A manual of autopsies : designed for the use of hospitals for the insane and other public institutions / by I.W. Blackburn.

MANUAL OF AUTOPSIES

BLACKBURN


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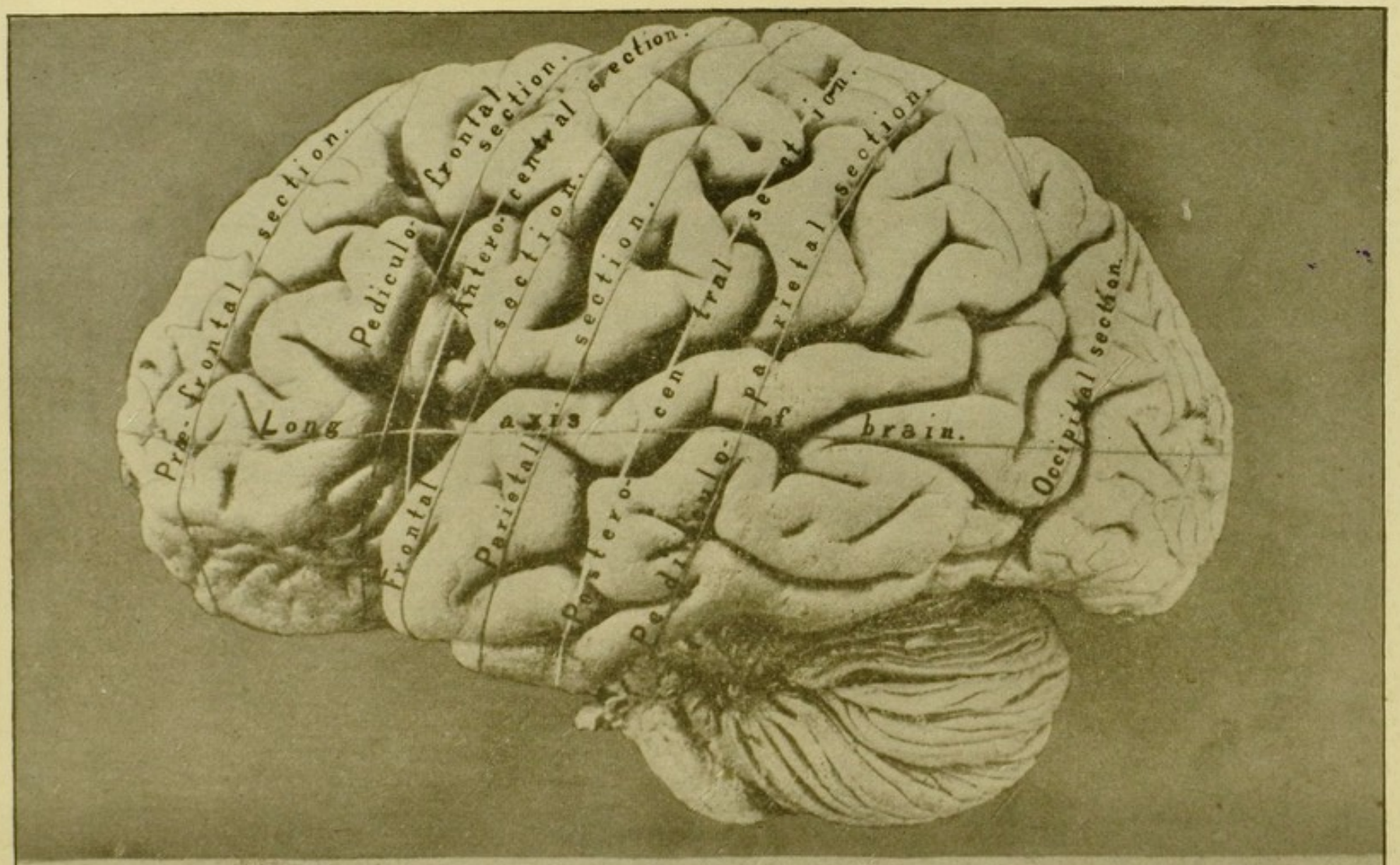

SECTIONS OF THE BRAIN.

A MANUAL

OF

AUTOPSIES

DESIGNED FOR THE USE OF

HOSPITALS FOR THE INSANE AND OTHER PUBLIC INSTITUTIONS.

BY

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ILLUSTRATED.

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PREFACE.

The subject of the adoption in American asylums of some uniform system of reporting autopsies has for several years engaged the attention of the Association of Medical Superintendents of American Institutions for the Insane. It is believed that about three thousand deaths occur annually in the various institutions represented by the Association. Many of these cases are available for the study of pathological conditions in brain and body resulting in insanity; and there is little opportunity for the observation of physical changes produced by mental disease outside of hospitals for the care of the insane. The material afforded the alienist is abundant, particularly since asylums have grown to proportions so large that insanity can be studied in all its clinical, as well as pathological, aspects in recent and chronic cases.

What is desirable, is to cultivate a power of observation and description; to develop the practice of scientific inquiry into the patient's physical and mental condition while living, and to increase our ability to demonstrate clearly whatever lesions may be visible after death. A uniform method of making such examinations has seemed to be desirable, in order that, by following the same procedure in all cases, we may have the data in a proper form for obtaining the most valuable results. The Medico-Psychological Association, of Great Britain, recognizing the importance of concerted action, has also had this subject under consideration.

Pathology, when aided by intelligent clinical study, will eventually throw great light upon the manifestations of insanity. There are many physical symptoms, and many mental conditions, that are dependent upon local cerebral changes, and the site of such lesions can be very accurately determined during the life of the patient and demonstrated after death. The various motor and special sensory centers have been particularly mapped out, but confirmation is desired in many directions, and fuller knowledge and wider application should be diligently sought. Many patients, through disordered mental states, are unable to aid us in making a diagnosis by intelligent statements of their feelings and conditions; but their acts may often become explainable through the findings of an autopsy. Disordered speech, ataxic conditions, stumbling over objects, convulsive seizures, local atrophies and paralyses, afford interesting indications for special search.

