ATLAS

OF THE

HUMAN BRAIN

AND THE

COURSE OF THE NERVE-FIBRES

BY

Dr. EDWARD FLATAU

WITH A PREFACE

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PROF. E MENDEL

TRANSLATED BY

WM. NATHAN, M. D. and JOHN H. CARSLAW, M. D.

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S. KARGER
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The ever-increasing importance of the anatomy of the brain, to physiology and pathology as well as to the treatment of cerebral diseases, renders it all the more necessary to have good illustrations of the brain surface and of sections through it.

The few plates, which are here published and which were prepared in my laboratory, should suffice to serve all practical purposes; and the annexed diagram of the course of the nerve-fibres seems specially well adapted for easy localisation.

I sincerely hope that the success of the work may be as conspicuous as the industry and care which the Author has expended upon it.

BERLIN, June 1894.

Mendel.

Preface.

The study of the central nervous system forms, undoubtedly, one of the most difficult branches of anatomy. Fresh material is not always available, and it is, therefore, found requisite that students, and also physicians in the post-mortem room, should have at their command illustrations of the brain, as nearly natural as possible in details and in size. Apart from costly models, this need can be satisfactorily supplied only by photographs of the brain in its fresh condition and unaltered by any preserving fluid. As no collection of such illustrations of the cerebral cortex and sections is as yet in general circulation, I have decided to publish the present Atlas and I hope that it may prove a welcome supplement to the ordinary text-books.

While there have been no important results to record for many years from work on the macroscopic anatomy of the brain, the new methods of investigation (by comparative anatomy, by experiment, and by silver-impregnation) have recently led to considerable advance in our views as to the histology of the central nervous system. It has, therefore, been necessary, in order to fulfil the purpose in view, to introduce, in addition to the photographs, some explanatory remarks and a diagrammatic representation of the course of the nerve fibres. It has been thought that the latter will be found all the handier for easy reference as I have departed from the usual plan (of indicating the course of the fibres in a single diagrammatic section) and have preferred to represent the tracts as supposed to be seen lying in a cerebral hemisphere artificially hollowed out.

The photographs were taken by rinsing the fresh brain or its sections in water and then fastening them with cement upon a plate, as nearly in their natural position as possible. The camera was then fixed by wooden screws so as to photograph directly from above downwards. The time of exposure (using small diaphragms) was five to ten minutes for sections of the brain and twenty to thirty minutes for uneven surfaces.

I take this opportunity of expressing my thanks to Professor Mendel and to the assistant of the laboratory, Dr. L. Jacobson, for the friendly interest which they have taken in my work. I wish also to thank my publisher, Mr. Karger, for the untiring care with which he has prepared the Atlas for the press.

Edward Flatau.

BERLIN, June 1894.

CONTENTS.

The course of the fibres

in the central nervous system.

Before beginning the description of the course of the fibres in the central nervous system, I think it advisable that we should become acquainted with the nerve cells and the important points in a transverse section of the spinal cord. — The nerve cells (Fig. VI. A. A'), which we meet with in the whole central nervous system, all possess several processes, or, in other words, they are multipolar. One of these processes, distinguished from the others by the symmetry of its calibre, is called the "axis-cylinder-" or "nerve-fibre-process" (Fig. VI. b, b') and runs directly into a nerve fibre. The remaining processes called "protoplasmic processes" or "dendrons" (Fig. VII. a. a') soon after their origin divide and subdivide into numerous very fine fibrils, which are lost in the immediate neighbourhood (Fig. VII, a. a'). With very few exceptions, the cells have only one nerve process, which runs either directly into a nerve fibre or divides into two nerve fibrils which form the origin of two separate nerve fibres. The nerve process terminates in very numerous delicate branches (Fig. VI. c, c') which are distinguished as the terminal ramification. The individual filaments of both kinds of processes lie very closely in contact with one another; there is never, however, any confluence or anastomosis, each process ending entirely free and independent. Thus, though the individual processes of the same cell and the processes of the neighbouring cells all lie closely in contact with, and encircle, one another (Fig. VI, c—a'), they never form a continuous network, but simply lie closely packed together, like the fibres of a piece of felt, there being neither confluence nor anastomosis. The physiological function of the nerve processes depends entirely upon whether they end in a motor or a sensory fibre. The function of the dendrons is not as yet positively known, some authors *(Ramon)* being of the opinion that they are nervous; others *(Golgi)* believe them to have a trophic influence upon the cells. A nerve cell, with its nerve fibre process and the terminal branches of the latter, forms a nerve unit or "neuron" of Waldeyer (Fig. VI, A + b + c; A' + b' + c'). The nervous system is made up of an immense number of those independent units, communicating with and influencing one another by contact.

On a transverse section of the cord (Fig. II), there is seen the grey substance (H-shaped), surrounded by the white substance. It is divided into two lateral halves by the ant. longitudinal fissure (Fig. II. 10) and the post. longitudinal septum (Fig. II, 9). The white substance of each lateral half is again divided, by the entrance of the anterior (Fig. II, r. a) and posterior (Fig. II, r. p) spinal nerve roots, into three parts, called respectively the anterior, lateral and posterior columns. These columns contain the following conducting systems:

I. Anterior column:
 a) anterior, uncrossed, or direct pyramidal tract (long path) (Fig. II. 1, red);
 b) anterior ground fibres (short path) (Fig. II. 2).

II. Lateral column:
 a) lateral or crossed pyramidal tract (long path) (Fig. II. 5 red);
 b) lateral ground fibres (short path) (Fig. II. 3);
 c) antero-lateral ascending tract or tract of Gowers (long path) (Fig. II. 4 blue);
 d) the direct cerebellar tract or tract of Flechsig (long path) (Fig. II, 6).

III. Posterior column:
 a) Column of Burdach or postero-external column (short path) (Fig. II. 7 green).
 b) Column of Goll or postero-median column (long path) (Fig. II. 8).

Speaking generally, the white substance of the cord principally contains longitudinal fibres, which are the continuations of the nerve processes of the cells. These nerve fibres give off collaterals at right angles which end in the grey substance in the same way as the original fibres, namely, in very numerous delicate terminal filaments, without anastomosis or confluence. In the grey matter the terminal ramifications of the fibres and collaterals lie in contact with and surround the cells.

In the grey substance an anterior (Fig. II, cornu ant.), a posterior (Fig. II. cornu post.) and a lateral horn (in the cervical and upper dorsal region) can be distinguished microscopically. The apex of the posterior horn is surrounded by the substantia gelatinosa of Rolando. It never reaches entirely to the surface of the cord, being separated from it by white matter (Lissauer's border tract, Waldeyer's medullary bridge) (Fig. II, L. R.). The two lateral halves of the cord are bound together by a commissure, the anterior part of which contains white fibres and is called the white commissure, ("commissura anterior sive alba"), — the posterior part, consisting entirely of grey matter and containing the central canal, is called the grey commissure ("commissura posterior sive grisea"). — The grey substance of the cord consists of neuroglia, of the nerve cells lying therein, with their processes and terminal filaments, and of blood-vessels. There are three varieties of nerve cells: a) motor cells, b) column fibre cells, c) Golgi's cells (reflex or inner cells).

a) The motor cells (Fig. III, a, black) are distinguished from the rest by their large size and their very numerous dendrons. They extend throughout the entire length of the cord in the anterior horns, forming well-defined groups in its two enlargements [the antero-median (Fig. II, 11) and the postero-lateral groups (Fig, II, 12)]. Each nerve process of a motor cell enters a nerve fibre of the anterior root (Fig. III, r. a.) of the same side, so that the fibres of the anterior root always take their origin unilaterally, from the nerve cells of the same side.

b) The column fibre cells (Fig. III, b–b′, c–c′, red and green) are those, whose nerve processes run into the columns, forming their longitudinal fibres. They are to be found in the so-called middle zone of the grey matter, (that is in the part between anterior and posterior horns), in the horns themselves, and in Clarke's column[1]) (Fig. II, 13; Fig. III, b′ red). The column fibre cells are classed as follows: a) cells whose nerve processes enter the columns of the same side (Fig. III, b red and green); b) cells whose nerve processes cross in the anterior commissure and enter the white matter of the opposite side (called commissural cells) (Fig. III, c. c′ red); c) cells whose nerve processes divide into two fibrils, one entering a column fibre of the same side, and the other, a column fibre of the opposite side (cellules à cylindre axe complexe) (Fig. III, c′ red). The course which the fibres take after they enter the white matter will be discussed more fully below.

c) Golgi's cells (Fig. III, d. blue) have very short nerve processes which never leave the grey matter but divide into terminal ramifications soon after their exit from the cell. These cells are found only in the posterior horn.

The nerve paths in the central nervous system may be classed as follows:

I. Projection fibres (which constitute the connection between the cortex of the brain and the periphery).

- A. Projection fibres of the cerebrum.
- B. Projection fibres of the cerebellum.

II. Association fibres (which connect different parts of the cerebral cortex).

- A. Commissural fibres (which connect identical parts of the two hemispheres).
- B. Association fibres in the proper sense (which connect different parts of the same hemisphere).

[1]) This consists of groups of cells which lie at the base of the posterior horn and which form a column extending from the 7th or 8th cervical to the 2nd or 4th lumbar nerve; further upwards in the cervical and downwards in the lumbar region, there are cells in this situation representing Clarke's column which are called Stilling's cells.

I. Projection fibres.

A. Projection fibres of the cerebrum.

a) The motor paths (tracts).

The motor paths or pyramidal tracts run in a centrifugal direction. The motor impulses originate in the cerebral cortex and are carried thence to the motor nuclei of the cranial and spinal nerves. The motor nuclei of the cranial nerves lie in the pons, medulla etc., while those of the spinal nerves lie in the anterior horns of the grey matter of the cord. The large pyramidal cells of the cortical motor areas with their nerve processes and terminal twigs, the latter encircling the cells of the motor nuclei, form the central motor path. The cells of the motor nuclei with their nerve processes and terminal ramifications in the muscles form the peripheral motor path. The anatomical course of the spinal motor nerves is as follows: They begin, as has already been said, in the large pyramidal cells of the motor area of the cortex (the central convolutions). These contain in their upper third the motor centres for the lower extremity — Fig. V. 1, red; in their middle third, those for the upper extremity — Fig. V. 1', red. Thence the pyramidal fibres pass into the white substance of the cerebrum (centrum semiovale Vieussenii) forming part of the corona radiata Reilii, which converges to the internal capsule, where the fibres lie in the posterior segment (Fig. V, caps. int., red shading). From this point the fibres run downwards passing through the crusta pedunculi into the pons and medulla, where they consist of two compact bundles, the pyramids, (Fig. V, Py. red) which can be seen macroscopically on the ventral surface and can be traced through the entire length of the medulla. In the part of the medulla where the I—II cervical nerves take their exit, the decussation of the pyramids may be seen, occupying a space of about 6 mm. in length. The pyramidal tracts here undergo a partial decussation. The larger, crossing, part (Fig. V, 3, 4, 5, red) passes into the lateral column of the opposite side where it cuts off the anterior horn from the rest of the grey matter and descends in the cord as the crossed pyramidal tract. A smaller part of the fibres (Fig. V, 6, 7, 8, green) remains on the same side and descends in the anterior column of the cord as the direct pyramidal tract. In the cord the course of these pyramidal tracts is as follows: the fibres of the crossed tracts give off (like those of all the longitudinal fibres) collaterals (Fig. V, col., red) at right angles, which run into the grey substance of the same side, where they terminate in small ramifications which lie in contact with and surround the motor cells situated there. Eventually the stem fibres bend at right angles and enter the grey matter, where they encircle the motor cells in the same way as the collaterals (Fig. V. 3, 4, red). Thus the fibres of the crossed pyramidal tracts decrease in number as they descend and terminate upon reaching the lowest part of the lumbar enlargement (III—IV sacral nerve).

The fibres of the direct pyramidal tract also give off collaterals (Fig. V. col., green) at right angles, which pass by the white commissure into the motor cells of the opposite side. The stem fibres share the same fate (Fig. V, 6, 7, 8, green). The direct pyramidal tract can be traced to the lower dorsal region only.

A motor impulse thus traverses two nerve units: 1. the large (cortical) pyramidal cell (Fig. VI, A), its nerve process (Fig. VI, b) and terminal ramification (Fig. VI, c), which invests the motor cell of the anterior horn — the central motor path[1]; 2. the motor cell of the anterior horn (Fig. VI, A′) — its process, which runs in the fibre of the anterior root (Fig. VI, b′) — and its terminal ramification in the muscle (Fig. VI, c′) — the peripheral motor path. The larger part of the fibres of the central path decussates en masse in the medulla (Decussatio pyramidum Tab. I, 24) and forms the lateral crossed pyramidal tract of the cord; the smaller part descends in the anterior column of the cord as the direct pyramidal tract, the fibres crossing gradually as they descend. The nerve processes of the anterior cornual motor cells are continuous with the fibres of the anterior roots of the same side and end in ramifications in muscles or glands. Therefore a motor impulse originating in, for instance, the right hemisphere, is carried to the other side (the left).

Of the ***cranial nerves*** there are six which are purely motor (oculomotorius, trochlearis, abducens, facial, accessory and hypoglossal) and three which are partly motor and partly sensory (trigeminus, glossopharyngeus and vagus). The motor paths of these nerves are analogous to those of the spinal motor nerves, i. e. they have a central and a peripheral path. The central path originates in the large pyramidal cells of the lower third of the central convolutions (Fig. V, 2 red), whence the fibres run to the angle of the internal capsule (Fig. V, caps. int. red dots). Then they arch downwards, decussate and pass soon afterwards to their nuclei, which lie in the parts around the pons. As regards their peripheral paths the opinions of different authors vary. From the physiological fact that the muscles supplied by them act bilaterally (in mastication, facial expression, movements of the eyes etc.) it might be thought that perhaps each nerve does not only contain fibres from the nucleus of the same side, but also some from the nucleus of the opposite side, or that perhaps the nuclei of the two sides are connected with each other. Anatomical facts, however, have not as yet been found fully to confirm these surmises.

Paths of the motor cranial nerves:

N. oculomotorius (n. III, Tab. I. 11). Central path: pyramidal cells of cerebral cortex (exact site unknown) — angle of the internal capsule — decussating pyramidal fibres (Fig. V, oc. red) whose terminal ramifications encircle the cells in the motor nucleus. Peripheral path: cells of the motor nucleus (Fig. V, III.), which lies below the anterior corpora quadrigemina — peripheral nerve-fibres of the same and of the opposite side. — The decussation of a part of the third nerve (Fig. XI, 5 green) has certainly

[1]) See page 4.

been demonstrated [1]). While the nerve processes of the cells in the nuclei enter the peripheral fibres, the dendrons are surrounded by the terminal twigs of 1. their own pyramidal fibres (Fig. XI, 1 black); 2. spinal sensory column fibres (Fig. XI, 4 red) by means of the fasciculus longitudinalis posterior (see below), this connection being of great importance on account of its influence upon the reflex movements of the muscles of the eye supplied by the III nerve; and 3. the fibres of the optic nerve (Fig. XI, 2 blue).

N. trochlearis (n. IV, Tab. I, 13; Tab. IV, 21). Central path: pyramidal cells of the cortex (site unknown) — decussating pyramidal fibres (Fig. V, t. red) and their terminal ramifications. Peripheral path: cells of the motor nucleus (Fig. V, IV — below the posterior corp. quadrigemina) — fibres of the peripheral nerve. The peripheral nerves themselves decussate near their surface attachment; whether they also contain fibres from the nucleus of the opposite side is as yet uncertain. The cells of the motor nucleus are, through their dendrons, in relation with 1. their own pyramidal fibres; 2. the sensory spinal column fibres; 3. the fibres of the optic nerve.

N. abducens (n. VI, Tab. I, 17). Central path: pyramidal cells of the cortex (site unknown) — decussating pyramidal fibres (Fig. V, ab, red) and their terminal ramifications. Peripheral path: cells of the motor nucleus (Fig. V, VI. — anterior part of the floor of the fourth ventricle) — peripheral nerve fibres from the nucleus of the same side. The cells of the nucleus are in relation with 1. their own pyramidal fibres; 2. the spinal sensory column fibres; and 3. the fibres of the optic nerve.

N. facialis (n. VII, Tab. I, 18). Central path: cells of the cortex (central convolutions — lower third) — decussating pyramidal fibres (Fig. V, f, red) — their terminal ramifications. Peripheral path: cells of the motor nucleus (Fig. V, VII, lateral and ventral to the motor nucleus of the abducens, distal end of the pons Varolii). — peripheral nerve fibres from the nucleus of the same and perhaps some from that of the opposite side. It is a well known fact that, in the common central facial paralysis of cerebral apoplexy, the lower branch of the facial alone is affected, while the upper (supplying the m. orbicularis oculi and m. frontalis) escapes. It is probable that the motor nucleus of the upper branch lies in the posterior part of the oculomotorius nucleus of the same side, the nerve processes of the cells of this nucleus running to the n. facialis of the same side *(Mendel)*, and the central path running so as not to be affected by the apoplexy. The cells of the motor nucleus (of the lower branch) are in relation with 1. their own pyramidal fibres; 2. the spinal sensory column fibres, and 3. the sensory fibres of the trigeminus and cochlearis.

