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BRAIN PREPARATIONS

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BY MEANS OF DEFIBRILLATION OR BLUNT DISSECTION

A GUIDE TO THE MACROSCOPIC STUDY OF THE BRAIN

BY

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TRANSLATED FROM THE FIRST GERMAN EDITION

BY

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With 4 Text Figures and 15 Plates containing 44 Figures

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PREFACE

At the Anatomical Congress in Kiel, 1927, I demonstrated the preparation of brain specimens according to the method of defibrillation or blunt dissection, which has been practised for a long while in the Anatomical Institute in Uppsala, and on that occasion was requested by several colleagues to publish a complete description of this method. The same wish has also been expressed by neurologists who have seen in our museum preparations made according to this method. I am now pleased to be able to comply with their requests.

Other writers who have dealt with this method of preparing brain specimens emphasise that this procedure requires much time and patience as well as a great deal of material. This is quite right in cases where an investigator uses it in attempting to solve some new scientific problem that may have arisen ; but in ordinary anatomical or neurological instruction, where the main purpose is to give students a clear conception of certain important anatomical facts based upon their own observations, the position is quite different. In my experience the latter object can be obtained relatively easily without wasting time or material if the work of preparation is only organised systematically. Even an inexperienced person can complete the preparation proper, as is described in the following pages, in seven or eight hours ; and all important points can be demonstrated on one brain, or, if necessary, even on a half-brain.

In order to be able to do this, very exact directions for the technical work in its various phases are, after all, absolutely necessary, and for this reason the present guide to brain preparation has become somewhat fuller than corresponding statements usually are. I consider it an advantage if the students are not too dependent upon constant personal supervision and detailed instruction of the demonstrator, but can conduct their tasks somewhat more independently. For the same reason I have decided to illustrate my exposition with numerous figures. Most of the illustrations are photographs of one and the same object in various stages of preparation, and show directly what one desires and is able to obtain by our method. As further evidence of the applicability of the defibrillation method, I have added at the end (Plates XII.–XV.) a few particularly instructive illustrations of special preparations which we have in our museum. As these in part show relationships of brain topography, illustrations of which can be sought in vain in the usual anatomical literature, they will perhaps arouse a certain amount of interest among experienced anatomists and neurologists. This book can thus also serve as a supplement to the expositions in text-books and atlases, but it was not my intention to replace these. Rather I would advise that the study of the text-books should go along simultaneously with the preparation of specimens herein described.

To the publisher I am indebted for his liberality in the matter of illustrations,

and to Dr. A. Jokl, of Vienna, my former assistant, for the language revision of the manuscript.

For the beautiful preparations which are figured in Plates XII. and XIII. I am indebted to my present student-assistant, Mr. T. Wahlén, and for the photography, to the technician of our Institute, Mr. Axel Halvardson.

J. WILH. HULTKRANTZ.

UPPSALA,
July 1929.

TRANSLATOR'S NOTE

When I was in the Anatomical Institute at Uppsala in the spring of 1929, I was very much impressed with Dr. Hultkrantz' method of teaching the anatomy of the brain, and decided that, on my return to Australia, I would introduce it there to my classes. Dr. Hultkrantz therefore kindly sent me a copy of this manual as soon as it was published.

Since my students have derived much benefit from these instructions, it occurred to me that they ought to be made available in English. No doubt the method of dissecting the brain described in this little book is not entirely unknown in English-speaking countries, but, since directions for a complete dissection of the brain according to this method are, I think, quite new, its appearance in English needs no apology. Many of the illustrations, too, are unique, and form a valuable supplement to the atlases already in existence.

My thanks are due to Miss Anna Menz for her kind assistance during the translation.

H. J. WILKINSON.

Adelaide, Australia.

CONTENTS

INTRODUCTION

The method which is described in the following pages, and which makes use of the splitting properties of the hardened brain for the purpose of demonstrating its structure, was founded by my teacher and predecessor in the chair for macroscopic anatomy at Uppsala, Professor Edvard Clason. He himself told me that he hit upon the idea, when, somewhere about 1880, he noted how surprisingly easily a few old discarded brains, which had lain for many years in acid spirit, could be taken to pieces in certain ways. He first made use of this experience for the preparation of a series of illustrative museum specimens, but it was not long before the members of his classes regularly made similar preparations. Therefore, when I took over the direction of these classes some twenty-five years ago, the method had already been proved in its chief aspects and found practicable, and so I made it my business to build further on the foundation and gradually perfect the method. Several factors contributed to this, such as, for example, the introduction of formalin as a fixative medium, through which the material gained greater elasticity and at the same time greater resistance, thus becoming much more suitable for the intended purpose than the spirit material previously used.

The investigation of the brain by means of blunt cleavage and defibrillation with forceps is certainly not new : on the contrary, since the advantages of a preparatory hardening of the organ had been realised, this was probably the most important method at the disposal of the investigators of the first half of the last century. I will only refer to the works of Gall and Spurzheim, Arnold, Foville, etc. After the introduction, however, of the serial section and reconstruction methods, and of the methods of embryological and experimental investigations, the macroscopic methods naturally lost their importance, since they never give a final solution of the problems which interest us at the present day. They can, nevertheless, serve a useful purpose in orientation, and in the stimulation and the direction of other kinds of investigation. However, here and there, works do appear which, with the help of the defibrillation method, make welcome contributions toward clearing up various questions which have not yet been settled. Thus, for example, Curran [1] teased out and described an association bundle, fasciculus occipito-frontalis inferior, running in the external capsule immediately superior to the fasciculus uncinatus. Jamieson [2] and Büttner [3] have used the method for the radiation of the brachia pontis into the white matter of the cerebellum. Also just recently Elze [4] investigated the course of the optic radiation, of the cingulum, of the fornix longus, and of the anterior commissure by means of defibrillation.

[1] *Jour. Comp. Neur. and Psychol.*, **19** (1909).
[2] *Jour. of Anat. and Physiol.*, **44** (1910).
[3] *Z. Anat. I.*, **84** (1927).
[4] *Z. Anat. I.*, **88** (1928).

Nevertheless, the macroscopic fibre-preparations ought not to claim any greater position in future than that of a simpler, more convenient accessory method in scientific brain investigation. On the other hand, since it can, on occasion, be of very good service, it must not fall into oblivion.

However, as a teaching method defibrillation, by which I understand every kind of blunt splitting, has so much the greater importance. He who has once become familiar with this method finds it difficult to understand how anyone can teach or learn, *e.g.*, the structure of the brain-stem, without making use of the possibility of separating from one another the structures which go into it, and in this way of obtaining a *direct* conception of the form, size and position of every structure. If one, however, looks through older as well as more recent instructions for the preparation of brain specimens, one is surprised to find that almost all of them are content merely to give directions for a simple inspection of the brain-stem from the outside and from the direction of the opened ventricles, and the study of a few frontal and horizontal sections. Strasser, in his *Anleitung zur Gehirnpräparation*, does indeed recommend the shelling out of the corpus striatum and the exposure of the crura of the corpora mamillaria ; but details concerning the methods of procedure are, however, not given. I have also received information from a number of colleagues about the methods of preparing the brain which are practised in their institutes, and have discovered that the blunt separation of the basal ganglia from the internal capsule, and so on, is almost never attempted ; and that the topography of these parts is studied almost exclusively from serial sections.[1] It may be possible to construct a three-dimensional picture mentally from mere surface views, but our presentation of form and position of the structures in question must surely become much clearer and more correct—and very much time is thus also gained—if we can isolate the structures from one another and observe them directly from all sides. The advantages of this latter procedure perhaps show up most clearly if we think how inconvenient it would be to have to study the thoracic organs only from frozen sections.

The essential thing about the method of preparation which was gradually evolved in Uppsala is just separating from one another the various morphologically differentiated parts of the brain, and in doing this preserving their natural boundaries as far as possible, so that the parts—as in a puzzle game—can be fitted together again in their original position. The guiding principle here also is to preserve so much from such parts of the brain as are less interesting that one can always orientate oneself about the topography of every single structure in relation to the whole brain. Following these principles, it often becomes necessary to interrupt temporarily the preparation of a tract, etc., and to take it up again later ; but since almost all structures are preserved in a fairly undamaged state when the preparation is finished, they can be studied systematically afterwards all the better. The

[1] In some American Universities the practicability of the defibrillation method for the anatomical instruction seems to have been realised. In a short account in the *Anat. Rec.* **3** (1909) Hoeve has mentioned a number of fibre systems which can be demonstrated in this way ; since, however, detailed instructions and illustrations are lacking, the demonstration is little suited to serve the student as a guide. As the chief instrument for blunt dissection he recommends a manicure stick.

completed preparation is of special service as an object of comparison in the study of serial sections through the brain. Sagittal sections also, the interpretation of which, as is known, is considered fairly difficult, no longer offer students any difficulty when they have the preparations they have made in front of them.

I should like to make a few more observations about the practical application of our method in the dissecting-room or neurological courses. If there is a dearth of material one can do with preparations such as are described in Chapter II. All the more important macroscopical or naked-eye features are exposed there, and the general view of their connexion with one another, which the completed preparations described in Chapter III. chiefly aim at, can, if necessary, also be obtained through the study of preparations specially made for demonstration.

It is very desirable that two (but no more) dissectors should always work on the same half-brain, because assistance is necessary, or, at any rate, very welcome, when preparing a brain ; only then has one a certain guarantee that both students see what they ought to see. Under these circumstances one can therefore manage with one brain for every four students. Furthermore, it is desirable to have at one's disposal for every course at least three brain hemispheres in order to make serial sections (about 0·5 cm. thick) in the three principal planes. One can observe better on free sections held in the hand than from preparations mounted in closed vessels.

If the material is more plentiful so that one brain can be allotted to every two students, then it is more useful for both to use one half-brain together for complete defibrillation according to the directions in Chapter II., and later to carry out the supplementary preparations described in Chapter III. on another half-brain. The procedure for opening up the ventricles described in Chapter III. corresponds more or less in its essentials with the methods indicated by other authors ; but here the cuts are so placed that all structures of interest to us are kept intact as far as possible, and can be studied in their natural position.

Through direct observations on every single structure such as can be made by one who uses the present method, not only in the course of the work but also on finished preparations, one relatively easily arrives at a clear three-dimensional or " plastic " conception of the inner topography of the brain, even of such points which experience has shown are difficult to understand. The synthesis of the separate memory pictures can be made still easier through the study of special preparations which give total pictures of the various systems. A few examples of such preparations made for our museum are illustrated and briefly described on Plates XII.–XV. Anyone who knows the defibrillation method needs no further directions for making such preparations.

CHAPTER I

THE TECHNIQUE OF THE DEFIBRILLATION METHOD

Material. According to my experience, every brain hardened in formalin can be used for defibrillation. The brains which are put at our disposal in the Institute at Uppsala are rinsed for a short time in water after their removal at autopsy, which generally occurs two to four days post-mortem, and occasionally still later. They are then placed in *Kaiserling's* solution I. [1] or simply in 10 per cent. formalin. After two or more weeks they are quickly rinsed, placed into 95 per cent. alcohol for twelve to twenty-four hours, and then transferred into the preservative solution (III.). In this way they can be kept as long as one likes. I have let such material lie for several years in a tub provided with a loose lid, with only a little liquid upon the bottom and covered with a towel, without its being rendered unfit for use.

Other modifications of the formol treatment give satisfactory results.[2] I have not had the opportunity of making systematic investigations into the most suitable hardening method. Occasional attempts have been made to improve the splitting properties of the brain, but up to the present without definite success. I have the impression, however, that the variation which different brains display in this respect depends more upon the degree of decomposition which has occurred before the hardening than upon inefficient methods. Nevertheless, it is evident that one need not make particularly great demands upon the freshness of the material.

Brains hardened in alcohol also sometimes give quite good results, but they are much more brittle and therefore give even a practised dissector a good deal of trouble.

Principles of the Method. In order to obtain good results with our defibrillation method, one must have a clear idea of the principles on which the procedure is based as well as of the actual purpose of the different manipulations. The different structures in the brain are to be separated as far as possible from one another in order that their relative position and the formation of every separate part can be studied. Therefore the boundary between the neighbouring structures must always be looked for first and then followed into the depth.

In defining boundaries, the **surface relief** and the **colour difference** often give the required information. When the material is well preserved, the cortical and nuclear substance always stand out clearly from the lighter white substance on

[1] This consists of 20 parts formalin, 3 parts potassium acetate, 1½ part potassium nitrate, and 100 parts water, while his Preservative Solution (III.) consists of 2 parts glycerine, 1 part potassium acetate, and 10 parts water.

[2] In case the smell of formalin from the newly prepared material is too unpleasant, one can treat the same, according to Neumayer (*Anat. Anz.*, **29**, 1906), with ammonia, without in the least affecting the keeping and splitting properties of the material.

account of their darker colour; but also within the white substance the various layers often differ in colour. In a section the longitudinally cut fibre-strands generally have, as is well known, a brighter sheen than those which are cut transversely. I will only refer to the pyramidal bundles in the pons, or to the tapetum and the optic radiation. Again, the microscopic structure, however, such as the thickness of the fibres, proportion of glia tissue, etc., can cause a difference which is clearly noticeable to the naked eye; thus, *e.g.*, the lemniscus lateralis looks darker than the brachium conjunctivum, and likewise the capsula externa than the corona radiata.

The **firmer or softer consistency** of the structures is likewise very useful, for the grey substance is always softer and more friable than the white. Nevertheless, certain masses of grey substance, *e.g.*, the thalamus, inferior olive and the red nucleus, can have a relatively firm consistency on account of the presence of numerous nerve fibres which penetrate into them or enclose them in a strong capsule. It should be noted that for testing the greater or less resistance of an organ, a sharp and heavy tool is much less suited for probing than a blunt light one. This is one of the reasons why the work should, as far as possible, be carried out with blunt instruments.

Further, in separating formations from one another, the differences in colour and consistency are also of great use in enabling one to follow the boundaries; but if, however, the various fibre tracts in the white matter are being investigated, it is, above all, the splitting qualities of the tissue which enable us to establish their course and to draw conclusions as to their origin and destination. This splitting quality of the tissue is determined by its finer structure; for since the resistance against tearing, or, in other words, the tensile strength, is greatest in the direction of the nerve fibres, the white substance must allow itself to be split most easily in the direction of the strongest fibre strands. In those places where the fibre systems which cross one another are about of equal strength, such as, *e.g.*, where fibres of the corpus callosum and of the corona radiata cross one another almost at right angles, no even tear surface can be obtained; for the tear alternately follows one or the other system, and any attempt to direct the splitting purposely into a definite direction meets generally with little success.

Naturally, it is only the stronger fibre strands that one can see in teased preparations, and any finer strands which may happen to cross through these must always be sacrificed; but an attentive observer will occasionally get a glimpse of such fibres just at the moment of splitting before they tear away.

In order to obtain splitting surfaces as near to nature as possible, one can make use of various knacks or manipulations. Occasionally one need simply take hold of the parts to be separated, either with the fingers or perhaps with forceps, and gently pull them apart. In other cases again, it is better to lift off one formation from another neighbouring one with a suitable instrument, or to force them apart as with a wedge.

In taking hold of and lifting off such formations, which are less resistant, one must, of course, be careful to distribute the necessary pressure upon a sufficiently

large surface, so that the tissue is not crushed. Very thin fibre lamellæ, such as are found in the internal capsule or round the nucleus dentatus, can be grasped with forceps with the necessary care, and gradually pulled off; but often still more care should be exercised by penetrating under the lamellæ with a fine probe or some other suitable instrument, and then detaching them gradually from what lies beneath. If one wants to use an instrument as a wedge to separate formations of a somewhat firmer consistency, it is very important that it should not have a sharp cutting edge, but one which is blunt and well rounded. Under no circumstances must it act like a knife or chisel and cut or squash the tissue, for it is meant to push the fibres apart before these are subjected to any pressure whatever. The diagram in text, Fig. A, says more than many words. The instrument is slowly advanced in the direction of least resistance with little tipping or lowering movements. It is also very important to have the surfaces of the instrument as smooth as possible so that friction does not damage the tissue elements or render more difficult the exact feeling for the resistance.

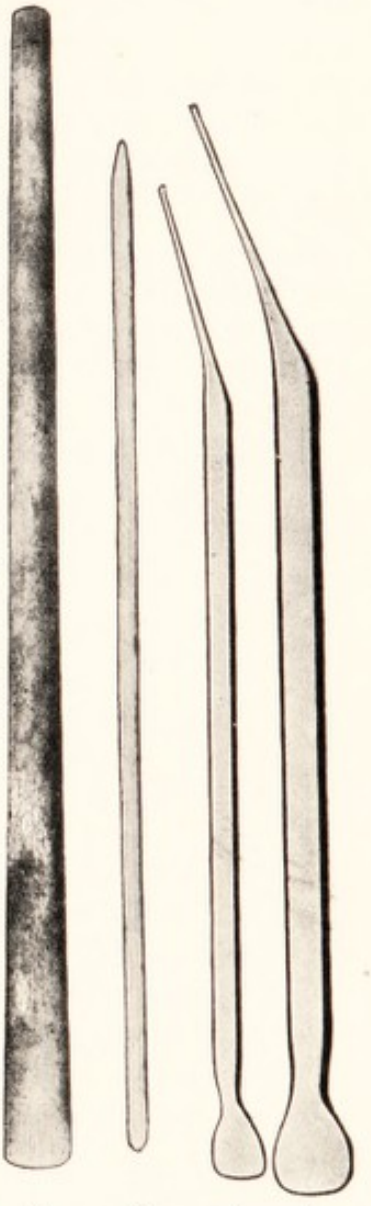
In the preparation of fibre bundles which lie upon the surface some difficulties are occasionally experienced in taking away the covering glia layer. On the free surface of the brain-stem, as well as on the walls of the lateral ventricles, this layer can be so strong in places that it not only obscures the fibre direction of the underlying white substance, but also changes the surface relief. In trying to peel off the glia one is tempted to use a knife because the consistency of this tissue is usually very tough; but with a little patience, however, this object is as a rule better achieved by scraping it off with a blunt instrument, or detaching it with a probe. If the probe is used, however, it is difficult to avoid losing a few fibres of the underlying tracts.

Fig. A.—For explanation, see text.

Instrumentarium. In the defibrillation method, spatulæ and awl-shaped instruments are those most frequently used. As a spatula, one can, in case of need, use either the handle of a small scalpel, provided that its edge, which is usually too sharp, has been well rounded off, or even a piece of wood cut into the same shape; but even if such an instrument can be given the proper shape, its surface is still generally too rough. Therefore finely smooth spatulæ made of bone are much to be preferred. It is convenient to have several of these of different sizes, but one can get on quite well with one such as is illustrated in text, Fig. B (*a*). Another very useful instrument, the awl, can be made very easily out of a thick bone knitting needle by reshaping the points with the aid of files and the finest sandpaper, and making the ends flat with a rounded edge, as shown in Fig. B (*b*).

Much of the work connected with the method can also be carried out with the probes which are found in ordinary anatomical sets. With these one can penetrate under thin white lamellæ and fibre strands and detach them from their bed for quite a long way. Lately, I have made my instruments, both spatulæ and probes, out of glass. These are so smooth that friction is reduced to a minimum, and in consequence the finer details are better preserved and the work is made much easier.

Another recommendation is their cheapness. I find that the types given in text, Figs. B (*c*) and B (*d*), are the most suitable and practicable. These are made from pieces of glass rod, which are drawn out at one end like a probe with a knob which is barely noticeable, and flattened off at the other like a spatula. Occasionally the closed ends of little forceps, for preference bent, can do the same work as a probe ; only one must take good care that the prongs of the forceps fit exactly on one another and are ground round at the points and edges. It is very convenient sometimes to use the forceps as pincers, if one wants to take away, *e.g.*, the medullary ledges of the cerebellar lobes. Perhaps it is hardly necessary to mention the fact that one can take hold of fragile formations with the forceps with much less damage if its spring is not too strong.



a *b* *c* *d*

FIG. B.—Defibrillation instruments ; *a* and *b* are made of bone, *c* and *d* of glass.

In the defibrillation method, sharp instruments are used only for quite definite purposes. For example, in making a relatively large section through the brain, a brain knife is necessary ; and in making museum preparations where beautiful execution is of special importance, it is very handy to have at one's disposal, for the final cleaning work, a knife bent at an angle and having a very thin two-edged blade ground like a lancet. One can manage quite well, however, with ordinary knives, provided care is taken to choose only those with the thinnest possible blades. The preparation of such delicate structures as nerve roots and so on can be done better with little bent scissors than with a knife.

While working, it is very useful to have an assistant to hold the brain in a suitable position and to pull apart the various structures as required. In this way much time is saved and the result, too, is much better. Moreover, since it is possible during the preparation to make various observations which cannot be made on the finished specimen, stress must be laid on the need for students always to work in pairs.

Particular attention must be drawn to the fact that the preparation must always be kept moist. This does not mean, however, that it always has to be placed in some preservative fluid. All that is necessary is to see that at every interruption of the work it is covered with a damp cloth, and when the work is ended it must be wrapped in such a cloth and kept in a closed vessel. Besides the above-mentioned Kaiserling Preservative Solution III, any fluid will do to moisten the cloth so long as it prevents the formation of mildew. If at any time the preparation should accidentally become a little dry, then it should be left in running water for a few hours, and then, if the drying process has not gone too far, the preparation will generally go back to its former consistency and former appearance.

If a finished preparation is to be kept for some time so as to serve as an object of study or as a pattern for preparation or modelling, it can be made more permanent in the following way. After washing the preparation for a while in lukewarm water, it is placed for about half an hour in a warm—but not too thick—solution of gelatine. It is then kneaded carefully to make the gelatine penetrate better and the excess is drained off. After it has become cold, it is dipped for a few minutes into a 5 to 10 per cent. solution of formalin.

Before going on to the precise description of the dissection of the brain according to the defibrillation method, I want to sum up here shortly the most important general rules :—

(1) *Always let the direction of the splitting be determined only by the structure of the tissue.*

(2) *Always try to work with as light a hand as possible.*

(3) *As far as practicable, always use blunt instruments with surfaces as smooth as possible.*

(4) *Always work in pairs.*

CHAPTER II

PREPARATION OF A HALF-BRAIN ACCORDING TO THE DEFIBRILLATION METHOD

(A) Outer Form. Soft Membranes. Nerves and Vessels

THE student must first view the half-brain from the median aspect and find out whether any one of the unpaired formations lying in the mid-line (such as the hypophysis, corpus pineale, septum pellucidum, art. basilaris, etc.) has been lost in the process of halving the brain.

