V. *The Cerebrum of* Ornithorhynchus paradoxus.

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[PLATES 20–22.]

Summary.

THE brain of *Ornithorhynchus* is completely devoid of convolution, simple in structure, and similar in many respects to the brains of the embryos of higher Mammals. It is, however, strictly Mammalian and not Avian in type.

It differs from most, if not from all, other Mammalian brains in many respects, of which the following are the most notable :—

It is destitute of corpus callosum; the structure which has been described under this name is limited exclusively to the hippocampus, and belongs therefore to the fornix. It forms a decussation or commissure above the anterior commissure. Fibres reach this decussation from all parts of the hippocampus, both in front and behind. The fibres from the decussation turn downwards in three sets (1) in front of the anterior commissure; (2) between the anterior commissure and the soft commissure; (3) above the soft commissure.

The hippocampus extends to the extreme anterior end of the hemisphere above the ventricle.

The rhinencephalon (pyriform lobe, natiform protuberance, &c.) extends at first along the base and afterwards along the mesial aspect of the hemisphere to the posterior extremity of the ventricle.

In the absence of the corpus callosum and septum pellucidum the cortex of the mesial wall of the hemisphere is continuous through the anterior perforated substance with the corpus striatum.

In a similar manner the putamen of the nucleus lenticularis is continuous, behind the cerebral crus, with the cortex of the rhinencephalon. Appearances therefore suggest that nucleus caudatus and putamen belong to the mesial wall of the hemisphere which has been involuted by the crus, the optic thalamus, and perhaps by the remainder of the nucleus lenticularis.

Historical.

The brain of the *Ornithorhynchus*, like all other parts of the animal, is very elabo-

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rately and beautifully figured in MECKEL's monograph.* He represents correctly the pyriform shape of the hemispheres; their surface perfectly smooth save for the deep grooves cut by the blood-vessels which, emerging from beneath the outer sides of the olfactory bulbs, radiate backwards. MECKEL does not appear, however, to have noticed the middle cerebral artery. He figures the blood-vessels which groove the internal surface of the hemisphere, as well as the deep groove which is continued forwards from above the hippocampus to the anterior extremity of the brain. The figure of a sagittal section in the median plane (Plate 7, fig. 7) is drawn with great accuracy, but the references to the figure are singularly incorrect, so incorrect, in fact, that we should infer that the pointer-lines were wrongly placed by the engraver if their disposition did not agree entirely with the description in the text. As the mistakes are made with regard to just those features which are, owing to the position of this animal amongst vertebrates, of highest importance, it is necessary to quote the words of the text in connection with the lettering of the figures. In the figure the hippocampus or ridge produced by the projection of the fascia dentata is called the "corpus callosum." The transverse commissure, which seems to take the place of the corpus callosum, is lettered as the "septum pellucidum." That there is no mistake in the lettering of the figures is evident from the following description of the former structure†:—"Corpus callosum adest quidem, sed breve, quum haud quatuor lineas longitudine aequet. Memorabilius etiam videtur, in dimidia duo lateralia, linea mediana haud confluentia, esse disjunctum. Equidem saltem in faciebus sese spectantibus internis nullum dilacerationis vestigium invenire potui."

As MECKEL makes no reference in the text to the structure which he figures as the septum pellucidum, it is impossible to tell how it came about that a large transverse commissure was thus named.

OWEN's description‡ is even less easy to understand than MECKEL's, although he corrects MECKEL's mistake with regard to the corpus callosum.

"My doubts as to the great development of the corpus callosum of the *Ornithorhynchus* were further justified by the indication of its nearer approach to the Oviparous type afforded by the simple bipartite condition of the tubercles called 'quadrigemina.' Well preserved specimens of *Ornithorhynchus* presented to me by Mr. THOMAS BELL, Surgeon, R.N., in 1838, have enabled me to determine this question. There is neither corpus callosum nor septum lucidum in the *Ornithorhynchus*.

"The part described by MECKEL as the corpus callosum corresponds with the fornix and hippocampal commissure, as it exists in the Marsupialia, excepting that the essential function of the fornix, as a longitudinal commissure, uniting the hippocampus major with the olfactory lobe of the same hemisphere, is more exclusively maintained in the *Ornithorhynchus*, in consequence of the smaller size of the transverse band of

* MECKEL, 'Ornithorhynchi paradoxi, Descriptio Anatomica,' Leipsic, 1826.

† *Loc. cit.* p. 33.

‡ TODD's 'Encyclopædia of Anatomy and Physiology,' pp. 382 383.

fibres uniting the opposite hippocampi, and representing the first rudiment of the corpus callosum, as it appears in the development of the placental embryo. The thin internal and superior parietes of one lateral ventricle are wholly unconnected with those of the opposite ventricle."

"The part described by MECKEL as the corpus callosum corresponds with the fornix and hippocampal commissure." This is not the case; it corresponds with the projection of the fascia dentata. "The essential function of the fornix, as a longitudinal commissure, uniting the hippocampus major with the olfactory lobe of the same hemisphere, is more exclusively maintained in the *Ornithorhynchus,* in consequence of the smaller size of the transverse band of fibres uniting the opposite hippocampi and representing the first rudiment of the corpus callosum, as it appears in the development of the placental embryo." It would appear from this to be clear that what OWEN regarded as the "longitudinal commissure," is the ridge on the mesial surface made by the fascia dentata, and not a commissure at all. It cannot well be the commissure which I have lettered as *D.F.*, since this runs transversely. Again, which is the transverse band of small size uniting the opposite hippocampi, and representing the first rudiment of the corpus callosum? OWEN has said above that there is no corpus callosum. The transverse commissure (MECKEL'S septum pellucidum) is not a small band by any means, although smaller than the anterior commissure. OWEN could not so have described the structure which was figured in MECKEL'S plate.

Either description is to me an inscrutable mystery. I cannot understand how MECKEL could have mistaken this thick round commissure for the septum pellucidum, or how OWEN could either have overlooked it altogether or else have described it as "a small transverse band."

On what ground, too, does OWEN maintain that "the essential function of the fornix, as a longitudinal commissure . . . is maintained" when, as will be shown presently, all such fornix as exists in *Ornithorhynchus* decussates in the middle line, is not united with the olfactory bulb, and may be, for all one can tell to the contrary, not a longitudinal commissure at all, but a series of tracts uniting together corresponding parts on the two sides?

The chief interest of the brain of this animal clearly centres about the question as to whether it does or does not contain a corpus callosum, and, therefore it appears to me desirable to sum up the literature of the subject in connection with this question.

Corpus callosum.—In the 'Philosophical Transactions of the Royal Society' for 1837 (p. 80), OWEN asserted that no corpus callosum or septum pellucidum are to be found in either Monotremes or Marsupials. He figures the brains of a large number of species (*Ornithorhynchus* is not amongst them) as showing a "fornix commissure" or transverse commissure superior to the anterior commissure, which represents, however, he says in one place "besides the fornix, the rudimental commencement of the corpus callosum." The same expression is used in his article "Marsupialia," in 'TODD'S Encyclopædia,' 1847, for OWEN was evidently not convinced that the corpus callosum is really absent

in these animals, although his whole description implies that this is the crucial distinction between non-placental and placental Mammals; a difference which he accounts for by the curtailment of intra-uterine life :—" I have since derived the most satisfactory confirmation of this coincidence from the repeated dissection of the brains of Marsupials belonging to different genera ; and although unable to explain how a brief intra-uterine existence, and the absence of a placental connection between the mother and fœtus can operate (if it be really effective and anything more than a relation of simple co-existence) in arresting the development of the brain, yet it is a coincidence which has not been suspected, and is, in various points of view, perhaps the most interesting of the anatomical peculiarities of the quadrupeds here treated of."

In his article " Monotremata," OWEN refers to the transverse commissure which he figures in the brain of *Echidna* as " the hippocampal commissure," but again he says later on that " the short transverse commissure above mentioned is the sole representative of the corpus callosum and fornix."

Whether or not OWEN asserted that the corpus callosum is totally absent in non-placental Mammals (and I cannot find such a definite statement made about any animal except *Ornithorhynchus*), he was understood to mean this, and he himself quotes with approval a table given by MM. EYDOUX and LAURENT (' Voyage de la Favorite,' p. 166) in which it is thus stated, " Corps calleux ; Monodelphes (existe) ; Didelphes (manque) ; Ornithodelphes (manque) ; Oiseaux (manque)." These writers add, " MECKEL a cependant admis dans les figures relatives à l'encéphale de l'*Ornithorhynque* l'existence du corps calleux ; mais, en étudiant avec soin l'encéphale de notre *Echidné*, nous nous avons reconnu que les descriptions de M. R. OWEN sont plus exactes que celles de MECKEL, et que les déterminations de l'anatomiste Anglais doivent être adoptées."

FLOWER published in the 'Philosophical Transactions' for 1865 (p. 633, *et seq.*) a series of observations upon the brains of *Echidna* and various Marsupials, with the object of disproving OWEN's teaching with regard to the corpus callosum. He did not study the brain of *Ornithorhynchus*, but in the brain of *Echidna* he says, " is seen the superior transverse commissure, very much reduced in extent, and in which the two portions, upper and lower, observed in the Kangaroo are no longer distinguishable," but he adds, " whatever parts of the placental Mammalian brain are represented by this commissure in the Kangaroo are also represented by it, though in a reduced degree, in *Echidna*."

OWEN recognized that the commissures of the non-placental Mammals are not disposed in the same way as, perhaps are not homologous with, the commissures of placental Mammals. He saw the difficulty but not the way out of it ; he relied so far as one can judge from his description upon naked-eye observations and very simple dissections, and did not trust his own conclusions. At one time he quotes with approval, as a summary of his own views, the bald statement that neither Marsupials nor Monotremes possess a corpus callosum ; at another time he talks about their having

the "rudimental commencement of a corpus callosum," and again at another time he gets over the difficulty by naming the commissure the "commissure of the hippocampus."

FLOWER* gives a most admirable and philosophical summary of the position of the question as it rests upon his observations, but in his conclusion he is, as it appears to me, unfair to OWEN. He may well resent the uncertain language which his predecessor used, but he should not deny him the merit of recognising an essential difference between the brains of placental and non-placental Mammals; and had his own observations been carried out, as they would be if made at the present time, by means of a series of sections, he would, I think, have maintained the justice of OWEN'S contention that the upper transverse commissure in non-placental Mammals is not sufficiently described as "corpus callosum"; indeed he would, I think, have allowed that the Monotremes, at any rate, have no corpus callosum at all.

FLOWER'S summary is too long to quote *in extenso*, but certain sentences may be extracted without giving a false impression. "The commissure radiates over the whole of the inner wall." "They are part of the great system of transverse fibres which bring the two hemispheres into connection with one another." "They cannot in any sense be confounded with the posterior crura of the fornix." "In all Marsupial and Monotreme animals it lies above the septum ventriculorum and especially above the precommissural fibres of the fornix." "Moreover, passing outwards into the hemispheres, it overarches or forms the roof of the lateral ventricles of the cerebrum." The test of a corpus callosum would appear to be summed up in this last sentence. The commissure which we know as corpus callosum consists of fibres uniting together homologous (and also, as SHERRINGTON has shown, heterologous) parts of the convex surfaces of the hemispheres. In *Ornithorhynchus* the transverse commissure in question does not, as my sections show, surpass the limits of the hippocampus.

With regard to other non-placental Mammals I cannot speak from observation, but FLOWER'S picture of the brain of *Echidna* represents a condition almost identical with that of *Ornithorhynchus* and HERRICK'S figures of sections of the brain of *Didelphys virginica*† show that in this Marsupial animal the disposition of the commissure is the same as in *Ornithorhynchus.* In certain Monotremes and Marsupials, therefore, the commissure does not fulfil Professor FLOWER'S test, and it is open to question whether any animal in which the hippocampus extends the whole length of the brain, above the ventricles, can have a corpus callosum.