N. access. Willisii (n. XI, Tab. I, 23). Central path: cells of the cortex (site unknown) — decussating pyramidal fibres — their terminal ramifications.

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[1]) Besides, the nuclei of the two sides are bound together by commissural fibres (Fig. XI, 3).

Peripheral path: cells of the motor nucleus (Fig. V, XI) (the posterior part of the motor nucleus of the vagus forms the motor nucleus of the n. accessorius vagi sive cerebralis; the cells in the anterior horn from the region of the 5th cervical nerve upwards form the motor nucleus of the spinal accessory nerve). The nerve processes of the nucleus of the cerebral portion enter the nerve fibres of the same side, which take their exit from the brain in the medulla and blend with the root of the vagus; the roots of the spinal portion take their exit from the lateral column of the cord, from the 5th cervical nerve upwards, the roots soon uniting to form one nerve — the spinal accessory. The cells of the motor nucleus are in relation with 1. their own pyramidal fibres and 2. the spinal sensory column fibres.

N. hypoglossus (n. XII, Tab. I. 42). Central path: cells of the cortex (lower third of central convolutions) — decussating pyramidal fibres (Fig. V, h, red) and their terminal ramifications. Peripheral path: cells of the motor nucleus (Fig. V, XII — this nucleus, 18 mm. in length, stretches, just beside the sulcus medianus in the floor of the fourth ventricle, to the striae acusticae) — fibres from the nucleus of the same and perhaps from that of the opposite side. The two motor nuclei are bound together by commissural fibres. Their cells are in relation with 1. their own pyramidal fibres; 2. spinal sensory column fibres; and 3. the sensory portion of the IX and X nerves.

Motor portion of the trigeminus (n. V, Tab. I. 40). Central path: cells of the cortex (perhaps lower third of the central convolutions) — decussating pyramidal fibres (Fig. V, tr. red) and their terminal ramifications. Peripheral path: motor nucleus [Fig. V, V: a) at anterior end of the floor of the fourth ventricle, region of the pons Varolii, b) motor cells which lie scattered in the central grey matter and which can be traced to the region of the corp. quadrig. and are also said to exist in the locus cœruleus *(Mendel)*]. — The nerve processes of the cells of the motor nucleus proper (classed under a) run into the motor root proper of the fifth. The cells classed under b) form the descending root and are connected with the motor root. These nerve processes (of the cells a and b) come from the nuclei of the same and of the opposite side *(Kölliker, Obersteiner, Edinger, Bechterew)*. The motor cells are in relation with 1. their own pyramidal fibres; 2. with sensory spinal column fibres (the latter carry the reflex impulses; for instance, trismus after peripheral irritation); 3. sensory fibres of the fifth.

Motor portion of the glossopharyngeus (n. IX, Tab. I, 21). Central path: cells of the cortex — decussating pyramidal fibres (Fig. V, g. red) and terminal ramifications. Peripheral path: motor nucleus (Fig. V, IX) = nucleus ambiguus (this nucleus which lies in the floor of the fourth ventricle is very closely connected with the motor nucleus of the vagus) — peripheral fibres from the nucleus of the same side.

Motor portion of the vagus (n. X, Tab. I, 22) = same paths as n. IX. The motor cells of the nuclei of n. IX and X are in relation with 1. their own pyramidal fibres; 2. the sensory spinal column fibres; 3. the fibres of the sensory part of the trigeminus.

b) Sensory and Reflex paths (tracts).

The sensory paths are centripetal, the sensory impulses being carried by the sensory nerves to the cord and thence to the cerebral cortex where they reach our consciousness; so that these paths must be traced from the periphery to the cortex instead of from the cortex to the periphery, as the motor paths were. The first (peripheral) station reached by the sensory fibres is in the cells of the so-called spinal ganglion (Fig. I, a, b, blue). The nerve processes of these cells divide into two fibres, one of which — the stronger and larger (Fig. I, p, blue) — runs towards the periphery and helps to form the sensory nerve; the central and smaller fibre (Fig. I, c, blue) runs into the cord and forms with analogous fibres the post. root. The spinal ganglion cells are the trophic centres for the sensory nerves and also probably conduct sensory impulses. The posterior roots enter the cord immediately behind the substantia gelatinosa of Rolando (Fig. II), each fibre dividing (after its entrance into the cord) into an ascending (Fig. I, 1, 2, 3, 4 blue) and a descending (Fig. I, 1', 2', 3', 4' blue) branch. These fibres ascend and descend longitudinally in the posterior columns from their dividing points. The descending fibres are all short, running a short distance downwards and bending at right angles into the grey substance where they end in numerous short tufts or ramifications. The ascending fibres are classed as short and long fibres. The short ascending fibres (Fig. I, 2, 3 blue) run a short distance upwards and terminate like the descending, in the grey substance. The long fibres (Fig. I, 4 blue) run upwards throughout the entire length of the cord to the medulla, where they bend at right angles and pass into the grey matter (nuclei gracilis and cuneatus), in which their free terminal ramifications end (Fig, I, nucl. grac., nucl. cun.). All the fibres (ascending and descending) give off collaterals (Fig. I, col. blue) at right angles which run into the grey substance. Thus all the descending fibres, the short ascending, and the collaterals of all the ascending and descending fibres, enter the grey substance of the cord. The collaterals and the stem fibres (the terminal ramifications of which may be considered as terminal collaterals) all end in the same way, i. e., in fine terminal ramifications, which lie in contact with and surround the cells of nearly all parts of the grey matter, but chiefly those of the same side. The cells encircled by these fibres and collaterals are as follows:

α) The most frequent termination is around the column fibre cells of the posterior horn and middle zone (Fig. III, 7, 8, 9, black). These cells probably take up the impulses brought to them from the periphery and by means of their nerve processes conduct them towards the brain (see below);

β) a considerable number run to the motor cells of the anterior horn (Fig. III, 10, black) constituting the so-called reflex collaterals of Kölliker or the collaterales postero-anteriores of Ramon;

γ) some run to the cells in Clarke's column (Fig. III, 11, black).

All these collaterals (α β γ) run to the cells of the same side.

5) A few of the collaterals decussate in the posterior commissure and run to the column fibre cells of the opposite side (Fig. III, 12, black).

Thus sensory impulses, beginning in the periphery, pass successively through the peripheral sensory nerve fibres — spinal ganglion cells — fibres of the posterior roots — and the terminal filaments of all the descending, and short ascending, and the collaterals of all the ascending and descending, posterior column fibres, which end in the grey matter; we have thus the peripheral sensory path or sensory conducting path of the I class.

Before describing the further course of these sensory fibres[1]) it is necessary that we should examine the posterior columns more closely:

As has been said, the post. roots enter the cord behind the substantia gelatinosa of Rolando. Soon after their entrance, they spread out like a fan, and divide into two portions: 1. the lateral portion (Fig. I, 1, 2, blue; Fig. III, 1, 2, 3, black), the fibres of which divide dichotomously immediately after their entrance and form part of the longitudinal fibres described above. The most lateral of them (viz. those lying at the border of the lateral column) form the so-called border tract of Lissauer (Fig. II, L. R.) or medullary bridge of Waldeyer or Flechsig's postero-lateral root zone. All ascending fibres of the lateral portion belong to the set of short fibres described above. 2. The median portion[2]) (Fig. I, 3, 4, blue; Fig. III, 4, 5, 6, black), very much larger than the lateral, consists of fibres which arch inwards and run to the different parts of the column of Burdach; here they divide into ascending and descending fibres. The course of the short descending fibres has already been discussed. The ascending fibres of this portion may be divided into long and short fibres. The short fibres (Fig. I. 3, blue), after running a more or less short course, bend into the grey substance. The long fibres (Fig. I, 4 blue) run up through the entire length of the cord from their entrance, not entering the grey matter until they reach the medulla. These long ascending fibres are gradually pushed more and more towards the median line as they ascend, by the entrance of the fibres of each successive posterior root (Fig. I, c, blue). In this way the long ascending fibres of the sacral nerves are pushed inwards by those of the lumbar, the lumbar by the dorsal, and the dorsal by the cervical; so that in the cervical region the ascending sensory fibres of the sacral nerve roots are nearest the posterior septum, while those of the cervical roots are most lateral. The short ascending fibres lie for the most part in the column of Burdach and it is, therefore, called a short path. It must not, however, be forgotten that these columns are largely composed also of long ascending fibres but that these long fibres are gradually pushed inwards as they pass upwards by the entrance of new fibres from the posterior roots; thus, running obliquely and leaving Burdach's column, they reach the column of Goll (Fig. I, 4 blue), in which they continue their course up to the medulla. The column of Goll consists entirely of long ascending

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[1]) *Cf. infra* page 10 — anterior and lateral columns.

[2]) This goes to form postero-external and postero-median columns (p. 2).

fibres. In the medulla the fibres end in the nuclei cuneatus and gracilis, as has already been described, the cells of these nuclei being analogous to the column fibre cells of the spinal cord. By this long path, peripheral sensory impulses are carried — through the peripheral sensory nerves — spinal ganglion cells — posterior nerve roots — and long ascending fibres, to the cells in the nuclei cuneatus and gracilis, constituting also a peripheral sensory path or sensory conducting path of the I class.

The sensory impulses, whose course so far we have just traced, are then transmitted upwards in the following manner. The nerve processes of the cells of the nucleus gracilis and nucleus cuneatus go to form fibres (fillet fibres), which arch across the median line (Fig. I, 17 blue), decussating with analogous fibres from the other side (superior pyramidal decussation), and form the mesial or superior fillet (lemniscus medialis). It is well to remark here that the most of the sensory cranial nerves have a crossed connection with the lemniscus medialis (Fig. I, 13, 14, 15, 16 blue) running with the latter towards the cortex. The fibres of the lemniscus medialis are at a higher level than those of the anterior pyramids and pass through the medulla, pons and crus, in the latter of which they lie in the tegmentum (Fig. VII, 4 blue). They then arch upwards to the internal capsule, where they lie in the posterior part of the posterior limb (the so-called carrefour sensitif of Charcot — Fig. I, c. s.) behind the pyramidal fibres. Thence they run in the corona radiata to the cortex of the posterior central convolutions and parietal lobe.[1]) In their course from the medulla to the cortex the fibres all give off collaterals. Some of the fibres do not reach the cortex but end in different nuclei of the anterior corpora quadrigemina, optic thalamus, lenticular nucleus etc. The path from the cells of the nuclei cuneatus and gracilis — nerve processes — decussation — fibres of the lemniscus medialis — carrefour sensitif — corona radiata, to the cerebral cortex forms the central sensory path or sensory conducting path of the II class. By this path the peripheral impulses, which were interrupted in the nuclei cuneatus and gracilis, have their transmission completed.

Besides the sensory paths just described, there are still others and these are of varied significance. These other paths, whose peripheral course has been discussed above (page 8), pass through the anterior and lateral columns. It was, in particular, shown how peripheral impulses reach the column fibre cells of the grey matter of the cord, through the collaterals and the terminal twigs of the short ascending and all descending posterior column fibres (peripheral sensory path, sensory conducting path of the I class). The nerve processes of these column fibre cells (Fig. III, b, c, red and green) run mainly in the anterior and lateral columns [2]) whose longitudinal column fibres they form. All these fibres (Fig. I, 5, 6, 7, 8, 9, 10, red and green) run upwards [3]) giving off collaterals

[1]) According to many authors, to the parietal, occipital and temporal convolutions.

[2]) Very few nerve processes from the column fibre cells go to the posterior columns (Fig. III, b, green).

[3]) Sometimes they give off also descending branches analogous to those of the fibres of the posterior roots.

(Fig. I, col., red and green) in their course and eventually bend at right angles to enter the grey substance of the cord, as do their collaterals. These fibres form:

1. the anterior ground fibres (Fig. I, 8 red);
2. the lateral ground fibres (Fig. I, 5, 6 red);
3. the tract of Gowers or antero-lateral ascending tract (Fig. I, 10 red);
4. the direct cerebellar tract (Fig. I, 7 green).

1. The anterior ground fibres (Fig. I, 8 red) consist of the nerve processes of the column fibre cells (the so-called commissural cells — Fig. III, c, c′ red), which decussate in the anterior commissure and terminate as longitudinal fibres. These run upwards for a short distance, giving off collaterals and bending ultimately at right angles into the grey substance (Fig. III, 13 red). The terminal ramifications of these nerve fibres as well as those of their collaterals encircle the motor and column fibre cells of different regions, mainly however, those of the same side.

2. The lateral ground fibres (Fig. I, 5, 6, red), also consist of the nerve processes of column fibre cells (Fig. III, some cells b, red), with this qualification that they originate partly from cells of the opposite side, partly from those of the same side. Their course also is an upward one; they give off collaterals (Fig. III, 14, red); after running a short distance they form terminal twigs, which, like the collaterals, end in the grey matter of the cord in the manner before described.

While the cells, in which the fibres of the anterior ground bundle originate, are to be found more in the anterior horn and the middle zone, those, in which the lateral ground fibres take their origin, are found scattered in all parts of the grey matter.

Thus the anterior and lateral ground bundles of fibres consist in preponderating degree of short column fibres (Fig. I, 5, 6, 8, red) and they therefore constitute short conducting paths. But besides these they are said to contain some long ascending fibres (Fig. I, 9, red) which originate in the commissural cells (i. e. column fibre cells whose nerve processes have crossed in the ant. commissure) *(Edinger)*.

3. The tract of Gowers (Fig. I, 10, red) is formed in the same way as the lateral ground fibres, with the exception that its fibres form long ascending fibres.

4. The direct cerebellar tract (Fig. I, 7, green) also consists of nerve fibres, which originate in the column fibre cells (Fig. III, b′ red) — namely, those of the columns of Clarke and the cells of Stilling. This tract is not distinctly seen below the lower dorsal region. The fibres are long and run upwards without any decussation to the cerebellum (Fig. IX, 1, blue), where they terminate in the vermis.

The further course of the anterior and lateral ground fibres and of the tract of Gowers is as follows:

The anterior ground bundle of fibres is found throughout the entire length of the cord. In the region of the decussation of the pyramids it is pushed backwards, but runs in the pons as the fasciculus longitudinalis posterior. These fibres end gradually in the cell-accumulations of the substantia reticularis grisea; they thus gradually decrease in number as they ascend upwards, until they reach the region of the oculomotorius nucleus and anterior corpora quadrigemina, where they are lost entirely. During their course these fibres give off collaterals to the motor nuclei of the nerves of the ocular muscles (n. III — Fig. XI, 4, red; n. IV; n. VI) and of the hypoglossus (n. XII)[1]). Physiologically, these fibres are the means by which the sensory spinal nerves exert a reflex influence upon the above-named muscles[2]).

The lateral ground bundle of fibres is also found throughout the entire length of the cord, the fibres gradually ending in the different cell-accumulations of the grey matter of the medulla and pons, of which the nucleus reticularis tegmenti is said to play an important part *(Bechterew)*. The fibres may be traced as far as the nucleus centralis superior (the region immediately behind the posterior corpora quadrigemina) where they are supposed to end. During their course the fibres give off collaterals to the motor nuclei of the V, VII, IX, X and XI nerves.

The tract of Gowers becomes visible in the lumbar region, its fibres running upwards to terminate in the small olivary body *(Bechterew)*.

We have now traced the fibres of the ant. and lateral ground bundles and those of the tract of Gowers to the cell-accumulations in the medulla, pons and crura. It is possible that fibres from these cell-accumulations (to which *Kölliker* has given the general name of nucleus magnocellularis diffusus) attach themselves to the fibres of the lemniscus medialis, and run with them to the cerebral cortex *(Bechterew, Kölliker)*.

According to this view, the physiological functions of the anterior and lateral ground bundles and of the tract of Gowers would be as follows: By means of the peripheral sensory path or sensory conducting path of the I class the peripheral sensory impulses reach the column fibre cells of the grey matter of the cord. Thus these cells constitute, as it were, the first station or halting-place[3]). They give off nerve processes which are either short (main part of the anterior and lateral ground bundles of fibres) or long (the tract of Gowers, the direct cerebellar tract, and some scattered fibres of the anterior and lateral ground bundles); either crossed (the anterior ground bundle, part of the lateral ground bundle and of the tract of Gowers), or uncrossed (part of the lateral ground bundle and of the tract of Gowers and the direct cerebellar tract). These nerve processes are of two kinds: 1. Long fibres (Fig. I, 9, 10, red) which carry impulses, first to the nucleus magnocellularis of *Kölliker* (central sensory path or sensory conducting path of the II class) and thence with the fibres of the lemniscus medialis (Fig. I, 11, 12, blue), to the cerebral cortex (central sensory path or sensory conducting path of the III class). These long fibres (forming the sensory conducting path of the II class) are supposed to decussate in the

[1]) These are analogous to the collaterals of the anterior and lateral ground fibres in the cord which run partly to motor cells of the anterior horns.