After that, one must study the external configuration and the main subdivisions of the brain. By comparison with an open skull (and, if possible, one in which the dura mater is intact) one orientates oneself with regard to the position of the brain in the cranial cavity, and acquaints oneself with the degree of correspondence with one another of these two structures in regard to form. The differences of form and size of, *e.g.*, the dorsum sellæ and the deep fossa media basalis cerebri, explain the form and size of the respective arachnoid cistern.

With forceps and scissors the larger cisterns, with the exception of the cisterna cerebello-medullaris, are now opened up and the nerves and vessels running therein are carefully loosened from the attached connective tissue trabeculæ and lamellæ. The branches of the internal carotid artery and the basilar artery are identified and followed a little way, after which they are removed. Especial care is needed for the preparation of the slender trochlear nerve which runs around the brain stem through the cisterna ambiens in company with the posterior cerebral and the superior cerebellar arteries. In order that this nerve may not be accidentally torn away later on, it is advisable to cut it off now, a few millimetres from its point of exit behind the inferior colliculus. The pineal body lying above the lamina quadrigemina and the great vein of Galen are freed from the surrounding rather dense arachnoid tissue.

After an inspection of the outer surface of the mid-brain which now lies clear, one can proceed to the separation of the cerebrum, etc., from the rhombencephalon. The section is so placed that it runs dorsally between the superior and the inferior colliculi and ventrally about 2 mm. above the pons ; it therefore divides the mid-brain into two. The hind-brain part of our preparation is kept for later study, and for the present we will devote our attention to the fore-brain part.

After an inspection of the Pacchionian bodies and of the superficial veins which flow into the dural sinuses, the pia mater with its vessels is removed piece by piece from the whole surface of the hemisphere. The arteries which run for the most part deeper in the sulci are pulled out carefully with the attached pial tissue ;

but one must not as yet penetrate into the choroid fissure and into the space under the corpus callosum. The connective tissue found here should for the present be left untouched.

One is now in a position to see clearly the segmentation of the pallium. The lobes and the intralobular fissures, as well as the typical sulci and gyri, are now identified, one after the other. For better orientation, the more important fissures and sulci can be marked with an aniline pencil. One must not neglect to look at the gyri profundi hidden in the depth of the larger fissures (*e.g.*, in the calcarine fissure).

The next feature to be studied is the insula. In order to get a good view of

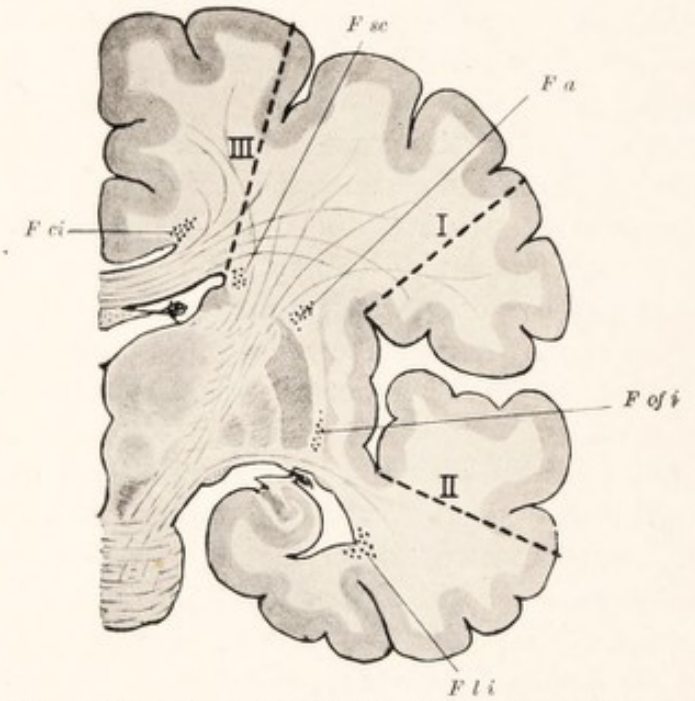


FIG. C.—I.–III. are the cutting planes (see text). The dotted fields are the cross-sections of the long association bundles. *F a*, fasciculus arcuatus. *F ci*, F. cinguli. *F l i*, F. longit. infer. *F of i*, F. occipito-frontalis inferior (Curran). *F sc*, F. subcallosus (or occipito-frontalis [Forel]).

this, the overhanging opercula must be removed. First cut off the temporal operculum ; guided by the left fore-finger which has been inserted in the lower part of the circular sulcus, one pushes the knife in the direction as indicated in Fig. C (Cut II.) from the point of the temporal lobe backwards and then upwards against the posterior part of the fissure of Sylvius. In the same way the operculum frontale, and lastly the superior (Rolandic) operculum, are removed (Fig. C, Cut I. ; *cf.* also Plate II., Fig. 3). The three severed pieces can then be fastened, in their original position to one another by means of pointed pieces of wood (*e.g.*, matches).

The superficial formations of the rhinencephalon are all now open for inspection, except parts of the gyrus dentatus. The study of these must not be postponed, because later on various details can easily suffer.

(B) The White Substance of the Cerebrum. Association Fibres. Corpus Callosum. Brain Ventricles

A very instructive picture of the spacial relations of grey and white matter in the pallium is obtained by completely removing the grey substance in any particular region of the cerebrum (Plate XIV., Fig. 38). We chose the inner side of the occipital lobe and with the glass or bone spatula remove the cortex, not only from the free surface of the convolutions, but also out of the deep calcarine and parieto-occipital fissures and the shallower subsidiary furrows (Plate I., Figs. 1 and 2). Between the broad depressions which thus arise, more or less high narrow ridges of white matter remain standing. From the rounded floors of these depressions, thin lamellæ of white matter, which are curved over their surfaces, can be peeled off with the spatula. These lamellæ consist of the short association fibres (*fibræ propriæ*, arcuatæ). In the front half of the calcarine fissure and in the lower part of the parieto-occipital fissure one must take care not to break through the wall of the posterior horn of the lateral ventricle, which is here very thin.

If the grey matter of the gyrus fusiformis as well as that of the neighbouring furrow is, in the same way, completely scraped away, and then if the strong ridge of the white matter of the above-mentioned gyrus is removed down to the level of the furrows, or even a little deeper, one comes across a system of long association fibres which run in a sagittal direction. This is the *inferior longitudinal fasciculus* [1] (Plate I., Fig. 2).

Two other large association tracts near the insula are just as easily prepared (Plate II., Fig. 3). If one scrapes to a depth of 2 or 3 mm. into the softer surface layer at the limen insulæ, where the vertical surface of the insula turns around into the basal horizontal surface of the brain, then one comes upon strong arch-shaped fibre bundles which can be followed without difficulty, on the one hand, in the direction of the point of the temporal lobe, and, on the other, into the white matter of the orbital gyri of the frontal lobe. This is the *fasciculus uncinatus*. The other association tracts (*fasc. arcuatus* or superior longitudinal fasc.) goes along the upper edge of the insula and can be exposed by carefully scraping away the cortex and the most superficial white layer in the circular sulcus and a little above it. Through the sagittal direction of its fibres this fasciculus can be clearly distinguished from the transverse fibres of the corona radiata, and can be traced forwards to the Rolandic operculum.

The *fasciculus cinguli* also belongs to the long association bundles. In order to lay it bare, first scrape off the cortex of the area parolfactoria, the gyrus cinguli (callosal convolution) and the isthmus gyri fornicati (taking care of the tænia tecta and the fasciola cinerea hidden in the depths of the sulcus corp. call.). If the ridge of white matter of the gyrus cinguli, as well as a little of the neighbouring white substance, are now removed, then the fasciculus in question comes to light as a strong fibre strand running lengthwise, which can easily be lifted off with the spatula from the underlying radiating fibres of the corpus callosum (Plate I., Fig. 1). The

[1] This can also be exposed from the lateral side through removal of the middle temporal gyrus. *Cf.* Fig. C, where the positions of the other long fasciculi are indicated.

fasciculus cinguli can be made separate without difficulty in its whole extent as far as into the gyrus hippocampi, but one should be content to free only its upper and anterior part. It should therefore be cut through behind the splenium and then detached from its bed from this point forward along with its radiations into neighbouring gyri. It should be traced forwards to a point under the genu of the corpus callosum.

The radiating fibres of the *corpus callosum* are now exposed fairly completely in the direction of the upper edge of the hemisphere and the medial side of the frontal lobe (forceps anterior). In order to get a view of the forceps posterior, parts of the præcuneus and cuneus have yet to be broken away. At the splenium and at the genu of the corpus callosum one must note the transition of the induseum griseum (striæ longitudinales) into the fascia dentata and the gyrus subcallosus respectively.

Between the anterior part of the body of the corpus callosum, the rostrum of the corpus callosum, and the fornix which runs upwards and backwards above the foramen of Monro, there stretches the thin *septum pellucidum*. This is cut out of its frame and the fornix is cut through above the foramen of Monro and is loosened from the corpus callosum towards the splenium. One can now obtain a view of the anterior horn and the middle part of the lateral ventricle. If one now carefully lifts up the posterior part of the corpus callosum and the fornix which here is attached to it, one sees that the cleft between them and the upper surface of the thalamus contains loose pial connective tissue (*velum interpositum*) which projects laterally with a thickened vascular border (the plexus chorioideus) into the lateral ventricle. The choroid plexus is loosened from the free lateral border of the fornix from the foramen of Monro anteriorly, up to a point behind the thalamus posteriorly.

In order to get a more complete view of the *lateral ventricle* the corpus callosum must now be removed. This is done by making three cuts. The first is made by inserting a knife into the anterior horn of the lateral ventricle as far as its lateral angle, and then cutting horizontally through the genu of the corpus callosum and the frontal lobe. A second, rather deeper cut is made through the posterior part of the corpus callosum and the underlying fornix just in front of the splenium and goes upwards and slightly backwards to the outer surface of the parietal lobe. The direction of these two cuts is indicated by dotted lines in Plate I., Fig. 1. These are now joined up by a third cut, which follows the lateral angle of the ventricle and on the outside runs 2 or 3 cm. away from the median plane. The direction of this last cut is shown in Fig. C (Cut III.). The piece cut out in this way is lifted off and its under-surface, with parts of the fornix and psalterium attached, is now inspected.

Along the lateral edge of the nucleus caudatus runs a bundle of long association fibres (*fasciculus subcallosus*, or fasciculus occipito-frontalis superior of Forel) which is revealed by carefully removing the transverse fibres of the corpus callosum (Plate II., Fig. 4).

The radiation of the callosal fibres which are coursing through the splenium out towards the temporal and occipital lobes and to the hippocampus can be demonstrated in the following way. With a probe or awl, which is pushed into the posterior

horn from the vertical part of the lateral ventricle, one searches for the thin wall which separates the horn from the calcarine fissure and perforates it. From this opening one splits bluntly (with the awl or a glass probe) up through the fibre mass of the splenium. If the two pieces are now held apart, a clear view is obtained into the trigone of the ventricle. If, now, the ependyma of the lateral wall is carefully scraped away, or, even better, is lifted off with a glass probe, then one sees distinctly how the fibres coming from the upper part of the splenium and slightly diverging form a distinct layer, the so-called *tapetum ;* if this layer, too, is removed, then the strongly marked horizontal strands of fibres, viz., the posterior or occipital stalk of the thalamus or Gratiolet's radiation, come into view (*cf.* Plate III., Fig. 6 ; and Plate VI., Fig. 13).

The velum interpositum with the plexus chorioideus (Plate II., Fig. 4) is now detached from the surface of the thalamus (the vena terminalis is cut through at the foramen of Monro) and the continuation of the plexus into the inferior cornu is pulled out through the choroid fissure ; if while doing this the edges of the fissure are held somewhat apart, one can see how the plexus is attached to the fimbria. If one examines the course of the fibres, which come from the lower turned-under part of the splenium, then one sees they form quite a thin layer only on the medial wall of the trigone of the ventricles and the posterior cornu ; the rest of the fibres extend with the fimbria into the inferior cornu and radiate out into the alveus.

(C) Nucleus Caudatus. Thalamus

One begins the preparation of the cerebral ganglia with the *nucleus caudatus*. In spite of its fragility, this nucleus can be taken out whole. To do this, the tough layer composed of ependyma, and neuroglia which covers it, must be kept intact, and the stria terminalis (tænia semicircularis) which runs along its medial edge and consists of relatively strong fibre bundles, must be taken out with it. For the present only the body and the head of the nucleus are dissected out, and the tail, which lies in the roof of the inferior cornu, is left behind. The nucleus and the stria terminalis are therefore cut through posteriorly at the place where they bend around behind the thalamus, and anteriorly, the stria is cut at the foramen of Monro, while the ependyma is slit through along the edge of the nucleus. After this, the lamina terminalis is freed from the columns of the fornix and the anterior commissure, and this lamina, the subcallosal gyrus and the fibres which radiate downwards from the rostrum of the corpus callosum are all turned down and cut off where they pass into the anterior perforated substance. Thus the medial aspect of the head of the caudate nucleus which is turned towards the area parolfactoria is brought to view (Plate III., Fig. 5). The laying free of this part of the nucleus is cautiously continued backwards and forwards until one sees the course both of the anterior commissure as well as of the most forward (most inferior) part of the internal capsule.

One has now sufficiently orientated oneself to be able to lift away the caudate nucleus from its bed. To do this one begins from behind, and with the spatula

penetrates under the stria terminalis and the tail, coming alternately from the medial and the lateral side, and separates them gradually from the internal capsule. Since the fibre bundles of the capsule become thinner under the head of the caudate nucleus and lie more scattered, the boundary here is less distinct, and below the anterior commissure there run only occasional bundles of the capsular radiation. The most inferior part of the head of the caudate nucleus (colliculus nucl. caud.) is best separated with a knife from the putamen of the lenticular nucleus with which it is continuous. The free caudate nucleus is figured in Plate V., Fig. 10, while its empty bed is seen in Plate III., Fig. 6.

Before one proceeds on to the dissecting out of the *thalamus opticus* some structures connected with it must first be treated. If one carefully scrapes away from the under part of the lateral wall of the third ventricle the relatively soft central grey substance, we find two well-defined fibre bundles issuing from the corpus mamillare, the anterior of which, the crus fornicis, goes up directly into the fornix, while the posterior of them, the crus thalami or bundle of Vicq d'Azyr, soon penetrates into the anterior part of the thalamus (Plate II., Fig. 4). The inferior part of the wall of the ventricle between the corpus mamillare and the tractus opticus (in other words, the tuber cinereum), as well as some loose fibre-bundles belonging to the olfactory tracts, ascending in front of and behind the anterior commissure, are removed (Plate III., Fig. 5) and the column of the fornix and the corpus mamillare made free, so that the latter, hanging to the bundle of Vicq d'Azyr, can be turned backwards (Plate III., Fig. 6).[1] Now the *ansa peduncularis* which bends laterally around the pes pedunculi, is brought to view ; it is chiefly constituted of fibres passing from the thalamus and the subthalamic region to the lenticular nucleus and the temporal lobe (inferior stalk of thalamus). One detaches the tractus opticus from the pes, cleans this, and pushes forward with the awl or the probe between the medial edge of the pes and the ansa, following the former exactly, in the direction of the anterior commissure, and finally cuts through the ansa with the knife directed towards the awl. (The cut is visible in Plate III., Fig. 6.)

With the cutting through of the ansa peduncularis a big obstacle to the lifting off of the thalamus from the internal capsule has been removed ; but the winding of the optic tract around the posterior border of the capsule also presents a certain amount of difficulty. However, this can be overcome if one carefully detaches the whole tract, together with its radiations to the superior colliculus, pulvinar of the thalamus and lateral geniculate body, from its foundation and from the stria terminalis which bounds it laterally, and displaces the tract medially from its hidden position close to the choroid fissure.[2] The necessary room for these preparations is obtained by strongly pulling down the splenium radiation to the inferior cornu.

After these preparations one simply penetrates with the spatula, at the cut surface through the mid-brain, into the easily visible substantia nigra of Sömmering,

[1] Sometimes, by very careful dissection, it is possible to demonstrate the existence of the tractus cortico-habenularis which goes over from the column of the fornix into the stria medullaris thalami (*cf.* Plate V., Fig. 11).

[2] In doing this, it is often difficult to avoid breaking the corpus genic. lat., but in most cases the parts remain connected together.

which lies between tegmentum and pes, until one can insert the point of the thumb into the cleft in order to wedge asunder pes and internal capsule, on the one hand, and tegmentum and thalamus on the other. (If the nail of the thumb is sharp it is well to use a rubber glove.)

If one wishes to get more information about the details, then, of course, it is better to work with the spatula and to proceed slowly, step by step, always taking great care not to interfere with the natural splitting. In the beginning, the separation is easy, but as one approaches the anterior and lateral edge of the thalamus, where the fibres from the lattice layer penetrate into the internal capsule, more force must be used before these fibres (*i.e.*, the peduncles of the thalamus) are loosened more or less out of the capsule and finally tear off. By changing the direction of the pressure applied, one can free the thalamus either with its radiation or without it (*cf.* Plate V., Fig. 11 ; and Plate VII., Figs. 16 and 17). The separation of the thalamus is best done from front to back.

The preparation which has now been removed consists of a part of the mid-brain and the proper thalamus (with or without peduncles) as well as of the tegmentum thalami (*hypothalamus*). If again at the cross-section through the mid-brain one now pushes the spatula in at the level of the aqueductus cerebri (Sylvii) and detaches the tegmentum mesencephali from the lamina and brachia quadrigemina and pushes it downwards, then the tear continues on anteriorly approximately along the boundary between thalamus and tegmentum thalami (Plate V., Fig. 11 ; and Plate VII., Fig. 16). A complete separation of these parts of the mid-brain is not necessary and one can stop on reaching the bundle of Vicq d'Azyr.

Into the ventral wedge-shaped tegmental part of the preparation the substantia nigra and the nucleus ruber are seen. The former is easily recognised by its darker colour, and the red nucleus can also be identified, thanks to the firmer consistency of its capsule, which is formed, for the most part, out of fibres of the brachium conjunctivum. If the surrounding rather softer substance is carefully peeled off, it will be found that fibres from this capsule go over into the ansa peduncularis (Plate V., Fig. 11 ; also *cf.* Plate XIII., Fig. 37, and Plate XV., Figs. 43 and 44). The third nucleus lying in this area, the corpus subthalamicum (Luys), cannot be prepared out very well, but its position is often indicated by a slight convexity on the underside of the tegmentum thalami and lateral to the anterior end of the substantia nigra (see Plate XV., Fig. 44).

(D) Capsula interna. Nucleus lenticularis

A glance on the upper side of the *internal capsule* which has now been laid bare in its whole extent is very instructive (Plate IV., Fig. 7 ; and Plate VI., Fig. 13). One can easily distinguish the bed of the nucleus caudatus from that of the thalamus. The two areas do not lie in the same plane and are separated from one another by an arch-shaped ridge which corresponds to the direction of the stria terminalis. The more steeply descending slope of this ridge towards the thalamus shows a rougher surface than the rest of the area. This is caused by the torn-off fibres of the thalamic radiations. The rest of the area is distinguished by the well-defined

and coarser fibre bundles which converge in a fan shape towards the pes. These coarse bundles come close together only in the pes itself, and elsewhere there is room enough between them to permit the passage of other fibres, viz., of the ansa lenticularis. On the surface of the pes remains of the substantia nigra are still adherent, and a little more laterally and upwards one often sees a little round impression caused by the corpus subthalamicum (*cf.* Plate VII., Fig. 18*). Under the nucleus caudatus the capsula interna has not the same appearance as under the thalamus. In the posterior and middle part of the bed of the nucleus caudatus the fibres (which in the main belong to the thalamic radiation) collect in coarse round bundles, between which thin bridges of grey substance connect the nucleus caudatus with the upper edge of the putamen of the lenticular nucleus (Plate III., Fig. 6 ; Plate IV., Fig. 7). In front one sees how the bundles in question bend over horizontally before they radiate as the corona radiata into the white matter of the hemisphere ; here they can easily be taken for fibres belonging to the fasciculus subcallosus. With regard to the most anterior part of the internal capsule which lies under the head of the nucleus caudatus and has thinner fibre bundles, we have already referred to this (see p. 14, above).

From the characteristic configuration of the internal capsule one can easily explain its angular bend which is so striking in horizontal sections through this region ; the genu corresponds to the ridge. It is important to recognise the fact that the direction of the fibres in the internal capsule does not coincide at all with the direction of the ridge, and that, in consequence, a tract which runs through the genu in a certain horizontal section must, in a higher section, lie in the anterior limb of the internal capsule ; while, in a lower section, it must lie in the posterior limb.

The *nucleus lenticularis* can be exposed from the lateral as well as from the medial side. In the former case (lateral) one must first remove with the spatula the grey matter of the insula and then remove layer by layer the underlying white matter. If the material is well preserved, the student will notice by the rather darker colour and softer consistency of its substance when he has come to the claustrum. Deep to that lies the external capsule which covers the outer surface of the lenticular nucleus. Inferiorly, at the limen insulæ, one can see distinct fibre strands running postero-anteriorly and lying in close association, but deeper to the fasciculus uncinatus. These belong to the fasciculus occipito-frontalis inferior (Curran). Apart from these the external capsule consists of thin lamellæ of fine fibres radiating upwards in a fan shape. If these lamellæ are taken away one after another the lenticular nucleus appears in relief more and more distinctly. The colour shimmering through gives an idea of its extent (Plate IV., Fig. 8).

Under the rounded-off lower edge of the nucleus one can easily penetrate with a spatula, but if one tries to lift it off from its bed a rounded well-defined fibre bundle which runs backwards and a little downwards from the under side of the nucleus becomes taut. This is nothing else than the dorsally running limb of the anterior commissure. In order that the lenticular nucleus may be detached from its horizontal bed it is well to cut through this bundle with scissors or a knife.

