegmentum.
Corpus trigeminale, and the superior cerebellar peduncle, and also arising from the upper lamina of the fillet. Superiorly it is continuous with the stratum reticulatum. The Dorsal Layer receives from below fibers belonging to the posterior longitudinal fasciculus, the Formatio reticularis (motor field of Meynert), and the superior cerebellar peduncle and red nucleus. Above, it fibers pass to the internal capsule, the lateral cinereum, and the substantia innominata of Reid.

The Fillet.

The fibers of the superficial lamina of the Fillet (we are following Huguenin's nomenclature), as generally described, are quite distinct from the fibers of the pons, over which they lie; they are lost inferiorly in the bundles of the motor field of the oblongata. Careful examination, however, leads us to describe fibers passing from the superficial lamina of the Fillet (s. l. fig. 32) downwards into the outer part of the pons. Their further course is uncertain to us, but they must enter form part of the crusta and anterior pyramids, or pass to
the cerebellum into the fibers of the middle cerebellar peduncle.

The different names that are given to portions of the filler by authors are very confusing. Thus, the part, s. l. fig. 32, is named by Forel, Schleipenscheibe, by Meynert the superior lamina of the filler, the anterior portion of the filler, or simply the filler (Schleife), and by Huguenin the superficial lamina of the filler. The part, s. l. is named by Forel the entire Schleife, by Meynert the inferior lamina of the filler, the base of the filler, the posterior portion of the filler, or the cerebellar division of the filler, and by Huguenin the deep lamina of the filler.

In his most recent work (Meynert. op. 2) Meynert recognizes an anterior and a posterior portion of the filler. The anterior portion arises from the cornu quadrig. The posterior from the velum medull. ant. (chimébas). and so from the superior vermiform process of the cerebellum. The former is a motor, the latter a sensory bundle. The former can be traced forward to the spinal cord where it forms the
external portion of the centra l
column; the latter is continuous into the
posterior columns of the cord. (For a fuller
description of the caudal portion, see Meynert's
article in Stricker's Histology).
Forel: A Schleifenschicht.

(1) The medial bundles appear to pass into
the nucleus. Forel is uncertain whether
they really belong to the Schleifenschicht,
he favours the view that they are
identical with the pedunculus substanti
nicipitalis of Meynert.

(2) The middle or main strands lose
themselves superiority in the tegmentum.
Some of the fibres stretch toward the
pulvinar, but cannot actually be
traced into it. Others go to the
cortex on mammillaria; they are
the fibres Meynert describes, passing
from the corh. mammillaria to the
tegmentum.
Forel denies that the fibres are
distributed to the sup. corh. quad.
or to the thal. thalamus.
In the dog, and rabbit, the above
description is easily verified, except
that the medial portion cannot be seen.
(3) At the level of the red nucleus, the outer part of the Schleifer-Grund becomes distinguishable as a separate bundle, the obere Schleife. In the dog its fibers can be seen among the fibers of the \textit{corpor. genic. intum.} and the arm of the \textit{sup. corp. quad.} It also apparently receives fibers from the most dorsal part of the black medulla of the sup. corp. quad. In man, its fibers can be followed to the \textit{corpor. genic. intum.} and the gray substance of the tegmentum that lies between the \textit{pulvinar}, the \textit{corpor. genic. intum.}, and the \textit{corpus callosum}. It is quite possible therefore that it is connected with the \textit{corona radiata}, but this has not been demonstrated.

B. \textit{Untere Schleife}. This arises as two groups from the \textit{sup. corp. quad.} and the \textit{primal app.} (vol. med. ant.), and the fibers of the \textit{schleifer-schleife}, obere \textit{Schleife}, and untere \textit{Schleife} alike end in the \textit{formatio reticularis} of the \textit{tegmentum Hugreni}. The superficial lamina of the \textit{feller} is connected with the arm of the \textit{sup. corp. quad.} of the opposite side, the
deep laminae meet the arm of the inferior cord, small, of the opposite side. Inferiorly, the fibers of both laminae form part of the motor field, and in this way pass to the anterior lateral column of the cord. Both laminae are motor in function.

We shall conclude this part of our subject by noticing the attempts of Meynert to arrive at the significance, motor or sensory, of the superior and inferior laminae, by means of a determination of their breadths in various animals. Thus he found that in the baboon, the breadth of the lamina is to the breadth of the motor field as 1 to 3.4; whereas in the mole, the proportion was as 1 to 8. As the animals are approximately of the same size, and as the comparative development of the fore and hind extremities seem is demanded the same, the breadths of the motor field may be regarded as constant, and consequently we must conclude that the laminae are more developed in the baboon than in the mole. From this, seeing that the outstanding difference between the two animals is in the relative expansion of the skin, the
great peripheral end-organ of tactile sensibility, Meynert is easily led to the conclusion that the laminae are sensory structures. In his most recent work, Meynert states that the inferior lamina is subject only to the inferior being motoric above.