[2]) *Cf. supra,* — connections of cells of nuclei of III, IV, and VI cranial nerves.

[3]) Analogous to the cells of the nucleus gracilis and nucleus cuneatus for the long ascending fibres of the posterior columns.

anterior commissure of the cord *(Edinger, van Gehuchten)*[1]. If we consider the column fibre cells of the cord as the first stopping place of sensory impulses, the second will be the cells of the nucleus magnocellularis. 2. Short fibres (Fig. I, 5, 6, 8, red — main part of the anterior and lateral ground bundles) which run only for a short distance, giving off collaterals and ending in the grey matter of the cord and medulla; their chief importance is that they go to form the reflex paths, whose more intimate anatomical relations will now be discussed.

The reflex paths run in 1. short and 2. long reflex arcs. The short reflex arc (Fig. V, A; blue = sens. cell, black = motor cell) consists of a sensory peripheral nerve fibre — spinal ganglion cell — fibre of the posterior root — its reflex collateral of Kölliker (see above, page 8, β) — a motor cell — its nerve process (ant. root fibre). Thus the sensory impulse by means of the reflex collateral of Kölliker (β) stimulates the motor cell by contact and leads to muscular contraction. The long reflex arc (Fig. XII) differs from the short, in there being a column fibre cell (Fig. XII, c, green) interposed between the terminal ramification of the reflex collateral and the motor cell. It is self-evident that the shorter the nerve process of the column fibre cell is, the less will be the reflex action; and, conversely, a long nerve process, giving the impulse more diffusion, will cause a wider reflex action. Therefore, if we think of the fact, that one long ascending fibre of the posterior column (by means of its collaterals) can exert an influence upon the grey matter throughout the entire length of the cord, we can easily understand why, for instance, the stimulation of one limb of a frog can call forth reflex movements of its entire body. It is believed that the reflexes can also be inhibited, most likely by fibres which run centrifugally from the cortex, perhaps in the pyramids. *Kölliker* inclines to the belief that these fibres outweigh the sensory reflex collaterals in their influence upon the motor cells. We see therefore that the column fibre cells conduct sensory impulses upwards (by means of their long nerve processes) and assist in reflex action[2], (by means of the collaterals of all their column fibres and by means of their short column fibres themselves). But the question, which column fibre cells carry the sensory impulses to the brain and which cause reflex action, must as yet remain unanswered. It is also uncertain whether the short column fibres act only as reflex fibres or not. It is possible that they may form sensory conducting paths of the II class, by the fibre from one column fibre cell running to a column fibre cell higher up, and this cell again sending a fibre to a cell situated still higher up, and so on, thus carrying the sensory impulse, as it were, from station to station (Fig. IV, b, b^1, b^2, b^3, red) one situated higher than the other, until it finally reaches the cell-accumulations in the medulla and pons whence it is carried to the cortex (Fig. IV, c, green).

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[1]) The fibres of the direct cerebellar tract undergo no decussation *(cf. supra)*.

[2]) As the column fibre cells are in connection (by means of their nerve processes and collaterals) with motor cells of various regions, they can also transmit the motor impulses which originate in the cortex to wider regions of the cord.

To summarize, the sensory paths are as follows:

a) A direct sensory path in the posterior column, consisting of 1. peripheral sensory path or sensory conducting path of the I class (Fig. I, 4, blue) (peripheral sensory nerve fibre — spinal ganglion cell — fibre of the post. root — long ascending posterior column fibre ending in the nuclei gracilis and cuneatus), 2. a central sensory path or sensory conducting path of the II class (Fig. I, 17, blue) (nerve process of the cells of the nuclei gracilis and cuneatus — superior pyramidal decussation — lemniscus medialis — carrefour sensitif — cerebral cortex). This path is supposed to carry the tactile and muscular sensibility from the periphery to the cortex.

b) An indirect sensory path (anterior and lateral ground fibres and the tract of Gowers) consisting of a 1. peripheral sensory path or sens. conduct. path of the I class (Fig. I, 2, 3, blue) (peripheral sensory nerve fibre — spinal ganglion cell — post. root fibre — short ascending fibre or collaterals of all the ascending and descending fibres — their ramifications, surrounding the column fibre cells), 2. a central sensory path or sensory conduct. path of the II class (Fig. I, 9, 10, red) (the long ascending fibre from the column fibre cell, which decussates in the ant. commissure and runs upwards in the ant. and lat. ground bundles and the tract of Gowers to the nucleus magnocellularis diffusus of Kölliker) and 3. the continuation of the central sensory path or sensory conducting path of the III class (Fig. I, 11, 12, blue) = the nerve processes of the above named nucleus which run with the lemniscus medialis to the cerebral cortex. This path is supposed to carry the sense of temperature and of pain from the periphery to the cortex. It is possible, that not only the long ascending, but also the short fibres, by the formation of chains of alternate fibres and cells (as described above), constitute sensory conducting paths of the second class (Fig. IV).

It is thus evident that both the direct and the indirect sensory paths decussate, the former in the bulb, the latter in the spinal cord[1]). Their decussation is thus analogous to that of the motor tracts, which also takes place, partly in the medulla and partly in the cord. It must, however, be added that many authors doubt the existence of an indirect sensory path whose fibres decussate in the anterior commissure of the cord. It is supposed that there is no decussation of the sensory fibres in the anterior commissure, that only a very small part of the post. root fibres [by means of their collaterals (see p. 9 δ)] cross in the posterior commissure (Fig. III, 12, black) but that this small part is not sufficient, as Lenhossek[2]) says, "to pass for the only anatomical basis of the decussation of the sensory conducting paths postulated by physiologists." This question can only be settled finally by further investigation.

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[1]) The direct cerebellar tract forms an exception in not decussating at all, but this tract has probably nothing to do with true cutaneous sensibility. The fibres run to the cerebellum and have probably an influence only upon the coordination of movement.

[2]) *Lenhossek*, Der feinere Bau des Nervensystems, 1893.

The paths of the sensory cranial nerves are analogous to those of the spinal sensory nerves, just as the paths of the motor cranial nerves are analogous to those of the spinal motor nerves. As the spinal sensory nerve roots have their origin in cells outside the cord (spinal ganglion cells) so have the cranial sensory nerves their origin outside of the brain. From their origin these sensory fibres run into the brain and there, like the fibres of the posterior spinal roots, they divide into an ascending and a descending branch. These give off collaterals in their course and their terminal filaments form ramifications, which surround the cells of the so-called sensory nuclei. This course, from the origin to the cells in the sensory nuclei, constitutes the peripheral sensory path or sensory conducting path of the I class. The cells in the sensory nuclei are analogous to the column fibre cells of the grey matter of the cord and to those of the nuclei gracilis and cuneatus. The fibres originating in them may be long, running uninterruptedly to the cerebral cortex (where they probably end in the post. central convolution and the parietal lobe) after having decussated in the raphé — central sensory path, sensory conducting path of the II class; or they may be short, ending soon in the various cells of the grey substance of the brain, and being concerned chiefly in reflex action. These short fibres may perhaps also form central sensory paths, sensory conducting paths of the II class, by forming chains of alternate cells and fibres, running progressively higher and thus ultimately reaching the cortex. The sensory paths of the individual cranial nerves are as follows:

Sensory part of the trigeminus (n. V.). Peripheral sensory path or sensory conducting path of the I class: peripheral sensory nerve fibre — cell of the Gasserian ganglion (analogous to that of spinal ganglion) — fibre of the sensory root running to the sensory nucleus. Central sensory path or sensory conducting path of the II class: cell of sensory nucleus (Fig. I, V situated at the anterior end of the floor of the fourth ventricle, in the region of the pons Varolii) — long ascending fibres (Fig. I, 16, blue), which cross in the raphé, joining the fibres of the lemniscus medialis and running with them to the cerebral cortex; the short ascending fibres (as well as the collaterals of all ascending and descending fibres) run to the motor nuclei of the trigeminus, facial and hypoglossus, and probably also to the motor parts of the IX and X nerves. The latter form principally reflex paths (for instance, trismus by irritation of the sensory part of the V). The sensory root fibres of the trigeminus divide into ascending and descending branches after their entrance into the brain. The descending fibres form the fasciculus which is called the "ascending root of the trigeminus"; although it is called the "ascending root", it must be remembered that it is really composed of descending divisions of the fibres which originate in the cells of the Gasserian ganglion. Its fibres (like the descending divisions of the fibres of the post. roots of the spinal nerves) terminate in ramifications which encircle the cells of the sensory nucleus of the V and, further down, the cells lying in the post. horns of the cord in the region of the first cervical nerve.

Sensory part of the glossopharyngeal and vagus[1]) (n. IX, n. X, Tab. I, 21, 22). Peripheral sensory path or sensory conducting path of the I class: peripheral sensory fibre of IX or X — cell of the jugular and perhaps of the petrosal ganglion (for the IX) or cell of the jugular and perhaps of the cervical ganglion (for the X) — fibre of the sensory root — division of this fibre after its entrance into the medulla, and terminal ramifications (as above) surrounding the cells of the sensory nucleus. Central sensory path or sensory conducting path of the II class: cell of the sensory nucleus (Fig. I, IX, X — lateral to that of the hypoglossus) — long ascending fibre (Fig. I, 13, 14, blue) from this cell — its decussation in the raphé and course with the lemniscus medialis to the cortex. The short fibres and all the collaterals run to the nucleus of the hypoglossus (reflex movements). Just as the descending branches of the fibres of the V form its "ascending root", so the descending divisions of the fibres of the IX and X form the so-called fasciculus solitarius (respiratory bundle of Krause). The fibres of this bundle end around the cells of the sensory nucleus and those of the post. horns of the cord as far down as the region of the VIII cervical nerve *(Krause)*.

Optic nerve (n. II, Tab. I, 5). The paths of this nerve are also essentially analogous to those of the spinal nerves. Though we have here no definite ganglia, still the bipolar cells of the middle layers of the retina are analogous to those of the spinal ganglion cells and the large ganglion cells of the deep retinal layers play the part of the column fibre cells of the cord.

The peripheral sensory (optic) path or sensory conducting path of the I class therefore consists of the peripheral process of a bipolar cell — the cell itself — and its central process, which encircles the large ganglion cell. The central sensory path or sensory conducting path of the II class consists of the large ganglion cells — their nerve processes, forming the fibres of the optic nerve, which undergo a partial decussation in the chiasma (Tab. I, 6). The fibres which come from the lateral (temporal) half of the retina (Fig. X, red) lie in the lateral part of the chiasma and run in the optic tract (Tab. I, 8), through the carrefour sensitif to the cortex of the occipital lobe of the same side. The fibres from the inner (nasal) half of the retina (the smaller portion) (Fig. X, green) decussate in the chiasma and run in the optic tract, through the carrefour sensitif, to the cortex of the occipital lobe of the opposite side. These two central paths are made up of long ascending fibres (Fig. X, a) which originate in the large ganglion cells of the retina. The short fibres (Fig. X, b) end in so-called "primary optic centres", viz. chiefly in the corpus geniculatum laterale (Fig. X, c. g.), the corpus quadrigeminum anterius (Fig. X, c. Q.), and the pulvinar thalami optici (Fig. X, pulv.), but also in the corpus geniculatum mediale and perhaps in the lenticular nucleus (reflex movements). Fibres from those primary optic centres then

[1]) These are described as one, there being no sharp anatomical line of demarcation between them.

pass to the cortex (*cf. infra*, "optic thalamus"). It must specially be mentioned that the fibres from the cells of the corpus quadrigeminum anterius (which are encircled by the short optic-nerve fibres) run to the nuclei of the nerves for the orbital muscles (viz. the III, IV and VI) a fact which is of great importance in the physiology and pathology of the eye.

Olfactory nerve (n. I). The sensory path of this nerve is analogous to the above. There are, that is to say, bipolar cells in the mucous membrane of the nose which represent the spinal ganglion cells. These form the peripheral sensory path or sensory conducting path of the I class, the terminal filaments of their processes encircling cells which lie in the olfactory bulb (Tab. I, 2) (analogous to the column fibre cells). The central sensory path (sensory conducting path of the II class) begins in these cells of the bulb, their nerve processes forming the fibres of the olfactory tract (Tab. I, 3). Some of these fibres probably decussate in the anterior commissure and run to the gyrus hippocampi, gyrus uncinatus and cornu Ammonis of the opposite side. The greater part remains uncrossed and runs to the corresponding parts of the cerebral cortex on its own side. Besides these long fibres there are said to be some short ones, which run to the cells in the olfactory tract and seem to constitute reflex paths.

N. acusticus (n. VIII, Tab. I, 19). The complicated anatomical relations of the organs of hearing have been in some degree cleared up by the recent investigations of *Flechsig, H. Held, Sala* and others. The auditory nerve (Fig. XIII, 1, black) divides just before its entrance into the medulla into two roots, which embrace the restiform body. The lateral or outer root = the n. cochlearis (Fig. XIII, 3, 4, black); the median or inner = the n. vestibularis (Fig. XIII, 2, black). The n. vestibularis is not concerned in the sense of hearing (it probably plays a part in the maintenance of equilibrium[1]) the n. cochlearis alone being the nerve for that sense. These nerves must therefore be discussed separately.

N. vestibularis. Peripheral sensory path or sensory conducting path of I class: peripheral sensory nerve fibre — cell of the ganglion of Scarpa — fibre of the median root — terminal ramification surrounding the cells of the sensory nucleus. Central sensory path or sensory conducting path of II class: sensory nucleus (Fig. I. $^{\mathrm{VIII}}$ = Deiter's and the main nucleus) — fibres from the main, and from part of Deiter's, nucleus (Fig. I, 15 blue) decussate in the raphé and run with the lemniscus medialis (like those of the other sensory nerves) to the cerebral cortex. Others of the cells of Deiter's nucleus are certainly in connection with the cerebellum[2]).

N. cochlearis. Peripheral path or sensory conducting path of the I class: peripheral sensory fibre — cell of the ganglion spirale (ganglion of Corti) — fibre of the lateral root — terminal ramification encircling the cells of the sensory nucleus.

[1]) See "Projection fibres of the cerebellum".
[2]) See "Projection fibres of the cerebellum".

C e n t r a l s e n s o r y p a t h or sensory conducting path of the II class: sensory nucleus (nucleus accessorius and the tuberculum acusticum). — The nerve processes of the cells of the tuberculum acusticum (Fig. XIII, t. a.) form the fibres of the striæ medullares (striæ acusticæ, Fig. XIII, 16, red); those of the nucleus accessorius (Fig. XIII, n. a.) form the fibres of the so-called trapezoid body (Fig. XIII, 5, green).

The s t r i æ a c u s t i c æ at first run in a dorsal direction, then bending downwards and inwards, (1) a part of them (Fig. XIII, 17, red) running to the upper olive (Fig. XIII, o. s.) of the same side, thence bending round (Fig. XIII, 17̇, red dotted line) to join the lemniscus lateralis of the same side (Fig. XIII, 18′ blue); (2) another part (Fig. XIII, 16′, red) crosses in the raphé and runs to the upper olive of the opposite side turning upwards round it and joining the lemniscus lateralis (Fig. XIII, 18, blue), of that side. There exists, therefore, a partial or chiasma-like decussation of the fibres of the striæ acusticæ.

The c o r p u s t r a p e z o i d e s consists of the nerve processes of the cells of the nucleus accessorius. The fibres run towards the median line and 1. a part of them (Fig. XIII, 7, green dotted line) immediately joins the lemniscus lateralis of the same side (Fig. XIII, 18′, blue); 2. others (Fig. XIII, 5′, green) run further inwards (to the raphé) and before they decussate form an intercommunication with the upper olive of their own side and with the nucleus trapezoides [that is, some of these fibres and the collaterals (Fig. XIII, 8, 9, green) end in these nuclei, and the nuclei in their turn send new fibres (Fig. XIII, 10, 11, green) to the fibres of the corpus trapezoides supplementing them in their further course]; they then cross in the raphé to the opposite side, where they again exchange fibres with the above-mentioned nuclei of that side (Fig. XIII. 12, 13—14, 15, green) and finally join the lemniscus lateralis of that side (Fig. XIII, 18, blue). There is, therefore, a chiasma-like decussation of the fibres of the corpus trapezoides also.