Towards the front it is also easy to force the nucleus from the neighbouring

white substance up as far as the anterior part of the internal capsule. The superior and posterior edge of the lenticular nucleus is rather thin, and somewhat dentate through its connections with the caudate nucleus ; therefore, in order that its limits may be more accurately defined, one must observe that the tear-surface of the corona radiata is not only different in colour, but its fibres are coarser than those of the external capsule. The spatula is now inserted between the superior boundary of the nucleus and the internal capsule, and, provided that a controlling finger is feeling along the upper side of the capsule, one can detach it gradually from the upper side of the nucleus. In doing this it is to be noted that the nucleus slopes away obliquely inwards, and one must keep as close as possible to the inferior surface of the capsula, otherwise there is a danger of getting in between the putamen and the globus pallidus with the spatula. In order to free the nucleus completely, however, one must help a little from the medial side. Therefore one loosens the anterior part of the nucleus which is visible under the internal capsule, lifts off the ansa peduncularis from the under side of the pes pedunculi and penetrates under the latter in the direction of the point of the lenticular nucleus. Finally, one can lever the whole nucleus laterally out of its bed (Plate V., Fig. 9).

In the exposure of the lenticular nucleus from the lateral side which has been described, it is occasionally difficult to dig out the nucleus undamaged. The nucleus suffers less damage, however, if it is dissected out from the medial side, but this can only be done at the expense of the internal capsule, which cannot in this case be kept intact, as it can hardly be loosened *in toto* from the lenticular nucleus and turned up sufficiently high. It is best to proceed by first penetrating between pes and ansa peduncularis, loosening the medial border of the capsule and then cutting through its fibre bundles at their transition into the corona radiata. One proceeds step by step backwards and downwards with the loosening and cutting through, so that finally the whole capsule can be lifted off in one piece from the lenticular nucleus. (One sees the line of division on Plate VI., Fig. 13.) The nucleus is then loosened from the white matter of the frontal lobe, from the external capsule, and finally from its bed, the sublenticular substance. In levering it out, one must not neglect to cut sharply through the anterior commissure, otherwise the nucleus breaks easily (Plate VI., Figs. 14 and 15).

The lenticular nucleus which has thus been dissected out is illustrated in Plate V., Fig. 12, and Plate VII., Figs. 20 and 21. On its upper medial side, which corresponds to the genu of the internal capsule, and is divided more or less clearly into an upper anterior and lower posterior facet, one can generally distinguish the boundaries between its segments, viz., the medullary laminæ.[1]

At the point and on the under side of the globus pallidus one sees the streaming in of the fibres of the ansa peduncularis, and a little further towards the front (about at the boundary between the putamen and globus pallidus) one also sees the anterior commissure, which is also found again at the under side of the nucleus before it goes over into the sublenticular substance (Plate VII., Fig. 21).

[1] Also at the under lateral side of the internal capsule one can occasionally establish the position of these boundaries. (See Plate V., Fig. 9 † and Plate VII., Fig. 19.)

One still has to inspect the bed of the lenticular nucleus and to study more closely the topographical relations of this important region of the brain. Observe that the anterior and greater part of the lenticular nucleus lies upon the anterior perforated substance and the orbital gyri lying nearest to this ; whilst its posterior part corresponds to the anterior end of the gyrus hippocampi with the amygdaloid nucleus and the inferior horn of the lateral ventricle. The lenticular nucleus is only separated from the latter formations by a relatively thin sublenticular layer of white matter in which one can prepare out fibre strands of the anterior commissure, the ansa peduncularis, the internal and external capsules, and the diagonal band of Broca (*cf.* Plate XII., and Plate XIII., and Plate XV., Figs. 41 and 42).

If one also wishes to use the present preparation for the study of the inferior cornu, one can lengthen the choroid fissure towards the front through a horizontal section running at the level of the anterior perforated substance, as a result of which one can turn over the temporal lobe sufficiently far to the outside in order to obtain the necessary room for the investigations. However, the method of preparation described in Chapter III. gives a far better view of the form of the structures lying here.

(E) The Outer Form of the Rhombencephalon. IV. Ventricle

In the hind-brain part of our preparation the investigation must begin with the delicate formations below the pons and the cerebellum, since these can easily be damaged in the later handling of the preparation.

At the anterior and lateral side of the medulla oblongata the remains of the arachnoid, the vessels and the pia are removed. While doing this the nerve roots must be carefully guarded, as they tear off very easily. One should cut around them carefully with a pair of fine scissors. If one turns over the roots of the glosso-pharyngeal and the vagus to the ventral side, one can see the cerebello-pontine angle with the place of exit of the facial and acoustic nerves, and the glomus chorioideum which sprouts out of the cornucopia. At the ventral circumference of the latter there is a narrow opening (foramen of Luschka) through which one can insert a fine probe into the lateral recess of the fourth ventricle.

On the dorsal side one penetrates into the cisterna cerebello-medullaris and carefully loosens the thin vascular membrana tectoria of the fourth ventricle (the tela chorioidea) from the under side of the cerebellum far enough to be able to see at the nodulus its transition into the smooth, half-transparent inferior medullary velum.

One inspects the floor of the fourth ventricle with its sulci, foveæ, etc. In the lateral angle under the brachium conjunctivum and above the fovea superior one should cut gently through the ependymal layer, and convince oneself that the bluish colour of this place (locus cæruleus) is due to the shining through of a darkly pigmented nucleus (substantia ferruginea). Finally, one investigates the lateral extension of the recessus fastigii and the recessus lateralis, the line of attachment of the tela chorioidea on the restiform body, and the ridges of white matter (obex, ligula) which often radiate into the tela.

Now we proceed to the *cerebellum*. From the point of entrance of the brachium

pontis one can follow the deep fissura horizontalis up to the incisura posterior where it lies under the folium vermis. In order to find the interlobular furrows on the superior surface one proceeds best from the section surface of the vermis, where one can easily get an idea of its position. The pia and vessels are first removed. The lobuli quadrangulares anterior and posterior are trimmed down a little with scissors or a knife, after which one removes the cortex and the smaller leaves of white matter with a spatula in order to see the arrangement of the chief ridges arising directly from the central core of white matter. These are then cut off so that only their roots remain (Plate VII., Fig. 22). For better orientation the corresponding lobuli of the vermis (culmen and declive) can be kept intact.

If, finally, the ala of the lob. centralis, which is now visible in its whole extent, is taken away, then one will have an uninterrupted view of the isthmus rhombencephali with the lingula lying upon the velum medullare superius, the brachium conjunctivum, and the fovea isthmi lateralis situated between it and the brachium pontis. This pit, which forms the caudal end of the sulcus lateralis mesencephali, is an important place topographically, since the auditory tract (lemniscus lateralis) comes to the surface here, and the root of the trigeminal nerve as well as the restiform body run along quite close to the floor of the pit.

On the under side of the cerebellum the chief furrows are likewise identified, the soft membrane and the vessels removed and the lob. biventer removed down to its roots. The inferior part of the tonsil which is now exposed is also removed, after which the remaining gyri of the same, which are directed inwards and upwards, are, by means of a spatula inserted into the boundary furrow towards the uvula, taken out of the swallow's nest (nidus avis) one after the other and cut off at their common root (Plate VII., Fig. 23). One must now convince oneself that the arched roof of the nest consists of the velum medullare inferius and forms only a very thin partition between the arachnoid space around the tonsil and the recessus fastigii of the fourth ventricle. Medially the velum medullare inferius hangs together more or less completely with the nodulus.

Through the removal of the above-mentioned small cerebellar lobes the brachium pontis, and its transition into the thick central core of white matter of the cerebellar hemisphere, has been exposed, with the exception of the place where it is covered by the flocculus (occasionally also by a parafloccculus). That little lobe can easily be loosened from its bed and now hangs only by a small stem (pedunculus flocculi), which runs medially under the brachium pontis. In order to be able to expose the pedunculus flocculi in its further course one must obtain a better access to the recessus lateralis of the fourth ventricle, for which purpose the tela chorioidea is cut through with a pair of fine scissors at its transition into the velum medullare inferius. Then one can easily see that the stem goes over partly into the velum medullare inferius, but that its stronger part continues along the medial side of the corpus restiforme towards the region of the vestibular nuclei. Caudally from the peduncle of the flocculus the dorsal root of the cochlear nerve runs obliquely over the restiform body. It can be lifted off from its bed together with the tuberculum acusticum without any difficulty.

(F) Inner Construction of the Rhombencephalon

One proceeds first to the separation of the ventral part of the crura cerebri (pes pedunculi), of the pons and of the pyramids (that means of the corticifugal tracts) from the tegmental region, through which the ascending tracts run. At the cross-section through the mesencephalon (see Plate VII., Fig. 22) one should first look for the substantia nigra of Sömmering, which is clearly distinguished by its colour. Here one penetrates with a spatula so far into the relatively soft tissue that one can lift off the tegmentum a little from the pes (Plate VIII., Fig. 24).[1] Where the substantia nigra ends the deep layer of the pons begins. If one keeps exactly to the boundary between the transverse fibres of the pons and the longitudinal fibres of the tegmentum, then it is easy to free the tegmentum from the dorsal side of the body of the pons by means of levering movements of the spatula. (Observe the strong dorsal convexity of the boundary line ! Plate VIII., Fig. 26.) At the inferior border of the pons the pyramidal tract emerges from the substance of the pons as a collected bundle, viz., the pyramis, which is surrounded by arcuate fibres which run across it. The pyramid is loosened from the olive and the interolivary substance medial to it, which is very firm in texture owing to the close mass of decussating fibres it contains. The tapering lower end of the pyramid is then torn away from the inferior part of the medulla oblongata. At the natural tear-surface which has thus arisen one can often see clear signs of the successive crossing of the bundles of pyramidal fibres (Plate VIII., Fig. 26). In order to study the course of the pyramidal tract through the substance of the pons one first makes a shallow incision into its median cut surface about 2 or 3 mm. from, and parallel to, its ventral border, and then, starting from this cut, one lifts off with the spatula the superficial stratum of the pons laterally and almost out to the root of the trigeminal nerve. In the stratum complexum thus exposed one sees scattered longitudinal bundles running through the transverse pontine fibres. By teasing away the latter, one longitudinal bundle after the other can be laid free, and it is easy to establish the fact that they arise out of the pes and go over inferiorly into the pyramid. Between the transverse fibre bundles of the pons, especially laterally where they go over into the brachium pontis, one sees irregular masses of softer grey substance (nuclei pontis).

The next procedure is the separation of the lateral side of the tegmentum from the brachium pontis, which encloses it. One begins at the sulcus mesencephali lateralis and follows it downwards to the fovea isthmi lateralis (Plate VIII., Fig. 24). But here one must proceed very carefully so that one can observe the course of the root of the trigeminal before it is damaged. As a precaution one should first insert a probe into the slit through which the nerve penetrates into the substance of the pons, and, by feeling for the direction of the least resistance, one should try to find the course which the nerve takes to its nuclei in the trigeminal area in the floor of

[1] If this is done with the necessary care we can often see how fine fibres, coming from the pes, pass through the substantia nigra in order to reach the tegmentum, and also how a fibre bundle (not constant) running obliquely over the under side of the pes (faisceau en écharpe of Féré) dives into the fovea interpeduncularis and continues into the tegmentum. Here we obviously have the pes lemniscus (*cf.* Plate I., Fig. 2 ; and Plate IV., Fig. 7).

the fourth ventricle. The probe can for the present remain there to serve as a guide.

Before we go any further we must find out more about the respective positions to one another of the three *peduncles* at their entrance into the body of white matter of the cerebellum. In the preparation illustrated in Plate VII., Fig. 22, the surface layer of the body of white matter consists chiefly of the remnants of the medullary ridges of the lobuli quadrangulares and the ala lobuli centralis; and between these ridges it consists of fibre lamellæ which correspond to the arcuate fibres of the cerebrum. If this layer is laterally made free of the brachium pontis, and then the whole is torn away medially, one sees directly at the natural tear-surface which has thus arisen that the surface fibres of the brachium pontis continue fairly straight towards the back, while medially to these other fibres appear which take a more transverse direction towards the vermis (Plate VIII., Fig. 24). Of these latter fibres those which lie directly upon the brachium conjunctivum and cross over it belong to the corpus restiforme, and can easily be loosened from their bed with a probe which has been inserted under them for a few millimetres. The lateral boundary of the corpus restiforme towards the brachium pontis is best approached from below. In the cerebello-pontine angle (*cf.* Plate VII., Fig. 23) the eighth and seventh roots are first loosened from the lower border of the pons and laid downwards. Between the dorsal cochlear root and the peduncle of the flocculus which is cut through, one inserts the awl into the furrow between the corpus restiforme and the brachium pontis, and gradually pushes these formations apart until the point of the instrument finally appears in the fovea isthmi lateralis. If in doing this one takes good care to follow the inside of the brachium pontis as exactly as possible, then the border between the deep bundle of pontine fibres which radiate into the white matter of the cerebellum and the corpus restiforme can be determined with sufficient exactitude. With a probe inserted from above into the slit (in the fovea isthmi lateralis) one can then split off these pontine fibres which run medially as thin lamellæ, from the underlying fibres of the corpus restiforme which run very much in the same direction (*cf.* Plate VIII., Fig. 24).

Another very instructive tear-surface on which one can study the arrangement of the fibres in the cerebellum is obtained if one takes hold of the lobuli semilunares superior and inferior at the back with the fingers and carefully tears them apart. The body of white matter then usually splits close above the *nucleus dentatus cerebelli* (Plate VIII., Fig. 25). As soon as the outline of this nucleus becomes visible one must now proceed very slowly. If care is taken, one notices how the tear, otherwise fairly horizontal, sinks into the depths at a place ventrolaterally from the nucleus and corresponding to the just-mentioned deep pontine bundle. By completely turning up the upper half of the body of white matter (as in Fig. 25), or by its removal, one can make room for the further exposure of the nucleus dentatus. Apart from the corpus restiforme whose bundles are turned outwards, the nucleus is still covered with a sheath of fine fibres (the fleece) which come from the cerebellar cortex. One should try to remove this sheath either by carefully scraping with the spatula, or by picking with fine forceps or a glass probe little fibre bundles from out

of the white matter next to the nucleus, loosening them and pulling them off as thin lamellæ from the surface, and out of the furrows of the nucleus. With a little patience one can unsheath the nucleus in this way fairly completely, so that its peculiar form and dark colour come more and more into evidence (*cf.* Plate XV., Figs. 43 and 44). Finally, one penetrates under the border of the nucleus and carefully lifts it up in order to get a better view of the hilus lying on its inferior aspect and serving as the exit for the brachium conjunctivum. It should be noticed that the lateral angle of the recessus fastigii generally reaches up to close under the hilus. In lifting up the nucleus the thin wall of the recessus often tears, and through the opening one then sees right on to the inferior medullary velum, which is arched over the nidus avis.

If one now cuts through the superior medullary velum and cuts off the root of the trigeminal in the depth of the fovea isthmi lateralis,[1] then the preparation, as illustrated in Plate VIII., Figs. 25 and 26, can be divided into two parts, of which the one (Fig. 27) is composed chiefly of the cerebellum and the pons, and the other (Figs. 28 and 29) of the tegmentum together with the corpus restiforme, brachium conjunctivum and nucleus dentatus.

A few more observations still have to be made on the last-mentioned tegmental portion of the preparation. One must first inspect the ventral side of the tegmentum which lay up against the body of the pons. The longitudinal fibres seen here form the *lemniscus* (Plate VIII., Figs. 26 and 29). Those fibres which lie nearest the mid-line, and which come up chiefly out of the inter-olivary substance, make up the medial lemniscus and are seen to diverge slightly as they ascend. They thus come to occupy the whole ventral side of the tegmentum at the transition of the brain stem from the rhombencephalon into the mesencephalon. The lateral fibres arise from the cochlear nuclei and form the lateral lemniscus. These go still more laterally and come to the surface in the sulcus lateralis mesencephali in order to run on to the inferior colliculus. The triangular field at the isthmus, where the lateral lemniscus crosses obliquely over the brachium conjunctivum (trigonum lemnisci), is already recognisable in well-preserved material in surface relief, and shows up from the white brachium conjunctivum on account of its rather darker colour. By scraping away the superficial glia layer together with the arch-shaped fibres of the tractus spino-cerebellaris ventralis (of Gower), which are only visible with difficulty, this becomes still clearer. Now one inserts the spatula in between the brachium conjunctivum and the lateral lemniscus (where the hedgehog's quill has been inserted in Figs. 25 and 29) and lifts off the lemniscus laterally, together with the inferior colliculus, from the brachium conjunctivum. Thanks to the relatively firm consistency of the brachium conjunctivum one can demonstrate it from the surrounding softer tegmental substance and thus show the spiral twisting which it makes before it reaches its decussation (*cf.* also Plate XI., Fig. 35).

At the lateral surface of the preparation (Plate VIII., Fig. 29), in the angle

[1] In most cases it is quite probable that the root of the trigeminal has already been torn at this point. In order to avoid this, one can cut through the pontine bundles lying above the nerve at an earlier stage of the dissection and display the nerve out of its slit.

between the corpus restiforme and the brachium conjunctivum, the root of the trigeminal nerve penetrates into the tegmentum; its fibres which bend caudally (radix descendens V.) can be followed a little way down. The ascending root is more difficult to prepare. At the ventral side of the medulla oblongata one must try to define against its surroundings the inferior olive which is enclosed in a firm capsule of medullated fibres. This is very easy on its lateral side, but medially the nucleus is very firmly connected with the inter-olivary substance through the fibres which come out of the hilus of the nucleus. In the exposure of the upper end of the olive one can with appropriate care isolate a fibre-bundle which is recognisable by its lighter colour, and which comes from the central part of the tegmentum and goes over into the capsule of the olive. This is obviously the central tegmental tract.

Various other details can be demonstrated on good material by the defibrillation method: but since they are hardly suitable for treatment in an elementary course I need not mention them here.

CHAPTER III

SUPPLEMENTARY PREPARATIONS ON A HALF-BRAIN

THE defibrillation method as described above aims at an exact demonstration of the form of the separate parts of the brain and their relative position to one another. For purely technical reasons, however, it is not quite so suitable for giving a comprehensive survey of such extensive and complicated formations as, *e.g.*, brain ventricles, the fornix formation and the extra-pyramidal system (cerebellum, nucleus ruber, corpus striatum). The study of the parts of the brain lying in the medial line has been made more difficult through halving the brain, and the cutting through of the mesencephalon has partly destroyed the connections between the various formations lying there. Therefore, if there be sufficient material, it is desirable that the dissectors should be given the opportunity of making certain complementary investigations on a whole brain. However, in such a case it is hardly necessary to destroy more than one-half of the brain. The other half can remain undamaged during the preparation so as to serve as an object of comparison, and can afterwards be cut off and used for other purposes, such as, *e.g.*, making serial sections, etc. The treatment of this extra material which may be placed at the disposal of the dissectors is as follows :—

(A) Pallium. Ventricle and Structures Bounding It

First one must investigate how far the arachnoidea penetrates into the fissura cerebri longitudinalis and transversa before it bridges over the clefts around the free borders of the falx and tentorium respectively and bounds off the cisterns. One opens the cist. chiasmatis, interpeduncularis and corporis callosi, inspects the circulus arteriosus Willisi, and removes the pial tissue and the vessels from the accessible sides of the hemisphere under preparation.

After inspection of the furrows and convolutions on the convex surface one removes the part of the hemisphere lying above the level of the corpus callosum by making a horizontal cut with a brain knife, or, better still, by a cut sloping somewhat medially. In order not to penetrate too deeply unawares one must investigate beforehand the distance of the corpus callosum from the superior border of the hemisphere. The direction of this cut is indicated in Fig. D, Cut I.[1]

By removal of the remains of the gyrus and fasciculus cinguli the whole upper surface of the corpus callosum with the striæ longitudinales can now be exposed.

[1] The anterior portion of the frontal lobe can also be taken away through a frontal cut about 1 cm. in front of the genu of the corpus callosum in order to make the region anterior to and below the latter more accessible.

The radiations of the genu and the splenium (forceps ant. and post.) are also prepared out (Plate IX., Fig. 30).

For opening up the *lateral ventricle* the greater part of the corpus callosum must be taken away ; only genu, splenium and a strip at the middle line which is quite narrow in front and rather broader at the back remain intact. The opening-up begins by making a window through the relatively thin covering of the anterior horn. With the assistance of a probe inserted into the ventricle one acquaints oneself with the extent of the cavity, and then cuts through the corpus callosum exactly along the lateral angle of the ventricle up to the point where this turns over vertically behind the thalamus (Fig. D, Cut II.). Medially, the bundles of the corpus callosum are cut through once again close to the line of attachment of the septum pellucidum and the fornix (Fig. D, Cut III.), and are removed one

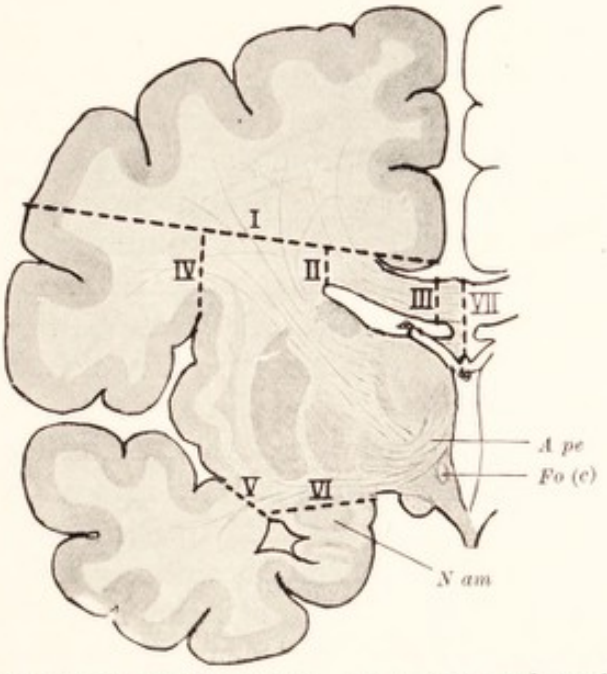


FIG. D.—I.–VII. are the cutting planes (see text). *A pe*, Ansa peduncularis. *Fo* (*c*), Crus fornicis. *N am*, Nucleus amygdalæ.

after the other. Behind the foramen of Monro one must proceed very carefully in order that the plexus chorioideus may be preserved in its natural position and in its connexions (Plate IX., Fig. 30).

From the posterior end of the opening thus produced one now inserts a probe behind the thalamus down to the floor of the trigonum ventriculi. One uses this probe as a guide, and first makes a clear frontal cut and then a vertical cut directed obliquely backwards but laterally. These are then connected by a horizontal cut at about the level of the middle temporal convolution. Through the removal of the wedge-shaped piece thus separated one obtains free access to the trigone and the glomus chorioideum and to the posterior horn (Plate IX., Fig. 31).