The hippocampus is the doubly folded margin of the cortex supported by a rod of white fibres, the fimbria or posterior crus of the fornix. If the hippocampus lies above the corpus callosum the fimbria (or fornix) must also have this situation, a curious reversal of the relation which these parts bear to one another in animals in which the corpus callosum is well developed! This is the only arrangement possible

* *Loc. cit.*, p. 648.

† 'Jl. of Comp. Neurology,' vol. 2, p. 1. February, 1892.

unless, indeed, the fibres from the alveus to the fornix interlace with those of the corpus callosum. In *Ornithorhynchus*, however, appearances are altogether against the existence of callosal fibres; the fibres of the anterior commissure which sweep beneath the corpora striata supply the whole of the convex surface, as well as a part of the mesial surface of the pallium.

Professor FLOWER's pictures of the inner surface of the hemisphere suggest that a more or less horizontal plate of commissural fibres, which constitutes the great corpus callosum of Man and most Mammals, is present in a rudimentary form in *Macropus*, *Phascolomys*, and *Thylacinus* (with which he says that *Phalangista* and *Didelphys* agree), but totally absent in *Echidna*.

I find it quite impossible to gather Professor HERRICK's views with regard to the dorsal commissure in *Didelphys*. Under the heading "Callosum and hippocampal commissure," he says* "it is not necessary to recount the various opinions and discussions of the callosum in the Marsupials. Until OSBORN, most authors had agreed that the callosum is absent, and functionally replaced by the anterior commissure." This is curiously oblivious of FLOWER, who especially opposed OWEN on this question, not to mention LEURET, FOVILLE, MAYER (who described *Didelphys virginiana* in 1842), and PAPPENHEIM, who, speaking about the dorsal transverse commissure in the same animal, says,† "le corps en question est bien un corps calleux . . . Cette commissure n'est donc ni un fornix ni un mélange du fornix avec le corps calleux." HERRICK continues, "Professor OSBORN has done much to place this whole subject in its proper light, and we agree with him in respect to the essential homologies of the dorsal commissural system . . . The motor cortex as such is thrown well cephalad, and the fornicate gyrus is carried forward along the mesial surface, as may be seen from an inspection of the transverse sections of Plate A. Thus it happens that the caudal portion of the dorsal commissural system is much more highly developed than the cephalic or callosal portion. The latter consists of a few fibres which spring from the region about the anterior prolongation of the splenial fissure, if this term may be applied to the fissure which bounds the cephalad continuation of the fornicate gyrus." No description of the tract in question is contained in the paper.

ZUCKERKANDL‡ also describes the brain of *Ornithorhynchus*, although he is careful to state that the brain was badly preserved. He also simply names the decussation of the fornix "der rudimentäre Balken," and, although the "Randbogen" is the structure under discussion, he overlooks the fact that it passes right above his supposed corpus callosum to the front of the hemisphere.

If, as appears to me to be the case, the corpus callosum is totally absent in

* *Loc. cit.*, p. 7.

† "Notice préliminaire sur l'anatomie du *Sarigue femelle* (*Didelphys virginiana*)," 'Comptes Rendus,' vol. 24, p. 186 (1847).

‡ 'Ueber das Riechcentrum.' Stuttgart, 1887.

Ornithorhynchus, it will be necessary to reconsider the whole question of the homology of the commissures in Vertebrata.

Sir WILLIAM TURNER does not describe the interior of the brain in his paper on *Ornithorhynchus*,* but he mentions the appearance of what he considers (adopting FLOWER'S view) to be the corpus callosum. "The anterior commissure and the rudimentary corpus callosum were seen at the surface of the section, and behind these was the hippocampus. A shallow antero-posterior fissure 6 millims. long was observed on the mesial surface of the pallium in front of and above the divided corpus callosum. It might possibly be the splenial fissure, and the slender band of the pallium between it and the corpus callosum would thus represent a rudimentary callosal convolution." The fissure in question, as seen in sections 5 and 6, is the extremely deep dentary fissure (or fossa, as I prefer to call it). The band of pallium, the fascia dentata. Unaware of the continuation forwards of the hippocampus, TURNER saw no reason for considering the dorsal commissure as anything but corpus callosum.

Method.

The whole animal was hardened in spirit. The skull had been opened, and therefore the spirit had at once reached the brain, which was in fair condition.

The left hemisphere was stained in carmine *en bloc* and then cut into an irregular series of sections. Finding, however, that it presented certain points of extreme interest, I determined to treat the right hemisphere with much greater care. It was therefore placed for a fortnight in a two per cent. solution of bichromate of ammonia, for even a brain which, like this one, has been for years in spirit will yield sections which can be stained by WEIGERT'S method if it is placed in a chrome-salt for a time. The hemisphere was next placed in a solution of carmine-alum for a week, washed in water, and after dehydration by alcohols of increasing strength, embedded in celloidin. When the celloidin had been firmly set by chloroform the brain was very carefully divided into fourteen blocks along the lines marked in the photolithograph (Plate 20, fig. 1). Each block was then cut into a series of sections of which a number, varying according to the apparent interest of the region, were mounted and labelled A to D or M or N as the case might be; about 150 sections in all (not including some 120 already prepared from the left hemisphere). A certain number of sections from each block were stained by WEIGERT'S method in order that the arrangement of the fibre-tracts might be determined with certainty.

Figs. 6–10 are diagrammatic, inasmuch as the cortex is not coloured at all, and the fibres are shown as they appear in the nearest section of the series which was stained with hæmatoxylin.

* 'Jl. of Anat. and Physiol.,' vol. 26, p. 357, April, 1892.

Description of Several Parts of the Brain.

The olfactory bulb is of moderate size, its maximal coronal dimensions being vertically 3 millims., transversely 4 millims. Its length is 3 millims. It is absolutely free from the cerebral hemisphere, the rounded neck of the crus, if such an expression is allowable, being crossed by the large anterior cerebral artery on its way to the outer surface.

The bulb is cupped on the under side, as in *Didelphys virginica* described by HERRICK;* the cupping is not, however, visible from the under surface, for it is occupied by glomeruli which lie in loculi of connective tissue. I do not gather from HERRICK's description or pictures that such an arrangement is found in *Didelphys*, nor am I acquainted with any animal in which it obtains.

The ventricle of the bulb is obliterated.

In minute anatomy the bulb presents no feature of particular interest.

The olfactory crus remains for some distance distinct from the hemisphere. It becomes progressively thinner until just before its attachment it is a flat band 2 millims. wide by ·5 millim. thick. The fibres of the olfactory tract lie on its ventral surface. It is situate remarkably near to the middle line at the spot where it adheres to the under surface of the hemisphere.

External form.—The general form and external appearance of the brain have been described so recently by Sir WILLIAM TURNER† that it is unnecessary for me to repeat a description which is already in the hands of all students. I would merely point out certain respects in which the brain is somewhat remarkable. Although the distinction between the rhinencephalon (using this term in an inclusive sense) and the rest of the hemisphere is deeply marked, the brain is absolutely destitute of convolution in the proper sense of the word. It is almost a pity that the furrow (the ectorhinal fissure) which separates the rhinencephalon from the rest of the hemisphere, is named a "fissure," for its origin is not due to the same mechanical causes as the origin of the fissures proper. Rather does it fall into the same class with the incisura pallii longitudinalis (longitudinal fissure) and incisura pallii transversa (transverse fissure) which are the gaps between the different organs which collectively constitute the brain. It is almost a crime to add another to the terms with which the nervous system is already smothered, but I am inclined to suggest that just as longitudinal and transverse fissures have given way to incisura pallii longitudinalis and incisura pallii transversa, so the ectorhinal (or, in human anatomy, collateral fissure) should give way to "incisura rhinalis."

The so-called "choroidal fissure" is not, of course, a fissure in any sense of the word. I have in another paper‡ suggested that it should be termed "hiatus ventriculi."

* 'Jl. of Comp. Neurology,' vol. 2, p. 1. February, 1892.

† 'Jl. of Anat. and Physiol.,' vol. 26, p. 357. April, 1892.

‡ "The Hippocampus," see p. 389, *infra*.

Is the dentary fissure a true fissure? The fact that the same terminology is used in this as in other parts of the brain has led, as I think, to fruitless attempts to homologize the several structures which make up the "hippocampus" with other parts of the pallium. The hippocampus is altogether different in constitution from the rest of the pallium, and forms, as was recognized by BROCA and by ZUCKERKANDL, a part of the rhinencephalon. Topographically it belongs to the rhinencephalon. It varies in size with the rest of the rhinencephalon. Its essential constituent, the fascia dentata, is, as I have shown in the paper referred to, absent when the olfactory bulb is absent.

The cerebral cortex is divisible, therefore, into the part which belongs to the rhinencephalon and the part outside it.

If we accept the view that the convolution of the brain is due to mechanical causes, that is to say, to the necessity for disposing of a layer of superficial tissue, the nutrient needs of which forbid its increase in thickness beyond a certain maximum, which is reached in very small brains, and which can only be disposed upon the surface of larger brains in a plicated manner; since, while the contents of a sphere equals πr^3, its superficies equals πr^2 only; it is obvious that the use of the word "fissure" in two distinct senses can only lead to confusion.

The formation of the dentary fissure is clearly not due to the causes just mentioned; indeed, the rhinencephalon is distinguished from the rest of the hemisphere by its slight tendency to convolution, and, therefore, in this case also, the use of the word "fissure" might be dropped with advantage and the term "fossa," *i.e.*, dentary fossa, used instead.

The hemispheres are absolutely destitute of convolution, although the projection upwards of the lateral lobe of the cerebellum causes the formation of a deep pit, which separates the occipital from the back of the temporo-sphenoidal region.

The external surface is deeply channelled by blood-vessels which lie in rounded grooves. The greater number of these vessels are branches of the anterior cerebral artery, which reaches the external surface by passing just above the base of the olfactory bulb, separating its crus from the frontal portion of the hemisphere which lies above it. Immediately on reaching the outer surface it divides into two branches, from which are derived other vessels which, diverging from one another, groove the outer surface of the hemisphere as far as its posterior border. A small branch of the anterior cerebral passes to the outer surface beneath the olfactory bulb.

The middle cerebral artery reaches the outer surface at a spot which may probably be regarded as the situation of the fissure of SYLVIUS, and breaks up into branches which do not supply so extensive an area as the anterior cerebral.

The ventral surface presents, at the front, the olfactory bulb. To the outer side of the bulb lies the optic nerve, and to the outer side of this again the immense fifth nerve. The dura mater constitutes a firm sheath for these structures which could not in my specimen be removed without injuring them.

The mesial surface presents at its upper part the unconvoluted internal surface of the hemisphere, of uniform breadth (5 millims.). It is grooved by five small arteries, which pass to its upper border from the posterior cerebral artery. They incline backwards as they pass towards the upper edge of the hemisphere. Behind the corpus callosum, *i.e.*, for more than half its length, the cerebrum forms a flat cap, which rests upon the optic thalamus, the mid-brain, and the cerebellum.

The brain is remarkable amongst Mammals in the continuation forwards of the hippocampus to its extreme anterior end; and, lastly, if my observations are correct, in the complete absence of corpus callosum.

The Hippocampus.—The margin of the ventricular slit is formed by the rhinencephalon below, the hippocampus above. These two meet in block 11 at the back of the slit.

The hippocampus lies, therefore, entirely above or dorsally to the velum interpositum. The ventricle has no descending horn, but extends in a horizontal plane above the crus and thalamus.