The l e m n i s c u s l a t e r a l i s (lateral fillet) (Fig. XIII, 18 or 18′, blue) therefore forms the real central auditory path of the n. cochlearis, and is to be distinguished as such from the lemniscus medialis, which forms the central path for the sensory spinal nerves and the sensory parts of the V, IX, X and n. vestibularis. The lemniscus lateralis consists of:

a) the crossed fibres of the striæ acusticæ (Fig. XIII, 16′, red) and corp. trapezoides (Fig. XIII, 5′, green);

b) uncrossed fibres of the striæ acusticæ (Fig. XIII, 17, red dotted line) and corpus trapezoides (Fig. XIII, 7, green dotted line);

c) as the corp. trapezoides also contains fibres from the upper olive and nucl. trapez. of each side (Fig. XIII, 10, 11, 14, 15, green) these fibres must also be considered as belonging to the lemniscus lateralis;

d) fibres from the nucleus lemnisci lateralis (Fig. XIII, n. l.) join the lemniscus lateralis in its course upward.

On reaching the upper border of the pons the lemniscus, thus formed, divides into an inner and an outer bundle.

The fibres of the inner bundle (Fig. XIII, 19, blue) end in the ant. (Fig. XIII, 21, blue) and post. (Fig. XIII, 20, blue) corpora quadrigemina of the same and of the opposite side. They represent the short ascending fibres which serve mainly as reflex paths. The fibres which end in the ant. corp. quadrigemina (Fig. XIII, 21, blue) are specially important. Their terminal filaments encircle cells, which are distinguished by their great size, and whose nerve processes (Fig. XIII, 24, black) are in relation with the nuclei of the nerves of the orbital muscles (n. n. III, IV and VI). As these cells are also encircled by the terminal filaments of the optic nerve fibres (Fig. XIII, 22, black) they constitute a common reflex path for the optic and auditory nerves (so that, for instance, there is movement of the eyes in consequence of optic and auditory stimuli). The corp. trapezoides also gives off collaterals, in its course, to the facial nucleus (Fig. XIII, 6, green) thereby forming a reflex connection (e. g. histrionic movements, pricking up the ears on auditory stimulus). Lastly, through the collaterals which end in the substantia grisea, an influence is exerted by auditory stimulation upon the respiration, the innervation of the bloodvessels etc.

The fibres of the outer bundle (Fig. XIII, 23, blue) augmented by fibres from the post. corp. quadrigemina (Fig. XIII, 25, blue dotted line) run through the capsula interna (carrefour sensitif) to the cerebral cortex (superior and middle temporal convolutions). These belong to the class of long ascending fibres and they form the real central auditory path. It is possible, however, that the short fibres by forming chains of alternate nerve processes and cells also constitute a central auditory path.

The motor and sensory tracts constitute the main part of the projection fibres which connect the brain with the "bulb" and the periphery. It has already been shown how these fibres run through the cord, medulla and pons to the crus[1]) and thence in the corona radiata to the cerebral cortex.

Besides these fibres there are other projection systems, which, originating in all parts of the cortex, converge partly to the crus and partly to the cerebral ganglia. All the projection fibres together form the corona radiata of Reil. The anatomical situation of these fibres (taking out of account for the present the corona radiata of the cerebral ganglia) is best studied on a section through the cerebral peduncle or crus (Fig. VII). In such a section, we see that the peduncle is divided into two parts by the substantia nigra Soemmeringii (Fig. VII, s. S.; Tab. VI, Fig. B, 3), the upper portion being called the tegmentum (Fig. VII, T), the lower, the crusta (basis, German "Fuss", Fig. VII, B). Here we meet with parts with which we are already acquainted:

In the middle third of the crusta lie the pyramidal tracts of the spinal nerves (Fig. VII, 3 red shading) which, originating in the motor zone of the cortex (Fig. V, 1,

[1]) The physiological distinction between centrifugal and centripetal fibres is not here taken into account, their anatomical situation alone being considered.

1′ red), run through the post. limb of the internal capsule, and continue their course through crus, pons, medulla and cord. Internal to these pyramidal spinal tracts lie the pyramidal tracts of the motor cranial nerves (Fig. VII, 2, red dots.), which run from the lower third of the motor zone of the cortex (Fig. V, 2 red) through the angle ("knee" or "elbow") of the internal capsule to the crus and motor nuclei further down. Immediately beneath the substantia nigra (Fig. VII, 4, blue) lie the central sensory paths of the cranial nerves, which run through the carrefour sensitif to the cerebral cortex (perhaps the post. central convolution and the parietal lobe).

In the tegmentum are found the fibres of the lemniscus medialis (Fig. VII, 4, blue), which, as we have seen, forms the central sensory path; these fibres run further centripetally, through the carrefour sensitif (forming the so-called tegmental radiation) and end in the cortex (posterior central convolution and parietal lobe). It is also to be mentioned that the fibres of the tegmental radiation run from the tegmentum through the regio subthalamica to reach the carrefour sensitif, a part of the fibres running thence directly to the cortex, another part running first along the base of the lenticular nucleus (Fig. VIII, 3′, blue) then arching through it (lenticular loop) to reach the cerebral cortex. The lemniscus lateralis — the central auditory path — is also found in the tegmentum.

Two paths, as yet un-mentioned, are also to be found in this section. Internal to the combined pyramidal tracts, lies the frontal (ant. or medial) pontal tract (Fig. VII, 1, green) and laterally, the temporo-occipital (post. or lateral) pontal tract (Fig. VII, 5, black dots.). The former contains fibres from the cortex of the frontal lobe which pass through the anterior limb of the int. capsule and go to the nuclei in the pons[1]). The temporo-occipital pontal tract contains fibres from the cortex of the temporal and occipital lobes which run through the post. limb of the internal capsule and also end in the nuclei of the pons.[1])

The projection fibres of the cerebral (central) ganglia consist mainly of fibres which connect the cerebral cortex with the optic thalami, the caudate nucleus and the lenticular nucleus. These ganglia are all connected, (1) with the cortex and (2) with the pons and medulla and through them with the periphery.

The optic thalamus (Tab. III, 11) is connected with the cortex by a vast number of fibres, the so-called "corona radiata of the thalamus". These fibres are classed into:

1. fibres which run from the frontal lobe through the anterior limb of the internal capsule to the thalamus — the ant. pedicle of the thalamus (Fig. VIII, 2, blue);
2. fibres which run from the parietal lobe through the int. capsule to the thalamus;
3. fibres which run from the occipital lobe through the post. limb of the int. capsule to the thalamus and form the post. pedicle of the thalamus; this is a large bundle and, with the fibres running from the occipital lobe to the corp. geniculatum laterale and corp. quadrigeminum ant., forms the so-called "optic radiation" of Gratiolet;

[1]) From here to the cerebellum, see "Projection fibres of the cerebellum" (middle peduncle).

4. fibres which run from the temporal lobe to the base of the thalamus = the lower pedicle of the thalamus (Fig. VIII, 6, blue); these fibres together with those of the lenticular loop (Fig. VIII, 3', blue — see page 20) form the peduncular loop (ansa peduncularis — Fig. VIII. 3' + 6 blue), which from below surrounds the entrance of the peduncle into the brain.

Besides the above the thalamus has connections with the pons, medulla and cord (Fig. VIII, 10 blue dotted line), whose exact relations, however, have not as yet been clearly demonstrated. It is probable that these connections are established by the fibres which run from the optic thalamus to the red nucleus (Tab. VI. Fig. B, 4), to the lemniscus medialis and to the commissura cerebri posterior.

As the caudate nucleus (Tab. III, 5) and the lenticular nucleus or nucleus lentiformis (Tab. VI, Fig. A, 8) are considered as one embryologically and as they have many properties in common, they will be discussed together.

The caudate nucleus and the outer part of the lenticular nucleus (putamen — Fig. VIII, [I]), constitute the corpus striatum, this body forming in reality a modified portion of cortex. The two inner parts of the lenticular nucleus (Fig. VIII, [II, III]) form the so-called globus pallidus. The caudate nucleus and the putamen are said to have the following connections: 1. with the cortex *(Meynert)*, by means of fibres which run through the internal capsule (Fig. VIII. 7, 9, blue dotted lines); 2. with the pons, medulla and cord by fibres which have not as yet been clearly demonstrated (Fig. VIII, 11, 13 blue dotted lines). Besides, there are fibres which originate in the nucleus caudatus (Fig. VIII. 4 blue) and putamen (Fig. VIII. 5 blue) and spread out in the globus pallidus, where they mingle with one another. If we consider the corp. striatum as a modified cerebral cortex, these fibres are then homologous to the other fibres of the corona radiata.

The globus pallidus is also said to be in relation with the cortex (Fig. VIII, 8, blue dotted line) and with the pons and medulla[1]) (Fig. VIII, 12 blue dotted line).

Though the function of all these ganglia is little understood, they stand at any rate in some sort of relation with the motor apparatus, and it is thought probable that the optic thalamus[2]) plays an important part in the emotions (psycho-reflexes).

B. The projection fibres of the cerebellum.

The cerebellum is connected to the rest of the central nervous system by three peduncles, viz.:

1. The posterior (inferior) cerebellar peduncles (corpora restiformia, pedunculi cerebelli ad medullam oblongatam — Tab. VII, Fig. B, 37);
2. The middle cerebellar peduncles (pedunculi cerebelli ad pontem — Tab. V, 43);

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[1]) For the relation of the tegmental fibres to the lenticular nucleus, see above, page 20.

[2]) For the relation of the optic thalamus to sight, see above, page 16.

3. The anterior (superior) cerebellar peduncles (pedunculi cerebelli ad corpora quadrigem., brachia conjunctiva — Tab. VII, Fig, B, 9).

The post. (inferior) cerebellar peduncle, which connects the cerebellum with the cord, chiefly consists of the following fibres:

a) Fibres of the direct cerebellar tract[1]) (Fig. IX, 1, blue; Fig. I, 7, green). These fibres originate in Clarke's and Stilling's columns, run throughout the entire length of the cord and by means of the restiform body reach the cerebellum, where they end in the vermis super. of the same side *(Monakow)*;

b) Fibres which run from the nucleus cuneatus of the same side (Fig. IX, 2, blue) to the vermis superior;

c) Fibres which run from the nucleus gracilis of the same (Fig. IX, 3, blue) and of the opposite side (Fig. IX, 4, blue) to the vermis superior;

d) Fibres which originate in Purkinje's cells of the cerebellar cortex and run to the lower olive of the opposite side (cerebellar olive fibres, fibrae cerebello-olivares of Kölliker — Fig. IX, 5, blue);

e) Fibres which originate in Deiter's nucleus (see n. vestibularis) and end in the roof nucleus of the opposite side (Fig. IX, 6, blue). These form the so-called direct sensory cerebellar tract, connecting the n. vestibularis with the cerebellum. They are said[2]) to continue their course in the anterior (superior) peduncles and, after their decussation, to run to the cerebral cortex.

The middle cerebellar peduncle consists of fibres which originate in the cerebellar cortex and which (a) run to the cells in the same and the opposite side of the pons (Fig. IX, 9, green) and thence with the (ascending) fibres of the anterior and lateral columns of the cord to the cerebral cortex (Fig. IX, 11, black) (the spinal bundle of Bechterew); (b) cross in the raphé (Fig. IX, 10, green) and end in the same cells of the pons as do the frontal and occipito-temporal pontal tracts (Fig. IX, 12, black; Fig. VII, 1, 5) thus forming a crossed connection between the cerebellum and cerebrum (the cerebral bundle of Bechterew).

The anterior (superior) cerebellar peduncle consists of fibres (Fig. IX, 8 red) which originate mainly in the corpus dentatum (also in the cortex) and run to the red nucleus of the opposite side. In the red nucleus there originate fibres (Fig. IX, 13 black) which run to the optic thalamus and thence (Fig. IX, 14 black) to the cerebral cortex (central convolutions?). This also constitutes a crossed connection between the cerebellum and the cerebrum.

Since the well-known experiments of Flourens the cerebellum has been considered the centre for coordination. As such it receives from the periphery various sensory impressions, which are probably transmitted from it, by special paths, to the organ of consciousness (cerebral cortex), where they give us our ideas of space and position. In

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[1]) For details, see page 11.

[2]) By Mendel and Flechsig.

the cerebral cortex there originate impulses which pass backwards to the cerebellum and exert a control upon the impulses of coordination, which arise in the cerebellum. These functions are exercised through the following anatomical paths: By means of the direct cerebellar tract (Fig. IX, 1, blue) the cerebellum is supposed to receive the visceral sensations, and by means of the fibres from the nuclei cuneatus and gracilis (Fig. IX, 2, 3, 4 blue), the so-called muscular sensibility. By the direct sensory cerebellar tract (Fig. IX, 6 blue) from the n. vestibularis, the cerebellum is connected with the semicircular canals of the labyrinth which play a very important part in the maintenance of the head in equilibrium. The paths, by means of which all those impressions from the periphery reach the cerebral cortex, run in the ant. (superior) cerebellar peduncle *(Bechterew)*. The paths, by means of which the cerebral cortex exerts its control upon the cerebellum, are supposed to run in the middle cerebellar peduncle (Fig. IX, 10 green).

As regards the motor paths, which carry the coordinating impulses which run from the cerebellum to the periphery, it is possible either:

1. that these motor paths are represented by the fibres which run from the cerebellum to the motor zone of the cerebral cortex (indirect path); according to Leube they run in the anterior (Fig. IX, 8, 13, 14) and according to Bechterew in the middle cerebellar peduncle[1]) (Fig. IX, 9 green);
2. or that (direct path) these regulating motor impulses are transmitted by fibres which run from the cerebellum through the posterior (inferior) peduncle to the cord where they end around the cells of the ant. horn. Kölliker suggests the hypotheses that these impulses first run in the fibrae cerebello-olivares (Fig. IX, 5, blue) to the lower olive and then, by means of the "olivary fibres" (Fig. IX, 7 blue), reach the lateral columns and through them the cells of the anterior horns of the cord.

In the manifold tracts of projection fibres above-described, we can plainly see that the most varied sensory impulses are always carried centripetally, i. e. from the periphery to the cortex and the motor impulses are conducted centrifugally i. e. from the cortex to the periphery.

II. Association fibres.

The association fibres are divided into two groups viz.:

1. *commissural fibres* and
2. *association fibres in the narrower sense of the word.*

The commissural fibres (Fig. VIII, 1, red) connect identical parts of the two hemispheres[2]). The real association fibres (Fig. VIII, 14, 15 green) connect different parts of one and the same hemisphere.

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[1]) Namely in the fibres, which run to the cerebral cortex with the fibres of the ant. and lat. columns of the cord, and according to Bechterew form a motor path.

[2]) In the cord, they connect identical parts of the grey matter of the two sides.

When connecting fibres are spoken of here, it is to be understood that they are nerve processes of cells whose terminal ramifications encircle other cells and the law that nerve units influence one another by contact is applicable here as elsewhere in the nervous system.

The commissural fibres of the cerebrum are represented by the corpus callosum (Tab. II, 1) and the ant. commissure (Tab. VI, Fig. A, 5). The corpus callosum consists chiefly of fibres which run transversely and connect the two cerebral hemispheres (Fig. VIII, 1, red); their course from the middle line is horizontal at first but most of them soon bend, spreading out like the rays of a fan to various parts of the hemisphere, each fibre however, connecting identical parts of the two hemispheres (radiation of fibres of corpus callosum). These fibres in this way connect all like parts of the two hemispheres excepting the temporal lobes, the base of the occipital lobes and the olfactory bulbs. The commissura cerebri anterior supplements the corpus callosum, in as much as it connects symmetrically the parts left unconnected by it[1]).

There are commissural fibres in the cerebellum also which connect like parts of its two hemispheres. and in the pons and medulla are commissural fibres which connect the nuclei of the cranial nerves of each side with one another. In the cord they run in the post. commissure and connect like cells in the two posterior horns. Lenhossek (Beiträge zur Histologie des Nervensystems, 1894) has also found them in the ant. commissure.

The real association fibres of the cerebrum are divided into short and long fibres. The short fibres (Fig. VIII, 14, green) (fibrae arcuatae propriae) connect two neighbouring convolutions of the same hemisphere. There are also in the various layers of the cortex short fibres which connect parts situated very close to one another (tangential fibres etc.).

The long association fibres (Fig. VIII, 15 green) connect convolutions, which though in the same hemisphere are some distance apart. They are divided into the following bundles:

1. The fasciculus longitudinalis superior, running in the direction of the second frontal convolution, connects the frontal with the occipital lobe.
2. The fasciculus longitudinalis subcallosus runs under the corpus callosum and also connects the frontal with the occipital lobe.
3. The fasciculus longit. inferior runs past the posterior cornu and alongside of the inferior cornu of the lateral ventricle and connects the occipital with the temporal lobe.
4. The fasciculus uncinatus surrounds the entrance of the Sylvian fissure and connects the inferior frontal convolution with the apex of the temporal lobe.

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[1]) As to the probable part which this commissure plays in the chiasma-like decussation of the olfactory nerve, see page 17.

5. The cingulum runs from the substantia perforata ant. through the gyrus fornicatus to the apex of the cornu Ammonis, its anterior part connecting the olfactory bulb with the frontal lobe, and its posterior part, the gyrus hippocampi with the temporal lobe.
6. The fascic. verticalis (the vertical occipital fasciculus of Wernicke) connects the inferior parietal lobe with the fusiform convolution.