Further, by a similar method, Meynert has endeavoured to determine in what part of the motor field the anterior and posterior extremities are respectively represented. He found that in the male, where the anterior extremities are chiefly developed, it is the outer part of the motor field that has the larger dimensions, while in the kangaroo-rat (Dipsochironimus musculus), where the posterior extremities are chiefly developed, the inner part is the larger. From this and other considerations, he concludes that the muscles of the posterior part limbs are represented chiefly in the median and basal portions of the motor field, the muscles of the anterior limbs in the outer portions of the motor field, both ventrally and dorsally.
Microscopic structure of the Brain

The general type of the cortex cerebri. The division of the gray matter into four layers, as described by Alred in the brain of the rabbit and the mouse, is that most easy of application in the brain of the mule. There is (1) An outer layer consisting of a fibrous matrix with only a few cells embedded in it, the cell-less layer of Alred; (2) A layer of small nerve cells; (3) A layer of large nerve cells; and (4) An internal layer of small nerve cells. The first three layers correspond to the three outer layers of Meynet, the fourth layer to Meynet's fifth layer (Claustral formation). It will be noticed then that the two layers of small nerve cells are really different formations. The pyramidal form of cell predominates.

The outermost layer demands more attention than it has hitherto received. By different authors, it has been looked upon as a nervous and a non-nervous layer. It is very probable that it partakes of the nature of both. In some places as in the region of the external olfactory convolution, very large cells, undoubtedly nerve cells, are found in it.
development varies in different localities. It is greatly developed in the external olfactory convolution, in some parts of the internal olfactory convolution, in the fore part of the gyrus fimbriatus (at the point of appearance of the internal olfactory mass, fig. 8), in the hind part of the gyrus in the neighborhood of the subiculum, and in the substantia reticularis of the hippocampus major. We think too that the bundle of longitudinal fibres, that lies in the Cortex of the gyrus fimbriatus immediately over the corpus callosum (fig. 23 a), must be looked upon as belonging to the outer-most layer. In all these localities the layer is largely formed of nerve fibres, so that it probably plays some important part in the construction of the nerve-fibre scheme. The fibres probably belong to the association system. We were more concerned however in our research in determining the varieties of structure that are found in the cortex with a view to the anatomical aspect of the question of cerebral localisation of function. For the general literature of this subject we refer the reader to our Doctor of Science Graduation Thesis "The Localisation of the Functions of the Brain 1877." We therefore examined the
cells of the various regions for differences in size, in conformation, and in closeness of aggregation.
The difficulties of such an inquiry are very great, and the conclusions derived from it very liable to error. Thus, on examining a series of successive transverse sections, we must remember that the differences observed between the cells of two sections may be due to the fact that the sections have not been cut similarly, that for example the frontal and occipital lobes have been cut at a different angle from the parietal lobes. Again a difference in the thickness of sections may deceive as regards the closeness of aggregation of the cells. Further it is difficult to obtain good preparations of the brain for high-power examination. The fluids in which the brain is prepared seem to produce alterations in its structure e.g. shrinkage spaces round the cells, a peculiar pitted appearance of various parts, etc. which add to the difficulty of determining the true form of the cells.

But apart from the consideration of individual cells, it is easy to make out that certain regions differ from one another in their formation as a whole. Those regions
according to our examination of the brain of the Mole are, the olfactory bulb, the olfactory lobe and external olfactory convolution, the internal olfactory convolution, the anterior part of the gyrus fimbriatus, the hippocampus major, the anterior part of the frontal lobe, the parietal lobe and the occipital occipital lobe. (We have used the terms frontal & parietal merely to signify the anterior, middle, and posterior portions of the cerebral hemisphere) At present we can only give briefly and imperfectly our observations on this head.