In order to open the *inferior horn* the Rolandic operculum must first be taken away. To do this one makes a frontal cut upwards, beginning at the ramus anterior ascendens of the fissura lateralis Sylvii, and then, using a finger inserted into the

upper part of the sulcus circularis Reili as a guide, one makes a sagittal cut directed from above downwards towards this furrow (Fig. D, Cut IV.). The operculum as well as the other detached pieces are kept so that they can, later on, be fitted together again. Now a probe is inserted into the inferior horn starting from the trigonum ventriculi, and the gyri temporales transversi Heschli and the relatively thin wall which divides the ventricle from the lower part of the circular sulcus are gradually cut through (Plate IX., Fig. 31). One should take care to make the cut as far lateral as possible in order not to damage the tail of the nucleus caudatus which lies in the roof of the inferior horn (Fig. D, Cut V.). When the cut has reached the limen insulæ the posterior lower part of the hemisphere is connected to the brain stem only by means of the anterior part of the gyrus hippocampi. Before this connexion is cut through the attachment of the plexus chorioideus to the fornix and the fimbria must be severed in order that the plexus may remain hanging to the brain stem when the temporal lobe is removed. In detaching the fornix from the plexus one begins at the foramen of Monro, cuts through the splenium and the fornix at the place indicated by the dotted line on Plate IX., Fig. 31, and slightly draws aside the hippocampal formation from the brain stem, so that enough room is obtained to enable one to detach the whole fimbria from the plexus. Finally, one turns to the basal side of the brain and inserts a knife into the angle between the anterior perforated substance and the gyrus hippocampi and cuts off this gyrus in a horizontal direction from the brain stem (Fig. D, Cut VI.).

At the posterior lower part of the hemisphere (Plate X., Fig. 33) which has been detached in this way one can study well the characteristic formation of the inferior horn. As a rule remains of the upper wall of the inferior horn, through which the fibre bundles of the stria terminalis which radiate into the nucleus amygdalæ run, must be removed, in order that a general view of the most anterior part of the cornu ammonis with its digitations can be obtained. An attempt should now be made to define with regard to its surroundings the amygdaloid nucleus, which is separated only by a thin sheath of white matter from the anterior end of the inferior horn. Towards the front and laterally this usually does not present any difficulties at all. In doing this one also meets with the transversely cut fasciculus uncinatus, which can be " defibred " out quite easily. By lifting up the free border of the fimbria, or by removal of the fimbria, one can obtain a view of the fascia dentata and follow it to its transition into the band of Giacomini (*cf.* Plate XII.). In the posterior horn one should look at the calcar avis and the (not constant) bulbus of the posterior cornu, and convince oneself of the fact that the former is due to the calcarine fissure, while the latter is formed by the bundles of the forceps posterior which have been pushed laterally through the deep parieto-occipital fissure.

The upper wall of the inferior horn, which is formed by the brain stem, is studied on the other part of the preparation (Plate XI., Fig. 34). The plexus chorioideus is loosened from its attachment along the stria terminalis, and one inspects the stria and the thin tail of the nucleus caudatus lying laterally from it. Now, if the two last-named formations are removed and the optic tract is detached from the pes pedunculi, one can establish in a careful defibrillated preparation that

the relatively thin white layer which forms the bed of the lenticular nucleus and separates the nucleus from the inferior horn, and more anteriorly from the anterior perforated substance, consists of different fibre systems, of which the lower ones belong chiefly to the sublenticular part of the internai capsule (bundle of Türck, optic radiation), while the ones lying higher originate mostly from the ansa lenticularis, the commissure anterior and the diagonal band of Broca. The figure in Plate XII. gives an illustration of what can be obtained by exact defibrillation in this area.

In order to obtain a view into the third ventricle the part of the corpus callosum which remains is separated from the other half of the corpus callosum by an incision (Fig. D, Cut VII.) which exactly follows the mid-line from the splenium to the genu, and (after cutting through the fornix and the attachment of the septum pellucidum) is taken away altogether. The thin roof plate of the third ventricle with the plexus chorioideus medialis is now visible, and is now cut through medially. During the detachment and removal of the velum interpositum with the plexus chorioideus which now follows, one should observe its firmer attachment laterally to the lamina affixa and medially to the stria medullaris thalami. One inspects the interior of the third ventricle and notes the massa intermedia, recessus triangularis between the fornices and commissura anterior and the opening of the aqueductus Sylvii below the commissura posterior. In order to be able to bend the cerebral hemispheres apart better in doing this, one can cut through the genu of the corpus callosum. Finally, one should try to split the septum pellucidum into its two lamellæ (Plate X., Fig. 32).

(B) The Brain Stem

After the pineal body and the mesencephalon have been freed from the surrounding meningeal tissues and vessels, one inspects the external configuration and the topography of this area of the brain. The pineal body is divided in the mid-line with a sharp knife or a pair of scissors. Before one proceeds to opening up the aqueduct of Sylvius and the fourth ventricle, one carefully loosens the under side of the cerebellum from the tela chorioidea of ventricle IV. and pushes a small strip of cardboard into the intervening space up to the level of the recessus lateralis so as to protect the tela in the splitting of the cerebellum. Now one inserts a probe from the direction of the third ventricle into the aqueduct, and with a sharp knife cuts exactly in the mid-line through the commissura posterior, lamina quadrigemina and the vermis cerebelli (Plate X., Fig. 32).

The two halves of the cerebellum can now be pulled so far apart that one can get a view of the tela chorioidea in its natural position. One should probe the foramen of Magendi, and with a pair of fine scissors cut through the tela in the mid-line, turn over the lobes laterally and inspect the fossa rhomboidea which is thus exposed.

Before separating the two cerebellar hemispheres completely from one another, it is advisable to acquaint oneself more closely with the position of the decussation of the brachia conjunctiva. For this purpose the lamina terminalis, the chiasma opticum and the floor of ventricle III. are cut through the mid-line up to

the subst. perforata posterior in order that the two halves of the brain can be drawn so far apart that the tissues in the tegmentum mesencephali are transversely put on the stretch. With a narrow spatula or with an awl one penetrates into the cleft between the corpora quadrigemina and scrapes the relatively soft and friable tissue carefully away ventrally from the aqueduct, until one reaches a firmer and somewhat lighter layer, which can be defined fairly easily in the form of a bundle about 8 mm. wide which crosses transversely through the tegmentum mesencephali dorsally from the upper border of the pons. After this bundle has been sufficiently isolated from its surroundings so that it can later be readily identified in median section, one cuts it through. After this the pons and medulla oblongata are divided exactly in the middle line.

In the detached half of the brain stem the connexions between the nucleus dentatus, nucleus ruber and corpus striatum now have to be prepared in their whole extent. The pia mater on the cerebellum is first removed and the fissures and lobes are identified. Then the hemisphere is split horizontally in the manner described above (p. 21), from the fissura horizontalis up to where the fibres of the brachium pontis stream into it. One then cuts through those pontine bundles which go to the upper half of the hemisphere and removes the latter. Now only a small amount of cleaning work is needed in order to reveal the nucleus dentatus and the brachium conjunctivum up to the trigonum lemnisci.

In order that one may be able to follow the brachium conjunctivum further, the lamina quadrigemina with the lemniscus lateralis and the thalamus must be taken away. First with a spatula one raises these formations away slightly from the tegmentum mesencephali and hypothalamus (*cf.* p. 15), then with a knife cuts through the lateral lemniscus along the sulcus lateralis mesencephali, both of the corpora geniculata and finally the fibre bundles which go over into the ansa peduncularis from the anterior part of the thalamus, after which one breaks off the whole thalamus (together with the lamina quadrigemina) from the capsula interna (Plate XI., Fig. 35). Now one returns again to the diagonally crossing bundle which was cut through earlier, carefully pares away the softer surrounding tissue, and convinces oneself that fibres out of the transverse bundle go over downwards into the brachium conjunctivum as well as upwards into the white matter surrounding the red nucleus. One can also establish the fact that some of the fibres of the brachium conjunctivum, in fact those lying at the upper medial border, do not participate in the decussation, but radiate into the capsule of white matter of the homolateral red nucleus. Moreover, one can conclude from the relatively great strength of the bundle of decussating fibres that it also includes other fibres than those belonging to the brachia conjunctiva.

In the tegmentum thalami (hypothalamus) the relatively firm white capsule around the nucleus ruber and its continuation into the ansæ peduncularis and lenticularis can be exposed without great difficulty by carefully peeling off the surrounding looser layers (Plate XI., Fig. 35).[1] Between the nucleus ruber and the

[1] If one has good material and works with appropriate care, one often succeeds in locating and preparing the fasciculus retroflexus (Meynerti), and occasionally the fasciculus mamillo-tegmentalis.

pes pedunculi one sees the subst. nigra of Sömmering. In order to separate completely the rubral system one penetrates at this point with a spatula, cuts through the ansa peduncularis and tears away the ansa lenticularis from the capsula interna. (For further details, see Plates XIII. and XV., Figs. 43 and 44.)

In the preparation now before us a few parts yet remain untouched, and can be used for further study. Sections can be made through these parts in whatever direction one likes, or one can repeat certain preparations described in Chapter II. For example, the cerebellar peduncules can be differentiated from one another, and if one takes away the nucleus caudatus and picks the nucleus lenticularis out of its bed from the lateral side, the characteristic form of the internal capsule stands out very clearly. Merely by breaking or tearing a piece of brain surprisingly beautiful and instructive " defibrillation " pictures can occasionally be obtained even on less well-preserved material.

PHOTOGRAPHIC ILLUSTRATIONS OF PREPARATIONS MADE ACCORDING TO THE DEFIBRILLATION METHOD

ALL illustrations of Plates I.–V. apply to one right cerebral hemisphere which was prepared according to the method described in Chapter II. and repeatedly photographed in the process. The preparation of the rhombencephalon of the same brain is illustrated by Figs. 22–29 of Plates VII. and VIII.

The Figs. 13–21 (Plates VI. and VII.) are made from another right hemisphere which was prepared in the manner described on pp. 17 and 18.

Plates IX.–XI. show the different steps of the investigation of the ventricles as well as a preparation giving a general view of the extra-pyramidal system as is described in Chapter III.

Finally, in the last four plates, viz., Plates XII.–XV., are figured a few preparations done according to our defibrillation method, which give a general survey of the brain and which are in the museum of the Anatomical Institute at Uppsala.

Unless otherwise stated, all preparations are figured three-quarters of their natural size.

Abbreviations

I–XII	Nerv. olfactor. — hypoglossus.	*C am*	Cornu ammonis.	*Co re*	Corpus restiforme.
I *tr*	Tractus olfactorius	*Ca e*	Capsula externa.	*Cu*	Culmen cerebelli.
II *ch*	Chiasma opticum.	*Ca i*	Capsula interna.	*De*	Declive (clivus) cerebelli.
II *tr*	Tractus opticus.	*Ca i (a)*	Capsula interna crus anterius.	*Dia B*	Diagonal band of Broca.
V *de*	Radix descendens trigemini.	*Ca i (g)*	Capsula interna genu.	*F de*	Fascia dentata.
VIII *d*	Radix dorsalis acustici.	*Ca i (p)*	Capsula interna crus posterius.	*Fa ar*	Fasciculus arcuatus.
VIII *v*	Radix ventralis acustici.	*Ca i (rl)*	Capsula interna pars retrolenticularis.	*Fa ci*	Fasciculus cinguli.
Alv	Alveus.	*Ca i (sl)*	Capsula interna pars sublenticularis.	*Fa l i*	Fasciculus longitudinalis inferior.
An le	Ansa lenticularis.	*Co c*	Corpus callosum.	*Fa of i*	Fasciculus occipito-frontalis infer.
An pe	Ansa peduncularis (see p. 14).	*Co c (g)*	Corpus callosum, genu.	*Fa rf M*	Fasciculus retroflexus of Meynert.
An pe (r)	Ansa peduncularis pars rubralis.	*Co c (sp)*	Corpus callosum, splenium.	*Fa sc*	Fasciculus subcallosus.
An pe (th)	Ansa peduncularis pars thalamica.	*Co ge l*	Corpus geniculatum laterale.	*Fa u*	Fasciculus uncinatus.
Aq S	Aqueductus Sylvii	*Co ge m*	Corpus geniculatum mediale.	*Fi*	Fimbria hippocampi.
Art ls	Arteria lenticulostriata.	*Co ma*	Corpus mamillare.	*Fl*	Flocculus.
Br co	Brachium conjunctivum.	*Com an*	Commissura anterior.	*Fl (pe)*	Pedunculus flocculi.
Br co (x)	Decussatio brach. conjunctiv.	*Co p*	Corpus pineale.	*Fo*	Fornix.
Cra	Cornu anterius ventric. later.			*Fo (c)*	Columna fornicis.
				Fol v	Folium vermis.

For M	Foramen Monroi.
Forc a	Forceps anterior.
Forc p	Forceps posterior.
Fov i l	Fovea isthmi lateralis.
Gy He	Gyrus of Heschl.
Gy hi	Gyrus hippocampi.
Gy sc	Gyrus subcallosus.
Ins	Insula.
Ins (l)	Limen insulæ.
La q	Lamina quadrigemina.
La q (ci)	Colliculus inferior lamin. quadrigem.
La q (cs)	Colliculus superior lamin. quadrigem.
Le l	Lemniscus lateralis.
Le m	Lemniscus medialis.
Li Gia	Limbus Giacomini (Band of G.).
Ling	Lingula cerebelli.
Lo bi	Lobulus biventer cerebelli.
Lo c	Lobulus centralis cerebelli.
Lo c (a)	Ala lobuli centralis.
Lo gr	Lobulus gracilis.
Lo q a	Lobulus quadrangularis anterior.
Lo q p	Lobulus quadrangularis posterior.
Lo sl i	Lobulus semilunaris inferior.
Lo sl s	Lobulus semilunaris superior.
Ma i	Massa intermedia.
Me ob	Medulla oblongata
N am	Nucleus amygdalæ
N ca	Nucleus caudatus.
N ca (co)	Colliculus nuclei caudati (see p. 14).
N de	Nucleus dentatus cerebelli.
N de (ca)	Capsula nuclei dentati (" the fleece ").
N de (hi)	Hilus nuclei dentati.
N le	Nucleus lenticularis.
N le (g p)	Globus pallidus nucl. lenticularis.
N le (l m)	Laminæ medullares nucl. lentic.
N le (pu)	Putamen nuclei lenticularis.
N ru	Nucleus ruber.
N ru (ca)	Capsula nuclei rubri.
No	Nodulus cerebelli.
Ol i	Oliva (inferior).
Pe	Pedunculus (crus) cerebri.
Pe le	Pes lemniscus (tract. corticobulbaris).
Pfl	Paraflocculus (flocc. secundarius).
Pl ch	Plexus chorioideus
Po	Pons
Po (br)	Brachium pontis.
Po (f pr)	Fasciculus profundus brachii pontis.
Po (s c)	Stratum complexum pontis.
Po (s p)	Stratum profundum pontis.
Po (s s)	Stratum superficiale pontis.
Py	Pyramis.
Py (x)	Decussatio pyramidum.
Py cbl	Pyramis cerebelli.
Ra op	Radiatio optica.
Se p	Septum pellucidum.
Se p (ca)	Cavum septi pellucidi.
Str t	Stria terminalis.
Str m th	Stria medullaris thalami (stria fornicis).
Su n S	Substantia nigra Sömmeringi.
Su pf a	Substantia perforata anterior.
Ta	Tapetum.
Tae ch	Tænia chorioidea ventriculi quarti.
Te	Tegmentum.
Th	Thalamus.
Th (p)	Pulvinar thalami.
Th (rad)	Radiatio thalami (stalks of thalamus).
To	Tonsilla cerebelli.
Tr cp	Tractus corticopontinus temporalis (Türck).
Tr c h	Tractus corticohabenularis.
Tr co	Trigonum collaterale.
Tr h	Trigonum habenulæ.
Tr le	Trigonum lemnisci (lateralis).
Tu	Tuber vermis.
Uv	Uvula vermis.
Uv (a)	Ala uvulæ.
V d'A	Fasciculus mamillothalamicus (Vicq d'Azyr).
Ve in	Velum interpositum (tela chorioid. ventr. III).
Ve m a	Velum medullare anterius.
Ve m p	Velum medullare posterius.
Ve t	Vena terminalis.
Verm	Vermis cerebelli.

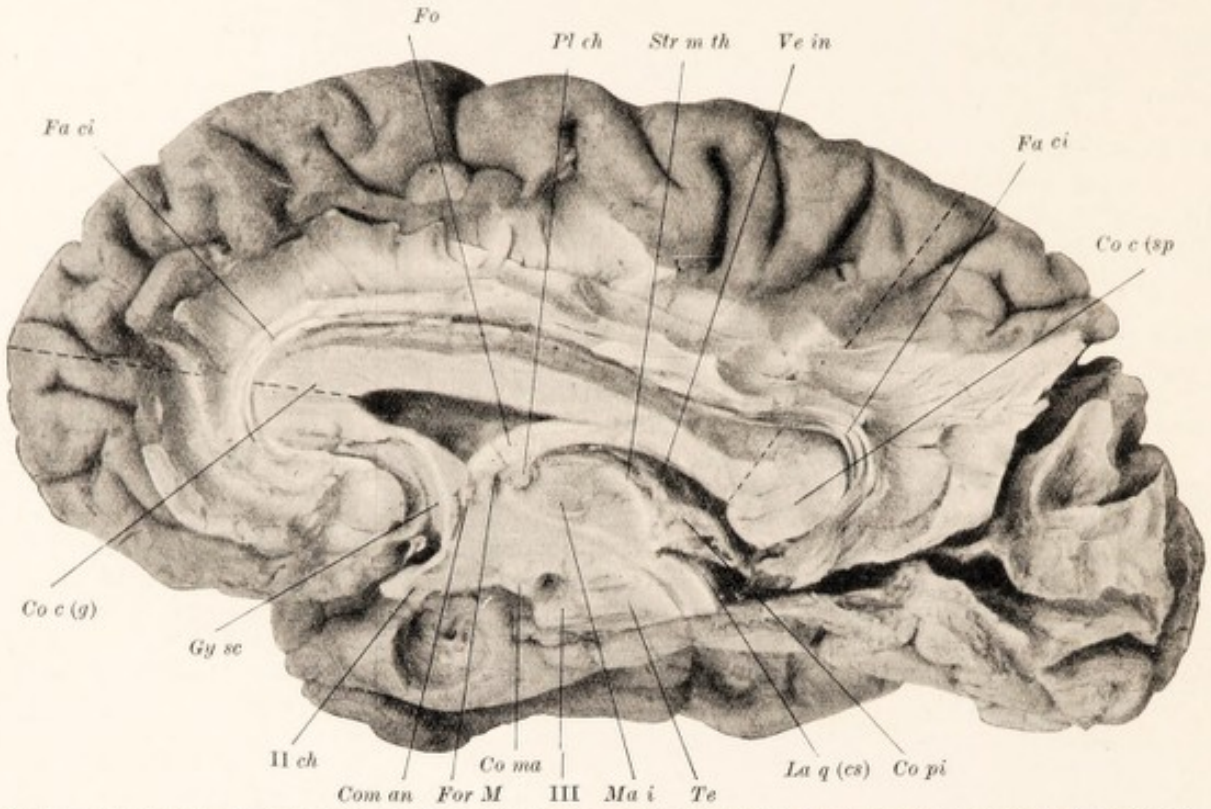


FIG. 1.—This preparation is made from a brain which has a very small anterior commissure, a rather thick splenium corp. call., and cystic degeneration of the pineal body. The cortex of the occipital lobe has been removed and the gyrus cinguli has been taken away in order to expose the cingulum. This fasciculus was dissected loose, but was put back again into its place. The septum pellucidum was cut out, and the fornix cut through. (The dotted lines show the direction of the sections mentioned on p. 12.)

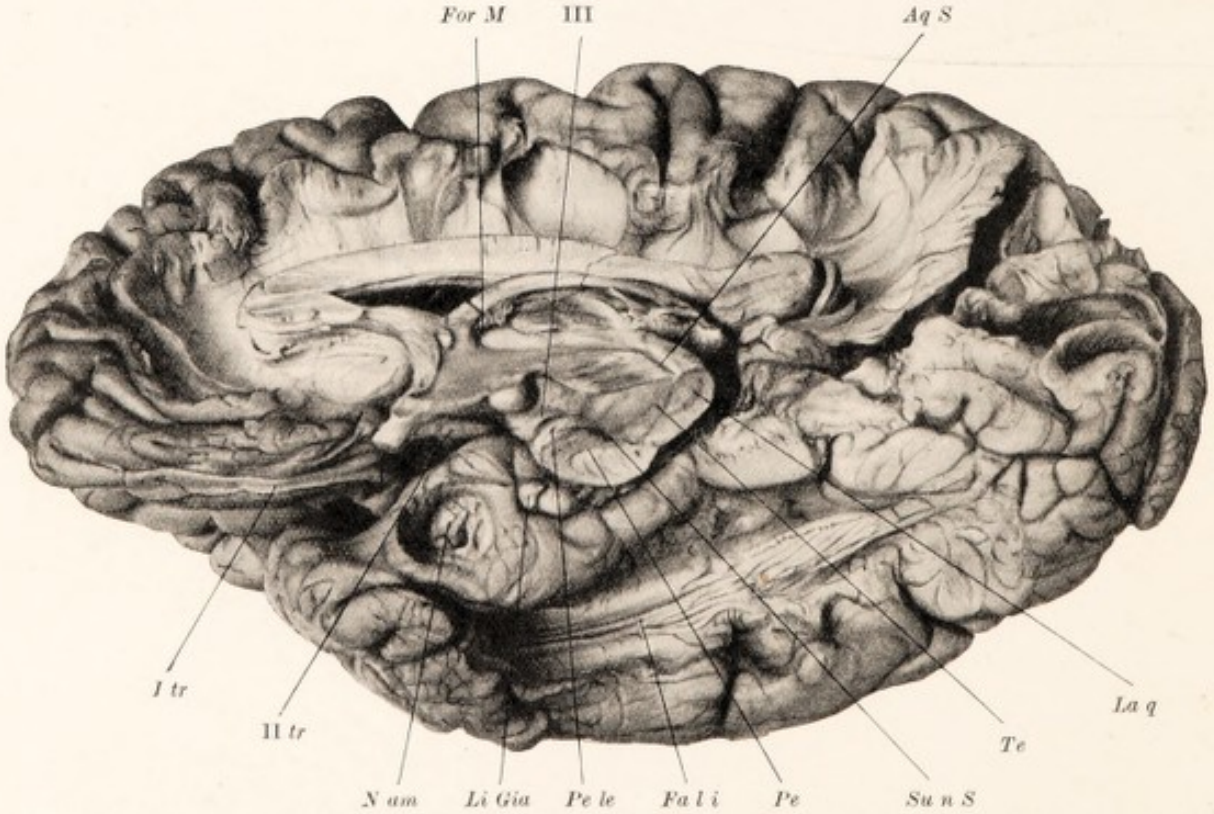


FIG. 2.—The same preparation as in Fig. 1, but seen obliquely from below. The gyrus fusiformis has been removed, and the fasc. longitudinalis inferior "defibred" into view. At the anterior end of the gyrus hippocampi, the amygdaloid nucleus has been exposed (immediately behind this a small opening has been made into the inferior horn). On the cross-section through the mesencephalon the cortico-bulbar tract (pes lemniscus) can be seen radiating into the tegmentum.