The cortex cerebri is strongly folded upon itself several times. First at the dorso-mesial edge of the hemisphere it descends as a broad flat surface which borders the incisura pallii (longitudinal fissure). This surface has a breadth of 5 millims. Then the cortex returns upon itself about the dentary fossa: its pyramids being at once arranged in the single sheet which is characteristic of the subiculum. The subiculum sweeps round into the cap of fascia dentata.

At no part of the hippocampus is there any ridge of longitudinal white fibres such as is characteristic of the fimbria, but from the very commencement of the hippocampus the convex surface of the cortex, which projects into the ventricle, is covered with a sheet of longitudinally running white fibres. It is best to call this indifferently the fimbria or fornix, although it is the homologue of the fimbria and alveus of higher Mammals, and is by no means a "corpus fimbriatum." It represents both pars libra and pars fixa of ZUCKERKANDL. Nor is there from behind forwards a distinction in the tract into fimbria, posterior pillar and body of the fornix.

The arrangement of this tract with regard to the fascia dentata is interesting. As seen in 10G it enters with the pyramidal cell-layer into the concavity of the cap of fascia dentata. The fascia dentata is quite devoid of fibres on its surface, but consists, as in other animals, of a layer of very small cells (granules) three or four deep, covered with molecular grey matter of rather greater density than the superficial layer of the cortex in other regions.

In 9 the fornix (or alveus or fimbria) is thicker and slightly folded upon itself on the deep surface of the fascia dentata.

In 8 it is still thicker and sweeps over the whole of the convexity of the subiculum* to form a continuous white lining for the ventricle.

* Using the term in a sense suggested in my paper on the hippocampus.

In 7G the fibres are beginning to collect on the mesial side of the hippocampus, in the angle between the fascia dentata and the convex surface of the subiculum.

At 7F the fibres of the two sides decussate in the so-called "rudimentary corpus callosum," or "hippocampal commissure."

In front of the decussation certain columns of fibres are seen running longitudinally in the substance of the mesial wall of the hemisphere. Others, a thick sheet, sweep up the inner side of the ventricle. A third group, now detached from the rest, lies in the angle beneath the outer limb of the fascia dentata. Some of the fibres of the last groups are longitudinal, others sweep into the nucleus fasciæ dentatæ.

The fascia dentata is at first (behind) uniformly curved, then folded at two right angles, then at one acute angle, which is sharpest at 6D, where the mesial limb is continued for some distance on the surface of the hemisphere. (See sections 10, 9, 8, 7, 6.)

The fascia dentata in front of the decussation constitutes a narrow convolution which is continued to the front of block 5, as seen in the lithograph and in the sections.

Its extreme anterior end is shown in the figure 5A.

I have found it impossible to judge the nature of the decussation or commissure of the fornix from the sections.

It is very clear that few, if any, of the fibres of this fornix system extend beyond the hippocampus at either end. It shows, at its occipital end, such a thin coat of white matter that it is impossible that any considerable number of fibres pass beyond the limits of the hippocampus into the medullary centre of the occipital lobe.

Throughout its whole extent the sheet of white fibres which covers the subiculum on its convex (outer) surface, *i.e.*, the alveus or white lining of the inner wall of the ventricle, grows thinner and thinner as the angle between the inner and outer walls is approached. The rest of the ventricle is, as will be presently shown, lined with white matter belonging to the system of the anterior commissure, and it is more likely that the white lining of the inner wall is reinforced by fibres from the commissure than that the lining of the outer wall receives fibres from the alveus.

The numbers of fibres crossing in the decussation is so large that we may infer that but few remain throughout their course in one hemisphere only; but I cannot see in the sections any appearances which enable me to decide whether the fibres from the front of one hemisphere pass to the front or to the back of the other.

Immediately in front of, or rather beneath, the decussation the main body of fibres (excluding the precommissural fibres already referred to) turn downwards and curve backwards as the anterior pillars of the fornix which will be described in connection with the corpus mammillare.

The Anterior Commissure is a transverse tract of great size, its cross-section measuring in my specimen $2 \cdot 5 \times 3 \cdot 25$ millims.

It is separated from the decussation of the fornix by the thin internal edge of the corpus striatum. It rests below upon the grey matter which forms the inner wall

of the hemisphere, intervening between the rhinencephalon and its mesial surface. It is, therefore, surrounded by grey matter on all sides. Its fibres form a broad thick sheet which invest and support the corpus striatum.

It is first cut in the middle line in 6E, but its anterior edge being concave, the thick flattened column is met with, obliquely cut, in sections farther forward. Indeed it may with propriety be described as having a forceps anterior and forceps posterior, for the fibres into which it spreads out on either side pass to all parts of the hemisphere.

In front of the decussation it is easy to follow the course of its fibres, for they are strictly limited to the region between the corpus striatum and the cortex; they form a thick external capsule for the corpus striatum; above the corpus striatum they constitute, as already said, the white lining of the outer wall of the ventricle, and supply, doubtless mingled with peduncular fibres, all parts of the cortex.

Behind the decussation the fibres are more difficult to follow, for they become involved with the peduncular fibres, but again, by block 9, they appear to have become distinct, for a mass of fibres lies beneath the nucleus lenticularis in the angle between it and the meso-ventral edge of the hemisphere, which seems to be continuous with the forceps posterior of the commissure, and but little affected by the peduncular fibres which lie dorsally to this part of the nucleus lenticularis.

The Grey Matter of the Hemisphere may be classified in three divisions:—

1. The grey matter of the mesial wall, with the nucleus lenticularis and nucleus caudatus.
2. The cortex of the rhinencephalon, with (or including) the hippocampus.
3. The cortex in general or pallium.

As there is no septum pellucidum, and the lateral ventricle extends for some distance in front of the commissures, the inner wall of the hemisphere includes a triangular region, bounded by the hippocampus above, the ventro-mesial edge below and the commissures behind, which is very difficult to homologize with parts of the human brain. Perhaps it is not possible to homologize it, for the smooth surface of the cortex which in the human brain lies in front of the rostrum, the "terrain desert," belongs to the pallium, and constitutes the common starting ground of the gyrus fornicatus and the gyrus geniculatus (ZUCKERKANDL) which latter dies away into the nerve of Lancisi; while the region which lies in front of the commissure in the brain of *Ornithorhynchus* is completely separated from the gyrus fornicatus by the hippocampus. It appears to be the part which, in higher Mammals, atrophies in becoming the septum pellucidum, as well as the anterior perforated substance.

It is composed of grey matter 1·3 to 1·5 millims. thick; more compact on either surface than in its centre, and containing branched cells of the pyramidal type. The cells are rather larger than those which are scattered uniformly throughout the corpus striatum, about 11 μ broad by 15 μ long, with apical, basal, and axis-cylinder processes; but partly because the tissue, although in many places well preserved,

is hardly fit for accurate histological work, and partly because the shape of the cells depends upon the plane in which they happen to be cut, I do not propose to draw far-reaching conclusions from apparent differences in minute structure.

More interesting than its minute structure is the fact that this tissue passes over at the ventro-mesial angle of the hemisphere into the corpus striatum, without the possibility of any line of demarcation being drawn between them.

It would appear, therefore, that the grey matter which lies on the inner side of the hemisphere is a part of the same formation as the nucleus caudatus. This reduces the latter very distinctly to the level of a cortical formation, differing morphologically from other parts of the cortex in the absence of a white coat. The grey matter of the corpus striatum lies on the axial side of the rhinencephalon, which in turn lies on the axial side of the pallium.

This grey formation reaches almost as far forwards as the ventricle, but projects in front of the part common to it and the corpus striatum as a rounded boss. Consequently in 4 the curious appearance is presented of a round nucleus of grey matter near the ventral edge of the mesial wall, quite distinct from the oval anterior end of the nucleus caudatus.

The anterior commissure passes, as already said, right through this grey matter, so that we find in 6J the appearance of a nucleus of grey matter between the anterior commissure and the commissure of the fornix.

It is noticeable that as the corpus striatum increases in width so also does the grey matter beneath the anterior commissure; the line which marks the outer boundary of the corpus striatum sweeps, therefore, in an even curve beneath the subcommissural grey matter.

The foramen of MONRO is seen in block 7. It is bounded above by the hippocampus and fornix, beneath by a small portion of this grey matter which rests on the anterior commissure.

It is not easy to define the posterior limits of this grey matter. The anterior commissure is last seen in 7J. By this time, as may be seen in the lithograph, the section passes through the third ventricle, and its mesial wall is the epithelial lining of the ventricle. Still the large-celled grey matter, which is characteristic of and common to both the mesial wall of the hemisphere and the corpus striatum, is continued backwards into the angle between the cerebral crura.

It appears, therefore, that grey matter of uniform structure constitutes the mesial wall of the hemisphere in front of the anterior commissure, the corpus striatum, and the wall of the third ventricle. Such at any rate is the conclusion to be drawn from my sections, but I should be very sorry to assert that it would not be possible in a really well-preserved brain, successfully stained, to recognize as many different formations as are described in human anatomy, although I am inclined to think that anatomical distinctions have been pushed too far. The minute structure of the brain should always be studied simultaneously with its configuration.

Central Grey Masses.—In describing the grey matter of the interior of the cerebrum, I have purposely used the expression corpus striatum, because in its anterior position it is not distinguishable into nucleus caudatus and nucleus lenticularis.

The corpus striatum is first seen towards the back of block 4 on the outer side of the ventricle, very near to, but not quite at, its anterior extremity. Its form in section, at this level, is a long oval placed obliquely. It is pierced by a few large bundles of peduncular fibres. It has a thick tract of longitudinal fibres at its upper end, between it and the epithelium of the ventricle, and it is supported on its outer side by ascending fibres of the anterior commissure.

Its ground substance is dense and stains darkly. Its cells are round, fusiform, or triangular with rounded angles. They measure 12 μ to 14 μ in diameter. They are frequently grouped in twos, threes, or fours.

In 5 the transverse section of the corpus striatum is much larger than in 4. The number of peduncular fibres by which it is traversed, especially at its upper part, is much greater. Although the cells in the grey matter on the mesial wall of the ventricle are somewhat larger than those in the corpus striatum, it appears, as already remarked, impossible to make a distinction between these two formations. The three regions, mesial wall of hemisphere, substantia perforata anterior, and corpus striatum are anatomically indistinguishable.

In 6 the corpus striatum is limited below and on the outer side by the anterior commissure. The number of penduncular fibres has increased greatly and bundles are beginning to divide its upper part into separate nuclei.

In 7 the number of fibres is still further increased so that the grey matter is honeycombed with them, and a portion of the grey matter which lies beneath the ventricular epithelium is continued across the middle line beneath the velum interpositum. This is rather an unexpected arrangement, for in the last sections of block 6, where the anterior commissure is at its maximum development, the ventricular slit reaches right down to the anterior commissure save for a thin sheet of ependyma, and the grey matter of the mesial wall is therefore completely separated from the corpus striatum, but as the vertical height of the anterior commissure is diminished, grey matter again intervenes between the commissure and the ventricle and follows the commissure across the middle line, so that the two corpora striata are in continuity through the medium of a thin sheet of grey matter which invests the anterior commissure. It is but a very thin sheet, for it is soon occupied by the descending fibres of the fornix, which it separates from the back of the anterior commissure, and yet it seems to me of importance as showing that in the absence of a corpus callosum, the grey matter which forms the lateral and anterior walls of the third ventricle passes into the grey matter of the mesial wall of the hemisphere (*i.e.*, of the region which, in brains containing a corpus callosum, becomes the septum pellucidum) and also into the grey matter of the corpora striata.

7I shows the round anterior end of the optic thalamus with fibres on the outer side

separating it from the nucleus caudatus; the velum interpositum resting on its upper surface and descending fibres of the fornix thrusting it aside from the ventricular cavity. This will be described immediately.