In addition to the degeneration of cerebral areas and tracts affecting the special functions, there are also forms of insanity in which the pathological conditions are well marked and constant. This is notably the case in general paralysis of the insane where the conditions are constant and quite uniform in their general characteristics; senile dementia, also, presents conditions of cerebral atrophy and compensatory changes which are quite constant.

It should not be a matter of discouragement that our knowledge of mental pathology is imperfect, as the same fact is largely true of many ordinary physical diseases. What we need is to enlarge our knowledge and to differentiate still further the functions of the brain. It is only by cultivating a habit of careful observation and comparison that accurate results can ever be obtained. For the purpose of directing thought in this channel, arousing wider

interest, and securing a uniform method of procedure, this Manual has been published with the sanction of the Association.

It is to be hoped that interest and attention can be secured in this matter, and a rule of practice followed of observing carefully what is seen. It should be our aim to avoid deductions and contentious theories. A careful description of the actual appearances of the brain and other organs of the body should be recorded. In many cases there are, undoubtedly, grave physical conditions of a chronic nature, apart from cerebral disease, that so influence the blood supply and the nutrition of the brain as to disturb its functions and produce insanity. It is important, therefore, that the whole body be examined as far as possible. Immediate results or surprising revelations are not expected, but patient endeavor and uniform methods must ultimately result in good.

We should seek to establish in each hospital the practice of making a series of accurate, unembellished records in such a form as to be available as contributions to mental pathology. An autopsy book, apart from all other case records, is kept in many asylums, and should be generally adopted. A large blank book is sufficient, or one containing as headings, at most, the name, date of death, age, clinical history, etc., of the patient. Unanimity and thoroughness in this direction will lead to more careful clinical studies and add new interest to many cases, especially to those which are regarded as chronic, but in which the most valuable and instructive data are often found.

Actuated by these motives, the Committee decided not to recommend any elaborate or burdensome table of forms, but embodied its ideas in the following report and resolutions, which were adopted at the forty-fourth annual

meeting of the Association at Niagara Falls, June 10–14, 1890.

"To the Association of Medical Superintendents of American Institutions for the Insane.

Gentlemen: Your Committee, to which was referred the consideration of the subject of autopsies in connection with asylums and hospitals for the insane, desires to make the following report:—

During the year the Committee has held two meetings for consultation, both at Baltimore. At the first meeting, in addition to two members of the Committee, there were also present Dr. W. H. Welch, Professor of Pathology of the Johns Hopkins University and Pathologist to the Johns Hopkins Hospital, and Dr. I. W. Blackburn, Pathologist to the Government Hospital for the Insane at Washington, D. C. The second meeting was held on Friday, May 16, 1890, also at Baltimore, at which Dr. Godding, Dr. Cowles, and Dr. Hurd were present (a majority of the Committee), in addition to Drs. Welch and Blackburn, as before. At this second meeting, after a full discussion of all the bearings of the question, the following conclusions were unanimously adopted:—

1. That it is not advisable to make any attempt to tabulate the results of autopsies in any uniform set of tables, as has sometimes been suggested, both in asylums and general hospitals. It is, however, advisable that every post-mortem be made according to an established routine, and for the guidance of the person making it a little manual should be prepared, which shall give the order and method of pathological procedure to be adopted by every asylum or hospital for the insane.

2. That accompanying such a manual there should be outline representations of the cortex of the brain, a scheme of the distribution of the cerebral vessels, and diagrams of sections through the various regions of the brain. This will permit of a uniform, graphic record, by pathologists and even by non-expert physicians, of the location of gross lesions like softenings, scleroses, or hemorrhages.

3. That pathologists and non-expert physicians who make autopsies should record accurately what they find, giving gross appearances and conditions, omitting inferences and opinions. In other words, they should describe to the best of their ability what they actually see, and leave the task of interpreting appearances and drawing inferences as to morbid processes to persons who have had special training in pathology and pathological work.

The above conclusions were in thorough accord with the views of Dr. Welch and Dr. Blackburn, and were confirmed by a verbal expression from Dr. Gannett, of Boston, transmitted through Dr. Cowles.

Your Committee consequently recommends that Dr. Blackburn, of the Government Hospital, prepare, with the co-operation of Dr. Welch and other pathologists, who have shown an interest in the matter, such a Manual of Autopsies, with diagrams, outlines, and schematic representations, for submission to the next annual meeting of the Association. To carry into effect these recommendations the Committee begs leave to offer the following resolutions :—

Resolved, That Dr. Blackburn, the Pathologist to the Government Hospital for the Insane, be requested to prepare for publication, as early as practicable, a manual of post-mortem examinations, for submission to the members

of the Association, with a view to its adoption at the next annual meeting.

RESOLVED, That the Secretary of the Association be authorized to procure the printing and distribution of the same at the expense of the Association."

On motion the report of the Committee was accepted, and the resolutions accompanying it were adopted.

In accordance with the foregoing action of the Association, this Manual, prepared by Dr. I. W. Blackburn, the Pathologist to the Government Hospital for the Insane, is herewith presented.

The Committee desires to record its appreciation of the work accomplished by Dr. Blackburn, and to express acknowledgments to Drs. W. H. Welch, Professor of Pathology, W. T. Councilman, Associate in Pathology, of the Johns Hopkins University and Hospital, and to W. W. Gannett, Instructor in Pathology at the Harvard Medical School, and Henry J. Berkley, Visiting Physician, Bay View Asylum, for assistance rendered.

(SIGNED), W. W. GODDING,
HENRY M. HURD,
DANIEL CLARK,
EDWARD COWLES,
H. E. ALLISON,
Committee.