PLATE II.

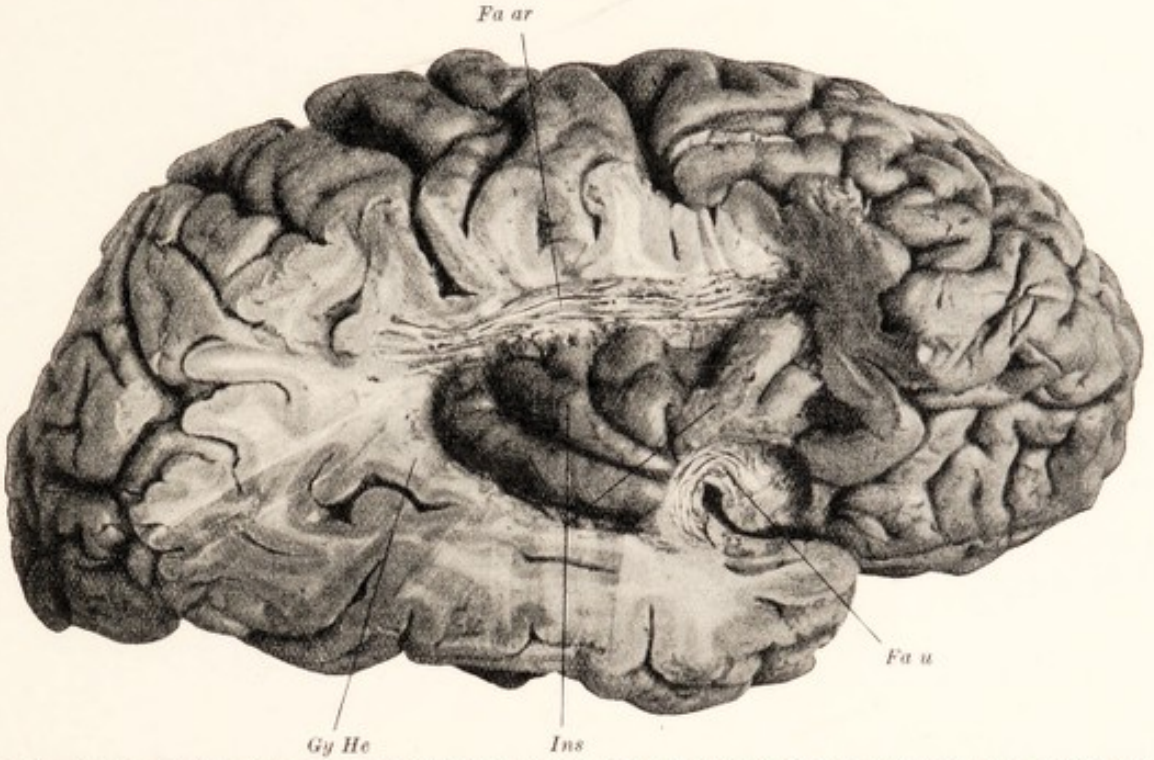


FIG. 3.—On the outside of the same hemisphere the insula has been exposed by cutting away the three opercula. On the upper border of the insula the fasc. arcuatus has been brought to view, and below, at the limen insulæ, the fasc. uncinatus.

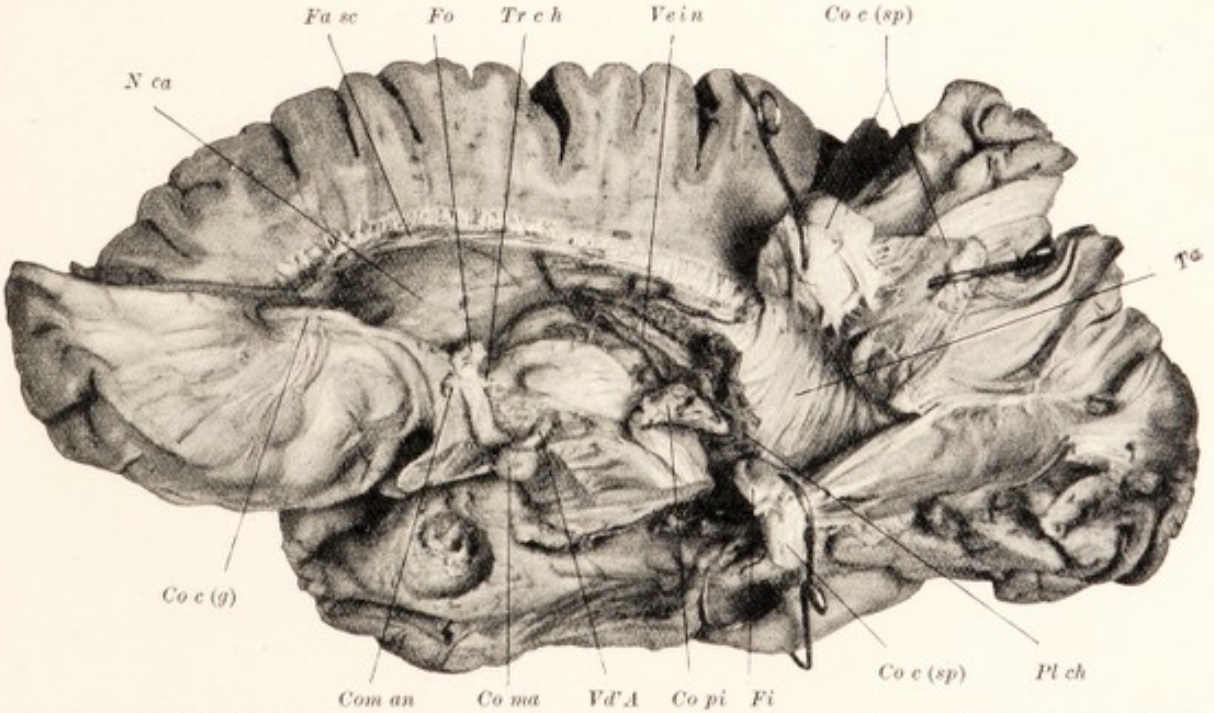


FIG. 4.—By cutting away the greater part of the corpus callosum, the nucleus caudatus and the velum interpositum (tela chorioidea), together with the chorioid plexus lying upon the thalamus, have now been exposed. The fasc. subcallosus was prepared. The splenium with its radiation was bluntly split so that the posterior horn is opened (*cf.* Fig. 5); the inferior part of the splenium is held downwards with one hook, and the upper and larger part is held upwards by two hooks. On the lateral wall of the ventricle which is opened widely in this way the tapetum is freed from the covering ependymal layer. On the side wall of ventricle III the substantia grisea centralis has been so far removed that one can see the columna fornicis and the bundle of Vicq d'Azyr (tractus mamillo-thalamicus).

PLATE III.

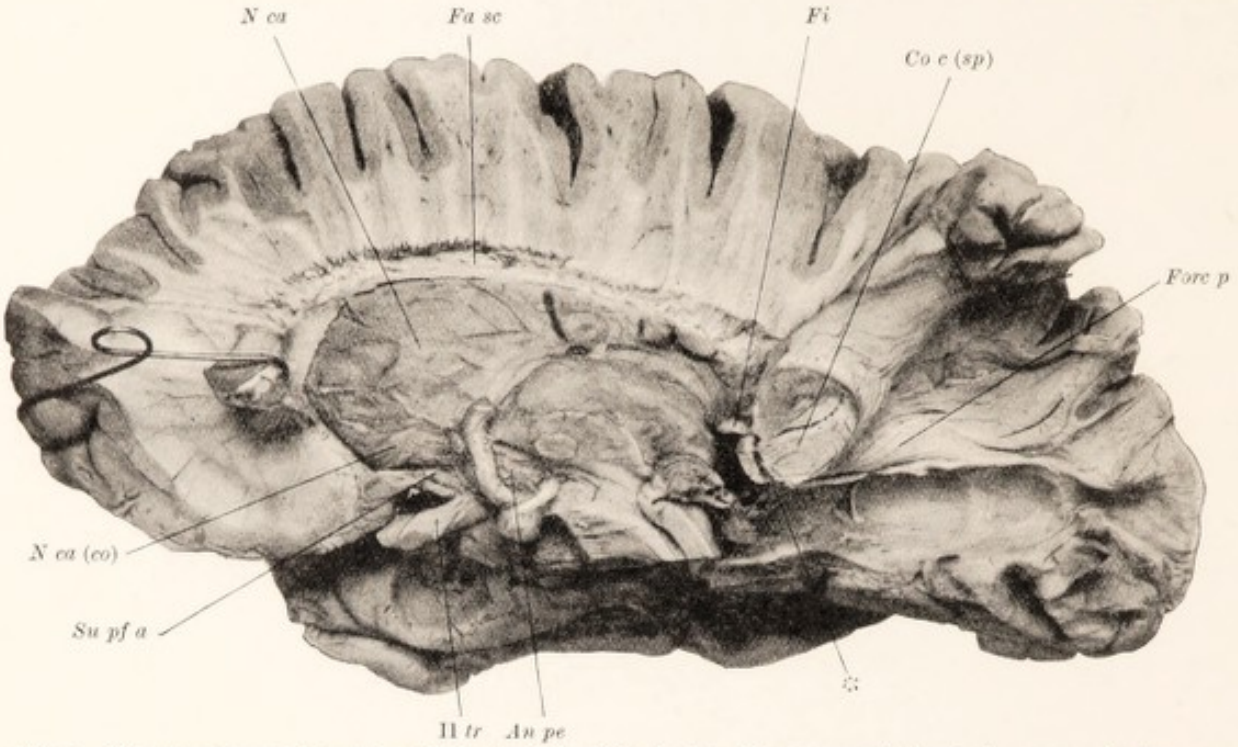


FIG. 5.—The genu corpus callosum is pulled anteriorly with a hook. The area parolfactoria, the gyrus subcallosus, and the lamina terminalis have been removed up to their bending into the anterior perforated substance under the head of the nucleus caudatus. The nucleus caudatus has been separated out, but has been put back again into its place; the velum interpositum with the plexus chorioideus has been removed. The separated parts of the splenium have been laid together again; but the line of cleavage, however, is still visible in the figure (*).

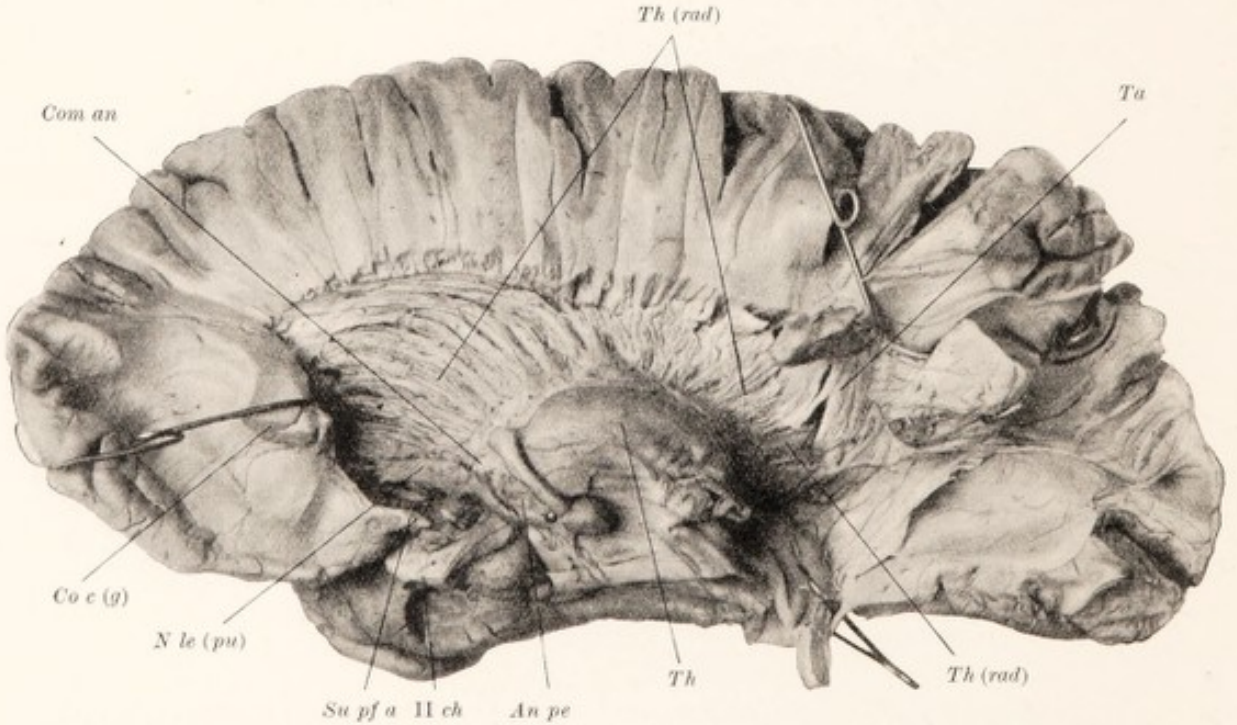


FIG. 6.—The nucleus caudatus has been lifted off from the capsula interna and cut away antero-inferiorly from its connexion with the putamen. The column of the fornix has been turned back together with the corpus mamillare in order to bring into view the ansa peduncularis, which has been cut through. The splenium is as in Fig. 4. The tapetum has been cut through and detached from the posterior part of the thalamic radiations (viz., the occipital stalk of the thalamus or optic radiation).

PLATE IV.

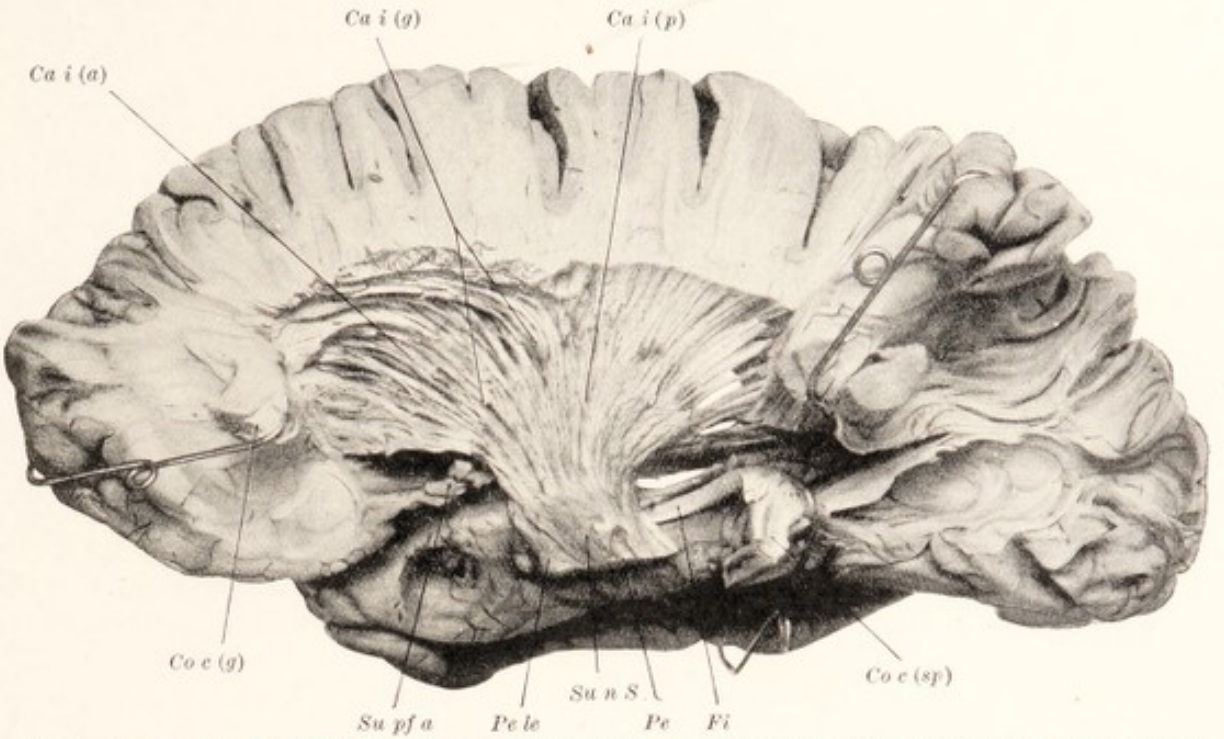


FIG. 7.—Through the removal of the thalamus with the part of the mesencephalon attached to it, and the greatest part of the thalamic radiations to the cortex, the inferior part of the internal capsule where it goes over into the crus cerebri has been exposed to view. On the capsule one notices a bow-shaped ridge corresponding to the genu of the internal capsule, which, however, is much less marked than in Figs. 13 and 18. On the crus lies the subst. nigra of Sömmering. The gaps through the posterior parts of the internal capsule are due to the fact that the insula and the lenticular nucleus have already been removed in this preparation.

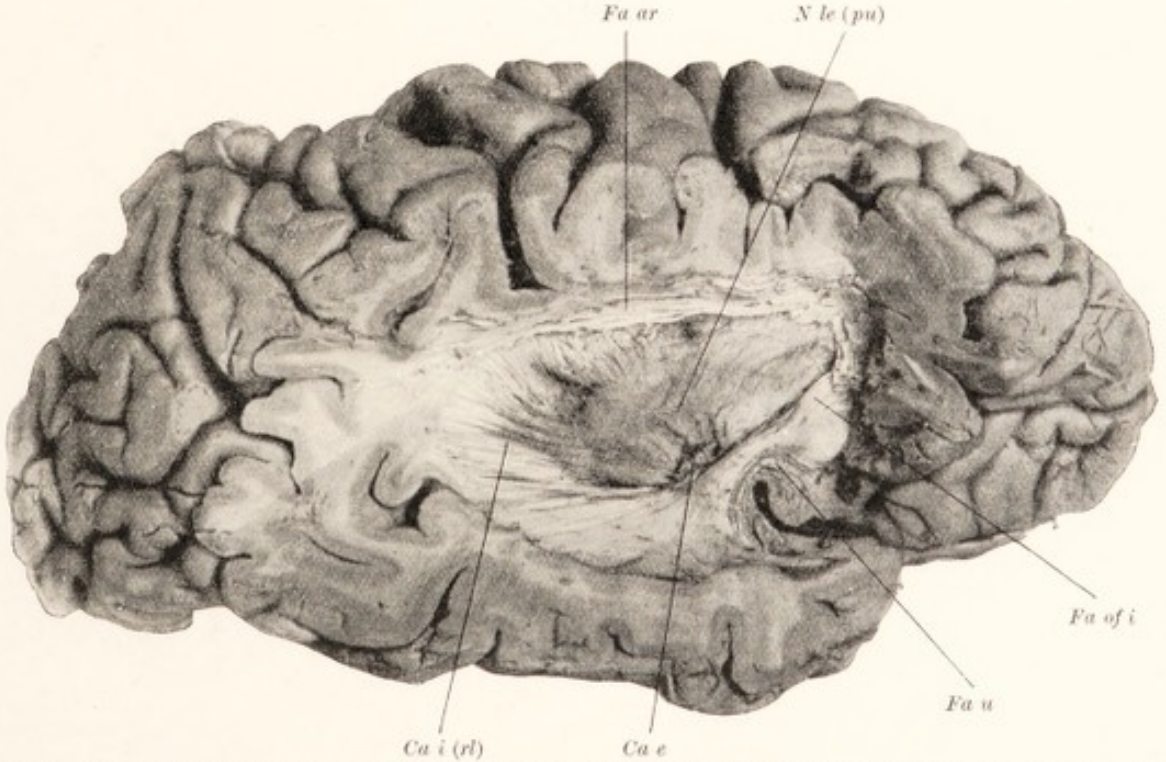


FIG. 8.—On the lateral side of the preparation the insula has been taken away and the external capsule has been peeled off from the lenticular nucleus. One sees the lenticulo-striate vein and the bundles of the external capsule which come up from under the nucleus. Between this nucleus and the fasc. uncinatus the inferior part of the fasciculus occipito-frontalis inferior (Curran) is seen to take its course.