There are also association fibres in the cerebellum, which run from convolution to convolution, forming the so-called wreath-shaped band of fibres of Stilling.

We see therefore, that, while the projection fibres connect the periphery and the cortex, the main function of the association fibres is probably psychical. The latter appear the most fitted to form the anatomical basis for the association processes of perception, thought and will. Although we find in these association fibres some anatomical peculiarites, still they have, for the most part, the same structural relations and laws of histological detail as the rest of the nervous system. By the contact of the dendrons of neighbouring cells, and by the contact of the terminal ramifications of nerve processes (and their collaterals) with the protoplasmic processes of cells, there is formed a fine, continuous, felt-like interlacement, which quite explains the most manifold and complicated combinations of their physiological functions.

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TAB. I.

F. Lobus frontalis.
T. Lobus temporalis.
O. Lobus occipitalis.
1. Fissura longitidunalis s. Incisura pallii.
2. Bulbus olfactorius.
3. Tractus olfactorius.
4. Stria olfactoria lateralis.
5. N. opticus.
6. Chiasma nerv. optic.
7. Substantia perforata anterior.
8. Tractus opticus.
9. Corpus mammillare.
10. Sulcus occipito-temporalis inferior s. Fissura collateralis.
11. N. oculomotorius.
12. Pedunculus cerebri.
13. N. trochlearis.
14. Sulcus temporalis inferior.
15. Tractus opticus.
16. Pons Varolii.
17. N. abducens.
18. N. facialis.
19. N. acusticus.
20. Cerebellum (lobus superior medius).
21. N. glossopharyngeus.
22. N. vagus.
23. N. accessorius Willisii.
24. Decussatio pyramidum.
25. Cerebellum (lobus inferior medius).
26. Sulcus cruciatus.
27. Art. cerebri anterior s. art. corporis callosi.
28. Fissura s. Fossa Sylvii.
29. Art. cerebri anterior.
30. Lamina terminalis.
31. Art. cerebri media s. art. fossae Sylvii.
32. Art. carotis interna.
33. Hypophysis s. glandula pituitaria.
34. Gyrus hippocampi.
35. Art. communicans posterior.
36. Gyrus uncinatus s. uncus.
37. Substantia perforata posterior.
38. Art. profunda cerebri s. art. cerebri posterior.
39. Art. basillaris.
40. N. trigeminus (radix motor.).
41. N. intermedius s. Portio intermedia Wrisbergi.
42. N. hypoglossus.
43. Medulla oblongata (oliva).
44. Medulla oblongata (pyramis).
45. Art. vertebralis.

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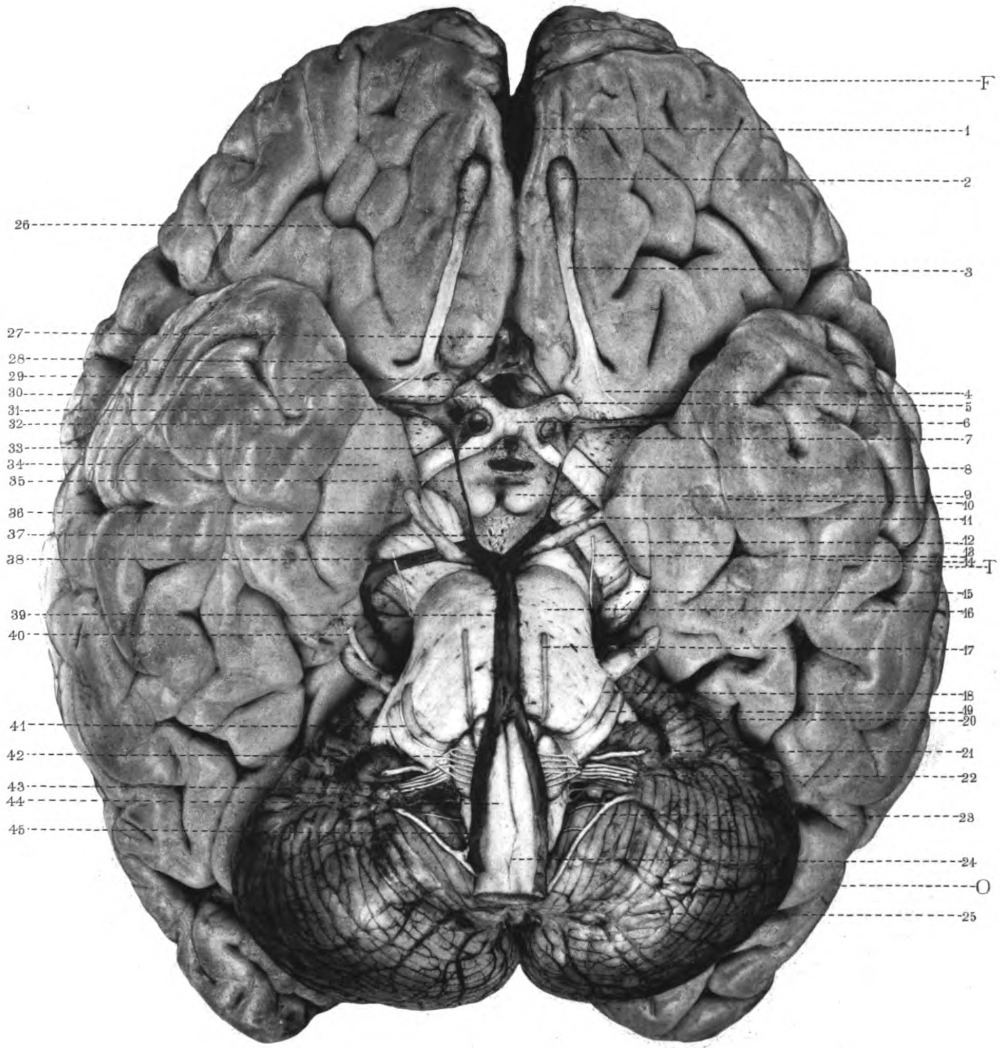

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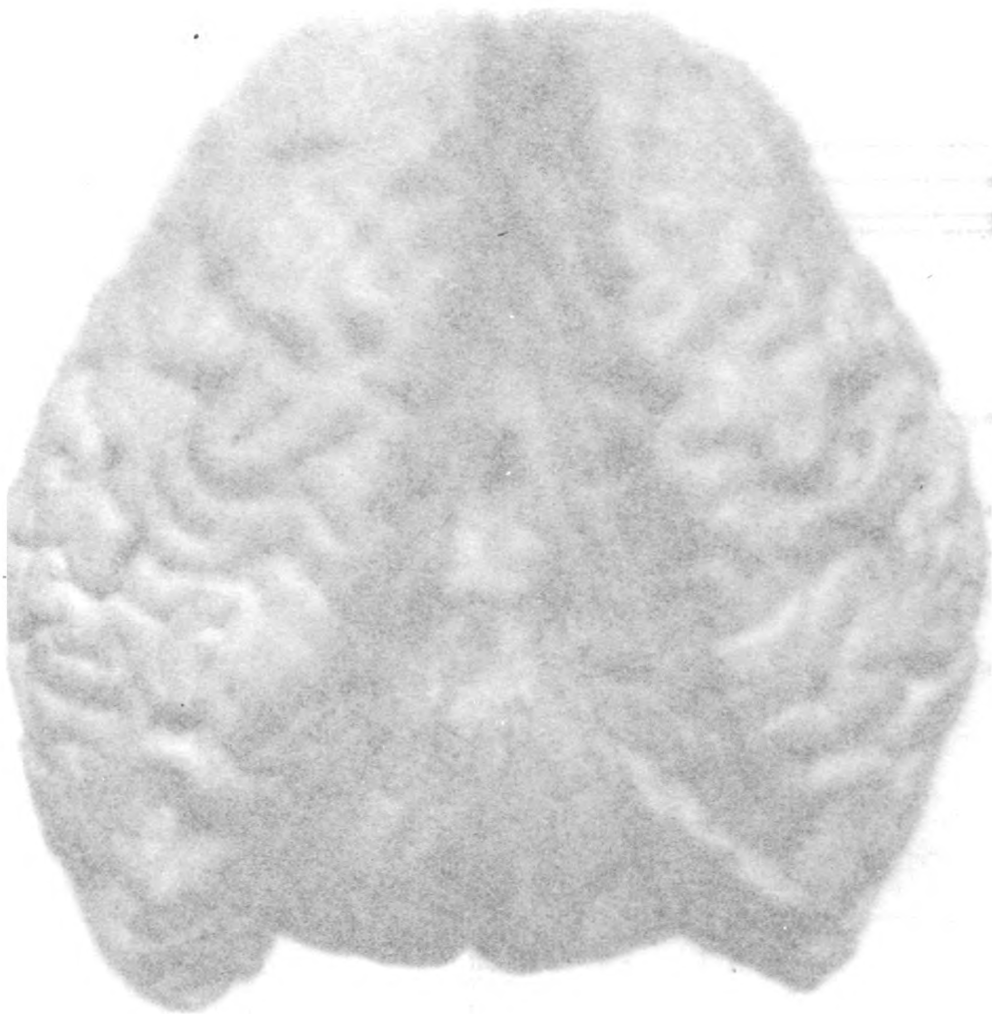
TAB. II.

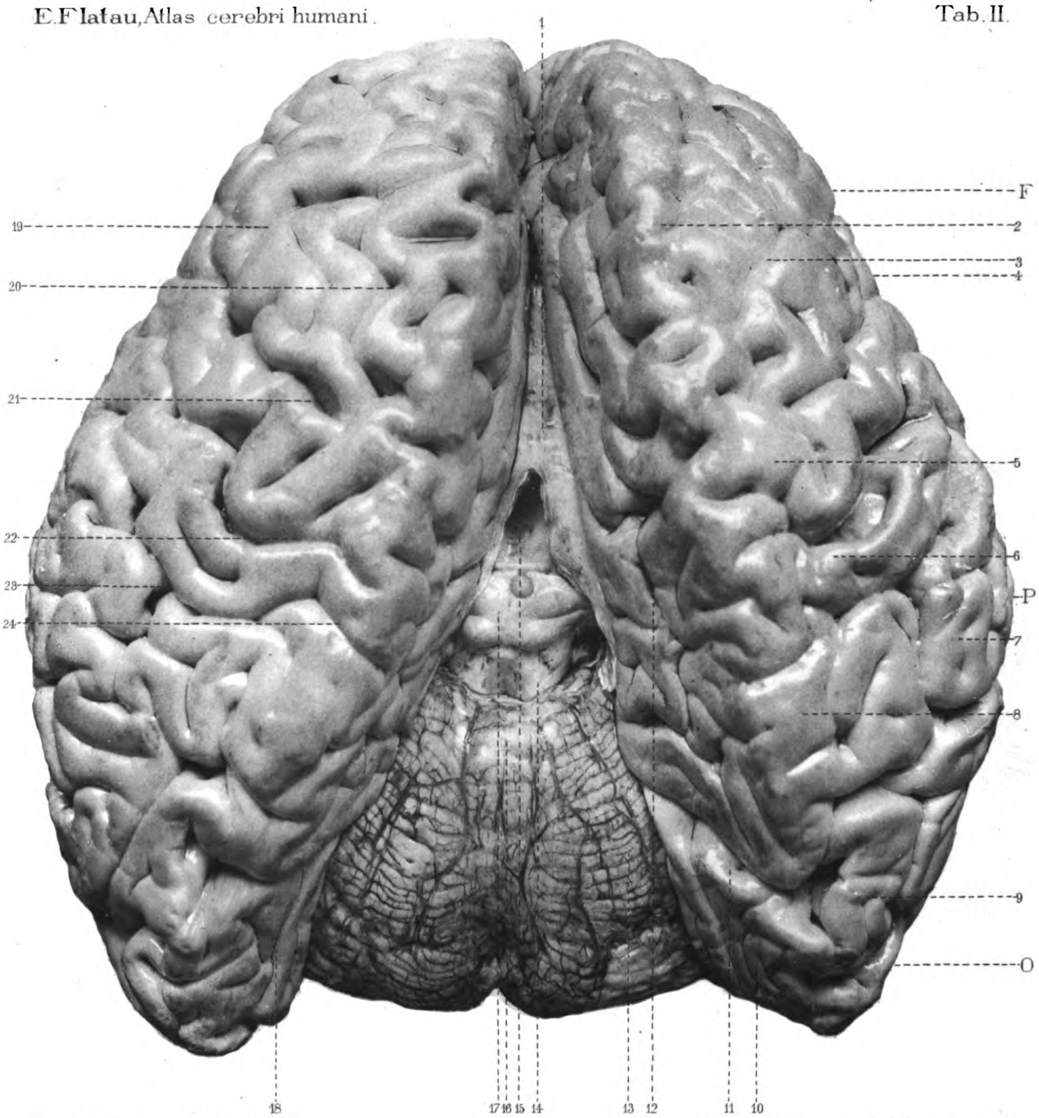
F. Lobus frontalis.

P. Lobus parietalis.

O. Lobus occipitalis.

1. Corpus callosum.
2. Gyrus frontalis superior s. primus.
3. Gyrus frontalis medius s. secundus.
4. Gyrus frontalis inferior s. tertius.
5. Gyrus centralis anterior s. praecentralis.
6. Gyrus centralis posterior s. postcentralis.
7. Gyrus parietalis inferior (Gyrus supramarginalis).
8. Gyrus parietalis superior.
9. Gyrus occipitalis superior.
10. Cuneus s. lobulus triangularis.
11. Fissura parieto-occipitalis.
12. Sulcus calloso-marginalis s. sulcus fornicatus.
13. Cerebellum (Lobus superior medius).
14. Brachium conjunctivum s. Pedunculus cerebelli. ad corpora quadrigemina.
15. Ventriculus tertius.
16. Cerebellum (vermis superior).
17. Corpora quadrigemina.
18. Fissura calcarina.
19. Sulcus frontalis inferior.
20. Sulcus frontalis superior.
21. Sulcus praecentralis s. sulcus praerolandicus.
22. Sulcus centralis s. sulcus Rolandi.
23. Sulcus interparietalis.
24. Sulcus postcentralis s. sulcus postrolandicus.