*Bulbus Olfactorius.* There can be no doubt that the structure of the bulbs differs widely from that of the rest of the cerebrum. We have already named and figured its chief layers (see figs 4, 5, 53) and would now only add that in the stratum gelatinosum there may often be distinguished a broad outer zone of scattered cells, a middle almost cell less zone, and a narrow inner zone of large cells forming a compact row generally one and rarely more than two deep. Not unfrequently however this division of the layer cannot be observed. The cells of the inner zone form a very remarkable layer, and in connection with the adjoining stratum granulosum at once remind one
of the cells of Purkinje and of the granule layer of the cerebellum. Two kinds may be distinguished: rounded and elongated. They each give off a central process that can sometimes be seen to bend round and join the outer strands of the stratum granulosum. What appears like a shrinkage space, generally bounds the peripheral part of the rounded cells so that it is difficult to describe their peripheral process or processes. The elongated cells are of great size and give off peripherally a thick process which can be followed for a great distance, often nearly as far as the stratum glomerulorum. For several reasons we cannot regard the bulbs as a modified part of the cortex cerebri tho' it has been found convenient to treat of it here.

The Olfactory Lobe and External Olfactory Convolution is characterised by the great distinctness and breadth of the second layer, which is composed of small darkly stained, closely aggregated fusiform cells; their external processes are seen passing into the first layer, at the outer part of which are the fibres of the external olfactory root as already described. The Cells of the deeper layers are irregularly disposed and are less closely aggregated.

Internal Olfactory Convolution. We have already described and figured the low power appearances of this region and have seen that it differs very
markedly from the cerebral type of structure. Fig 54 gives a high power view of this region. We would call special attention to the Cells (a) which are very small, and might be thought to be connective tissue corpuscles. They are in our opinion nerve corpuscles. They give off very fine branches and apparently lie in a meshwork of nerve fibres. They resemble the granules of the cerebellum and the strata granulosae of the olfactory bulbs. In this region we see also very large multipolar nerve cells. These are not modified pyramidal cells but are comparable to the multipolar cells of the nerve nuclei and the spinal cord. The two forms of cells that have been mentioned are quite exceptional in the cerebral type, and make us hesitate to believe that the internal olfactory convolution is simply a modification of the cortex. This region attains a great development in the Mole. So far as we know this is the first time it has been figured. The only description of it we have been able to find is a very brief one by Meynert (Stricker's Histology p. 412-414.)

Gyrus fimbriatus. Anterior part. The structure of the anterior part of the gyrus fimbriatus differs from that of the neighbouring parts of the cortex, in that its cells are more numerous, more darkly stained, narrower, and more elongated. As we
have pointed out the gyrus is continuous anterolaterally with the inner part of the olfactory lobes, the cells of the two regions being similar.

**Hippocampus Major**. Sections of the hippocampus vary a good deal according to the part from which they are taken. We shall describe the appearances presented by such a section as is figured in fig. (25.) We shall reverse the usual order of description and commence with the innermost layer.

We have (1) fibres of the fornix corresponding to the medulla cerebri.

(2) A layer of ground-substance (5), in which however cells are not entirely wanting; large cells with processes directed horizontally (i.e. parallel with the fibres of fornix) are found, chiefly at the margin of layers (1) and (2), but also sometimes throughout the layer.

(3) A layer of pyramidal cells (4), the upper pyramidal lamina, consisting of modified large pyramidal cells (third layer of ordinary cortex), four or five deep. There are no small cells such as Heiden has described. I have not been able to observe their internal processes, which probably there fore break up immediately into a fine network. Nor can I say I have satisfactorily made out their lateral processes.

(4) The external or peripheral pro
cases of the pyramidal cells, just mentioned, are very long and tapering, and as they run parallel to one another for a considerable distance without branching, they give rise to a very beautiful striate appearance, whence this layer gets the name of the stratum radiatum. The fibres seem embedded in a very fine fibrous matrix, which contains besides bloodvessels numerous round, nuclear like bodies, and small (connective tissue?) cells.

5. A layer of fibres (6.5.) running at right angles to the apical processes of the pyramidal cells; in this layer cells also are found. At points opposite the nuclear layer (n), layer (5) is seemingly quite distinct from the layer we are just going to describe.

6. A layer (a) similar to the first or cellless layer of the cortex cerebri.

7. The nuclear layer which corresponds to the second layer of the ordinary cortex.

8. A layer of larger multipolar cells to the inner side of which are the Cells somewhat modified of the lower lamina of the pyramidal layer.

There are not really so many different layers; as will have been understood from our former description of the hippocampus,
the number is increased by the involution that has taken place.

The substantia reticularis, so far as we have made out, is never found to border the nuclear layer.

From the description given by Meynert of the hippocampus of Man it would seem that the Mole differs from Man in having layer (3) Parietal region. The mid or parietal region of the hemisphere is characterized by the great development of the third layer, which consists of large pyramidal cells. These are found extremely large in sections through the motor Centre for the forelimbs, and also in sections through the Centre for the hind limbs. (For determination of these centres see later) But I cannot say that these Cells are exclusively confined to the Cortex of these parts stimulation of which produced movement. They are found in regions behind and to the outer side of the Motor Centre.