CONTENTS.

LIST OF ILLUSTRATIONS.

METHOD

OF

MAKING AND RECORDING

AUTOPSIES.

INTRODUCTORY.

The object of a post-mortem examination varies in different cases; it may be merely to determine the cause of death when the symptoms have been obscure or unknown; to account for sudden or violent death; or to study the lesions of disease. In any case the examination should be as complete as the circumstances will admit, and the operation should be performed in a methodical and careful manner, and recorded by an assistant at the time.

The **record** should be written, as nearly as possible, in the order of the examination; and for this reason the operator should have a definite plan, and finish each step in the operation before proceeding to the next.

The record of the examination may be headed by such preliminary data as will render the account more complete within itself, and it may be followed by a **synopsis** giving the conclusions arrived at by the operator; but in no case should the opinion of the examiner be substituted for a carefully worded description of the appearances found.

The **synopsis** may take up the organs in the order of their physiological or pathological importance, and normal

appearances may be omitted; but in the record a definite plan should be adhered to and every part should be mentioned.

In a limited number of cases it will be found impossible to follow the regular method in either the operation or the record; in such it will be proper to depart from the rule and give the organ, or condition, of greatest importance the precedence.

In this Manual, intended, as it is, for a laboratory guide, no pretense is made to medico-legal accuracy; and when such points are mentioned they are intended as hints rather than directions. For the same reason, little is said about the examination of the bodies of the new-born, suicides and those dead from violence. For information upon such questions the reader is referred to works given in the list at the end of the Manual.

Below will be given the principal headings of the record and the steps of the operation, as a synopsis of what will afterward be taken up in detail.

It has not been thought necessary to explain the reasons for the order adopted in the examination, as the fact that it is based upon the well-known method of Virchow should be sufficient to recommend it. For slight changes from the usual methods of dissection the indulgence of the reader is asked; they have been suggested by the writer's experience.

THE RECORD.

The record should contain the following divisions:—

1. Preliminary data.
2. A brief history of the case, with reference to the clinical records of the hospital.
3. External examination of the body.

4. Internal examination.
5. The synopsis, or diagnosis; giving the opinion of the examiner.
6. The cause of death.

THE OPERATION.

The operation should have the following order :—

1. External examination, including the determination of the signs of death, and the manner thereof if ascertainable by external indications.
2. Opening the body cavities, and a preliminary inspection before dissection, beginning in most cases with the cranium.
3. Dissection and removal of the organs, beginning, as a rule, with the cranial cavity.
4. Return of the organs after examination, and closing the cavities.

ORDER OF DISSECTION AND EXAMINATION OF THE ORGANS.

I. **Cranium.** 1, Scalp. 2, Skull. 3, Dura mater. 4, Arachnoid. 5, Pia mater. 6, Brain. 7, Organs of the face. 8, Upper cervical portion of the spinal cord removed with the brain. (Unless of special importance, the remainder of the cord may be removed after the thoracic and abdominal organs have been examined and the cavities closed.)

II. **Thorax and Neck.** 1, Pericardium and heart. 2, Lungs. 3, Mediastinum and thoracic

walls. 4, Organs of the neck and floor of the mouth. (In some cases the larynx and trachea should be opened before removing the lungs.)

III. **Abdomen.** 1, Omentum. 2, Spleen. 3, Left kidney, supra-renal capsule, and ureter. 4, Right kidney, supra-renal capsule, and ureter. (The intestines may be removed and the whole urinary tract examined *in situ* before removal.) 5, Bladder, prostate gland, vesiculæ seminales, urethra. 6, (*a*) Testicles, spermatic cord, penis; (*b*) Vagina, uterus, Fallopian tubes, ovaries, parametria. 7, Rectum. 8, Duodenum, portio intestinalis of the common bile duct. 9, Stomach. 10, Hepatico-duodenal ligament, gall ducts, portal vein, gall bladder, liver. 11, Pancreas, semilunar ganglia. 12, Mesentery. 13, Small and large intestines. 14, Retro-peritoneal lymphatic glands, receptaculum chyli and thoracic duct, aorta, vena cava inferior.

IV. **Spinal Canal.** 1, Dura mater. 2, Pia mater and arachnoid. 3, Spinal cord. 4, Vertebral column.

INSTRUMENTS.

Two strong section knives, with thick, strong handles; length of blade, 3¾ to 4 inches; width, ⅝ to ¾ of an inch; handle, 4 inches.

Four scalpels, assorted sizes.

One strong, straight bistoury, with long blade.

Two curved bistouries (one probe-pointed, one sharp-pointed).

One brain knife, with blade about 12 inches in length, may be made with detachable handle, to admit of placing in a case.

Two broad dissecting forceps.

One strong vulsellum forceps.

Three scissors (one of large size with one blade sharp-pointed and the other rounded at the end; one medium sized, with both blades pointed; one very small, for opening arteries, etc., one blade probe-pointed, the other sharp-pointed).

One enterotome.

One costotome, or rib-shears.

One strong bone forceps, straight.

One blowpipe, with stop-cock.

Two probes.

One saw, with movable back.

One pair chain hooks.

Two large half-curved needles, and thread.

One grooved director.

One steel hammer, with fenestra in the handle to admit the end of the chisel (of use in wrenching off the calvaria); it should have a wedge end, and a blunt hook on the handle.

One chisel, with guard at about ⅓ of an inch from the edge; handle fitted to the opening in the hammer handle.

One No. 8 catheter.

One steel band measure graduated in both systems.

One hand drill.

One double saw for dividing the laminæ of the vertebræ.

One large angular bone forceps with short blades and handles, 12 to 14 inches long, for opening the spinal canal.

The above may be placed in a case (without lining), and compartments may be made for small bottles of glacial acetic acid, collodion, carbolized oil, and solution of iodine. Some wire, or double-pointed carpet tacks, will be needed to fasten on the calvaria.