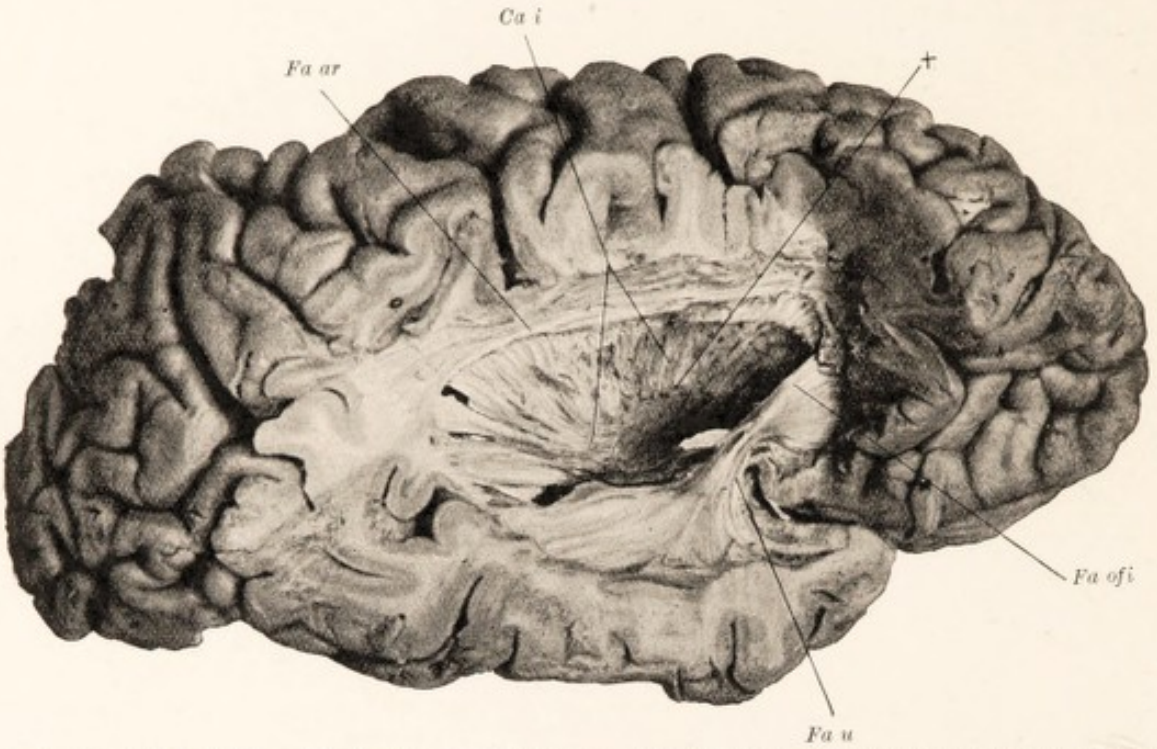


FIG. 9.—Here the lenticular nucleus has been removed from its funnel-shaped bed up to a small remnant of it which still clings to the outer (inferior) surface of the internal capsule. One can here easily distinguish the boundary (+) between the putamen and the globus pallidus.

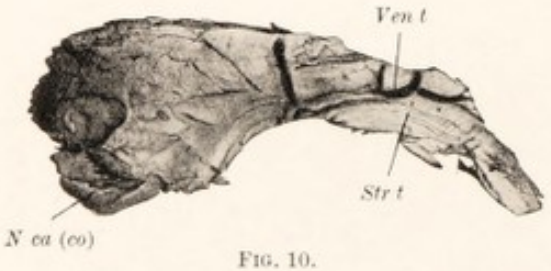


FIG. 10.

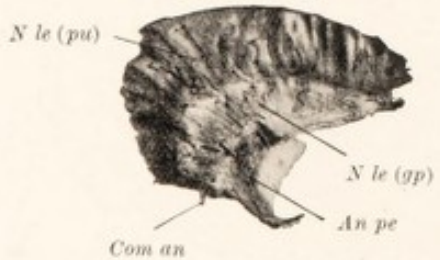


FIG. 12.

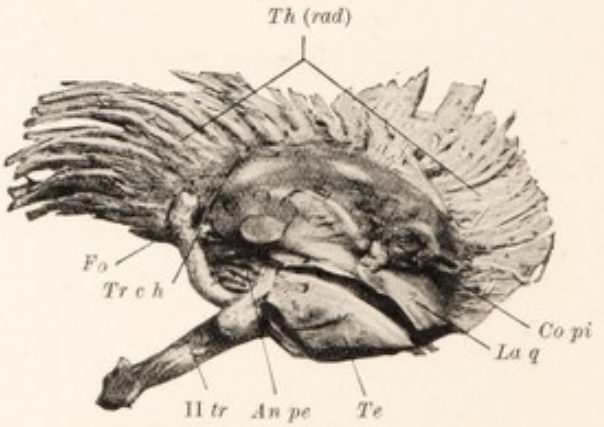


FIG. 11.

FIGS. 10–12.—The cerebral ganglia which have been dissected out, seen from the upper medial aspect.

FIG. 10.—The nucleus caudatus and a part of the stria terminalis. Most of the tail has been left. The most inferior part of the head (colliculus of the caudate nucleus) is somewhat damaged.

FIG. 11.—The thalamus with its radiations and with the upper part of the mesencephalon. Through blunt splitting the lamina quadrigemina and the thalamus proper have been separated from the tegmentum mesencephali and the hypothalamus, from which issues the ansa peduncularis. Notice the cortico-habenular tract going out from the column of the fornix.

FIG. 12.—The lenticular nucleus with the anterior commissure and the part of the ansa peduncularis going to the globus pallidus.

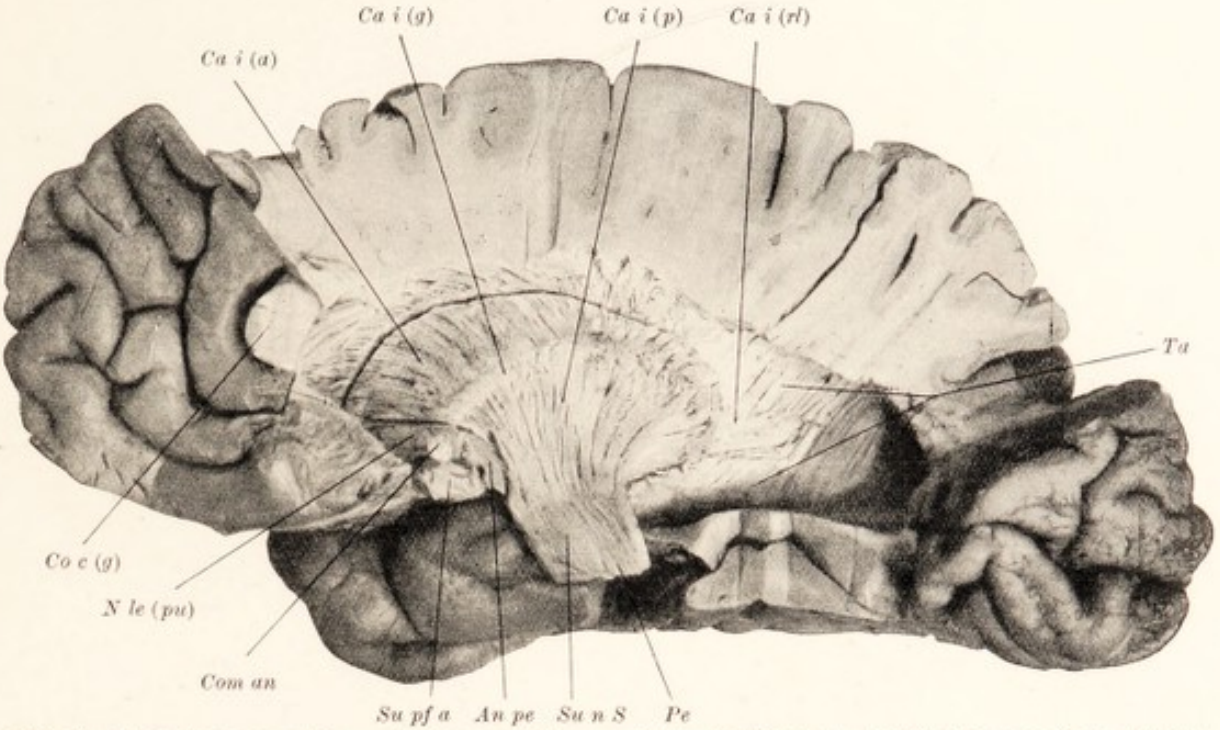


FIG. 13.—The above preparation, which corresponds somewhat to that illustrated in Fig. 7, comes from another brain which is characterised by a well-marked anterior commissure and hydrocephalic dilatation of the lateral ventricle. In removing the thalamus, its stalks radiating into the internal capsule and corona radiata are left intact. The internal capsule which has been dissected free and placed back again in its natural position shows here very clearly a ridge crossing the direction of the capsule bundles, which indicates the genu of the internal capsule seen in horizontal sections. Anteriorly and inferiorly one sees the transverse sections of the ansa peduncularis, the anterior commissure, the anterior perforated substance and the bridge which connects the head of the caudate nucleus with the putamen. The tapetum is prepared as in Fig. 6, in order to expose the occipital stalk of thalamus.

FIG. 14.

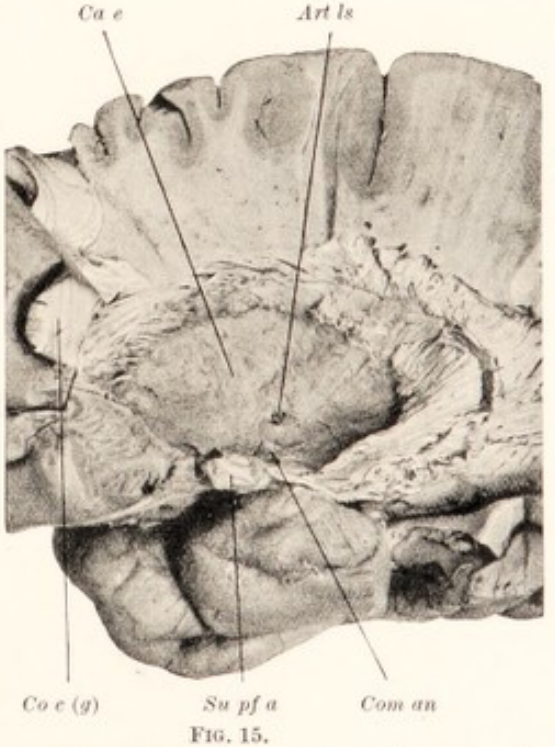


FIG. 15.

FIG. 14.—The internal capsule has been removed and the inner superior surface of the lenticular nucleus exposed. One sees the laminæ medullares and the ansa peduncularis going to the globus pallidus.

FIG. 15.—The lenticular nucleus has been lifted out of its bed. On the floor of the space one notices the continuation of the anterior commissure which has been cut through on leaving the lenticular nucleus (*cf.* Fig. 21); piercing the outer wall (capsula externa) is seen a branch of the lenticulo-striate artery.

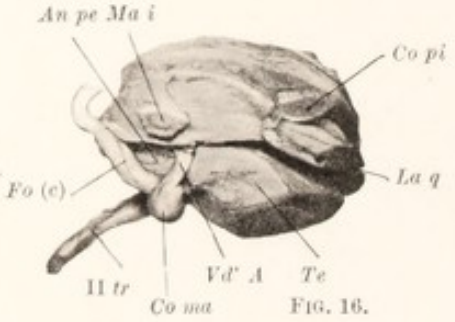


FIG. 16.

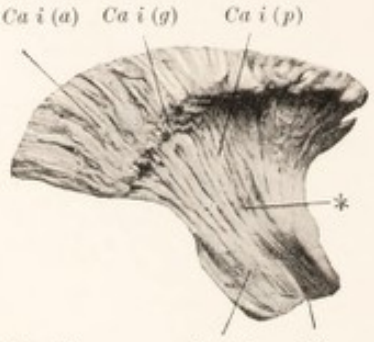


FIG. 18.

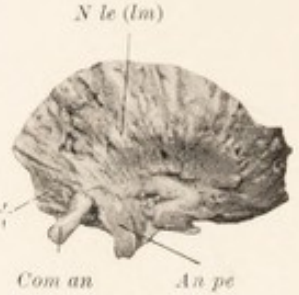


FIG. 20.

FIG. 17.

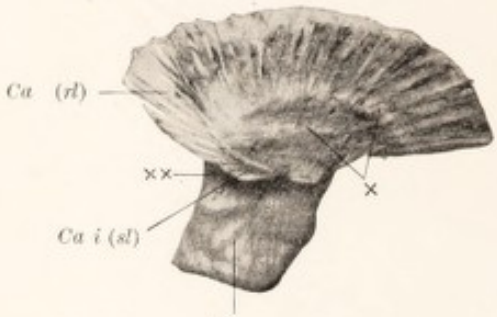


FIG. 19.

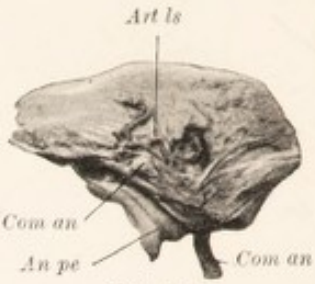


FIG. 21.

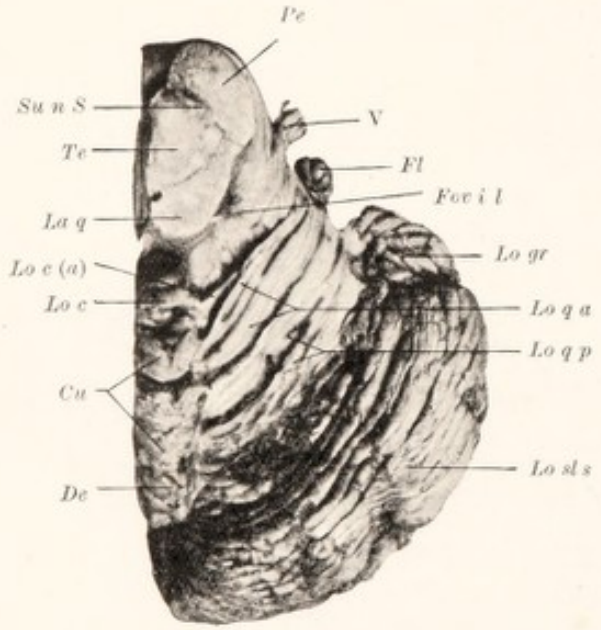


FIG. 22.

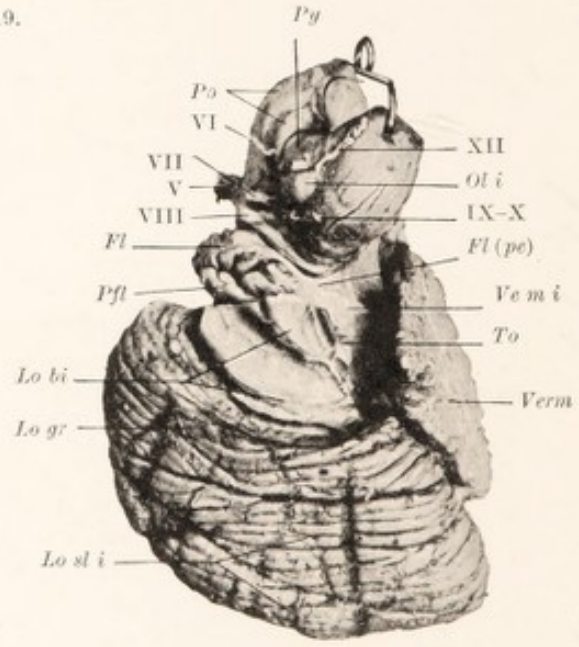


FIG. 23.

FIGS. 16 and 17.—The thalamus with the tegmentum thalami (hypothalamus) removed from the preparation last described, and seen from the medial and the lateral inferior aspect. Of the stalks of the thalamus, only remnants of the posterior one are found here (Fig. 17 †). Anteriorly in the same figure one sees the cross-section of the ansa peduncularis.

FIGS. 18 and 19.—The internal capsule of the same brain from the supero-medial and the infero-lateral aspect. In the first figure the above-mentioned genu-ridge stands out strongly. On the crus one sees remnants of the subst. nigra, and somewhat further superiorly one sees a little depression (*) for the subthalamic body (Luys). Through the clefts, clearly visible in this region, fibres of the ansa lenticularis run between the bundles of the capsule; of this one can easily convince oneself by careful preparation. On the underside (Fig. 19) is seen the position of the medullary laminæ of the lenticular nucleus (×). Under the sublenticular part of the internal capsule one notices the broad furrow (× ×) for the lateral geniculate body and the optic tract.

FIGS. 20 and 21.—The lenticular nucleus belonging to the same brain, seen from the supero-medial and from the inferior aspect. In the first figure, one sees the cut surface towards the caudate nucleus (†). In both figures the ansa peduncularis and the anterior commissure stick out. On the inferior aspect (Fig. 21) note the lenticulo-striate artery and the cut posterior end of the anterior commissure.

FIG. 22.—The right half of the hind-brain seen from above. In the preparation the quadrangular lobes and ala of the central lobe have been taken away; only the roots of their medullary ridges have been left behind.

FIG. 23.—The same preparation from below. The medulla oblongata has been bent ventrally by means of a hook. Here the biventer lobule and the tonsil have been removed up to their roots. One sees the inferior medullary velum which separates the nidus avis from the recessus fastigii.

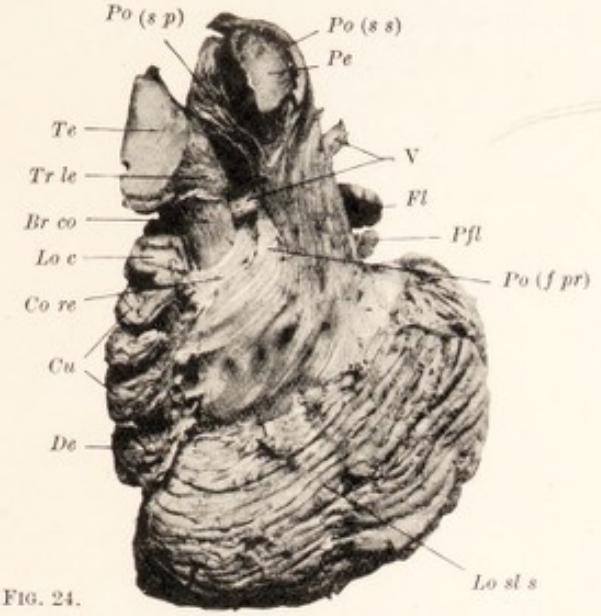


FIG. 24.

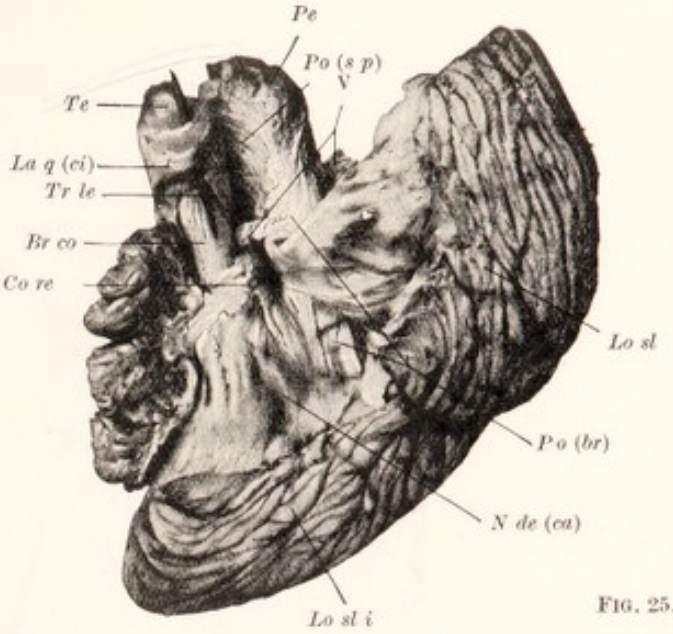


FIG. 25.

FIG. 24.—The same half of the hind-brain as in Figs. 22 and 23 seen from above. The superficial layer of the white medullary body has now been removed in order to show the streaming in of the three cerebellar peduncles. Notice how the restiform body lies over the brachium conjunctivum and how lateral to the latter there appears a deep bundle of the brachium pontis which streams out medially in a similar manner. The tegmentum has been lifted away from the crus and the pons. In the cleft, corresponding to the lateral fovea of the isthmus, one sees the passage of the trigeminal nerve.

FIG. 25.—The same preparation from below. The superior and inferior semilunar lobules have now been torn apart, by which the white medullary body is split just above the nucleus dentatus. The upper half into which the deep bundles of the pons principally stream has been reflected laterally so that one can see the nucleus dentatus, which is enveloped in its capsule, as well as the radiation of the restiform body. The lateral lemniscus has been detached from the brachium conjunctivum; a hedgehog quill has been pushed in between them.

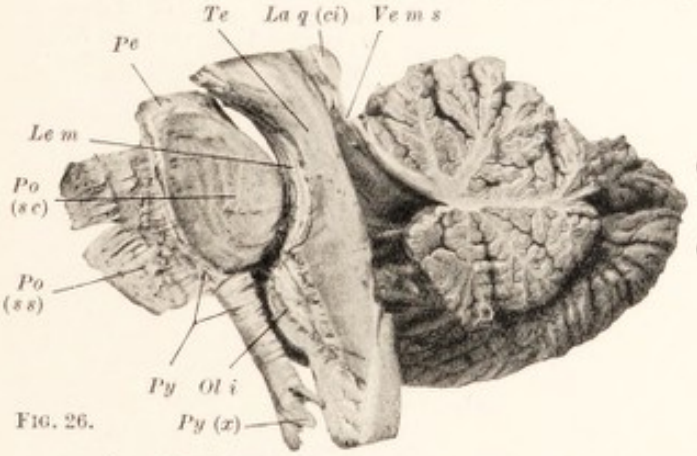


FIG. 26.

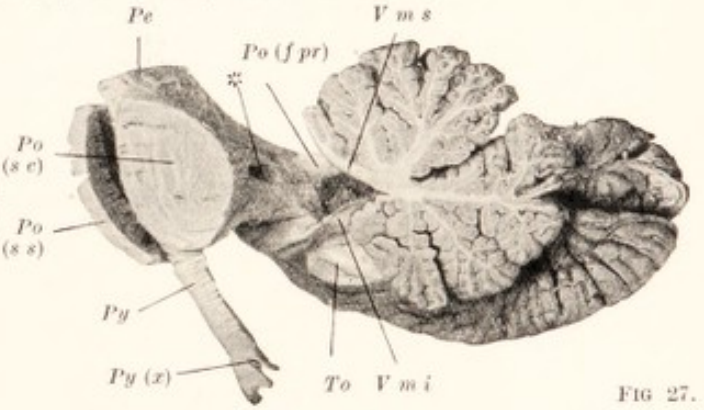


FIG. 27.

FIG. 26.—The same preparation from the medial side. Crus, pons and pyramid have been separated from the tegmentum and medulla oblongata. Through lifting away the superficial layer of the pons the pyramidal bundles which run vertically through the pons are exposed. Notice the crossing bundles at the lower end of the pyramid.

FIG. 27.—The cerebellar-pontine part of the former preparation. On the medial side of the brachium pontis one sees the cleft for the passage of the root of the trigeminal nerve (*).

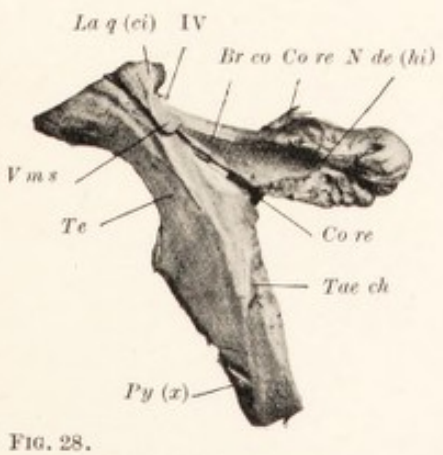


FIG. 28.