After a very careful and prolonged examination of the brain with a view to the confirmation of Betz's results I had to conclude that in the Mole there was no characteristic difference between Motor and what were to us non motor areas. Nevertheless in the motor regions the pyramidal cells are certainly larger and more markedly
numerous than in the non-motor regions. I could
find no difference between the cells of the centres for
the fore, and those of the centres for the hind limbs.
I also examined the motor and non-motor areas of
the brains of a dog and cat, and can here fully
confirm Betz's statement that giant cells are found
in far greater number in the cortex that surrounds
the crucial sulcus than elsewhere. They are not
uniformly distributed, but seem to form clusters,
much as it were. I also found them in the motor
region marked G+ G in Ferri's illustration of the
Cat's brain, and elsewhere, but they were very few
in number.
For an examination of the question of motor cells
we refer the reader to the Thesis already men-
tioned.

Vesicular cells of origin of fifth nerve

We can only further take up the consideration of
the large vesicular cells of the Corpora quadrig-
emina. They are found in the outer part of
the grey matter of the aqueduct of Sylvius as
far forwards as the mutes. They are in clusters
of two or three or more. They are never found
in the grey matter that immediately underlies
the aqueduct of Sylvius but may occupy any
other part of the outer circle of the Central
grey matter. They are most abundant on the outer and under side of the aqueduct. They may be traced downwards as far as section 22 where they lie to the outer side of the fourth ventricle; they are found here in very great number forming indeed the largest collection of cells in this part of the brain. I have also found them in the medulla cerebelli which overhangs the fourth ventricle. There can be little doubt that these cells are found in all mammals. Steedman describes them in the dog, cat, rabbit, and mouse, and Henle, Turner, and other anatomists have figured them in man. It is more interesting to enquire if they are represented in birds, reptiles &c. Steedman, in his account of the brain of birds, describes three groups of cells between the pars peduncularis and the lobe opticus. The middle group was composed of round or spindle-shaped cells of about 0.38 mm. in diameter, interwoven by nerve fibres passing in all directions. Speaking of frogs he says: As peculiar to the upper part of the optic lobe are to be remarked large round cells (0.24 to 0.40 mm.) which are particularly found where the upper part of the lobe joins the pars peduncularis. These cells seem to us to represent the large vesicular cells of mammals.

Different views have been held as to the connections of these cells with nerves.
1. According to Stelling, Hildebrand, and Henle, these cells are the origin of the fourth nerve.

2. According to Meynert, of the great descending root of the fifth. In the dog, Hildebrand admits that some of the fibres of the small root of the fifth arise from them. There can be little doubt about that the latter is the correct view (origin of 5th). A confirmation of this is found in the fact that in the mole where the fourth nerve is apparently absent the cells are extraordinarily abundant.

All the fibres arising from these cells do not however enter into the formation of the descending root of the fifth nerve. Some according to our observation pass down to the outer part of the motor field. Meynert states that fibres arising from these cells cross the middle line and go to the cells of the opposite motor field.

We shall now notice an interpretation which Meynert and others put upon these cells. They are regarded as the typical form of the cells of origin of the sensory nerves; in other words as sensory cells. The cells of the interspinal ganglia of the Sasserian ganglion, and of the anterior auditory nucleus have similar characters, and are also to be looked upon as sensory cells. Against this view, there are many objections.
thus, it is somewhat singular that the sensory cells should be in the interspinal ganglia, and not in the posterior cornua of the spinal cord. But as the subject is yet one of mere speculation we need not discuss it in this paper. From the fact that sensory cells are found in the anterior nucleus of the auditory nerve, in which the nervous intermedius Luschberge, a vaso-motor nerve according to Bernard, takes its origin, Vouguenin is inclined to think that the cells are vaso-motor. This view that the cells are vaso-motor, or, we would add, trophic, seems to us not an improbable one. It is supported by what is known of the functions of the interspinal ganglia. It cannot be said however that inter spinal the position of the cells corresponds more than very generally to the limits of the vaso-motor centre as determined by experiment. Thus in rabbits the centre extends for about 3 m.m. above the calamus scriptorius to the upper portion of the fourth ventricle. Its upper boundary is not exactly known. It is situated bilaterally at some distance from the middle line in that portion of the medulla which corresponds to the lateral column of the cord.

That these cells give off fibres to the medulla, is also in accordance with what we should expect on the supposition that
they are vaso motor. May it not be that their
great development in the mole has something to do
with the burrowing habits of the animal, and the
varying conditions of pressure under which it lives.