In the laboratory many additional instruments will be of use; as, graduated glasses for measuring liquids, both metric and common systems; scales with weights of both systems; injecting syringes, large and small; graduated cones for measuring orifices; a pair of calipers; a mallet of heavy wood for driving the chisel (much safer than the steel hammer). Many other instruments may be used, depending upon the purpose of the pathologist, to whom they will suggest themselves.

It need scarcely be mentioned that a good compound microscope and accessories are essential to complete the work begun on the autopsy table; and almost equally important is a good microtome for preparing the sections. The microtome should be on the sliding principle, having the widest range of usefulness, and should have an ether freezing apparatus for cutting tissues in the fresh condition.

The laboratory should be well supplied with glass jars for hardening and preserving specimens. The clamped museum jars made by Whitall, Tatum & Co., Philadelphia, are perhaps the best. The sizes which will be found most useful are: 9 by 8, 6 by 8, 4½ by 6, 3 by 4, and 3 by 20 inches; the last is used for hardening the spinal cord.

PRELIMINARY DATA.

Write the number of the autopsy, the date, the temperature and condition of the weather if likely to modify the preservation of the body. Note the mode of death, if by it the appearances of the organs may be affected. The time of death should always be given, and the interval in hours until the operation was commenced; in some cases the time spent in the examination.

The name, age, sex, color, nationality, social condition, and occupation should be given when known. It may be useful to give the place of residence at the time of admission to the hospital, date of admission, ward, bed, and name of attending physician.

HISTORY OF CASE.

A brief history of the case may be prefixed to the record to guide the pathologist in his study, and to render the account more complete in itself. This should give the clinical diagnosis at the time of admission, and the subsequent developments and changes in the disease; any known or supposed cause; history of hereditary or family disease; of specific disease; injuries, etc. For complete history a reference should be given to the clinical records of the hospital.

EXTERNAL EXAMINATION.

The external appearances of the body should never be neglected. Even apparently unimportant details may prove of great value when taken in connection with the internal signs of disease. In medico-legal investigations the external examination assumes a greater relative importance; it

should include every detail necessary for identification of the body; but in ordinary cases all points which may have direct or indirect relation to the disease or cause of death are always to be observed and noted.

The external examination should be systematic and careful; beginning with the cranium and extending to the feet; it should be completed before the second part of the operation is commenced.

Note the signs of death, and evidences of putrefaction, if present; determine the presence and degree of cadaveric rigidity; ante-mortem or post-mortem discolorations; observe if they disappear on pressure, and, if necessary, incise to determine their nature. Carefully distinguish between cadaveric lividity and ecchymosis; and do not mistake the external or internal staining due to decomposition of the coloring matter of the blood, for either congestion or putrefaction. The ecchymosis may be distinguished by the presence of fluid or coagulated blood *outside of the vessels*, within the interstices of the tissues; in post-mortem discolorations the blood is still *within* the vessels, though the tissue may be somewhat stained by diffusion of the coloring matter of the blood.

Give the state of nutrition of the body; the height; the probable weight; degree of development, especially in children and the new-born. This will include the condition of the sutures, fontanelles, the genital organs, and the umbilicus and cord.

Note the circumference of the head and shoulders, and the general shape and proportion of head, body and limbs. Note any deformity, arrest of development or marked peculiarity of head, face, body or limbs. Prominent racial characteristics of head or face are to be noted, giving the type to which they belong, *e. g.* negroid, Mongolian,

prognathous, etc. Carefully notice any injuries, or external signs of disease; locate and describe them, and give points bearing upon the age of wounds or other injuries. Observe the condition of the skin generally and locally, noting signs of simple or specific lesions. The hair, beard, eyebrows and nails should receive attention in special cases.

The orifices of the body should be examined for abnormalities, injuries, foreign bodies, discharges, etc. The lips, teeth, gums, tongue, fauces and nasal passages are to be included in this examination. Note the condition of the cornea, the pupils, and conjunctiva, and, if any disease of the eyes be discovered, remember to make a special examination of the optic nerves and tracts.

After completing the examination of the anterior portions of the body inspect the posterior parts with equal care.

An external examination as complete as that suggested will rarely be required. In most cases a glance will detect abnormal conditions, and the normal may be mentioned collectively. Much, however, will depend upon the purpose of the operator and the nature of the case. We cannot become too well acquainted with the effects of disease upon the body; and often a careful external examination will aid in a marked degree the understanding of internal appearances.

INTERNAL EXAMINATION.

We may now pass to the second great division of the operation, the internal examination, which is commenced by opening the body cavities.

Of the three great cavities, cranial, thoracic and abdominal, the one to be first opened depends upon the nature of

the case and the importance of a preliminary internal inspection before dissection.

In the examination of the bodies of new-born children, the order of opening and internal inspection is, abdomen, thorax, cranium; and this sequence may be followed in cases of injury or disease of the abdominal or thoracic organs making these cavities of chief importance. In cases where poisoning is suspected the abdominal cavity is the first to be opened and examined.

In the study of mental diseases, as the contents of the cranial cavity are of greatest importance, the order of internal inspection should be, cranium, abdomen, thorax; and, as this is the usual order, it may be followed in all ordinary cases.

On account of the intimate relation between the condition of the cerebral vessels and sinuses, and the degree of fullness of the heart cavities and great veins, it is recommended that in all cases the three principal cavities should be opened and their contents inspected before a single organ is removed or an appreciable quantity of blood escapes.

With an understanding of the above we may begin, for our purpose, with the cranium, and proceed to describe its dissection, before taking up the inspection of the other cavities.

CRANIUM.