The nucleus caudatus is hardly as yet separated from the nucleus lenticularis, but a very large number of bundles of fibres, some large, some small, are cut transversely. They clearly enter the corpus striatum from behind, and are, for the most part, destined for its substance, but in all sections a certain number may be seen emerging from the outer surface of the nucleus and joining the system of fibres belonging to the anterior commissure. It is impossible to follow the course of such bundles of fibres in a series of transverse sections, but there cannot, I think, be much doubt that (1) the majority of the peduncular fibres which enter the corpus striatum from behind are lost in its substance; (2) a number of bundles traverse the corpus striatum to reach the cortex; (3) while it is impossible to say whether all the bundles of fibres which are seen partly within and partly without this body are passing directly from the peduncle to the cortex, few if any are entering from its cortical surface to lose themselves in its substance.

A remarkable difference in structure between the ventricular and extra-ventricular portions of the corpus striatum has now become established. Towards its convex surface, its cells are, as in its anterior part, both large and numerous. The ventricular portion, on the other hand, shows a denser more deeply staining ground substance, but few cells, and these are not so large as in the outer portion.

7L. The peduncular fibres may now be said to form an internal capsule. The grey commissure is seen bridging across between the thalami.

8A. The nucleus lenticularis, as a thin capsule of grey matter, sweeps round the outside of the internal capsule and above the portion of the anterior commissure exposed in this section, into the cortex of the pyriform lobe. It is traversed, or partially traversed by many bundles of fibres; those which separate it from the nucleus caudatus differing from those which traverse it elsewhere merely in being an association of bundles larger than the rest. On its basal side the bundles are so numerous as to leave but a network of grey matter amongst them. The nucleus caudatus is contracted into an oval column.

9H. An inner nucleus fills the concavity of the shell of the nucleus lenticularis. It occupies, with regard to the latter, the relation of nucleus ruber to putamen. It seems, however, to be split off from the optic thalamus rather than from the corpus striatum, and, although its cells are not so large as those in the rest of the thalamus, they are nevertheless larger than those of the nucleus lenticularis.

10. The putamen is so thin as almost to resemble a claustrum. It is, however, quite distinct in structure from the large nucleus ruber. A few large cells lie on its concave surface. Its lower thicker border has withdrawn from the cortex of the pyriform lobe.

11G. The nucleus ruber has almost disappeared, but the putamen is still distinct.

The tail of the nucleus caudatus is thicker and inclines towards the temporal cortex.

12. The putamen and tail of the nucleus caudatus, reunited, form a capsule for the central white core of the occipital lobe. It is last seen in 12D.

I am unwilling to draw wide conclusions from the study of a single brain, and shall hope to compare with the brain of Ornithorhynchus brains of Marsupials and Rodents, both adult and embryonic; nevertheless, I can hardly leave the basal grey matter of the hemisphere without pointing out that the appearances presented by a series of sections carried through this region strongly suggest its formation by reduplication in front of the peduncular fibres.

Nucleus caudatus and putamen form a common structure which is continuous with the wall of the hemisphere both in front of and behind the cerebral crus, and appears to be a portion of the wall of the hemisphere which has been thrust outwards (or pitted in) by the crus and optic thalamus.

In minute structure the nucleus ruber resembles the thalamus rather than the corpus striatum.

Cortex.—The brain is, as already remarked, totally destitute of convolution. Save for the grooves made by blood-vessels, and for the bulging of the hemisphere into occipital and temporo-sphenoidal lobes, the cortex forms a uniformly curved case for the white matter and central grey masses. It is, relatively to the size of the brain, very thick, measuring in the spirit-hardened brain at its thinnest part, *i.e.*, on the upper surface of the hemisphere near its internal border, 1·3 mm., at its thickest part, *i.e.*, near the meeting place of the external and basal surface, 3·5 mm., the maximum diameter of the hemisphere being 15 mm.

In minute structure it is extremely uniform, presenting neither marked stratification of the elements of which it is composed at any given spot nor notable differences in structure in different regions, and yet it is easy to see that, both in their relative number and in their arrangement, the elements vary in disposition in different regions.

The "pyramids" are very irregular in form, being as often triangular, stellate, or fusiform as distinctly pyramidal in section. Very frequently the process which would be regarded as apical, were the orientation of the section not known, is directed centrally not peripherally.

Large pyramids are undoubtedly most numerous in the anterior and dorsal part of the cortex, *i.e.*, in blocks 5, 6, 7, dorsal to the corpus striatum.

Only in the cortex of the rhinencephalon, and in certain parts of the inferior and external surface of the hemisphere, are the small pyramids collected into so distinct a layer as in the brain of most Mammals.

The superficial stratum moleculare has a uniform thickness of about 30 μ; it is almost destitute of cells.

The small pyramids commence rather abruptly beneath the stratum moleculare

and give way with every transition in size into large pyramids, the maximum diameters of which are about 22 μ and 12 μ; in the occipital region some of the pyramids have a transverse diameter of as much as 17 μ.

Granules are scattered uniformly throughout the layer of pyramidal cells, and nowhere collected in a separate stratum. They are more numerous in the basal and posterior region of the cortex than in the dorsal and anterior region.

Fusiform cells are seen in the deepest stratum of the cortex, but it is only in certain places that they can be said to form a layer.

Perhaps it is justifiable to say, although our standard is uncertain, that the cortex is simple in minute structure.

Optic Thalamus.—This mass of grey matter, although a part of the primary fore-brain and not of the cerebral hemisphere, is conveniently included in a description of the latter. It appears first in 7I as a round darkly staining mass supported and enveloped by fibres which enter its substance in thin bundles. The head of the thalamus is in this section separated from the ventricular epithelium by descending fibres (anterior pillars) of the fornix.

7K. The descending fibres of the fornix have divided into two almost equal groups; the one of which runs as a thick bundle along the upper surface of the thalamus, the other descends to the large corpus mammillare. The corpus mammillare depends from the floor of the ventricle as a thick round tubercle of grey matter. Between the two bundles, the thalamus reaches the middle line, in the grey commissure.

7L. An immense number of bundles enter the thalamus from its under and outer sides. Large when they first enter, they rapidly diminish in size. Beneath the thalamus they interlace with fibres of the internal capsule and curve both inwards and outwards, in a manner which renders it unwise for me to make assertions with regard to their destination.

8A. The thalamus has increased greatly in size and its outer part, which is traversed by many bundles of fibres, differs from its inner portion in structure.

The middle, soft, or grey commissure occupies the whole of block 8 and a large part of block 7. The bridge is not by any means, however, limited to grey matter, for a distinct and considerable tract of fibres crosses in its posterior and lower portion. They spread out in all directions after passing the middle line.

The portion of the thalamus which enters into the formation of the wall of the ventricle is continuous with the corpus mammillare and projects between the crura cerebri. It causes the crura to be thrown far outwards so that in 8C, for example, the fibres of the crus lie on the outer side of the thalamus rather than beneath it.

The thalamus is still seen in the anterior sections from block 10 in which the aqueduct of Sylvius and the grey matter around it also appear, but its outer margin is ill defined.

Comparatively simple although the structure of the brain of this lowest of Mammals is, it is nevertheless vastly too intricate to allow of the analysis of its fibre-tracts by

means of series of coronal sections only. I have, therefore, confined myself in my description to its more striking features.

In the hope that I may soon receive from Australia some brains of *Ornithorhynchus* thoroughly well hardened in a chrome-salt by an expert collector, I have abstained from describing in this paper many things which my sections show in a fairly satisfactory and unmistakable manner.

Corpus Mammillare.—This body is large and well-defined, and great interest attaches to its structure in this animal on account of the great size of the fornix, for it would seem to offer an opportunity of settling the vexed question of the relation, to the corpus mammillare and to one another, of the descending pillar of the fornix and the bundle of Vicq d'Azyr.

From the decussation of the fornix a certain number of fibres enter the mesial wall of the hemisphere in front of the anterior commissure, but by far the greater number curve backwards and downwards on either side in the wall of the ventricle as the anterior pillars of the fornix, which almost rest upon the back of the anterior commissure.

In 7I the whole column appears to be descending, but in 7J it is seen that only part, about one-half, of the fibres descend, the rest begin to ascend again, resting on the upper surface of the optic thalamus. The descending fibres sweep down at some little distance from the ventricular epithelium towards the corpus mammillare, or rather towards the deep prolongation of the floor of the ventricle which occupies the situation of this structure between the crura cerebri. A small number of large cells, with their long axes placed vertically, lie amongst these fibres just above their entrance into the back and outer side of the corpus mammillare.

The bundle which passes backwards beneath the foramen of Monro and then skirts along the dorso-mesial edge of the thalamus in the situation of the tænia thalami needs investigation.

Had I stained all the sections on one side of the brain by WEIGERT's method it would doubtless have been possible to follow the course of these several bundles of fibres; as it is I can merely point out that the study of the brain of *Ornithorhynchus* will probably enable us to determine the course of several at present ambiguous tracts.

Minute Structure of the Thalamus.—The appearance presented by this tissue in my sections depends upon its deficient preparation; but while I am unwilling to enter into a detailed description of the microscopic appearance of a tissue which has not been prepared especially for this purpose, I am bound to say that this brain is sufficiently well hardened to show all the more important features of its structure, and that the different parts of the brain may well be compared with one another.

The anterior tubercle of the thalamus consists of a dense, darkly-staining matrix, containing large round cells. These cells differ, however, in a marked way from the cells of the corpus striatum and of the cortex, for instead of staining darkly and exhibiting well-defined angular bodies, they belong to the type of soft cells, the bodies

of which are seldom seen, since they break down in the hardening reagents, leaving behind nothing but clear round vesicular nuclei lying in round spaces.

It is not uniform in structure, however. Its posterior portion which spreads far outwards into the internal capsule, by the bundles of which it is traversed, contains cells which are much larger and more definite in form than any to be found in its anterior portion or in the corpus striatum. The largest of these are found on its under side where they form an almost distinct group, homologous probably with one of the subthalamic nuclei. They measure as much as 30 μ by 14 μ. Their long axes are placed horizontally, and they appear to be in connection with the white fibres which cross the middle line on the under side of the commissura mollis. Athough the largest of the cells form an ill-defined group by themselves, others almost as large are found throughout this region, and extend across the middle line in the commissura mollis.

[This paper contains little more than a series of detached observations, which are published with some reluctance. Although I had been familiar with the main facts in the cerebral organization of *Ornithorhynchus* for some years, I had postponed their publication in the hope of obtaining a supply of well-preserved specimens, from which it would be possible to construct a complete monograph. The interest which attaches, however, to the description of the corpus callosum as a chapter in the history of science, and the peculiar features in the disposition of the rhinencephalon, which may serve to throw light upon the relation to one another of the two portions of the cerebral hemisphere, seemed to justify a preliminary communication.

Since this paper was written, DR. JOHNSON SYMINGTON has published observations which confirm my conclusion that the corpus callosum is absent in *Ornithorhynchus*. DR. SYMINGTON, indeed, extends this statement so that it includes all non-placental Mammals:—"It appears to me, therefore, that the cerebral commissures in the Monotremata and Marsupialia present several characters by which they can be distinguished from those of the placental Mammals, viz., (1) the anterior commissure is as large, and generally much larger, than any other transverse commissure of the cerebrum, and it unites the whole of the cortex of the two hemispheres, except the gyri dentati and hippocampi majores; (2) they have no true corpus callosum; and (3) the superior transverse commissure is simply a commissure for the gyri dentati and hippocampi majores."*—A. H., June, 1893.]

* JOHNSON SYMINGTON. "The Cerebral Commissures in the Marsupialia and Monotremata." 'J. of Anat. and Physiol.,' vol. 27, p. 69, October, 1892.

Description of Plates.

PLATE 20.

Fig. 1.—Photo-lithograph of the right half of the brain of *Ornithorhynchus* from the mesial aspect. *Magnified* 2 *diameters*.