Anterior nucleus of auditory nerve. The anterior
nucleus of the auditory nerve (fig. 33 a. a. n)
seems to us an important structure morphologically.
On its outer side is a ventricular space lined by
epithelium similar to that of the ventricles. Pos-
teriorly the space is seen to communicate with the
fourth ventricle of which it must be regarded
as a diverticulum— a fact, we think, that places
in clearer light, the relations of the auditory nerve
to the olfactory nerve (including bulb, tract, and
internal olfactory convolution), and to the optic
nerve (including retina, optic tract, and basal
optic ganglion of the tectum cinereum).
Experimental

We shall now give the results of our experiments on Mole, the objects of which have already been stated.

We have little to say of the mode of experimentation. The animal was etherised and the brain exposed. This was easily effected on account of the thinness of the skull. The effects of etherisation were allowed to pass off. Paradic electricity was used as the stimulus; the apparatus being one sense, du Bois Reymond’s Electrometer, and Electrodes of blunted needles with points about 2 m. m. apart. The distance of the secondary coil, sufficient to produce movements, varied in different cases, but as a rule, a current so weak as scarcely to be detected by the tongue, or at all events one that could easily be borne by this member, sufficed. The surface of the brain was kept moist by the application of saline.

In the experiments we made, we found that stimulation of a definite part of the cortex almost uniformly produced movements of the anterior limbs of the opposite side. The movements varied from a slight quivering or tremor, to a well marked convulsive movement, alternately of the flexors and extensors, the limb being at the same time drawn upwards and inwards close to the thoracic walls. The latter movements were most like an exaggerated representation of the rapid scraping movements so characteristic of the fore leg of the Mole. They appeared to us however to be rather tetanic than purposive in character. From the absence of convolutions in the brain it is difficult to specify exactly the situation of any area, but the line of the fronto-parietal suture (on that side of the brain
of course in which the spine has not been removed) may be taken as a convenient and sufficiently accurate guide. The centre for the anterior limits is immediately in front of this line, and extends to within a short distance of the middle line. We did not succeed in mapping out precisely the area of this centre, but it was not a very circumscribed one. In some cases it seemed to extend outwards to some distance.

(See fig 57)

Where the brain had been properly prepared (we exclude here those experiments in which excessive haemorrhage and other causes vitiated the results), and where the results had been once obtained, there was seldom any difficulty in getting the movements in question. The connection between stimulation of the area indicated, and the described movements, was again and again tested, and found to be so constant that the results could be predicted with confidence. The chief difficulty we had to contend with was the general and unmeasured restlessness of the animal. Owing to this, though it is possible the co-ordination of centres may have had something to do with the results, the movements set up in one foreleg were often followed by movements of the opposite limbs and indeed of the whole body (we do not here refer to tremor movements); but as the movements (definitely localised) of the foreleg almost always preceded these general and indefinite movements, and often took place without them, and as also the movements of the foreleg resulting from the stimulation were such that their advent could be detected even during any casual movement of the limbs, we were led to conclude that the general movements were either accidental or secondary, and that the special movements of the forelimb were alone directly caused by
stimulation of the area described.

In several experiments, a slight tremor: tetanus of the limb whose centre had been stimulated, was observed to take place spontaneously at intervals. This was especially noticed after the stimulation had been repeated a few times, and was referred by us to nervous discharges taking place spontaneously in the cells of the cerebral cortex, in consequence of a tendency to excitement, or as Hughlings Jackson would express it, in consequence of the 'condition of unstable equilibrium', brought about by the faradic irritation. On the other hand it was sometimes found that if the centre had been stimulated much, further stimulation for a time gave no result, but these were again forthcoming after a short period of rest; two or three minutes seemed to suffice.

On several occasions after the experiment had been continued some time clonic spasms occurred, beginning first in that fore limb on whose centre we were operating, and gradually extending to the body generally. Sometimes however the attacks were markedly unilateral, the animal curling up on the affected side. It was noticed in one or two cases that stimulation of the motor centre failed to produce movements.