The **scalp** is usually divided by an incision made over the vertex, from one mastoid process to the other. If desirable to keep the incision out of sight after the body is prepared for burial the middle portion should be curved backward, making a long flap of the anterior part of the scalp. All the structures should be divided down to the

bone, so that when the flaps are reflected the skull-cap will be left bare except where covered by the temporal muscles. These are to be neatly dissected away from their fossæ and turned downward over the scalp. The inner surface of the pericranium and the external surface of the calvaria are now exposed for examination.

The **scalp and pericranium** are to be examined for injuries, extravasations, and forms of inflammation, especially those involving the subjacent bone.

The **external surface of the skull** should receive a careful examination for all signs of disease or injury, exostoses, irregular development of the bones, supernumerary bones, premature closure of the sutures, or persistence of those normally united. Marked asymmetry should be noted, and any other peculiarities of shape, especially the various forms of the vertex. The size should be noted and at least two diameters taken: the antero-posterior and the transverse.

By applying strips of lead to the surface of the skull-bone, the various outlines may be taken, and transferred to paper for a permanent record.* The three principal outlines may be taken in special cases. The first around the greatest circumference of the skull, in a line with the middle of the forehead and the occipital protuberance; the second is the profile, from the root of the nose to the occiput; the third over the vertex from one mastoid process to the other.

The **skull-bone** may now be sawn and the cranial cavity

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* An instrument used by the writer for this purpose may be briefly described. It resembles a pair of calipers with the curved portion of the arms replaced by lead strips. These strips are closely applied to the skull, and then, by opening the instrument, they are removed without changing their shape. The arms are again brought together, and the outline, thus re-formed, traced upon paper. The instrument was suggested by a similar one used by Prof. Flint, to determine the shape of the chest.

opened. The bone may be divided in any way preferred by the operator, but the incision easiest made, and perhaps as good as any, is the circular, which extends from the middle of the forehead around to the occipital protuberance.

Another method much used is to remove a wedge-shaped section of the calvaria, starting the one incision at the upper part of the forehead, and the other at the posterior end of the sagittal suture; the two meeting at the mastoid processes. The advantage of this method is that the calvaria retains its place when the scalp is replaced, whereas if the circular incision is used the piece must be fastened on with wire, or otherwise.*

In ordinary cases the saw should not pass through the whole thickness of the bone; the external table and the diploë are sawn and the inner table broken through with the chisel and mallet. Should fracture be suspected the saw must completely divide the bone, even at the risk of injuring the membranes and the brain.

After the bone is separated the dural adhesions still hold it in place. To tear these away the wedge end of the hammer or the chisel is inserted into the saw-cleft and a strong lateral wrench given which will loosen the bone. The blunt hook is now inserted and a strong pull will generally bring the bone away.

Very often the adhesions are so firm that removal in the above manner is impossible, and such is the rule with young children and very old persons; the dura must then be cut around in the line of the saw, and the calvaria and dura are

* By the use of double-pointed carpet tacks the calvaria is very easily and quickly fastened in place. Holes are drilled on either side of the saw-cut a little wider apart than the points of the tacks, which are then driven in and hold the bone perfectly secure.

brought away together. It may be even better to remove the brain at the same time to lessen the risk of injury to the most important organ.

If the skull-cap has been removed in the usual manner we may now examine the inner surface and edges of the bone.

Note the density, thickness, color, and relative amount of cancellous tissue of the bone. Notice any signs of injury, inflammation, new growths, caries, hemorrhage between dura and bone, and unusual dural adhesions.

Note the appearance of the sutures internally, and the Pacchionian and arterial depressions, if abnormal.

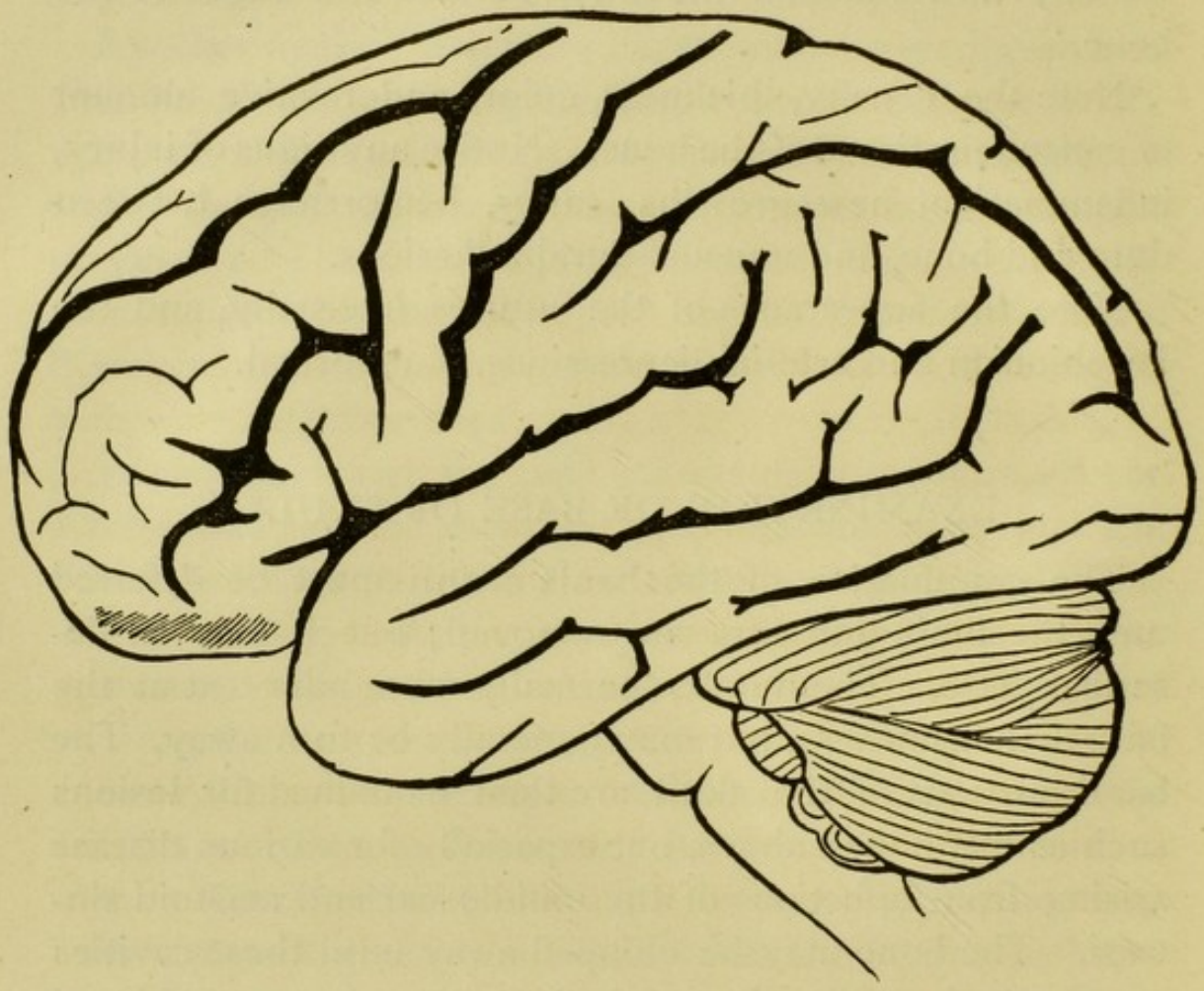
EXAMINATION OF BASE OF SKULL.