The lines indicate the divisions between the blocks into which the brain was cut. A series of sections was taken from each block. The dura mater was left on the basal aspect of the brain.

Section 4E.—Carried through the extreme anterior end of the lateral ventricle, shows the junction of the flat olfactory crus with the under side of the hemisphere.

Section $4E_2$ exhibits the commencement of the nucleus caudatus on the outer wall of the ventricle. A distinct nucleus of grey matter is also seen at the ventro-mesial angle of the section ; the fibres of the olfactory crus form a narrow area to the outer side of this nucleus.

Section 5A.—The anterior end of the hippocampus. The fascia dentata lies almost at right angles to the plane of the large pyramids of the subiculum. Fibres from the front of the commissure of the fornix are descending in the ventricular wall.

Section 6D.—Diagrammatic view of a section in front of the commissure of the fornix and the anterior commissure. The appearance of the fibres as stained with WEIGERT's hæmatoxylin, has been added to a drawing made from a carmine preparation. The cortex is curving over into its scabbard of fascia dentata. The fibres of the fornix system constitute a capsule for the hippocampus, to which they are limited. The lateral, superior, and part of the mesial cortex is supplied by fibres of the anterior commissure.

Section 6J passes through the anterior edge of the commissure of the fornix, and cuts the anterior commissure. It shows the continuity of the grey matter of the mesial wall above and below the anterior commissure with the nucleus caudatus. On the ventral side of the section is seen the rhinencephalon, bounded both on its mesial and lateral aspects by fissures, which leave but a narrow sheet of fibres as a connection between it and the rest of the hemisphere.

PLATE 21.

Section $5B_2$, through the extreme anterior end of the hippocampus, shows the relation of the fibres of the fornix-commissure to the mesial wall, and the descent of its precommissural fibres. The tract of cortex to which the fibres of the olfactory crus are applied is beginning to be separated from the general cortex by mesial and lateral fissures.

Section 7F cuts the commissure of the fornix.

Section 7G is carried just behind this commissure.

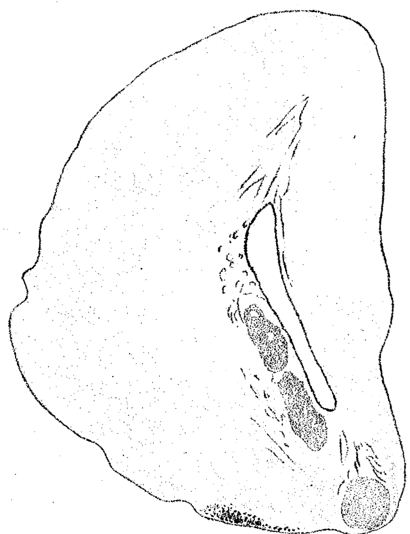
Sections 8, 9, 10G show the way in which the fornix dies away upon the surface of the hippocampus behind its commissure.

PLATE 22.

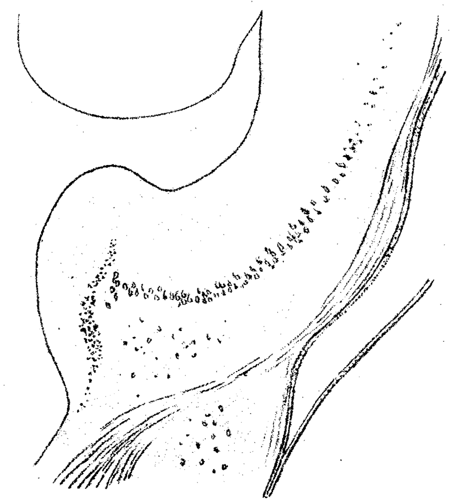
Sections 7E, 7J, $7K_2$, 8C, 9E, from preparations stained after WEIGERT'S hæmatoxylin-method.

F. Fornix.
D.F. Decussation or commissure of the fornix.
D.P.F. Descending pillars of the fornix.
S.C.B. Supra-commissural bundle (tænia thalami).
A.C. Anterior commissure.
W.C. White fibres in the commissura mollis.
O.T. Optic tract.
C.O. Optic chiasm.
P.L. Pyriform lobe (rhinencephalon).
C.S. Corpus striatum.
N.C. Nucleus caudatus.
P. Putamen.

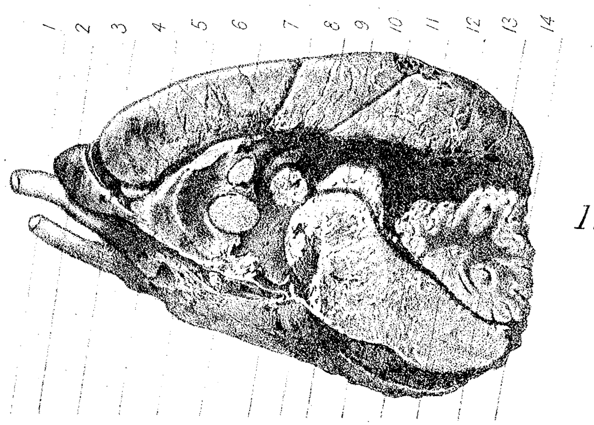
4E



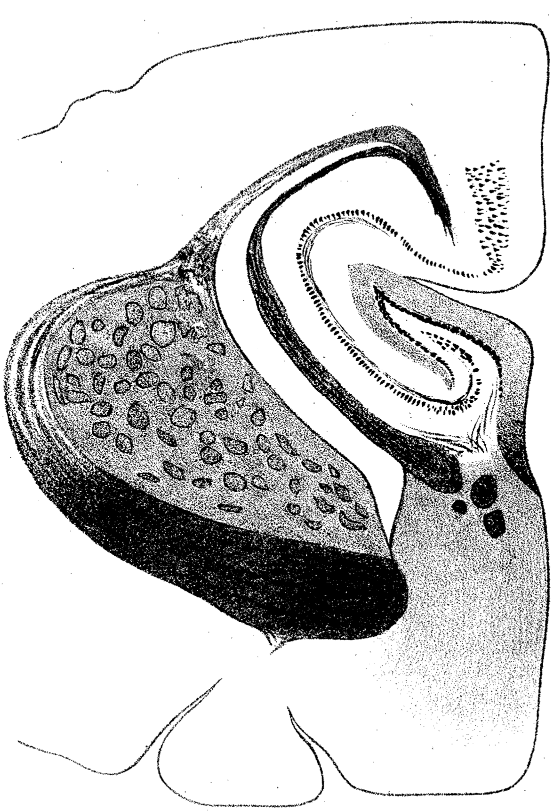
4E²



5A



1.



6D

6J

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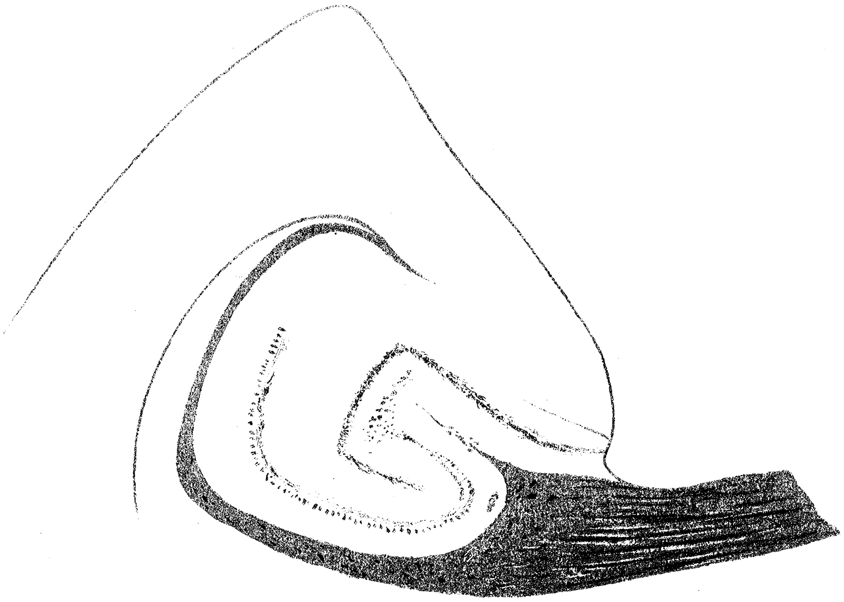
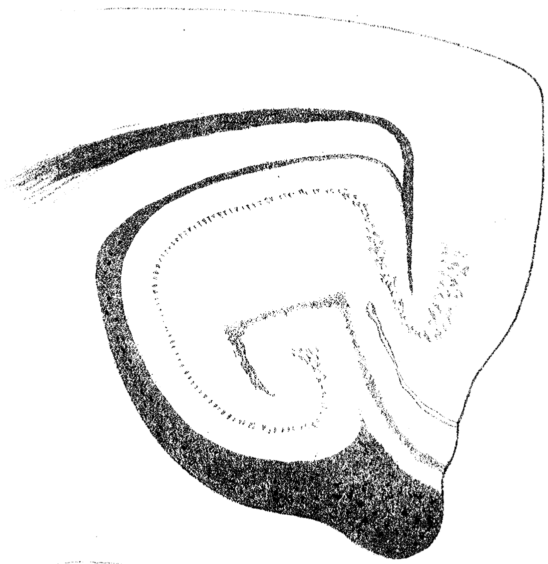
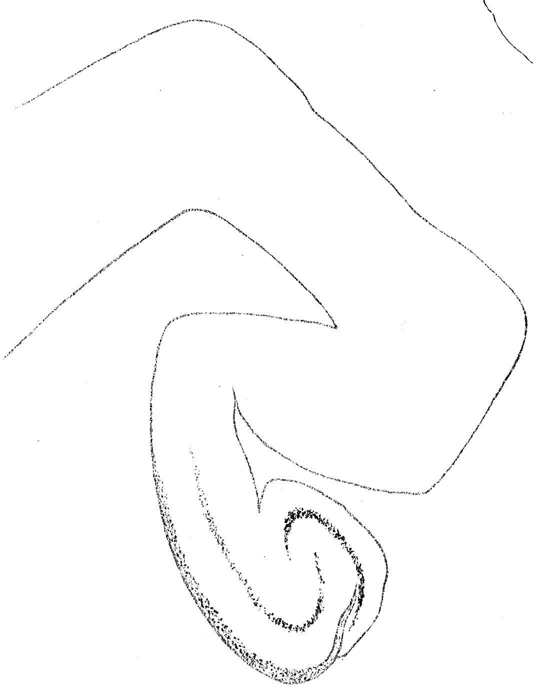


7 F.

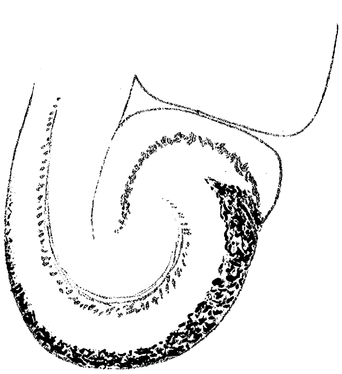


7 G.

5 B 2.



10 G.



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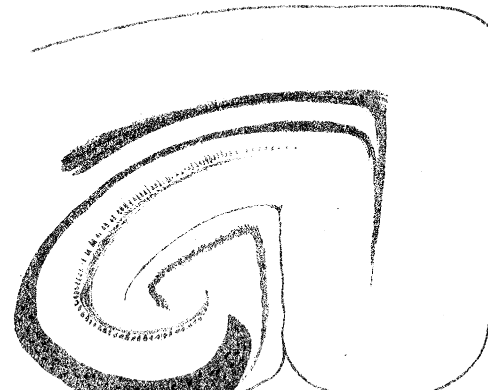

8.