The centre for the hind legs was less frequently found, and our results in the cases in which it was found did not exactly correspond with one another. It is situated opposite, or perhaps a little behind, the line of the fronto-parietal suture and near the middle line. Stimulation at this point gave the
localised movements of the opposite hind leg, tetanic in character. On several occasions they were unaccompanied by any other movements. On placing the electrodes at a point a little further in front, movements of both fore and hind limbs were repeatedly obtained. In one animal, the left side of the brain having been exposed, the centre for the right hind leg was at once found; stimulation producing twitching of this leg only. A little in front, the centre for the fore leg was found as usual. In this animal the centre for the hind legs was likewise found on the other side. In both these experiments it was observed that to obtain results a much more careful selection of a point of stimulation was requisite in the case of the hind limbs than in the case of the fore limbs, and the consideration of this, joined to the fact that we have scarcely ever failed to find the centre for the fore limbs while it was only in our last experiments that we succeeded in finding that for the hind limbs, led us to the conclusion that the centre for the anterior limbs is considerably larger than that for the posterior limbs. We were not able however to map out as accurately as we had desired the difference in size of the two areas. Pins were stuck in to indicate the position of the centres and the brains preserved for future reference.
(See p. 126 for microscopic examination of areas.) In one experiment it is noted that on stimulating the cortex in front of the centre for the fore leg, tonic movements of the nose on the opposite side were obtained, the nose being sometimes quite curved towards this side.

Our experiments on the mole have, then, added another to the list of animals in which stimulation of definite parts of the cortex has produced localised movements. They throw little fresh light on the general subject of brain stimulation. Whether the results were due to a vital excitation of the cortex or to the action of extrapolar currents on the lower ganglia, must be decided by a reference to more special experiments. We think however that we have a supplementary argument in favor of the former view in the fact that under similar physical conditions, different strengths of current were required to cause forth the same movements. Thus we found that the minimal strength of current requisite to produce movements was represented by a distance of the secondary coil from the primary of 12.6 m. m.; on one occasion of 7.4 m. m. on another, while on some occasions the distance was less than this. Variation of this kind though less in degree, were observed...
even during the course of an experiment on the same animal. It is difficult to account for these differences on the theory, that they are due to variations in the physical condition of the cerebrum, affecting the diffusion of currents, as nothing has occurred which would account for so great a change in the conducting power; at all events it is easier and more natural to suppose, that they are due to changes in the vital condition of the cells or fibres, for these, we should expect to be greatly affected by circumstances (e.g. amount of haemorrhage during operation, condition of animal, temperature of room, state of surface of brain as to moisture, slight injury of brain in removing pia-mater etc.), that would have little effect on the electrical conductivity of the brain substance. In this way we would account for the different strengths of stimuli required. These experiments have also demonstrated that the centre for the fore leg is larger than that for the hind leg, though it cannot be said accurately by how much. The relation of the development of the various cortical areas to peculiarities in the functional development of the animal is a very interesting one, though as yet it has been little attended to. Thus in the bat, applying what we have found in
the mole, we should expect the centre for the anterior limbs to be more extensive than that for the posterior limbs, while in the Kangaroo we should expect just the opposite. The question then arises, Is the increased size of the centre (in the mole) due merely to excessive development of the ordinary centre, or is it due to the fact that the surrounding parts of the brain have taken up the function of this centre? This is a question which at present cannot be answered. The arguments that are successfully adduced to disprove the theory of functional substitution by neighbouring parts of the brain, are less forcible here, where the increased development of a centre must have been so slowly brought about. We should however be inclined to support the former view. Still more important is it to ask the more general question, Are the centres for the same movements found in different animals in morphologically similar regions; are the centres for the fore legs in Monkey, dogs, Cats V to be regarded as homologous? In Figs 55, 56 V 67 are represented brains of man, monkey, dog, cat, rabbit, mole and rat; the centres for the fore legs being coloured blue those for the hind legs red. Centres which produced movements of both limbs are coloured yellow. We have in all cases
Fig 58. (1) A. three sulci that represent fissure of Rolando in dog. f.e. = Crucial fissure. The motor area has been made too large.