The examination of the **basis cranii** must be deferred until the brain and dura are removed; but it may be described here. The dura is normally more adherent at the base than elsewhere, but may generally be torn away. The basal portions of the skull are then examined for lesions such as mentioned above, but especially for carious disease arising from affections of the middle ear and mastoid sinuses. The bone may be chipped away until these cavities are exposed, or a section of the bone may be removed and examined at leisure.

The structures of the **orbits** may be examined from within by cutting away the orbital plates above them, and a good view of the **larynx** and **pharynx** may be obtained by removing that part of the base composed of the sphenoidal process of the occipital bone and the occipital process of the sphenoid bone.* Such

* For this purpose a trephine has been devised by Prof. Klebs.

methods may be resorted to when these parts are of unusual interest, and examination in the usual manner would too much disfigure the body.



VIEW OF THE BRAIN FROM THE SIDE.

DURA MATER.

The **outer surface** of the dura is to be examined for signs of inflammation—also hemorrhage, degree of tension, its thickness and the condition of its vessels and sinuses.

The membrane is now divided in the line of the saw, and

the two sides reflected one after the other, exposing the inner surface and the convexity of the brain.

The condition of the **subdural space** should be first noticed; it may be filled with serum, pus, or blood, or it may be unusually dry, indicative of increased intra-cranial tension.

The **inner surface** of the dura should be examined for all varieties of inflammatory deposits; pigmentation, hemorrhage, abnormal adhesion to the pia mater, and neoplasms.

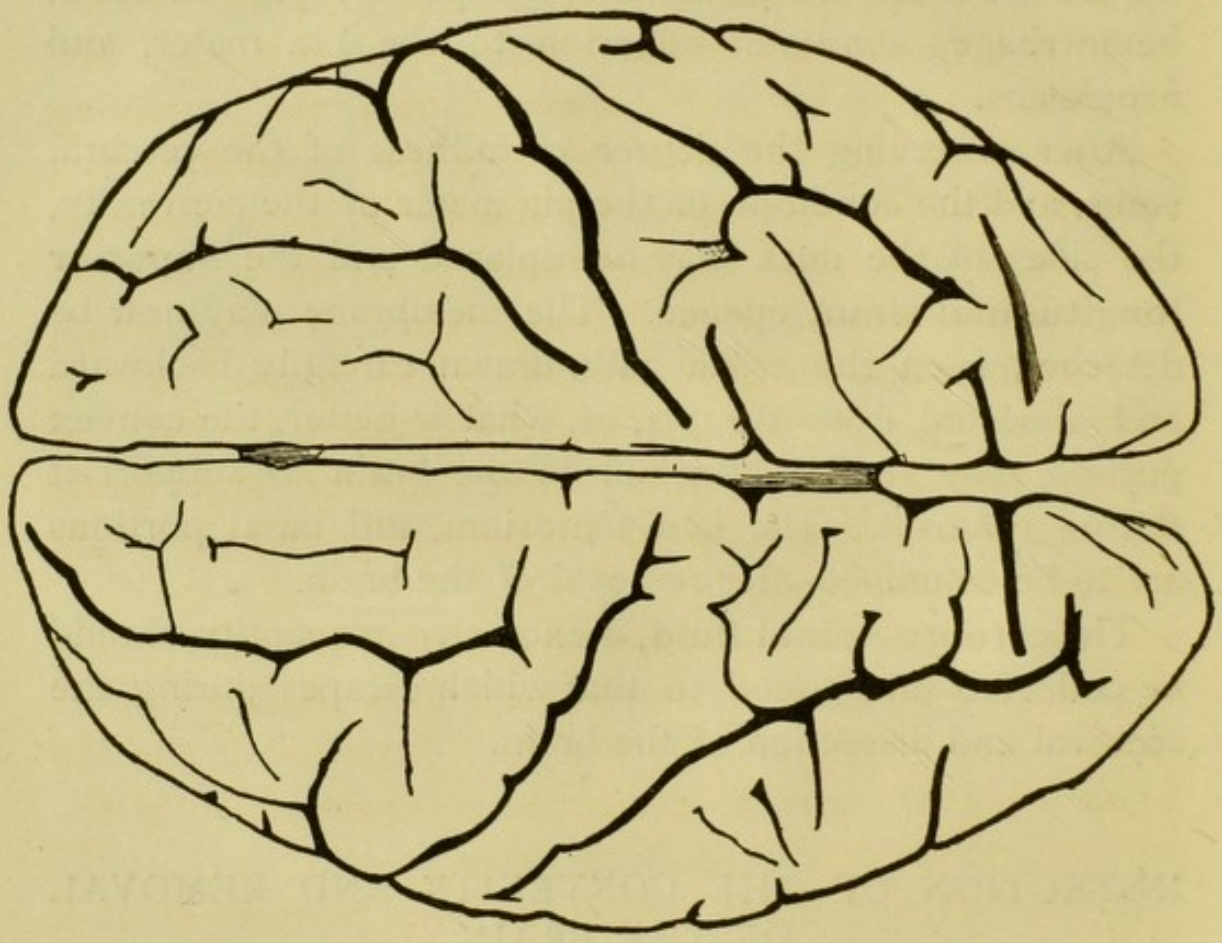
After observing the degree of fullness of the cerebral veins, and the condition of the pia mater of the convexity, the sides of the dura may be replaced and the **superior longitudinal sinus** opened. The membrane may now be detached from the crista galli, drawn carefully backward and dissected from the pia, or, what is better, the convex portion may remain attached to the brain to support it during removal. The falx, tentorium, and basal portions are to be examined after removal of the brain.