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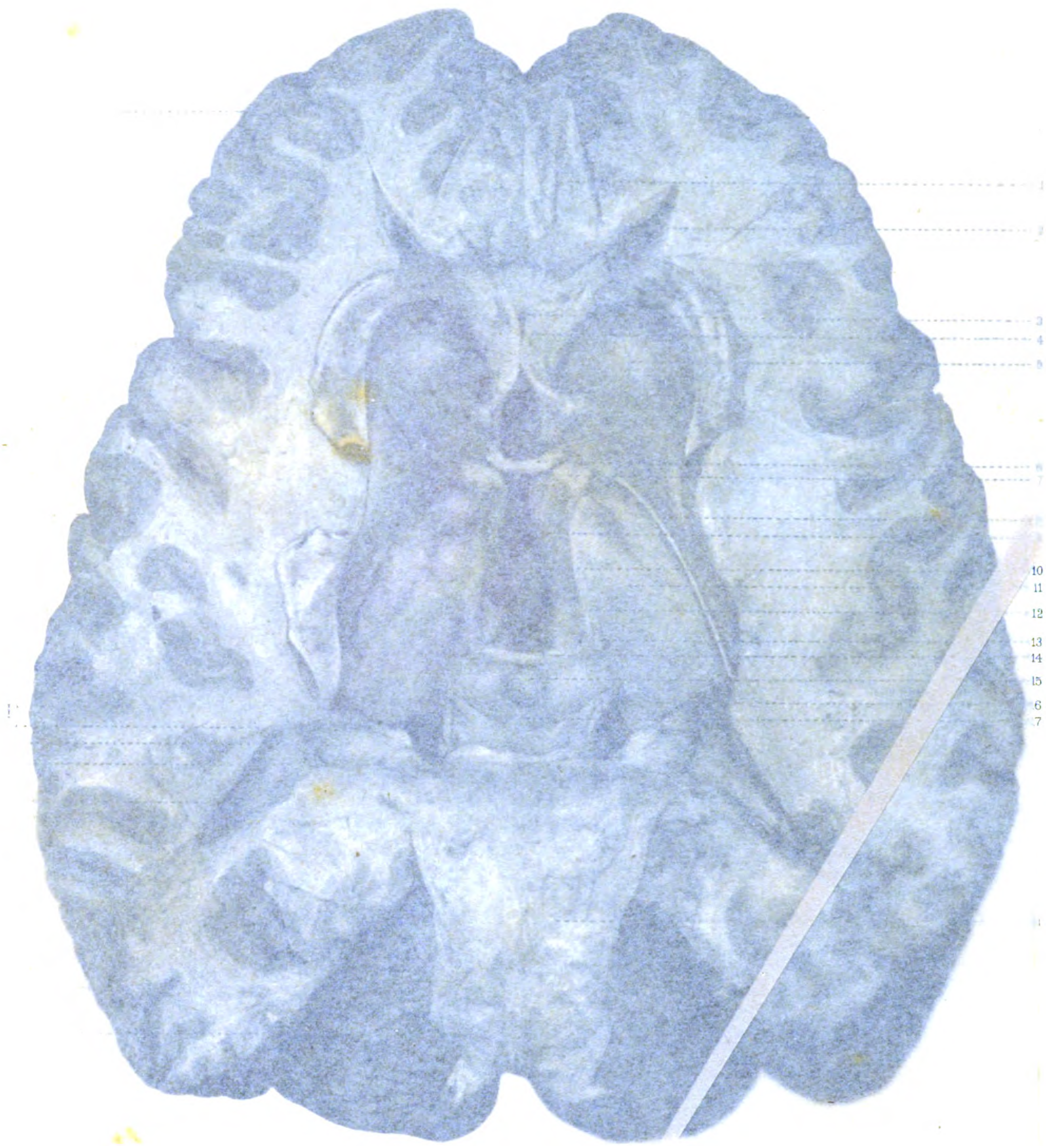
TAB. III.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
1. Corpus callosum (pars anterior).
2. Cornu anterius ventriculi lateralis.
3. Ventriculus septi pellucidi s. ventriculus quintus.
4. Septum pellucidum.
5. Nucleus caudatus.
6. Commissura cerebri anterior.
7. Columna fornicis.
8. Stria terminalis s. taenia cornea.
9. Ventriculus tertius.
10. Commissura mollis s. grisea.
11. Thalamus opticus.
12. Taenia ventriculi tertii s. taenia thalami.
13. Ganglion habenulae.
14. Commissura cerebri posterior.
15. Glandula pinealis.
16. Pulvinar thalami optici.
17. Corpora quadrigemina.
18. Corpus callosum (pars posterior).
19. Fimbria.
20. Cornu Ammonis s. Pes hippocampi major.
21. Calcar avis s. Pes hippocampi minor.
22. Cornu posterius ventriculi lateralis.
23. Cerebellum (Lobus superior posterior).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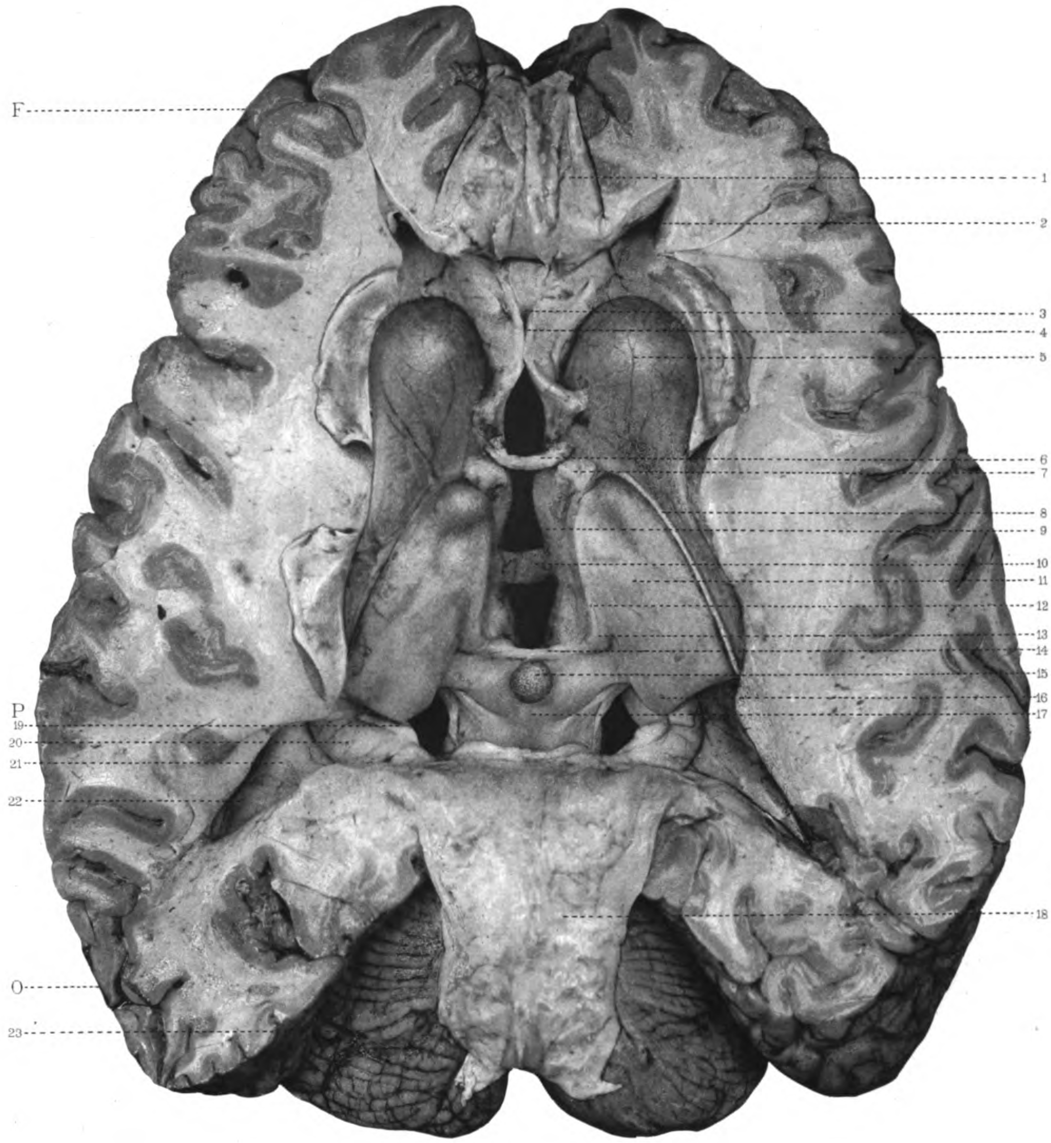

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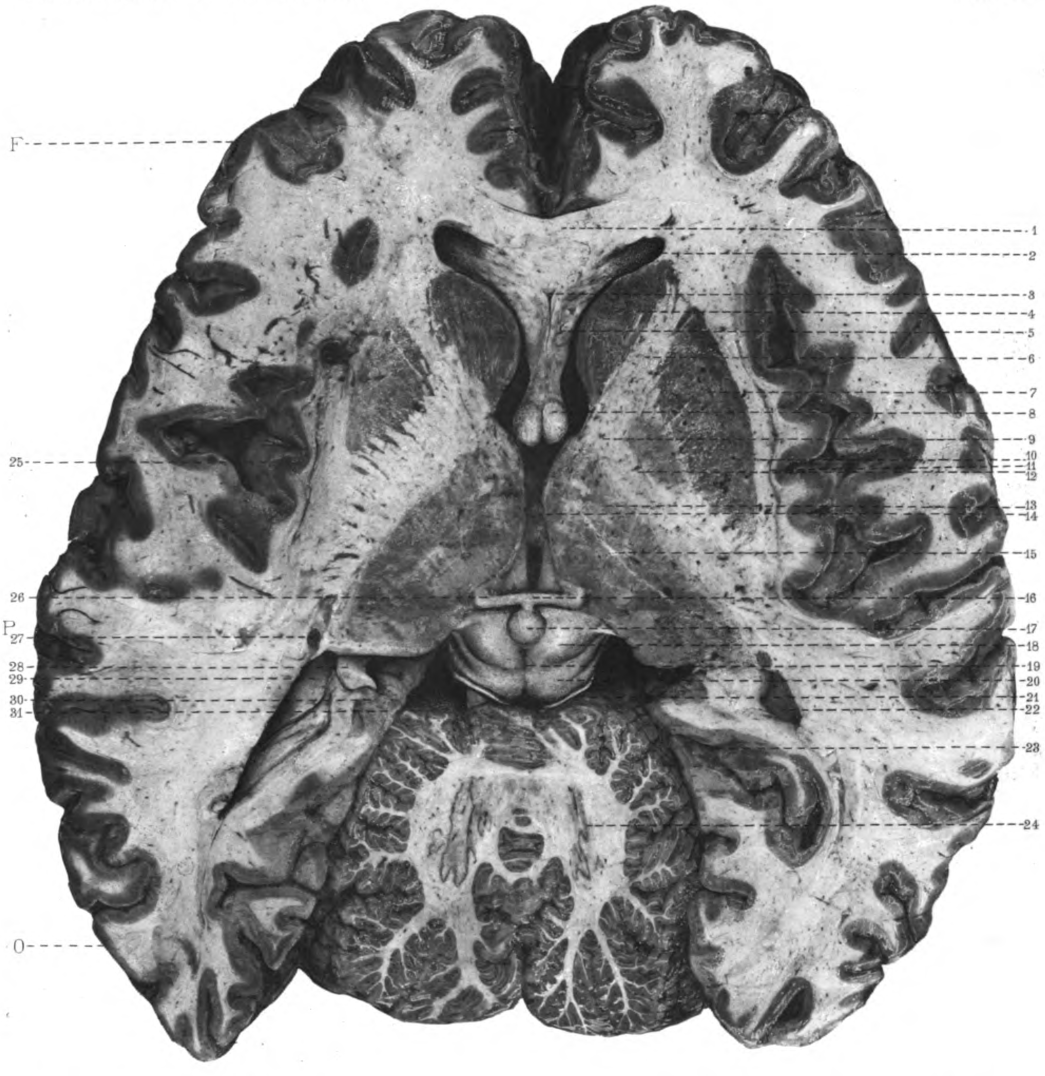
TAB. IV.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
1. Corpus callosum.
2. Cornu anterius ventriculi lateralis.
3. Ventriculus septi pellucidi s. ventriculus quintus.
4. Nucleus caudatus.
5. Septum pellucidum.
6. Capsula interna (pars anterior).
7. Nucleus lentiformis.
8. Columna fornicis.
9. Capsula interna (genu).
10. Capsula externa.
11. Claustrum.
12. Capsula interna (pars posterior).
13. Thalamus opticus (nucleus lateralis).
14. Ventriculus tertius.
15. Lamina medullaris thalami optici.
16. Pedunculus conarii.
17. Glandula pinealis s. conarium.
18. Corpus quadrigeminum anterius.
19. Sulcus corp. quadrigem. longitidunalis.
20. Corpus quadrigeminum posterius.
21. N. trochlearis.
22. Cornu inferius ventriculi lateralis.
23. Fissura parieto-occipitalis.
24. Nucleus dentatus.
25. Insula Reilii.
26. Ganglion habenulae.
27. Nucleus caudatus.
28. Fimbria.
29. Cornu inferius ventriculi lateralis.
30. Fascia dentata Tarini.
31. Gyrus hippocampi s. gyrus occipito-temporalis medialis.



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TAB. V.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
T. Lobus temporalis.
1. Gyrus frontalis superior s. primus.
2. Gyrus frontalis medius s. secundus.
3. Gyrus frontalis inferior s. tertius.
4. Sulcus frontalis inferior.
5. Sulcus frontalis superior.
6. Sulcus praecentralis.
7. Gyrus centralis anterior.
8. Sulcus centralis s. sulcus Rolandi.
9. Gyrus centralis posterior.
10. Sulcus postcentralis.
11. Sulcus interparietalis.
12. Gyrus parietalis inferior (Gyrus supramarginalis).
13. Gyrus parietalis inferior (Gyrus angularis).
14. Gyrus temporalis superior s. primus.
15. Sulcus temporalis superior s. primus.
16. Gyrus temporalis medius s. secundus.
17. Sulcus temporalis medius s. secundus.
18. Gyrus temporalis inferior s. tertius.
19. Ramus anterior ascendens Fissurae Sylvii.
20. Gyrus frontalis inferior (pars opercularis).
21. Gyrus frontalis inferior (pars triangularis).
22. Ramus anterior horizontalis Fissurae Sylvii.
23. Gyrus frontalis inferior (pars orbicularis).
24. Sulcus cruciatus.
25. Bulbus olfactorius.
26. Tractus olfactorius.
27. Gyrus rectus s. orbitalis medialis.
28. Insula Reilii.
29. Fissura Sylvii.
30. Pons Varolii.
31. N. abducens.
32. N. trigeminus.
33. Medulla oblongata (Pyramis).
34. N. facialis.
35. N. acusticus.
36. Decussatio pyramidum.
37. N. hypoglossus.
38. Medulla oblongata (Oliva).
39. N. cervicalis primus.
40. N. accessorius Willisii.
41. N. vagus.
42. N. glossopharyngeus.
43. Pedunculus cerebelli ad pontem.
44. Cerebellum.
45. Sulcus horizontalis magnus cerebelli.

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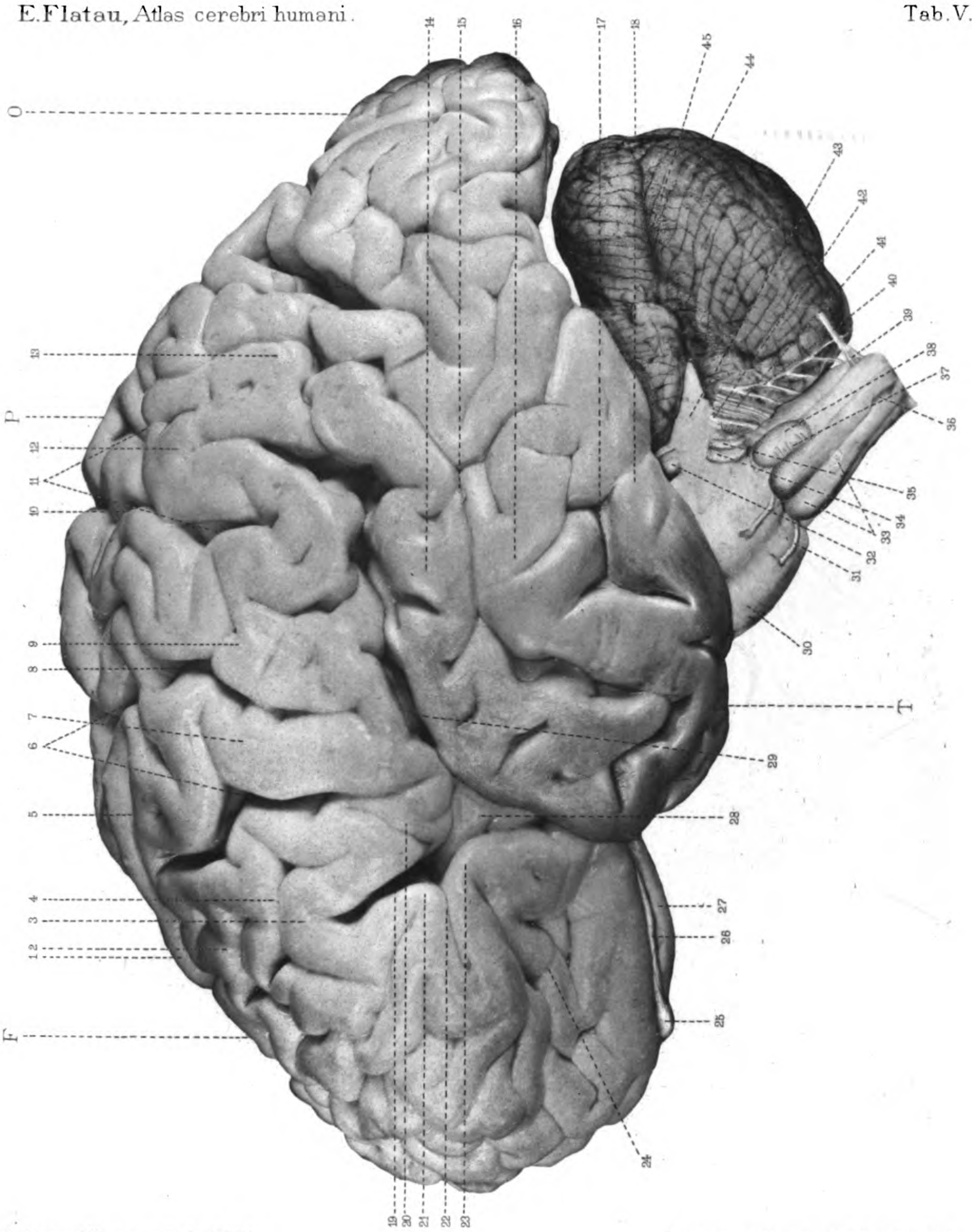

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TAB. VI.

Fig. A.

F. Lobus frontalis.
T. Lobus temporalis.
1. Fissura Sylvii.
2. Insula Reilii.
3. Fornix (columna fornicis).
4. Chiasma nervorum opticorum.
5. Commissura cerebri anterior.
6. Nucleus amygdalae.
7. Ventriculus tertius.
8. Nucleus lentiformis.
9. Claustrum.
10. Thalamus opticus.
11. Capsula interna.
12. Ventriculus lateralis.
13. Septum pellucidum.
14. Ventriculus septi pellucidi s. ventriculus quintus.
15. Nucleus caudatus.
16. Corpus callosum.
17. Centrum semiovale Vieussenii.