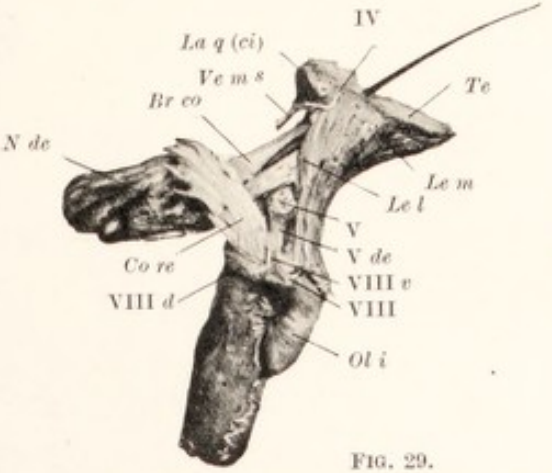


FIG. 29.

FIGS. 28 and 29.—The tegmental part of the same preparation with the restiform body, brachium conjunctivum and nucleus dentatus from the medial and lateral aspect. In Fig. 29 one notices the entrance of the trigeminal nerve with its descending root and the embracing of the restiform body by the two roots of the auditory nerve.

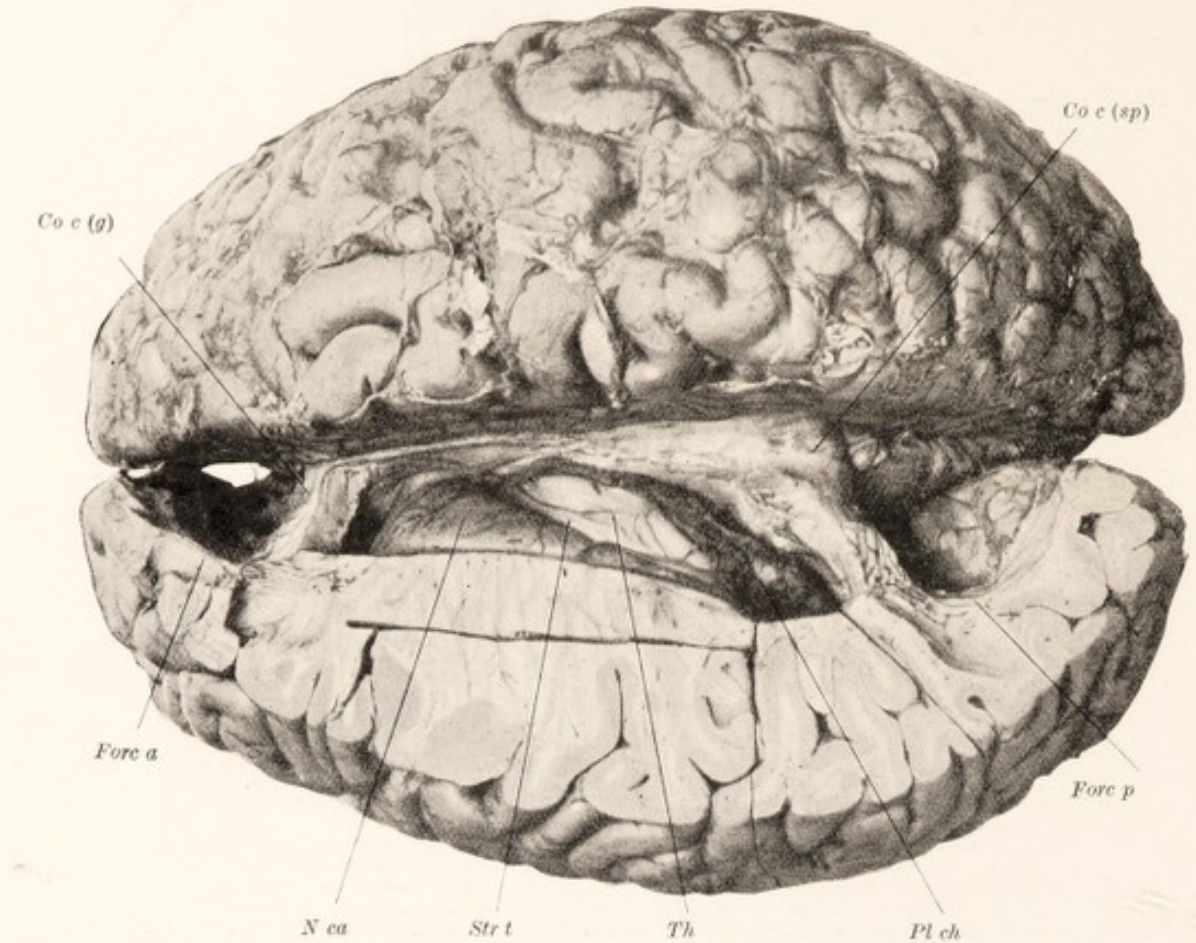


FIG. 30.—In this brain the upper part of the left hemisphere has been removed. Through the removal of a great part of the corpus callosum the left lateral ventricle has been widely opened up. The choroid plexus in this preparation almost completely covers the fornix. The forceps anterior and posterior have been exposed. One sees the sections by which the Rolandic operculum and the lateral wall of the trigone of the ventricle have been removed.

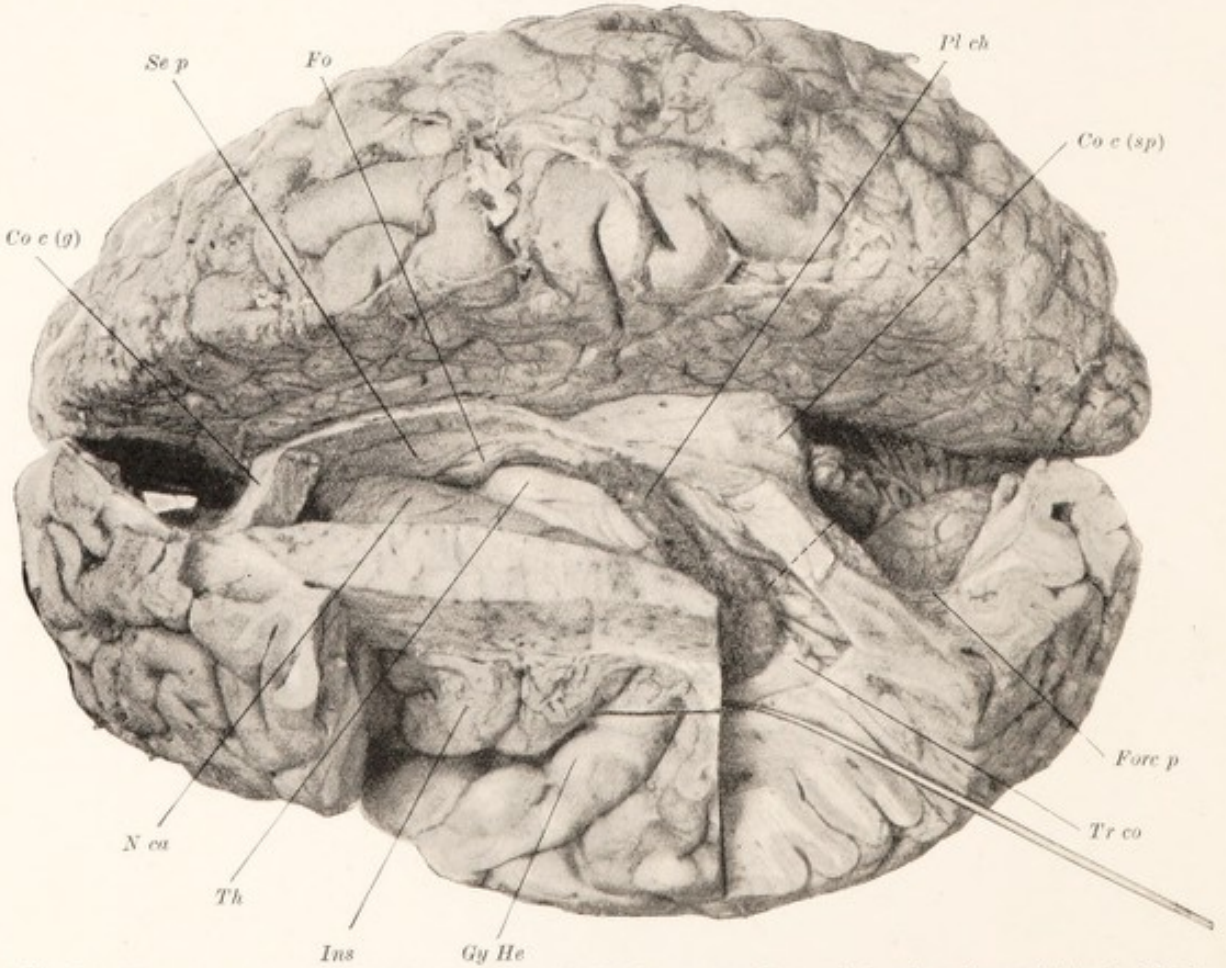


FIG. 31.—From the trigone of the lateral ventricle, which is here exposed, a probe has been inserted into the inferior horn. The ventricle is opened up by cutting through Heschl's convolution and along the inferior border of the insula. The dotted line indicates the place where the splenium is cut through.

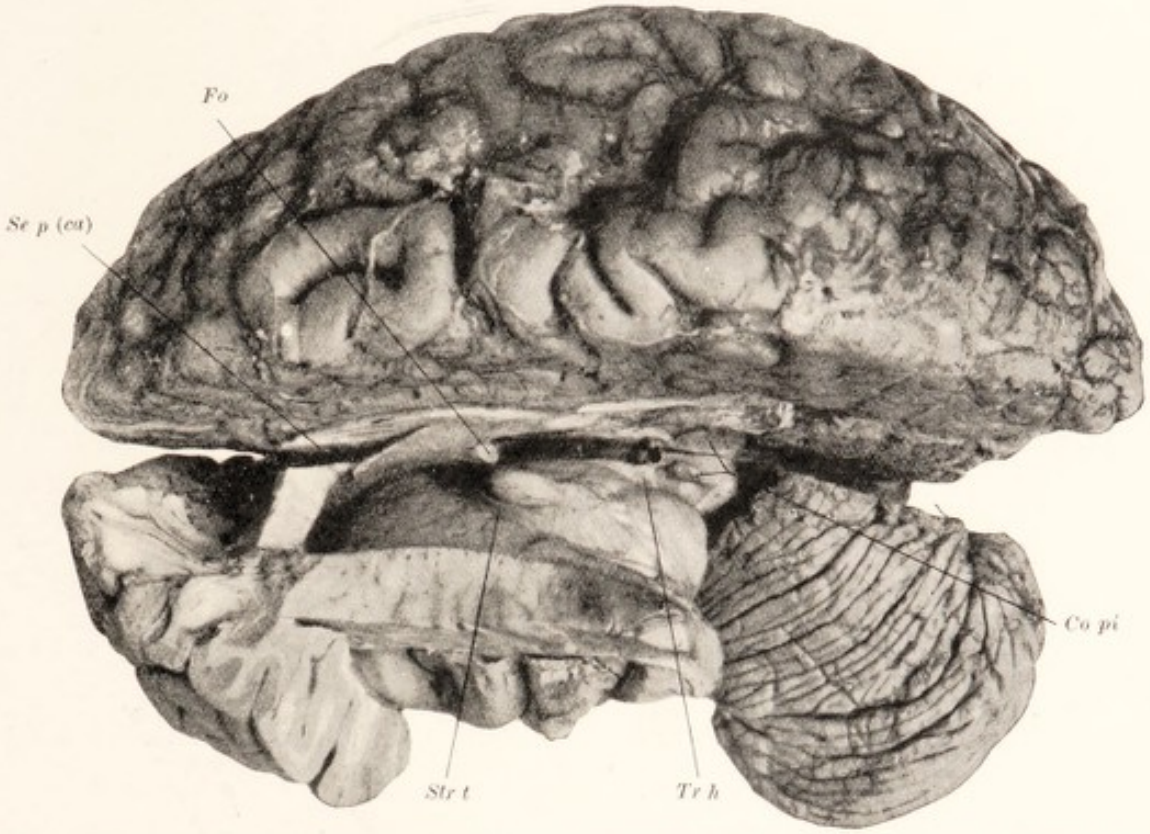


FIG. 32.—The occipital and temporal lobes have now been completely removed. The corpus callosum with the attached fornix is taken away up to the mid-line. The genu of the corpus callosum, the pineal body, lamina quadrigemina and cerebellum are sectioned medially. The cavum septi pellucidi has been opened up. The plexus chorioideus has been removed.

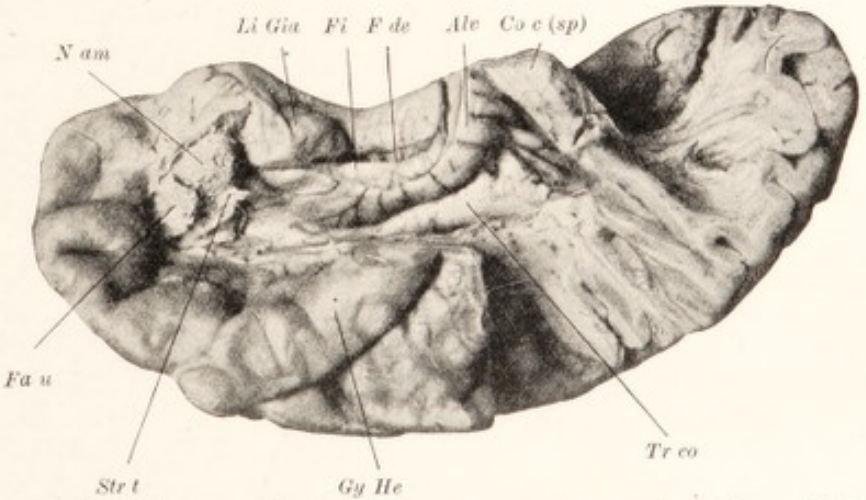


FIG. 33.—The separated occipito-temporal part of the former preparation seen from above. The inferior cornu lies open; at its anterior end the amygdaloid nucleus with the fibres of the stria terminalis entering into it, as well as the fasc. uncinatus, have been dissected out.

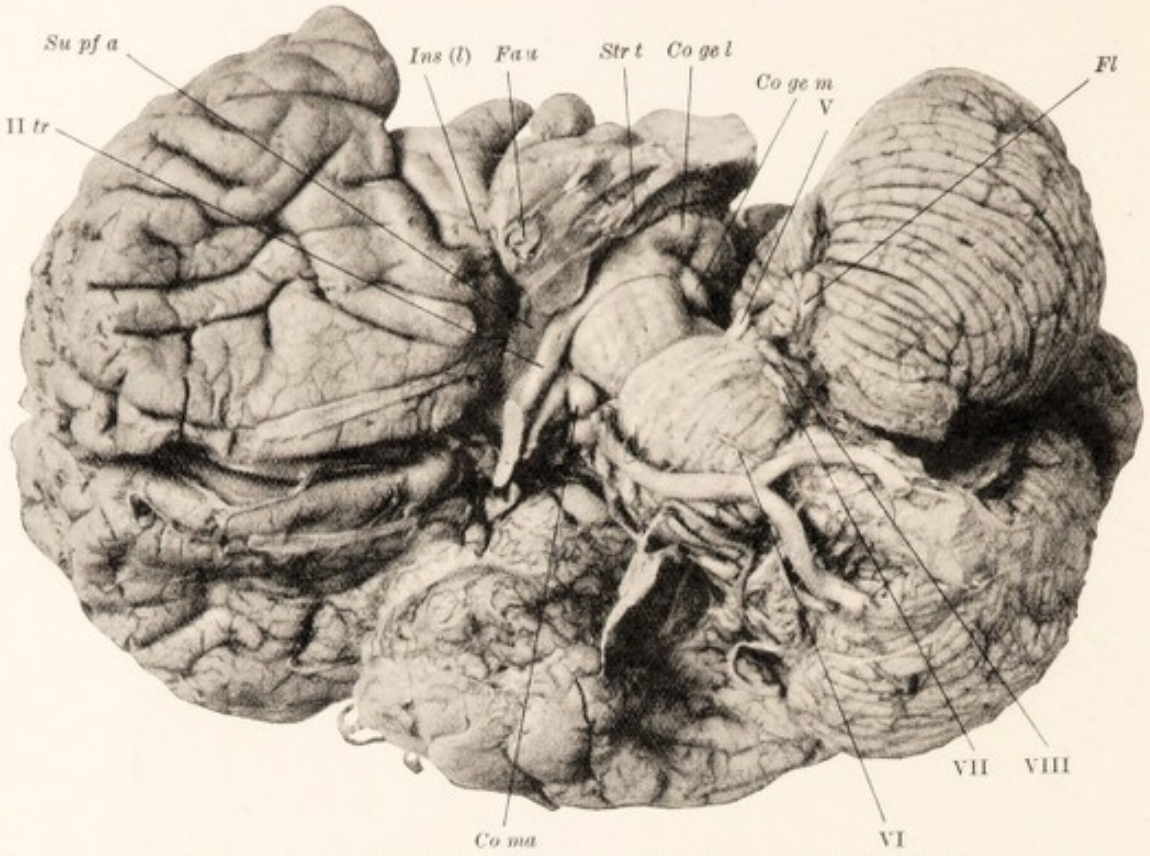


FIG. 34.—The preparation illustrated in Fig. 32 seen obliquely from below. The most anterior part of the superior wall of the inferior cornu has been separated by the cut shown in text, Fig. D. In front, on the section surface, one sees the fasc. uncinatus cut through.

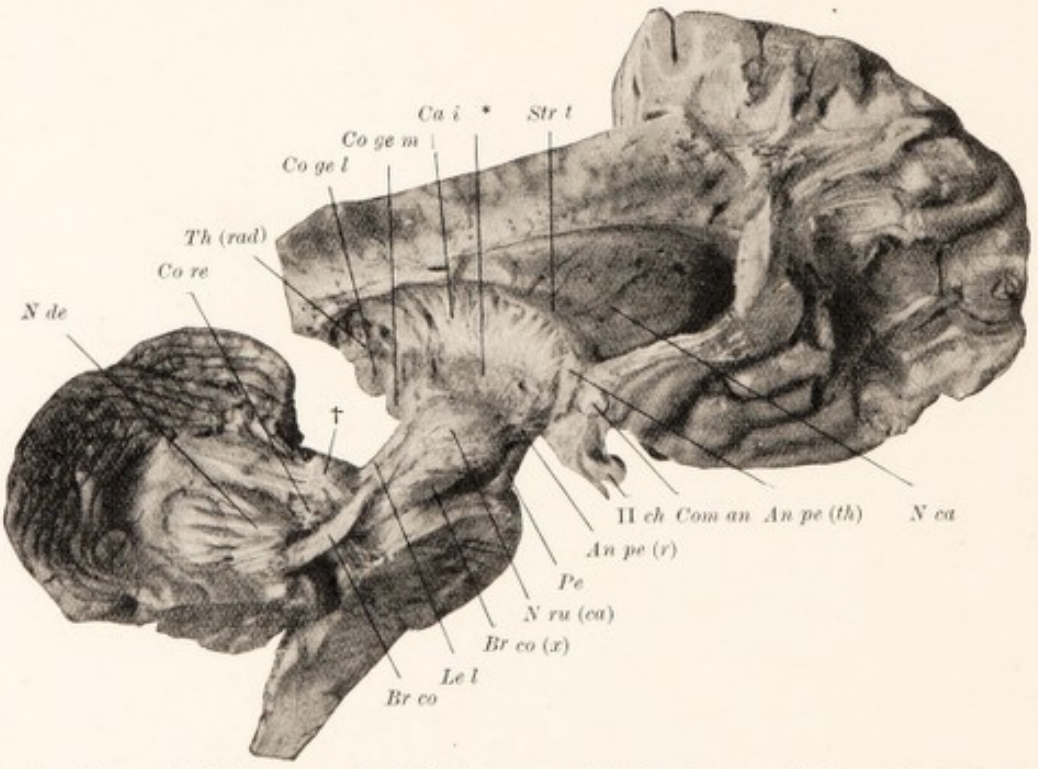


FIG. 35.—The dissected half of the same brain has been separated from the intact half exactly in the mid-plane. View from within and above. The upper half of the cerebellum has been torn away and the bundles of the pons (†) streaming into this part have been cut off (*cf.* p. 21). The lamina quadrigemina and the thalamus proper have been lifted away from the tegmentum and, after cutting through the lateral lemniscus, both corp. geniculata and the part of the ansa peduncularis coming from the thalamus, have been simply broken loose from the internal capsule. The brachium conjunctivum, its decussation, and the red nucleus surrounded by its fibrous capsule have been prepared out of the surrounding softer tissue. Notice the spiral turn of the brachium conjunctivum, the layer of fine fibres (*) lying between the red nucleus and the internal capsule, through which goes the ansa lenticularis, and the bundles of the ansa peduncularis which come from the capsule of the red nucleus.

PLATE XII.