The **cerebro-spinal fluid,** if excessive in quantity, should be collected and added to that which escapes during the removal and dissection of the brain.

INSPECTION OF THE CONVEXITY AND REMOVAL OF THE BRAIN.

The special examination of the brain begins when the convexity is exposed by reflection of the sides of the dura mater. It is only at the moment of exposure that an accurate knowledge of the true condition of the pia mater and the convolutions can be obtained. Contact with the air changes the color of the blood within the vessels; unavoidable injury to the pia and arachnoid allows the fluid

beneath to escape, and convolutions that may be found at first widely separated, approach each other and appear much less shrunken. For these reasons the external appearances of the convexity should be noted at once, even before the study of the dura is completed, certainly before the brain is handled.



View of the Brain from Above.

The **brain** may now be removed. Insert the fingers of the left hand between the dura mater and the frontal lobes and draw the brain backward until the olfactory nerves can be seen lying within their fossæ; gently detach these from their positions and draw the organ farther backward

until the optic nerves are visible and slightly stretched from their foramina. The optic nerves and carotid arteries are severed, the pituitary body detached from its fossa, and as the cranial nerves appear they are cut as close to the dura as possible. When the tentorium is reached it must be divided close to the petrous portion of the temporal bone and as far backward as possible to liberate the cerebellum. By this time it will be necessary to support the brain by applying the left hand to the convexity, while the organ is allowed to drop backward until the remaining cranial nerves and the upper part of the spinal cord may be seen. The nerves are severed and a long, narrow-bladed bistoury is introduced, edge outward, as far down into the spinal canal as possible, and the vertebral arteries, spinal accessory nerves, and cord are divided by forward cuts on each side. The right hand is now applied to the base, so that the medulla oblongata is between the fore and middle fingers, the left hand supports the convexity, and the organ is lifted from the skull.

If the dura of the convexity has been allowed to remain, its posterior portions must be severed as the brain is removed; the membrane is then folded around it and the organ is placed upon its convexity for examination of the arteries and pia arachnoid of the base.

At this stage of the operation the basal portions of dura and skull are to be examined; having completed these structures we may resume the study of the brain.

EXAMINATION OF BASE OF BRAIN.

The **base of the brain** should be minutely examined for signs of disease in membranes, arteries, cranial nerves, and the basal parts of the brain itself.

The **arachnoid and pia** are to be carefully searched for inflammatory deposits of all kinds: thickening, opacity, abnormal adhesions, etc. The **arteries**, for atheroma, aneurisms, emboli, thrombi, dilatation, and tortuosity. The small arteries of the various groups supplying the basal ganglia and capsules, should be withdrawn, floated in water, and searched for miliary aneurisms, atheroma, and calcification. Anomalies of development and distribution of the main arteries are to be recorded and distinguished from the results of disease. The Sylvian and other principal fissures are to be opened up and search made for lesions of the vessels. In cases of cortical softening, hemorrhage, and the like, endeavor to find the vessel or vessels at fault.