(2) A. fissure of Rolando in monkey. In both, 1, 2, 3, 4 are motor centres
followed Ferrier's localisations except in the rabbit, where we give Hirster's areas, and in the mole where we give those obtained by ourselves. We may regard the brains of the monkey, the dog, and the rabbit, as the representatives of three great types. In the first type, we find the centres for the fore and hind legs clustered round the fissure of Rolando, in the second round the Crucial sulcus at the anterior extremity of the fourth convolution (the convolution that bounds the longitudinal fissure), and in the third situated close to the longitudinal fissure, having to their outside a freely marked sulcus. It is very tempting to jump to the conclusion that the fissure of Rolando and the Crucial sulcus are homologues; that the ascending parietal and frontal convolutions in monkey represent the anterior part of the fourth convolution or the sigmoid gyrus of dog; and that the same convolutions are represented in the rabbit by the marginal convolution. No such simple explanation can however be accepted. We shall notice briefly some of the views that have been advanced of the homologous of the motor region. Hitzig (quoted by Cursch) thinks the fissure of Rolando is represented in dogs by three sulci (A in fig. 58 (1)) by the anterior portion of the middle
intrahemispherical sulcus, by a small sulcus running forwards and upwards from this, and by another small sulcus, also running forwards and upwards, and often in connection with that last mentioned (see fig. 58 (1)). Betz, arguing on the supposition that giant cells are found only in motor regions (Betz regards this as proved), arrives at a different conclusion as to the homology of the segment gyrus in dogs. In Man the paracentral lobule, which lies on the medial aspect of the hemispheres, contains most giant cells, and is therefore to be regarded as the most typically motor region. The transition from the brain of man to that of dogs is effected by the diminished development of the frontal lobes, and by the displacement outwards and forwards of the paracentral lobule, which now comes to lie on the external surface of the brain. Intermediate stages in this transition may be traced in the brains of various species of Monkeys. He concludes, then, that the crucial sulcus is represented in man by the sulcus that limits anterolaterally the paracentral lobule, and that the motor region in dogs corresponds to this lobule, and not to the ascending frontal and parietal convolutions of man, which are entirely wanting. There is consequently (1) he says, no true Sylvian fissure in the brain of a dog. Pansch has investigated the subject from a de-velopmental standpoint: There are three primary
sulci on the lateral aspect of the rudimentary hemisphere. The second of these is the fissure of Rolando; it is represented in adult dogs by the fissure marked A in fig. 58. (4). Of the cruciate sulcus, he only says it does not belong to the group of primary sulci. Others (see Muchr) regard the cruciate sulcus of the dog as represented in man not by the fissure of Rolando, but by a sulcus in front of this, which must be looked on as belonging to the second frontal sulcus (see fig. 59 (2), f 2 r a). According to Meynert the cruciate sulcus is unrepresented in man. This sulcus is generally regarded as the anterior extremity of the callosomarginal sulcus, in which case it is difficult to correlate it with any thing in man.

We have no need to say that a subject about which there is so great a variety of opinion stands in much need of further elucidation. The homology of cerebral areas has doubtless been much advanced by morphological and developmental considerations, but we must not take the results arrived at by these methods as final. There is every reason why the question should also be attacked from the functional side. From this point of view we are taught to attach only a secondary importance to the sulci. These are
modified within very considerable limits by the
functional development of special brain areas.

We think, then, that a comparison of those areas
that are functionally similar will afford a
valuable corrective to deductions drawn from
more purely anatomical Considerations. Hitherto
we have limited ourselves to the discussion of
the motor areas, but it is evident that a compar-
sion of the sensory areas in various animals
would yield equally important results. At present how-
ever this is impossible as the localisation of these
areas is very imperfectly made out. Before leaving
this subject we would call attention to the marked
differences in the size of the same centres in different
animals, as compared with the cortex of the cereb-
rum as a whole, and also to the variable devel-
opment of the brain in front of and behind the
Centres. A glance at figs. 55-57 will show the
extent of these differences in the case of
the Centres for the fore and hind legs, in the
localisation of which there is pretty general
agreement amongst experimenters. We are at
once struck by the greater relative size of
the Centres in the Monkey as compared with
those in the dog and Cat. Again the great
mass of the brain in the latter animals lo
behind the limb centres; in front of them, there is very little brain substance: whereas in the monkey, and still more in Man (taking homology and pathology as our guides in the determination of the Centres), the parts of the brain in front of the centres are exceedingly well developed. These facts bring before us in a remarkable manner what has already been arrived at from other considerations, viz., that the anterior lobes of man especially, but also of monkey, and of course the functions which pertain to these, are almost unrepresented in the lower animals. It will be seen that while the centres in the rabbit, guineapig, and mole agree in being about midway between the anterior and posterior extremities of the cerebrum, those in the rat are much further forwards. If this localisation should be confirmed, the rat would be placed in a very low scale as far as the development of the frontal lobe is concerned. Meynert has pointed out that in brains of lower type than those of man and monkey, the gyri formickies may appear on the external surface of the hemisphere both at the temporal, and frontal extremity. Indeed, in some cases, as in the dog, by pressing forwards in front of the Crucial fissure the
gyrus comes to form the whole frontal extremity of the cerebral lobe; so that as Meynert remarks "in man and Monkeys different parts of the brain are situated behind the frontal bone than those which are there situated in other Mammals."