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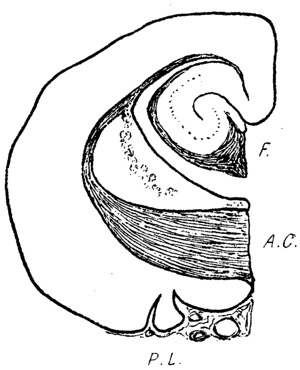
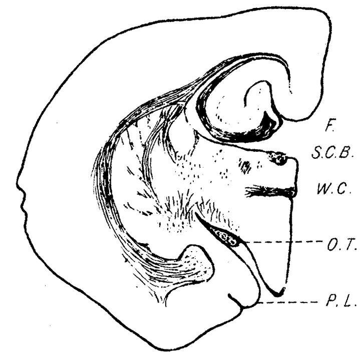
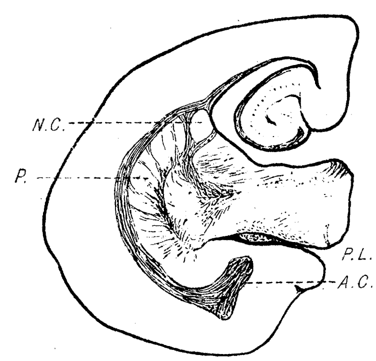


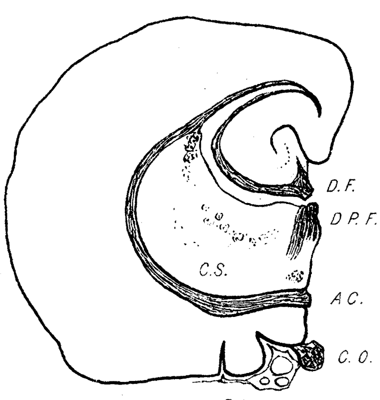
7 E.



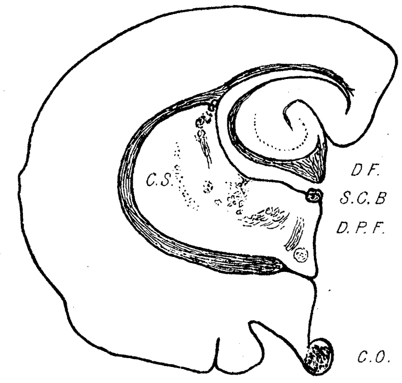
8 C.



9 E.



7 J.



7 K2.

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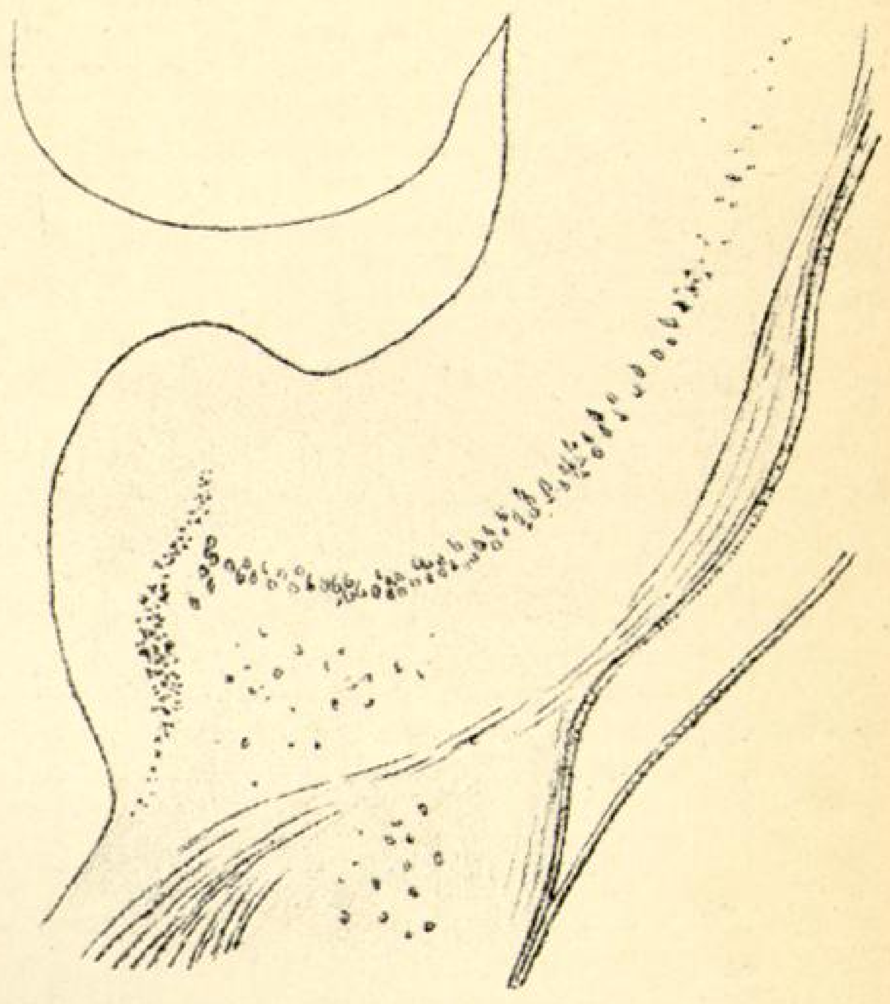
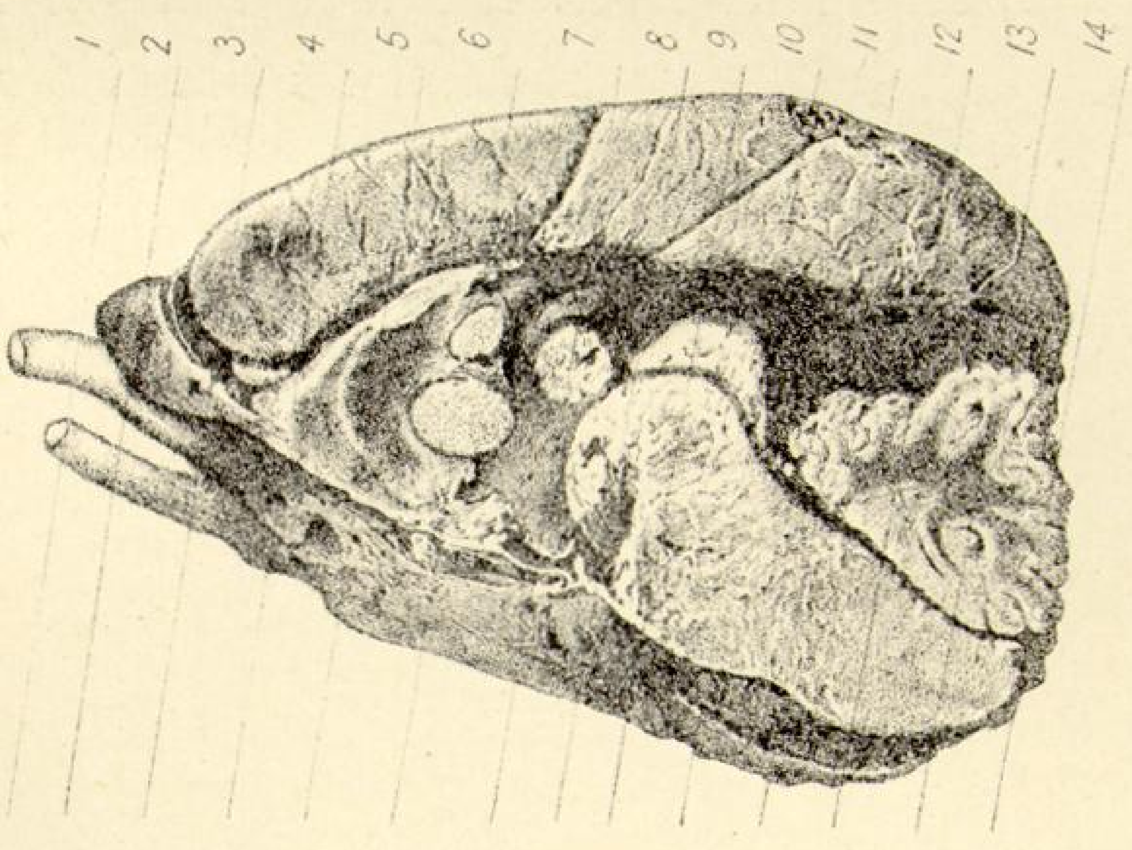
4E