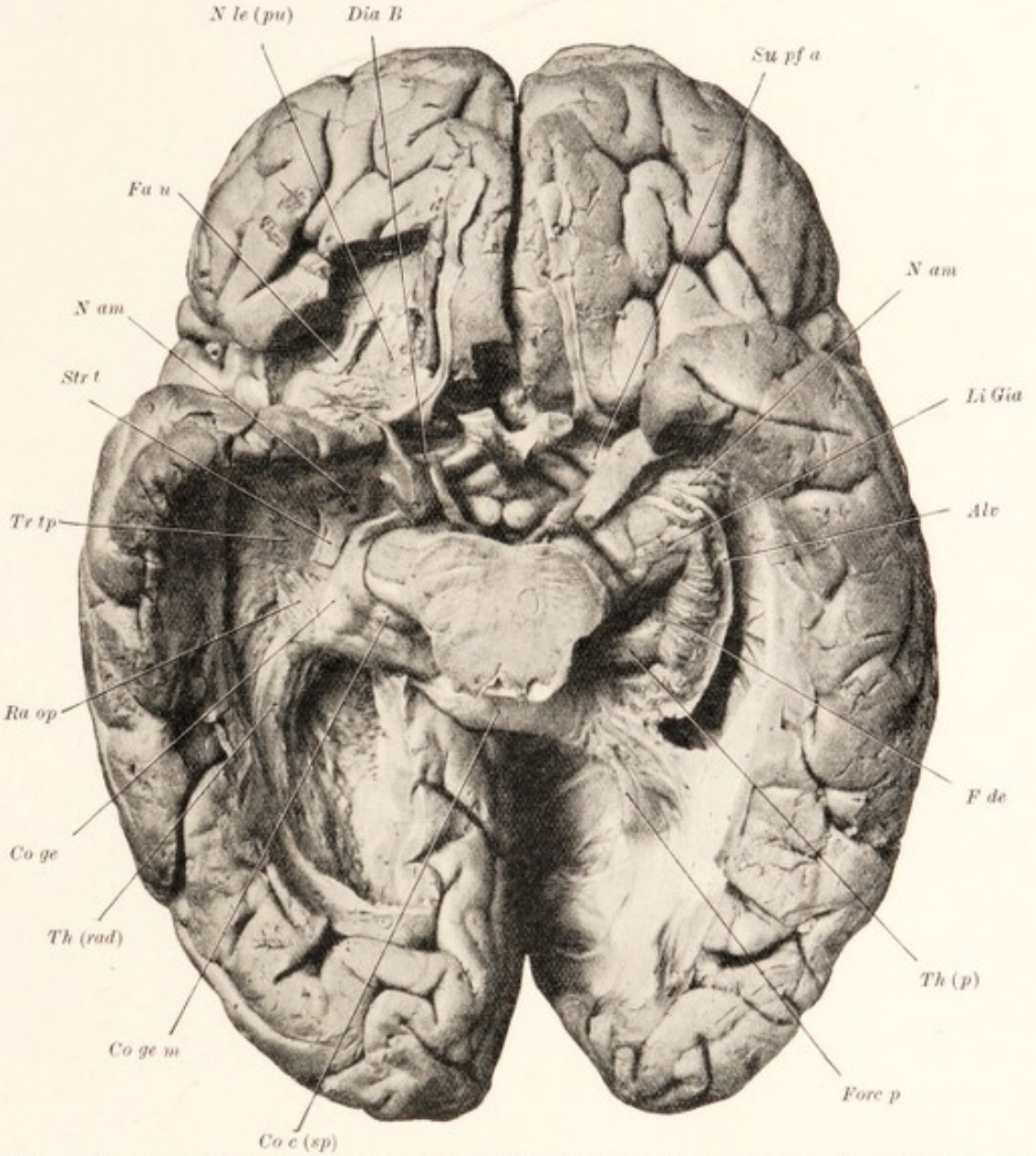


FIG. 36.—Base of the cerebrum, in which the structures lying around the inferior cornu have been prepared. In the left hemisphere (right in this figure) the gyrus hippocampi (except the uncus) and part of the adjoining gyri, have been taken away, whereby the inferior cornu has been opened and the fascia dentata, going over into the limbus Giacomini, and the amygdaloid nucleus have been exposed. The forceps posterior on this side has also been prepared. In the right hemisphere, the whole hippocampal formation and the inferior wall of the posterior and inferior cornu have been removed. On the lateral upper wall of the same, the superficial ependymal and glial layer has been peeled away; likewise the tapetum. The tail of the caudate nucleus and the stria terminalis have been removed except the inferior terminal part of the stria going into the amygdaloid nucleus which is still left intact. In the retro- and sublenticular radiation of the internal capsule revealed in such manner, one notices posteriorly the strongly marked Gratiolet's radiation running sagittally mostly from the posterior part of the thalamus, and anteriorly one notices the somewhat transverse temporal radiation (Türck's bundle) passing from the temporal lobe into the lateral part of the crus, crossed by the stria terminalis and the optic tract. External to the lateral geniculate body, one sees the optic radiation proper going out from the same nucleus. In this preparation, only the first part of the optic radiation has been preserved, in which the fibres run obliquely anteriorly, before they form the "temporal knee" and bend around backwards in a sagittal direction. On this side of the preparation also the point of the temporal lobe has been cut away and a part of the orbital gyri removed in order to show the frontal radiation of the fasc. uncinatus and the anterior part of the putamen. In the anterior perforated substance the diagonal band of Broca has been exposed.

PLATE XIII.

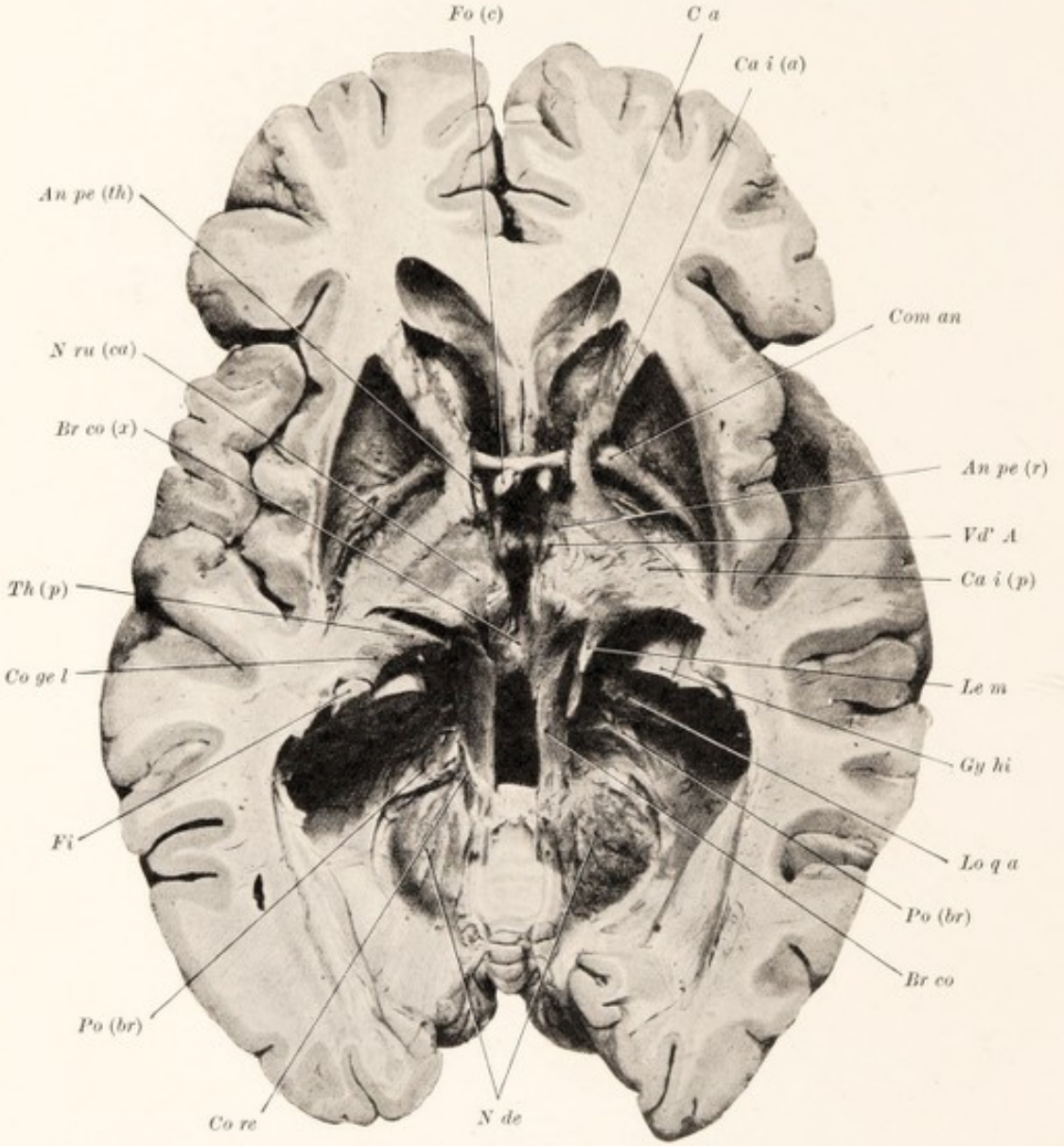


FIG. 37.—The brain has been cut through horizontally somewhat above the anterior commissure and through the posterior commissure. The hippocampal formation has been cut through at the posterior end of the thalamus, while the medial part of the occipital lobe, the corresponding part of the cerebellum up to the level of the nucleus dentatus, and the lamina quadrigemina have been removed. The dentate nuclei and the brachia conjunctiva streaming out of them have been exposed up to their decussation and their passage into the red nuclei. One notices that some fibres of the brachium conjunctivum go also to the red nucleus of the same side. Of neighbouring formations, there have been left, on the left side, part of the brachium pontis and restiform body, and, on the right, a fibre bundle which belongs chiefly to the medial lemniscus. On the left side one sees parts of the pulvinar and lateral geniculate body; but the rest of the grey matter of the thalamus has been removed and the medullary capsule around the red nucleus has been left exposed. On the right side one can see especially the fan-shaped radiation of fibres towards the internal capsule, and anteriorly the bundle going over into the ansa peduncularis. On the left has been left the part of the ansa coming from the thalamus. The nucleus lenticularis and the head of the caudate nucleus have been cleared out of their beds; the anterior commissure and the ansa peduncularis have been left intact.

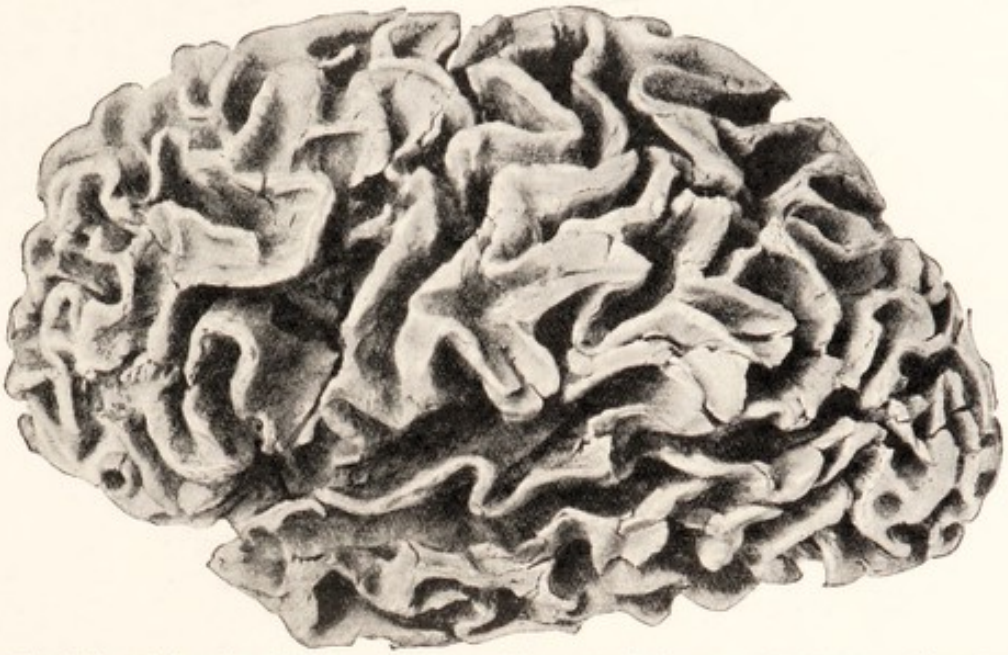


FIG. 38.—The left hemisphere in which the grey matter of the cortex has been completely removed in order to show the medullary centre with the narrow, high ridges and the broad furrows (two-thirds nat. size).

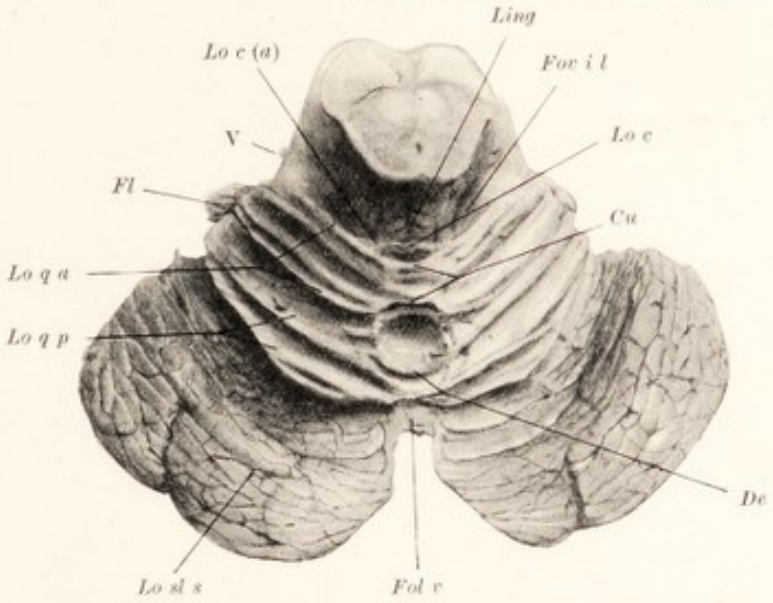


FIG. 39.—The medullary body of the cerebellum seen from above (two-thirds nat. size). With the exception of the lingula, folium and lobulus semilunaris superior all the lobules of the upper side have been removed up to the roots of their medullary ridges. Notice that the arrangement of the medullary ridges is not quite symmetrical.

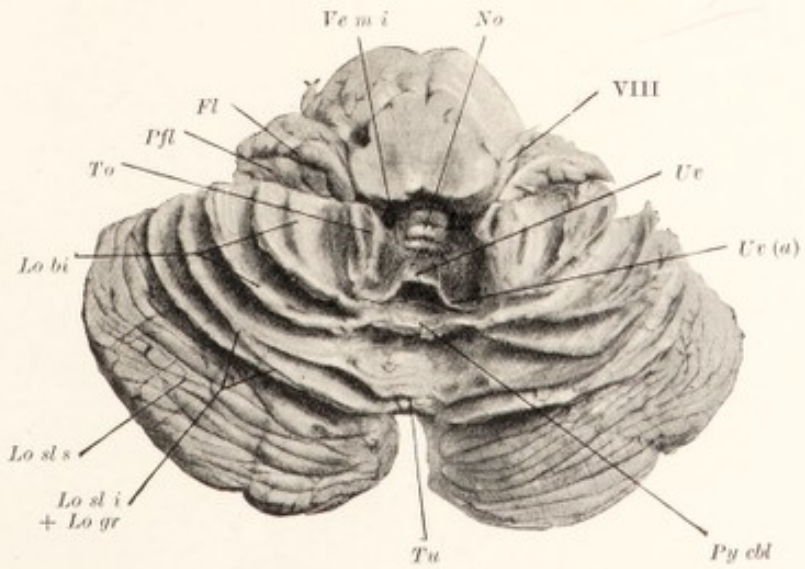


FIG. 40.—The same preparation seen from below (two-thirds nat. size). All the lobules of the underside, with the exception of the nodulus and flocculus, have been removed. Also here notice that the medullary ridges are not perfectly symmetrical. In the roof of the empty nidus avis one sees the inferior medullary velum.

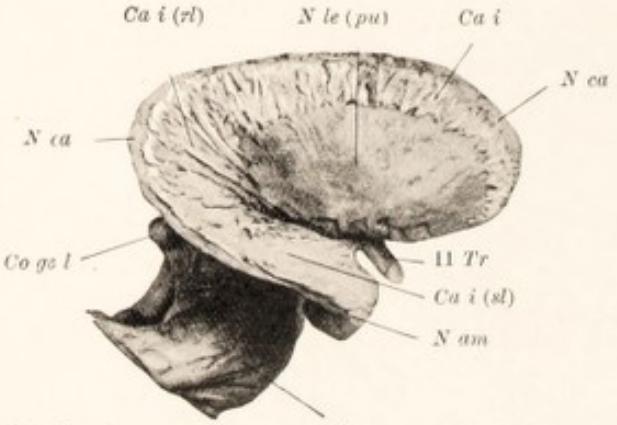


FIG. 41.

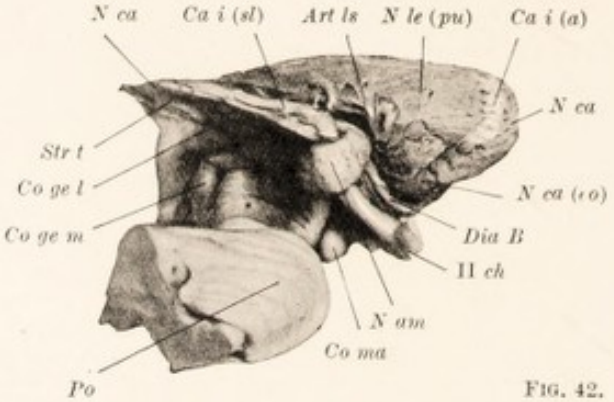


FIG. 42.

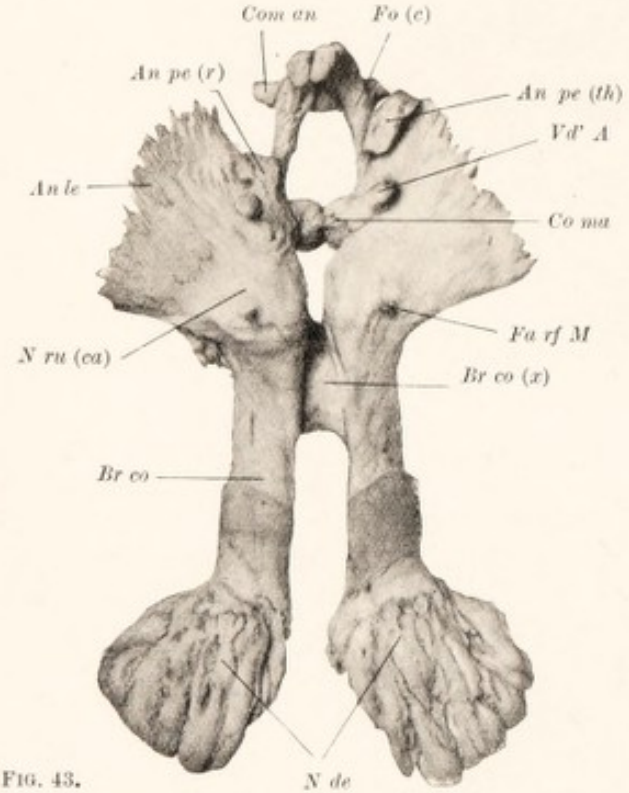


FIG. 43.

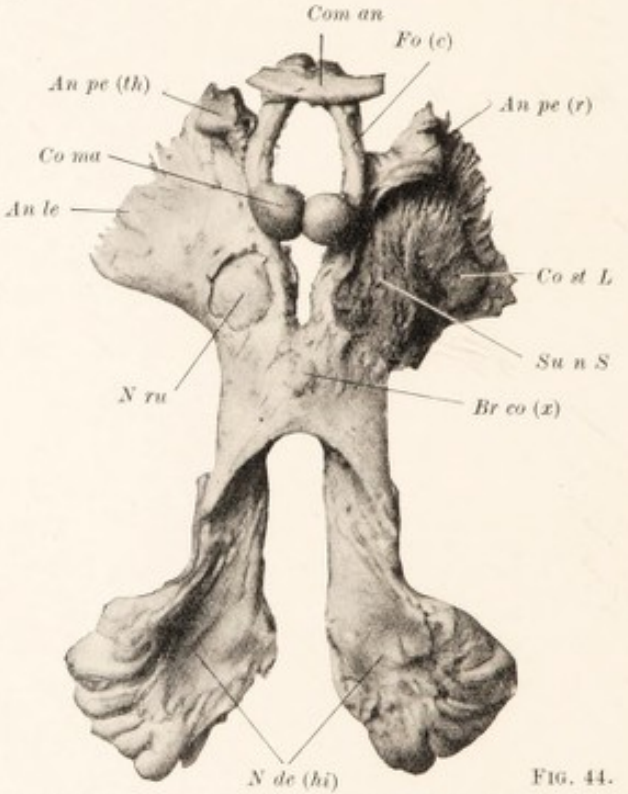


FIG. 44.

FIG. 41.—The right half of the brain-stem from the lateral side (two-thirds nat. size). The insula and external capsule have been removed and the amygdaloid nucleus has been dissected out of the temporal lobe. One sees the lateral edge of the nucleus caudatus, which is separated from the lenticular nucleus by the internal capsule. Notice the great breadth and the almost sagittal direction of the fibres of the capsule in their retro-lenticular part. In the sublenticular part, the direction of the fibres is less distinct because of its crossing with other fibre systems (*e.g.*, anterior commissure).

FIG. 42.—The same preparation seen obliquely from the inferior aspect (two-thirds nat. size). Notice how the head of the caudate nucleus and the putamen of the lenticular nucleus connect up with one another below the anterior end of the internal capsule. Out of the underlying anterior perforated substance the diagonal band of Broca has been dissected out.

FIG. 43.—The rubral system has been prepared out *in toto* (nat. size); view from above (*cf.* Plate XIII.). In the preparation the corp. mamillaria with their crura and a part of the anterior commissure have been preserved. The brachium conjunctivum on each side is seen streaming out of the dentate nucleus; it will be noticed that, between the restiform body and the inferior colliculus its superficial layer, on account of its darker colour, shows up quite distinctly. At the upper end of the decussation and a little dorsal to it, the brachia go over into the white medullary capsule of the red nucleus, which is penetrated by the fasciculus retroflexus of Meynert. Further anteriorly is the bundle of Vicq d'Azyr. From the capsule of the red nucleus fibres stream out in a lateral and obliquely anterior direction (ansa lenticularis); on the left side one sees antero-medially, near to the crus fornicis, a bundle bending around and going inferiorly (ansa peduncularis); on the right the same is seen covered by the thalamic part of the ansa which has been left in the preparation.

FIG. 44.—The same preparation seen from below (nat. size). The first parts of the brachium conjunctivum (at the hilus of the nucleus dentatus) are covered by ependyma of ventricle IV. It is seen that it is chiefly the lateral, inferior, fibres of the brachium conjunctivum which take part in the decussation. On the left side (right in the figure) the substantia nigra of Sömmering and the corpus subthalamicum (Luys) still remain; anteriorly one sees the bundle of the ansa peduncularis bending around inferiorly and laterally. On the other side the last-named nuclei have been removed and a part of the medullary capsule of the red nucleus has been dissected away, in order to show its relation from this aspect. Anteriorly is seen the part of the ansa peduncularis coming from the thalamus.

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