Again, comparing the under surfaces of the brain of the mole and of Man, we find that anteriorly the basal surface of the former is entirely taken up by the external and internal olfactory Convolutions; while the basal surface of the latter is almost as entirely taken up by Convolutions of the frontal lobe.

The question of the relation of the development of various regions of the brain to the functional development of the animal is one of great interest and importance, but one into which at present it is impossible to enter.
Methods (Histological)

In all cases the brain was taken out of the skull almost immediately after the death of the animal.

Hardening. The method of hardening adopted at first, and generally followed, was as follows: The membranes having been stripped off, the brain (naked) was placed whole in a mixture of equal parts of rectified spirit and Water. After remaining in this for 18 hours, it was transferred to a solution of chromic acid, quarter per cent. In a day or two the solution was renewed and the brain kept in it for three weeks or a month. It was then transferred to rectified spirit, at first somewhat diluted, the strength being gradually increased till it reached full strength; in this it was kept till required. Before embedding, it was placed overnight in absolute alcohol.

I also tried a method recommended by Hamilton: -

The brain was placed for a week in Miller's fluid 3 parts, and methylated alcohol 1 part (it is wise to change the solution after a few days). It was then transferred to a solution of 3 parts, chromic acid, quarter per cent, and one part spirit in which it was kept for another week. It was afterwards placed in Chromic acid, one sixth per cent, until sufficiently hard (it took about 10 days).
it was then washed in water, and kept till wanted in pure spirit.

For showing in rough sections the macroscopic relations of parts, the brain was hardened in a mixture of equal parts rectified spirit and water, the proportion of spirit to water being gradually increased until full strength rectified spirit was used. Latterly I worked a good deal at the method of freezing brain recommended by Hamilton in the Journal of Anat. & Phys. Jan 1878, to which I refer the reader for particulars. I will mention however several slight but important modifications, which seem to contribute greatly to the certainty and the success of the results. In the first place, I found it better to transfer the portion of brain to be cut, directly from the bichromate solution to the syrup, and not to allow it to steep overnight in water as recommended by Hamilton. Six or eight hours was quite long enough for the brain to remain in the syrup. It must be remembered however that Hamilton experimented on much larger portions of brain than myself which may account for the difference in the length of time found best in the two cases. My remarks refer especially to pieces of brain such as the corresponding corpora quadrigemina and crura cerebri of the cat (i.e. 5 pieces about
the thickness of one's thumb). On taking the brain out of the syrup, it is wise to remove as much of this as possible, especially from the ventricles and other spaces, where it is apt to collect in considerable quantity. If this is not done, the portions where the syrup remains do not cut so well, and besides they stick firmly to the surface of the razor. After removal from the syrup, the piece of brain should be put in a solution of gum for a period of 48 hours (or longer) and then frozen in gum and cut in the usual manner.

**Chromic acid method**

The brain was embedded in paraffin and cut secundum artes. The sections were mounted on numbered slides, so that the relative position of every section was known. The sections were stained in logwood, which gave admirable results. It is better to use dilute solutions so as to allow of slow staining. My best preparations took from 30 to 45 minutes to stain. The sections were dehydrated by alcohol, cleared up by oil of cloves, and mounted in dammar.

The great objection to the chromic acid method is the excessive brittleness of the sections; they very often break into pieces on being removed from the alcohol or the razor to water, and
if the specimen gets crumpled in anyway, as it almost necessarily does when it is a large one, instead of unfolding when floated out, it almost constantly breaks up. But for this drawback, this method is much to be recommended.

By Hamilton's first method, the sections held together much better, but the brain in many parts, especially near the margins, presented a peculiar riddled appearance, which was evidently abnormal. Logwood gave diffuse staining (I did not try Carmine but from observations I have since made it would seem that sections prepared in Müller and bichromate of potash stain much better in Carmine than in logwood). It is necessary to say however that the hippocampus major, especially the organ-pipe fibres of the pyramidal tracts, came out well after this method.

Method of freezing. So far as I have yet had experience of it, Hamilton's method of freezing may be recommended as the best. The sections can be cut off extreme thinness without their having any tendency to break up: indeed their fault is, that they roll up with too great ease, and are apt to be marked by creases. The margins of the section are perfect. There are still however what seem to be shrinkage cavities, and other appearances which are probably
induced during the process of hardening. But these are less marked than in the sections prepared by the usual methods. Carmine stains the sections much better than logwood. I may add that the brain of a mole yields about 230 transverse sections, and that in two cases all of these were permanently mounted. Perhaps I should also state that the conclusions arrived at in the foregoing thesis are based upon an examination of about 1000 microscopical specimens which I found it necessary to prepare for the investigation of this subject.

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