$4E^2$



5A



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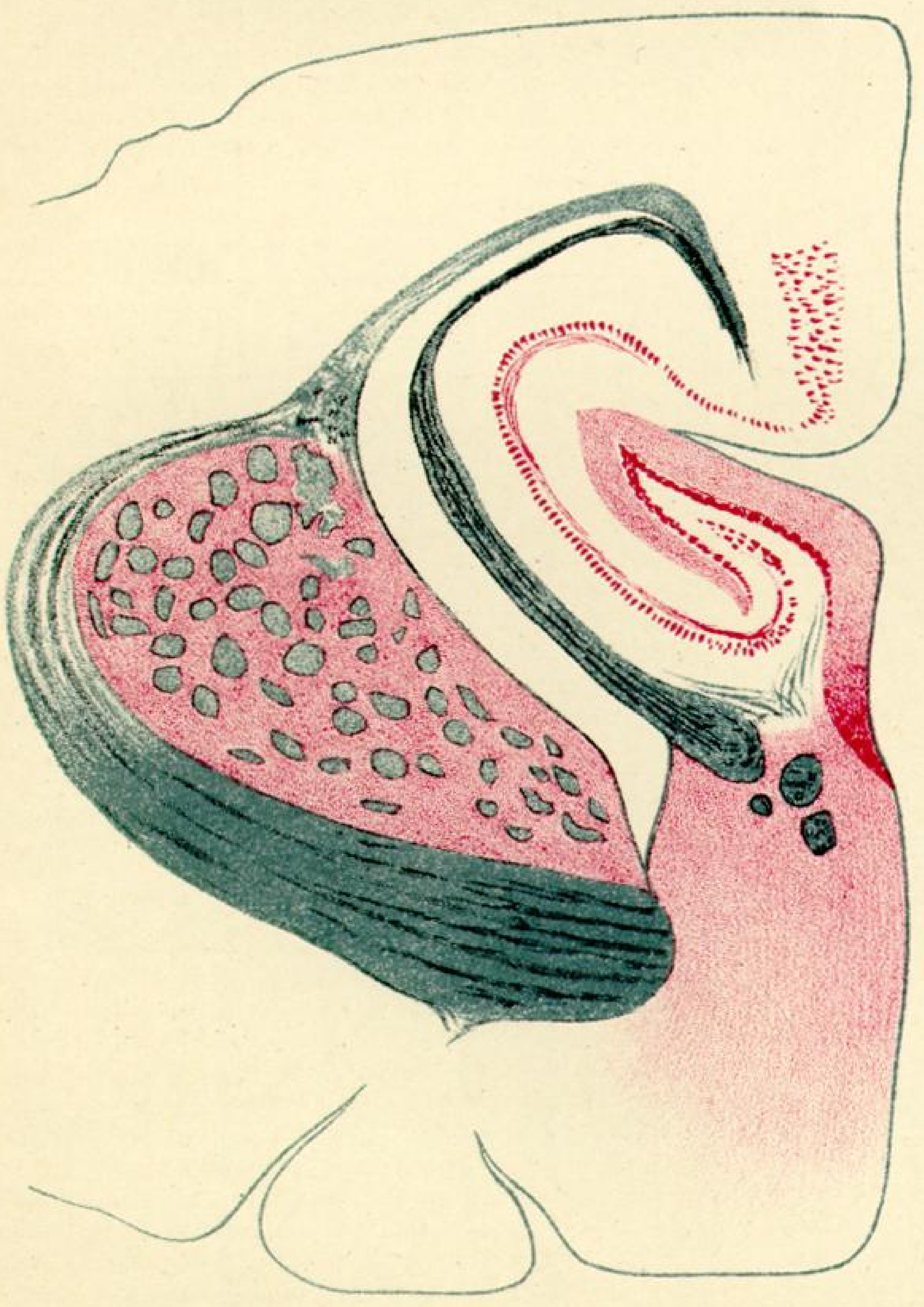
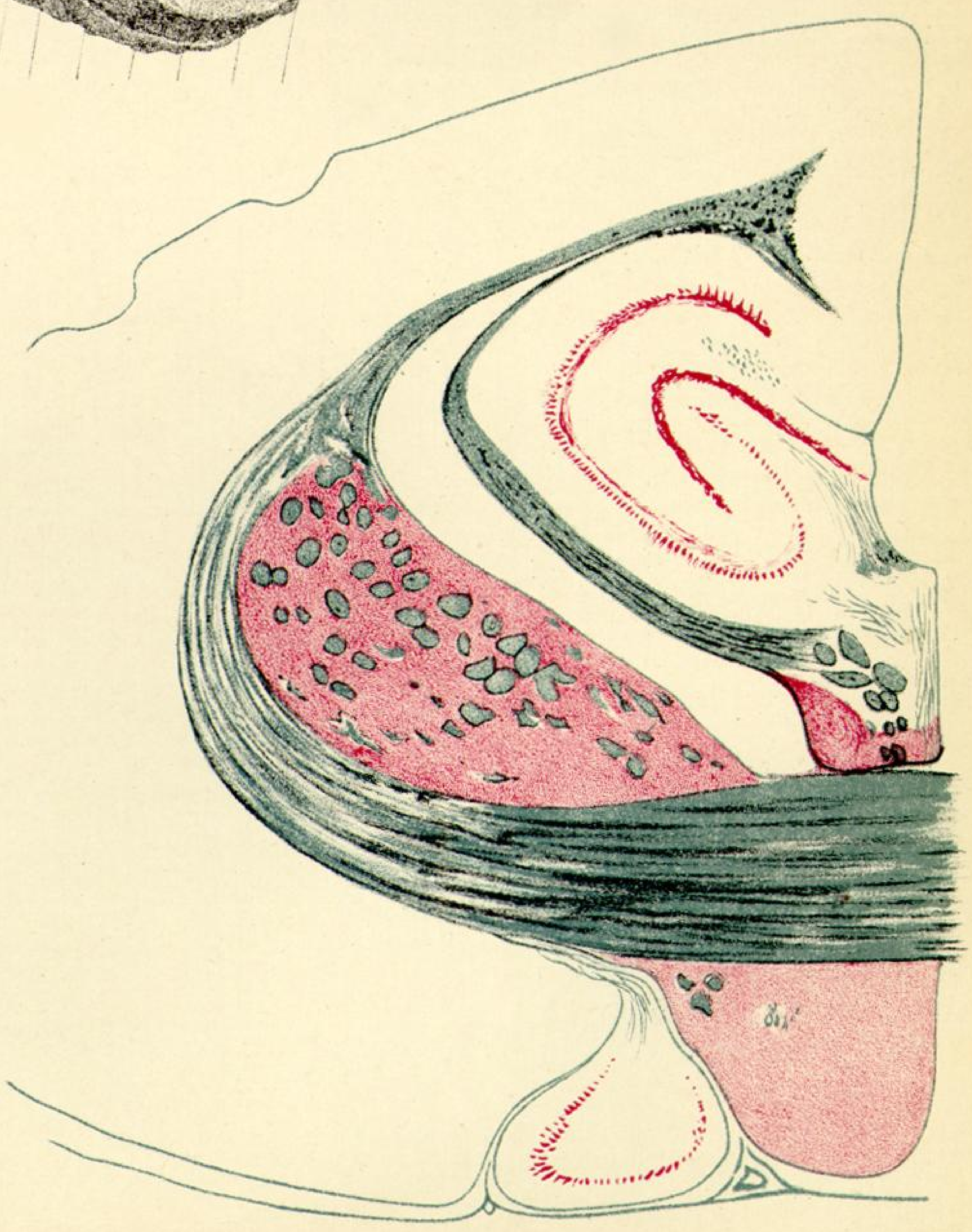


6D



6J

PLATE 20.

Fig. 1.—Photo-lithograph of the right half of the brain of *Ornithorhynchus* from the mesial aspect. *Magnified 2 diameters.*

The lines indicate the divisions between the blocks into which the brain was cut. A series of sections was taken from each block. The dura mater was left on the basal aspect of the brain.

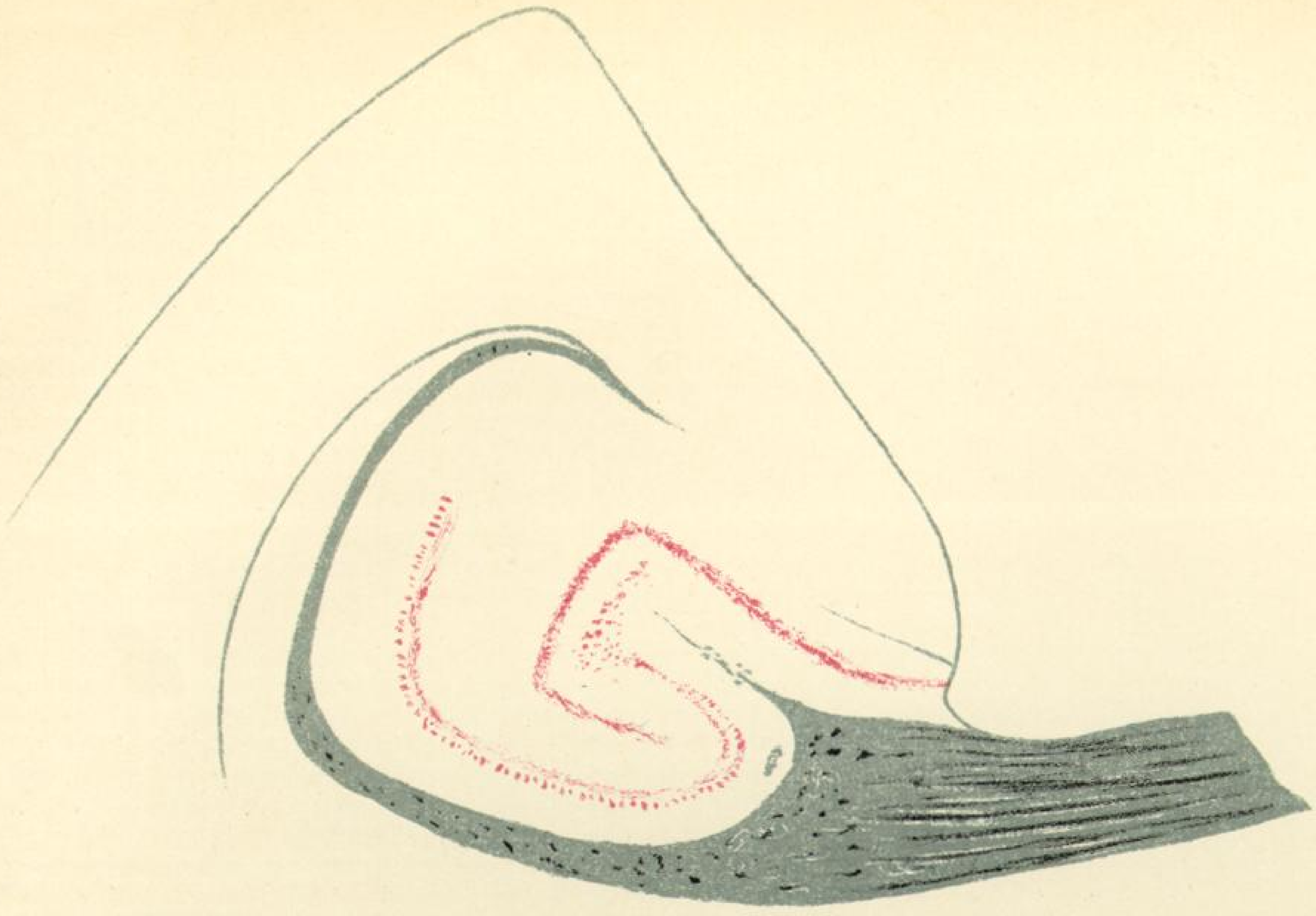
Section 4E.—Carried through the extreme anterior end of the lateral ventricle, shows the junction of the flat olfactory crus with the under side of the hemisphere.

Section 4E_2 exhibits the commencement of the nucleus caudatus on the outer wall of the ventricle. A distinct nucleus of grey matter is also seen at the ventro-mesial angle of the section ; the fibres of the olfactory crus form a narrow area to the outer side of this nucleus.

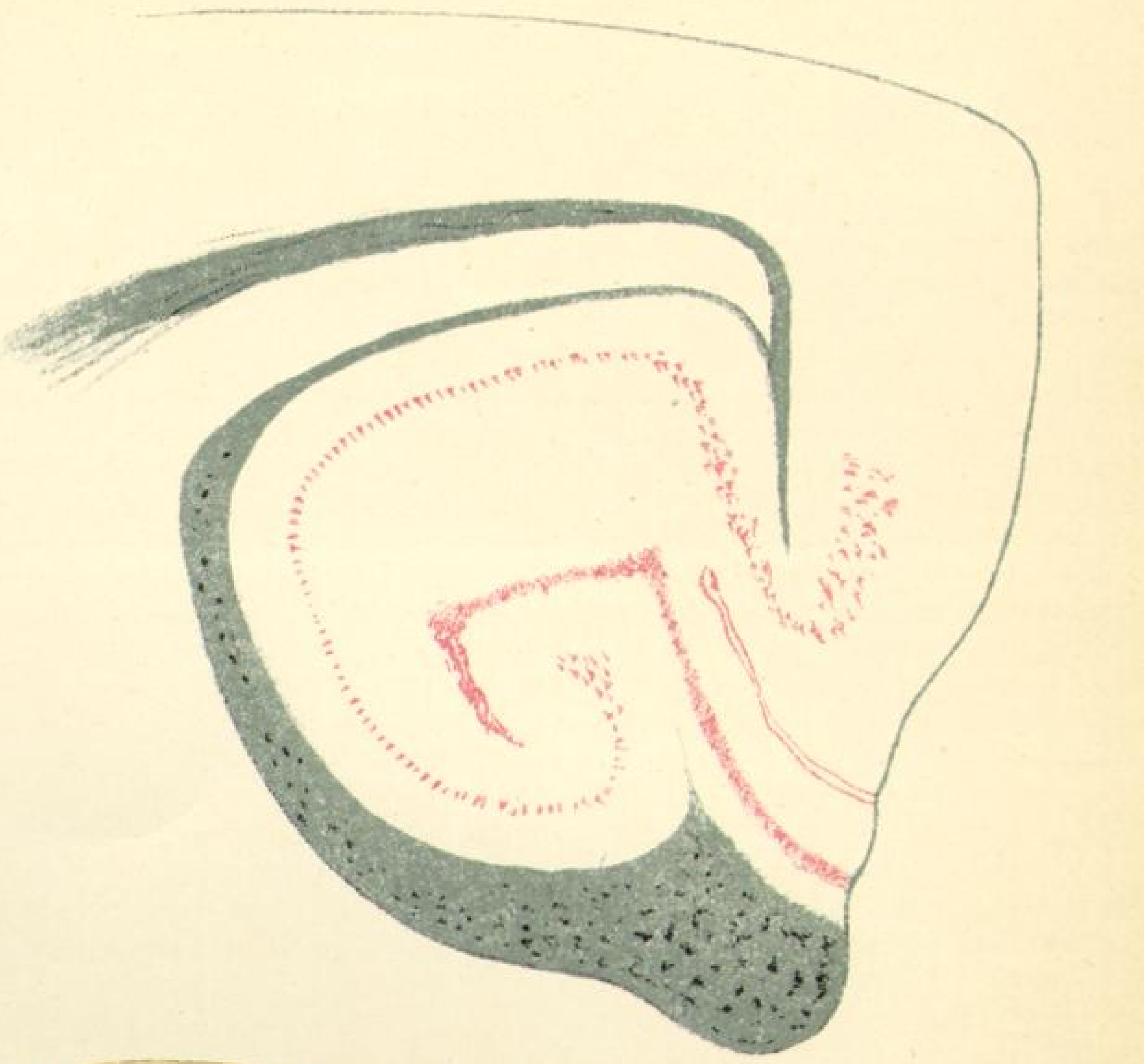
Section 5A.—The anterior end of the hippocampus. The fascia dentata lies almost at right angles to the plane of the large pyramids of the subiculum. Fibres from the front of the commissure of the fornix are descending in the ventricular wall.