Fig. B.

F. Lobus frontalis.
T. Lobus temporalis.
1. Fissura Sylvii.
2. Pons Varolii.
3. Substantia nigra Soemmeringi.
4. Nucleus tegmenti s. ruber.
5. Pedunculus cerebri.
6. Corpus subthalamicum s. corpus Luysii.
7. Pedunculus cerebri — Initio capsulae internae.
8. Cornu inferius ventriculi lateralis.
9. Nucleus caudatus.
10. Commissura cerebri posterior
11. Nucleus lentiformis.
12. Capsula interna.
13. Thalamus opticus.
14. Insula Reilii.
15. Fornix.
16. Nucleus caudatus.
17. Ventriculus lateralis.
18. Corpus callosum.
19. Centrum semiovale Vieussenii.

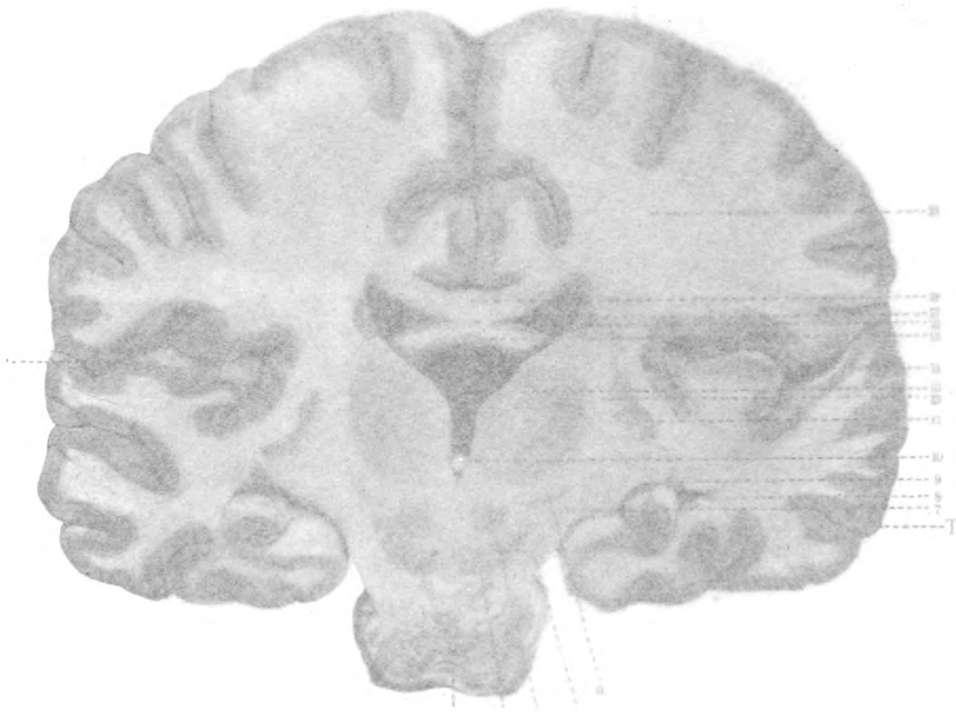
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FIG. A.

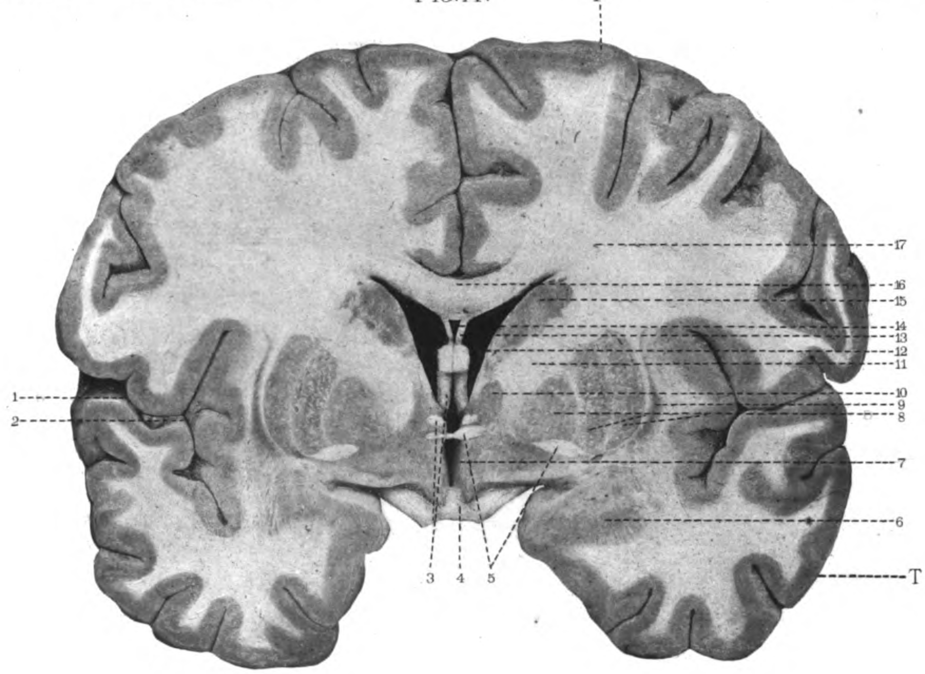
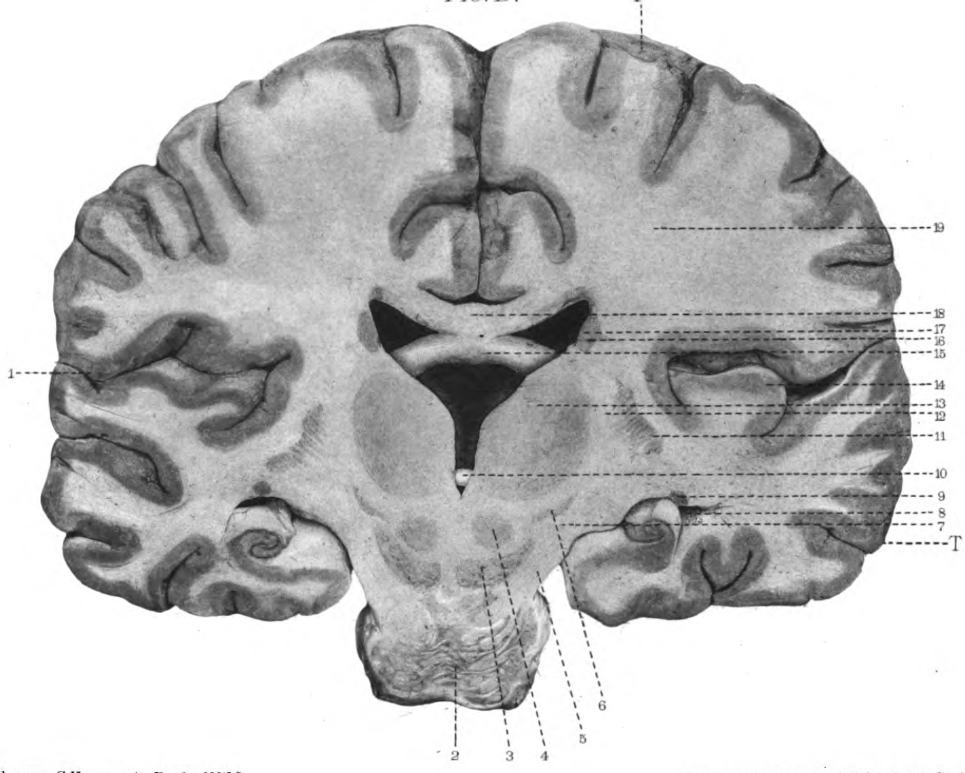


FIG. B.



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TAB. VII.

Fig. A.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
T. Lobus temporalis.
1. Fissura parieto-occipitalis.
2. Cuneus s. lobulus triangularis.
3. Fissura calcarina.
4. Splenium corporis callosi.
5. Thalamus opticus.
6. Crus fornicis.
7. Pulvinar thalami optici.
8. Fascia dentata Tarini.
9. Gyrus hippocampi.
10. Lobulus monticuli.
11. Lobulus centralis.
12. Laminae transversae
13. Pyramis.
14. Lingula.
15. } Uvula.
16. }
17. Nodulus.
18. Medulla oblongata.
19. Fossa rhomboidalis s. ventriculus quartus.
20. Velum medullare anterius.
21. Corpus quadrigeminum posterius.
22. Pons Varolii.
23. Aquaeductus Sylvii.
24. Corpus quadrigeminum anterius.
25. Aditus ad aquaeductum Sylvii.
26. Gyrus occipito-temporalis lateralis s. gyrus fusiformis.
27. Pes pedunculi cerebri.
28. Sulcus occipito-temporalis inferior.
29. N. oculomotorius.
30. Thalamus opticus (superficies medialis).
31. Corpus mamillare.
32. Commissura mollis s. grisea.
33. Uncus.
34. Recessus infundibuli.
35. Columna fornicis.
36. Commissura cerebri anterior.
37. Chiasma.
38. Septum pellucidum.
39. Nucleus caudatus.
40. Rostrum corporis callosi.
41. Fissura Sylvii.
42. Genu corporis callosi.
43. Gyrus fornicatus.
44. Sulcus corporis callosi.
45. Sulcus calloso-marginalis s. sulcus fornicatus.
46. Gyrus cinguli.
47. Sulcus paracentralis.
48. Lobulus paracentralis.
49. Isthmus gyri fornicati.
50. Praecuneus s. lobulus quadratus.

Fig. B.

1. Foramen Monroi.
2. Thalamus opticus (tuberculum anterius).
3. Sulcus choroideus.
4. Pedunculus conarii.
5. Pulvinar.
6. Corpus geniculatum mediale.
7. Lemniscus.
8. Sulcus lateralis mesencephali.
9. Brachium conjunctivum s. pedunculus cerebelli ad corp. quadr.
10. Trigonum n. hypoglossi.
11. Trigonum n. acustici.
12. Calamus scriptorius.
13. Funiculus gracilis.
14. Funiculus cuneatus.
15. Fornix.
16. Corpus callosum.
17. Ventriculus lateralis.
18. Ventriculus septi pellucidi s. ventriculus quintus.
19. Septum pellucidum.
20. Nucleus caudatus.
21. Columna fornicis.
22. Commissura cerebri anterior.
23. Ventriculus tertius.
24. Taenia ventriculi tertii s. taenia thalami.
25. Stria terminalis s. taenia cornea.
26. Thalamus opticus.
27. Ganglion habenulae.
28. Corpus quadrigeminum anterius.
29. Glandula pinealis s. conarium.
30. Brachium conjunctivum corp. quadrigem. post.
31. Sulcus corp. quadrigem. longitidunalis.
32. Corpus quadrigeminum posterius.
33. Locus coeruleus.
34. Velum medullare anterius.
35. Eminentia teres.
36. Stria s. chorda acustica.
37. Corpus restiforme s. pedunculus cerebelli ad med. obl.
38. Ala cinerea.
39. Tuberculum cuneatum.
40. Clava.
41. Fissura longitidunalis posterior.
42. Sulcus paramedianus dorsalis.
43. Sulcus lateralis dorsalis.

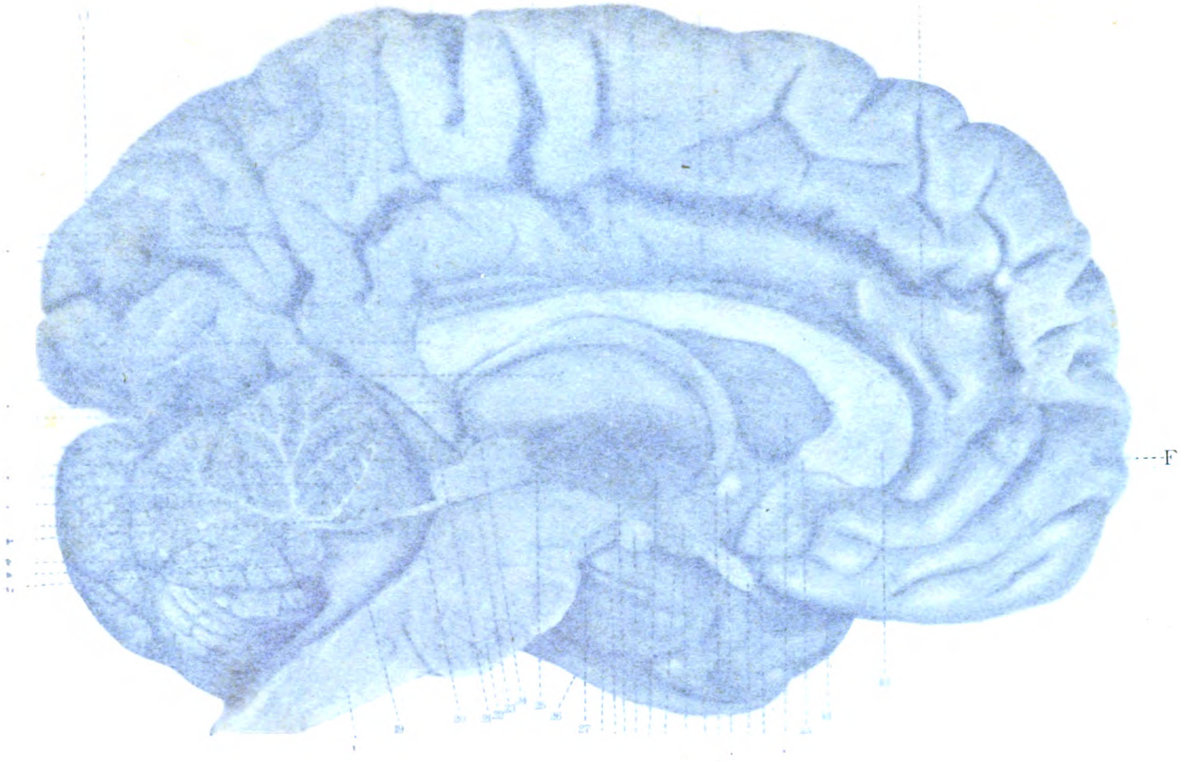

Fig. B.

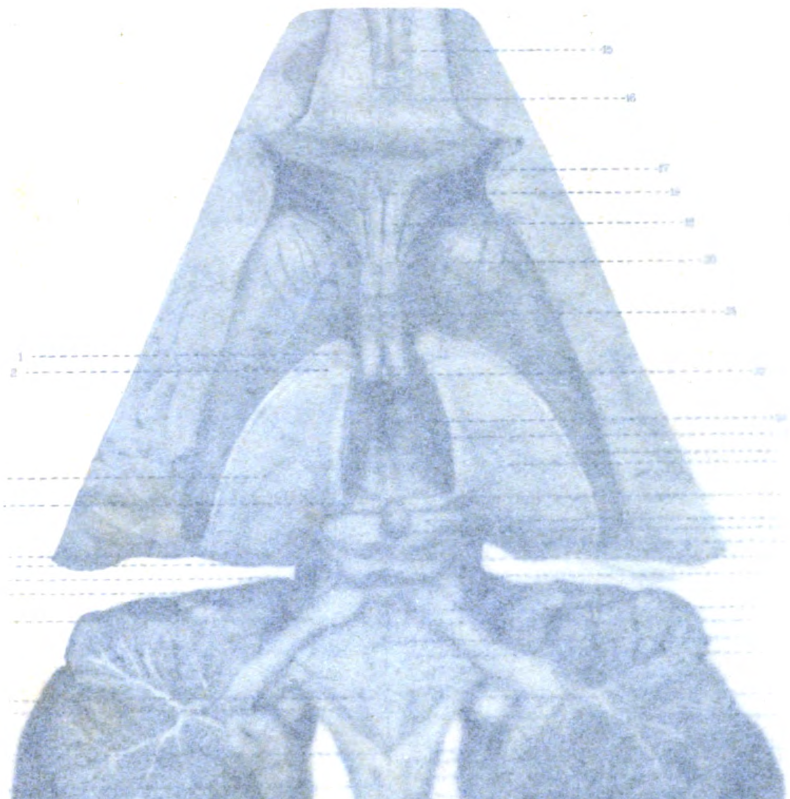

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FIG. A.

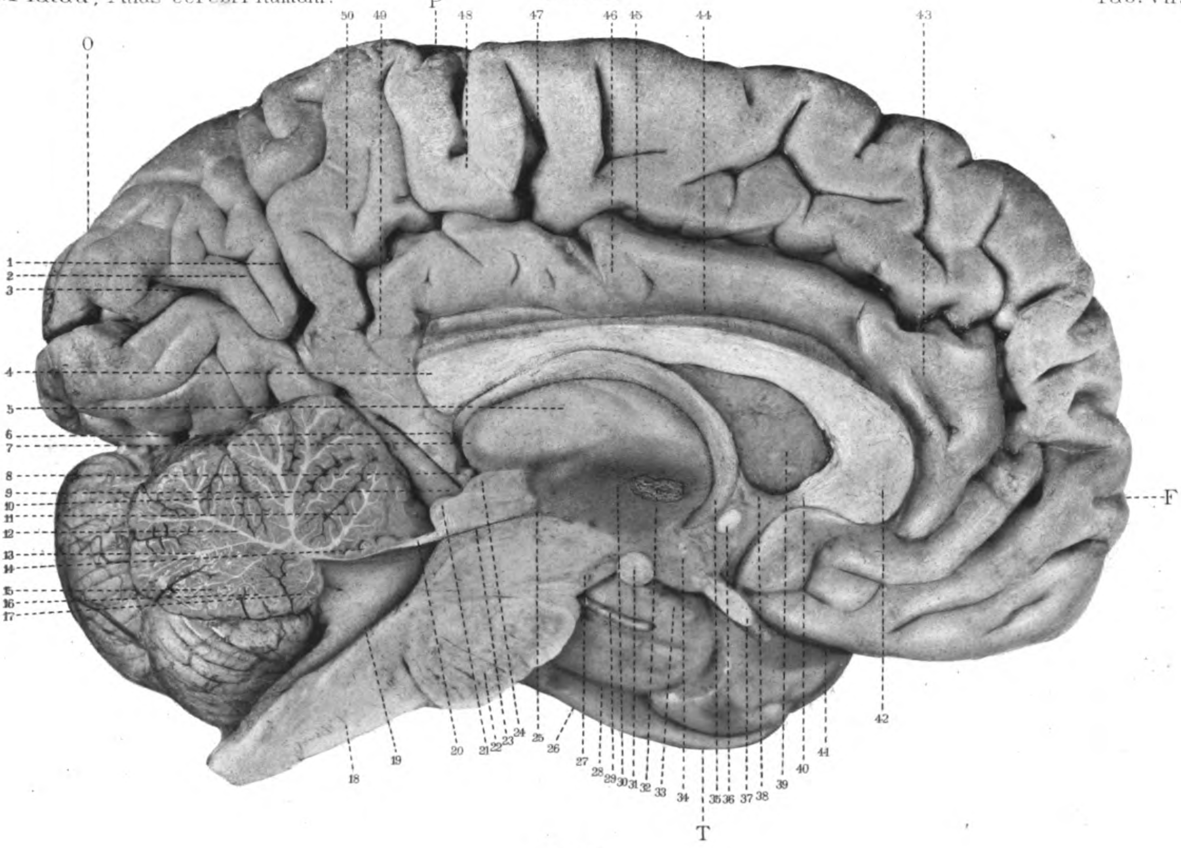
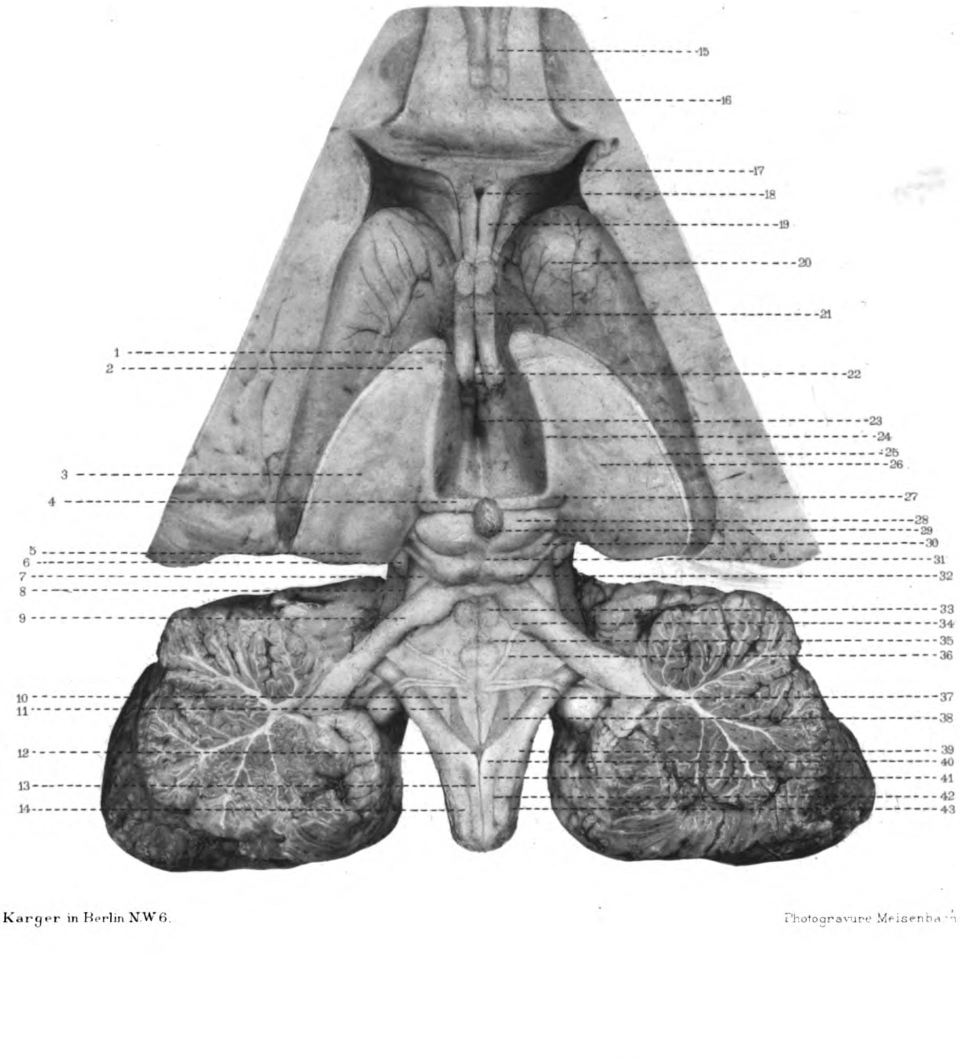


FIG. B.



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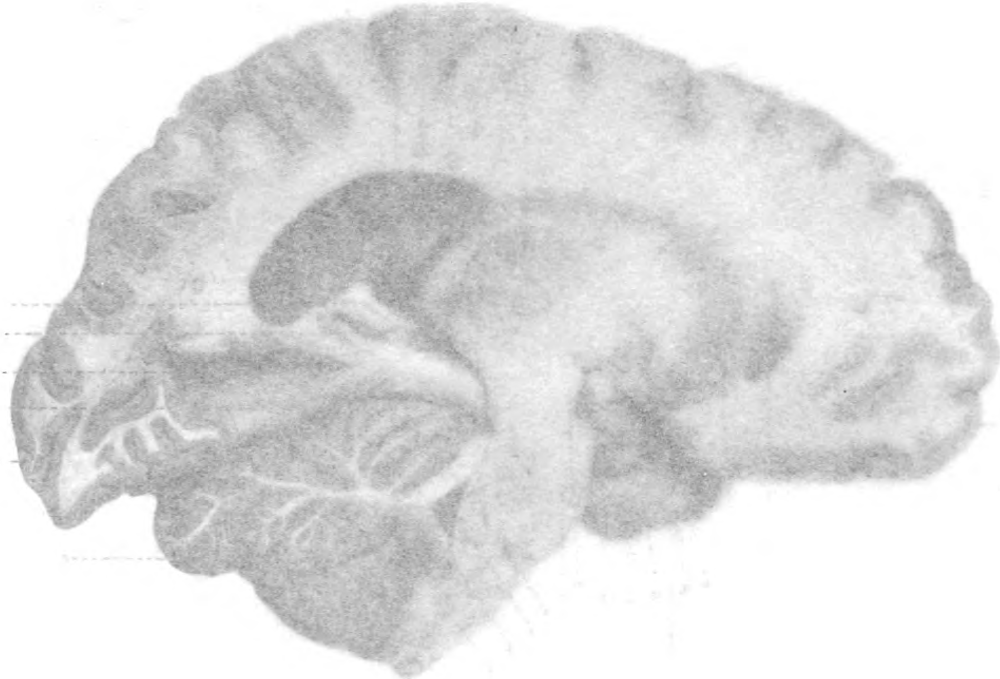
TAB. VIII.

Fig. A.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
T. Lobus temporalis.
1. Fimbria.
2. Fascia dentata Tarini.
3. Fissura parieto-occipitalis.
4. Gyrus hippocampi.
5. Cerebellum.
6. Medulla oblongata.
7. Corpus restiforme.
8. Fossa rhomboidalis s. ventriculus quartus.
9. Brachium conjunctivum.
10. Pons Varolii.
11. Pes pedunculi.
12. N. oculomotorius.
13. Tractus opticus.
14. Gyrus uncinatus s. uncus.
15. Nucleus lentiformis.
16. Fissura Sylvii.
17. Nucleus caudatus.
18. Cornu anterius ventriculi lateralis.
19. Thalamus opticus.
20. Nucleus caudatus.
21. Pulvinar.
22. Cornu inferius ventriculi lateralis.

Fig. B.

F. Lobus frontalis.
P. Lobus parietalis.
O. Lobus occipitalis.
T. Lobus temporalis.
1. Fissura parieto-occipitalis.
2. Fimbria.
3. Fascia dentata Tarini.
4. Cerebellum.
5. Nucleus dentatus.
6. Medulla oblongata.
7. Fossa rhomboidalis s. ventriculus quartus.
8. Pons Varolii.
9. Pes pedunculi.
10. N. oculomotorius.
11. Gyrus occipito-temporalis lateralis.
12. Tractus opticus.
13. Uncus.
14. Fissura Sylvii.
15. Nucleus lentiformis.
16. Corona radiata Reilii.
17. Thalamus opticus.
18. Nucleus caudatus.
19. Cornu inferius ventriculi lateralis.
20. Cornu posterius ventriculi lateralis.



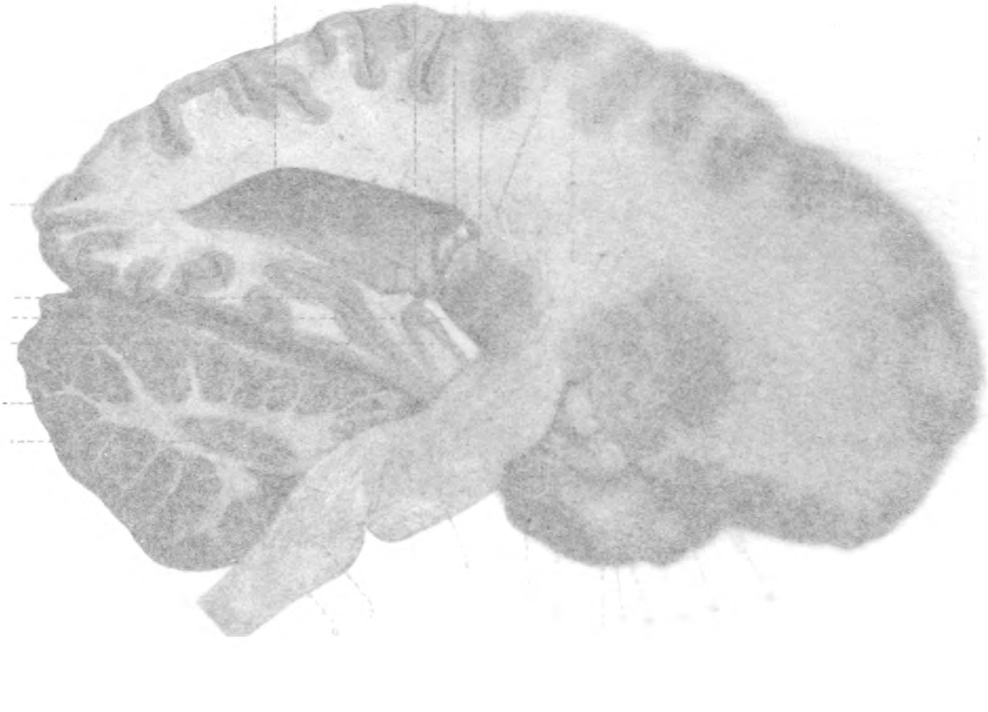


FIG. A.

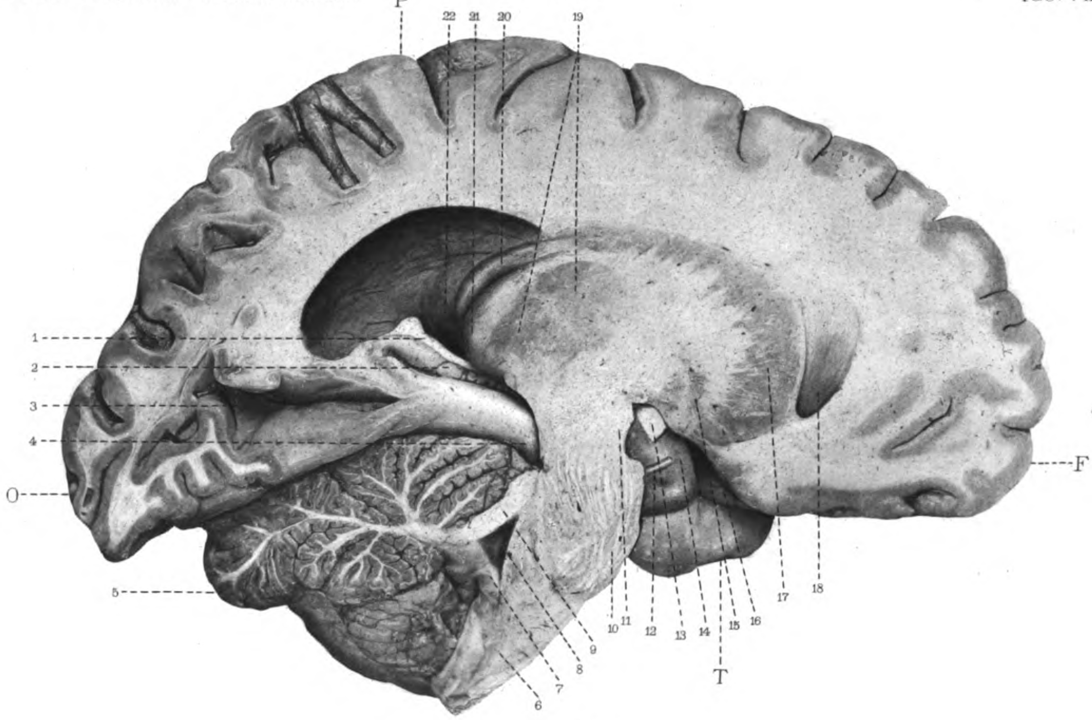
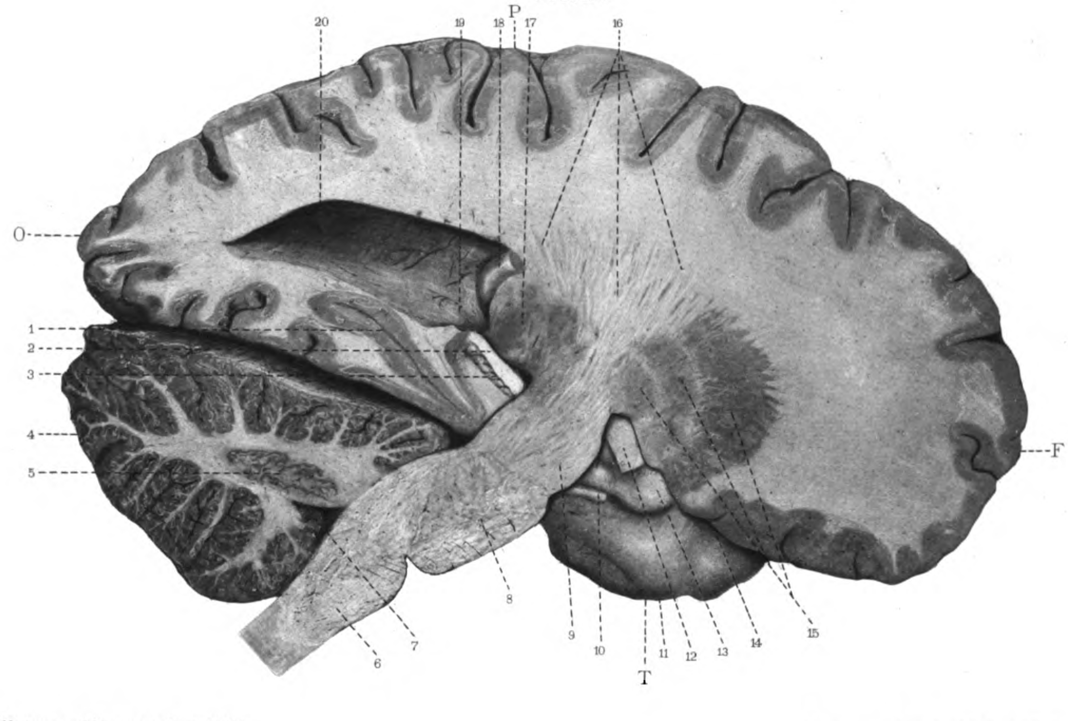


FIG. B.



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