Section 6D.—Diagrammatic view of a section in front of the commissure of the fornix and the anterior commissure. The appearance of the fibres as stained with WEIGERT'S hæmatoxylin, has been added to a drawing made from a carmine preparation. The cortex is curving over into its scabbard of fascia dentata. The fibres of the fornix system constitute a capsule for the hippocampus, to which they are limited. The lateral, superior, and part of the mesial cortex is supplied by fibres of the anterior commissure.

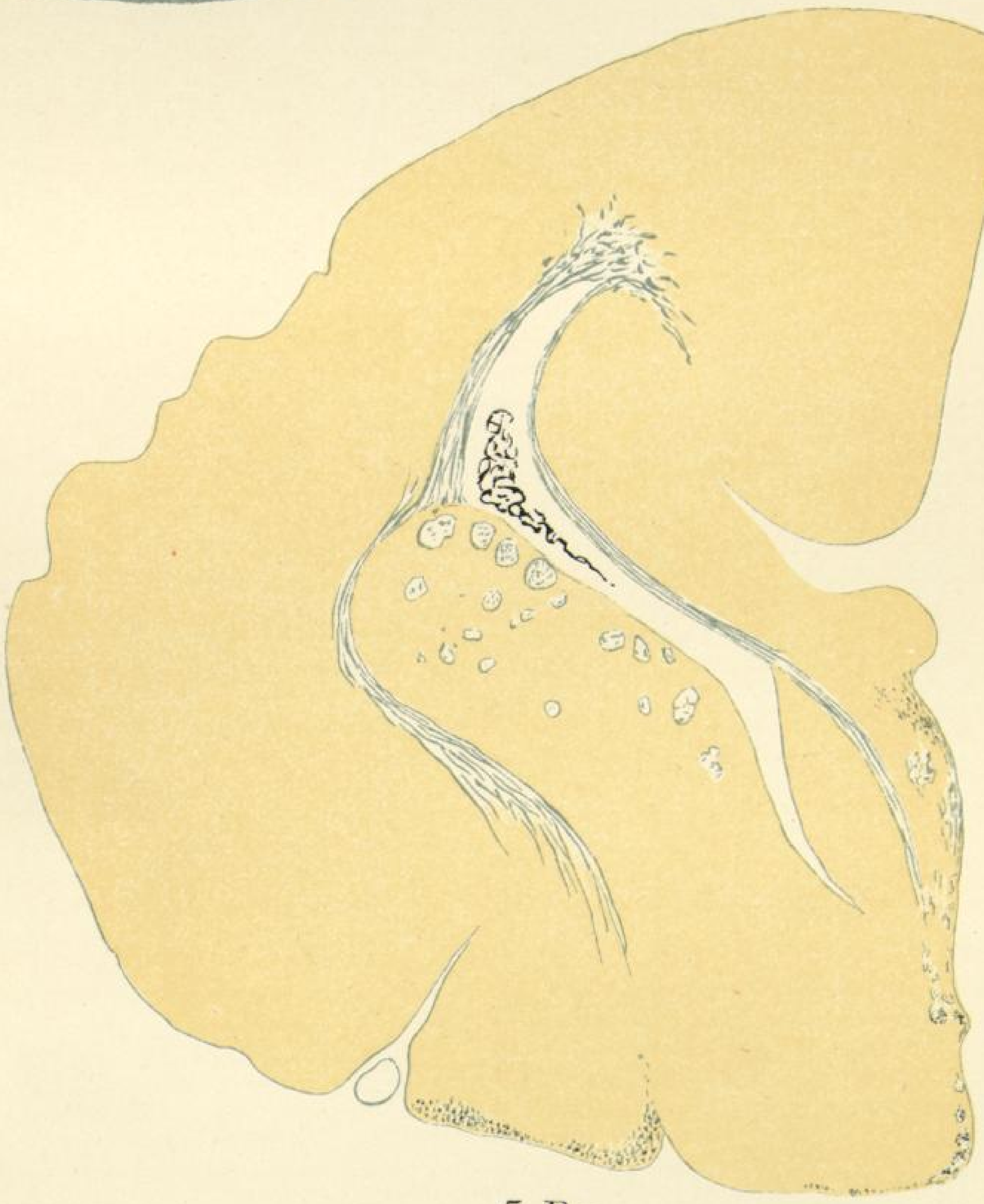
Section 6J passes through the anterior edge of the commissure of the fornix, and cuts the anterior commissure. It shows the continuity of the grey matter of the mesial wall above and below the anterior commissure with the nucleus caudatus. On the ventral side of the section is seen the rhinencephalon, bounded both on its mesial and lateral aspects by fissures, which leave but a narrow sheet of fibres as a connection between it and the rest of the hemisphere.



7 F.

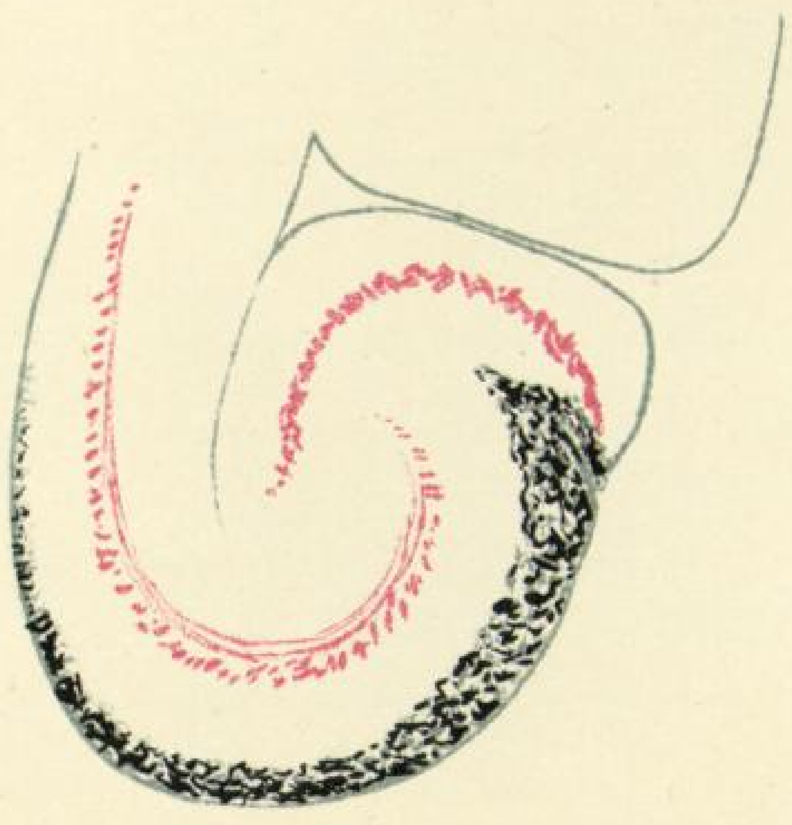


7 G.

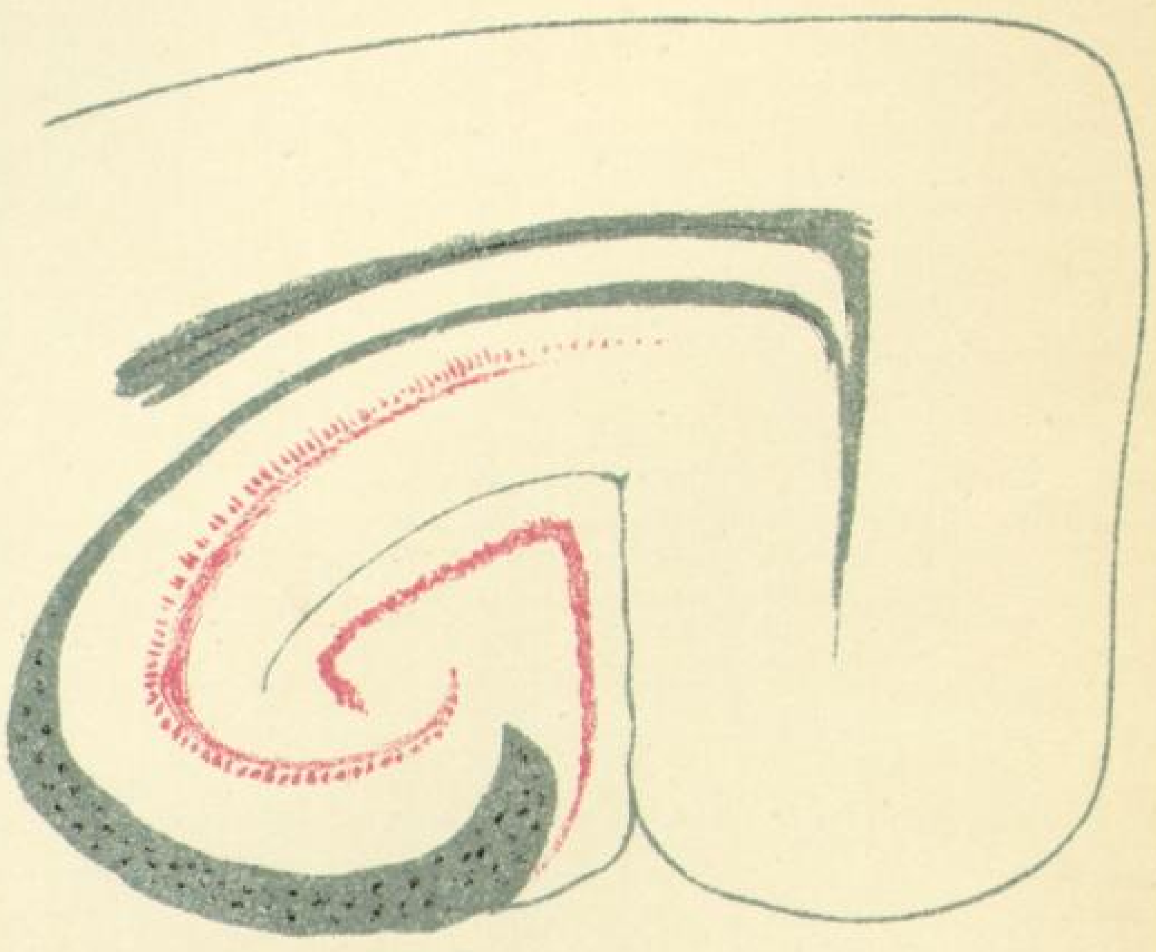


5 B 2.

10 G.



9.



8.

PLATE 21.

Section $5B_2$, through the extreme anterior end of the hippocampus, shows the relation of the fibres of the fornix-commissure to the mesial wall, and the descent of its precommissural fibres. The tract of cortex to which the fibres of the olfactory crus are applied is beginning to be separated from the general cortex by mesial and lateral fissures.

Section 7F cuts the commissure of the fornix.

Section 7G is carried just behind this commissure.

Sections 8, 9, 10G show the way in which the fornix dies away upon the surface of the hippocampus behind its commissure.