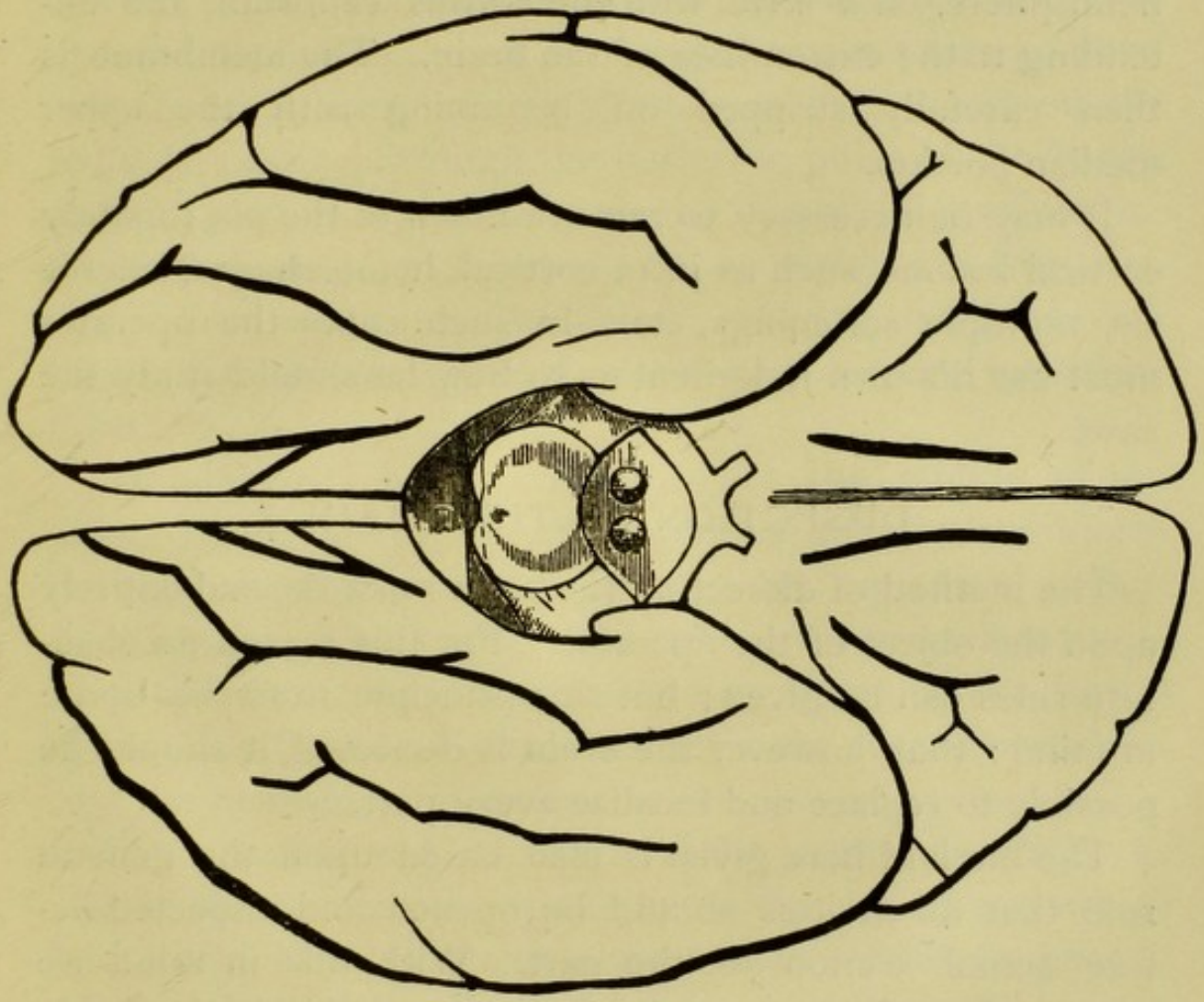
The **cranial nerves** are to be examined, and should changes be discovered, the deep origins of the nerves are to be exposed by section in the after-examination of the brain.

Lesions of the **brain substance** or of any of the parts of the base are to be noted, though their extent will have to be determined by dissection, after completing the examination of the exterior.

The organ is now turned over and the first examination of the convexity supplemented by a careful search over the surface for lesions of any kind. The dura may now be dissected from the margins of the great longitudinal fissure, and the median surfaces exposed for study.

At this time a **general study of the brain** is most convenient. It should include the determination of the general

consistence of the organ; its shape, as modified by disease; peculiarities of development, or of fissure, or of gyral formation. To study the last it may be necessary to open up many of the fissures, and even to remove the greater part of the pia mater, though, as a rule, this



View of the Brain from Below.

should not be done when a microscopical examination is to be made.

In certain cases where the pia mater is adherent to the convolutions, denoting chronic meningo-encephalitis, it is deemed important by some authorities to remove the pia

mater from the whole cerebrum, and to localize the points where the greatest adhesions occur. This may be done if desired, though it will be better to preserve small portions for microscopical study with the membranes still adherent.

When the pia is to be removed a longitudinal incision through it is to be made on the median surface of each hemisphere, on a level with the corpus callosum, and extending to the extremities of the brain. The membrane is then carefully stripped off, beginning with the upper median portion.

It may be necessary to remove much of the pia to study cortical lesions, such as intra-cortical hemorrhages, sclerosis, multiple softenings, etc. In such cases the operator must use his own judgment as to how he should study the case.

DISSECTION OF THE BRAIN.

The method of dissecting the brain must depend entirely upon the object of the operator. For this reason no absolute rules can be given; but this principle must be borne in mind: that, however the brain is dissected, it should be possible to replace and localize every part.

The method here given is also based upon the general rule that all cavities should be opened and inspected before actual section of the part. With this in mind we open and examine the ventricles before dividing the brain into sections.

The **ventricles** may be opened from below, but a better view is obtained from above. The hemispheres are separated until the corpus callosum is well exposed, and an incision is made in it at the angle formed by its junction with the median surface of the left hemisphere, the latter being held slightly up, so that the knife shall not injure the floor

of the ventricle. The incision is now extended the whole length of the corpus callosum, and the anterior and posterior horns are opened by freely incising the median surface of the hemisphere in the direction of these cavities. The right ventricle is opened by a similar procedure.

The knife is then entered into the foramen of Monro, and the central portions of the corpus callosum are divided and turned backward, exposing the velum interpositum and choroid plexuses. An incision is then made on the left side, passing through the posterior pillar of the fornix, and the piece is turned over to the right. The velum interpositum, choroid plexuses, and pia mater are then dissected away and turned backward, showing the third ventricle, optic thalami, pineal gland, and corpora quadrigemina.

An incision is now carried through the middle of the pineal gland, the corpora quadrigemina, and the vermiform process of the cerebellum, opening the aqueduct of Sylvius and fourth ventricle. The whole ventricular cavity is now open excepting the descending horns of the lateral ventricles; these are examined after the crura are divided and the hemispheres separated.

The quantity and character of the ventricular fluid, the size of the cavities, the condition of the ependyma, are to be noted. Note inflammatory deposits, adhesions, hemorrhages within the walls, and softenings of the basal ganglia, if present.

Notice thickening, or unusual adhesions of the velum; and cysts or other new formations of the choroid plexuses.

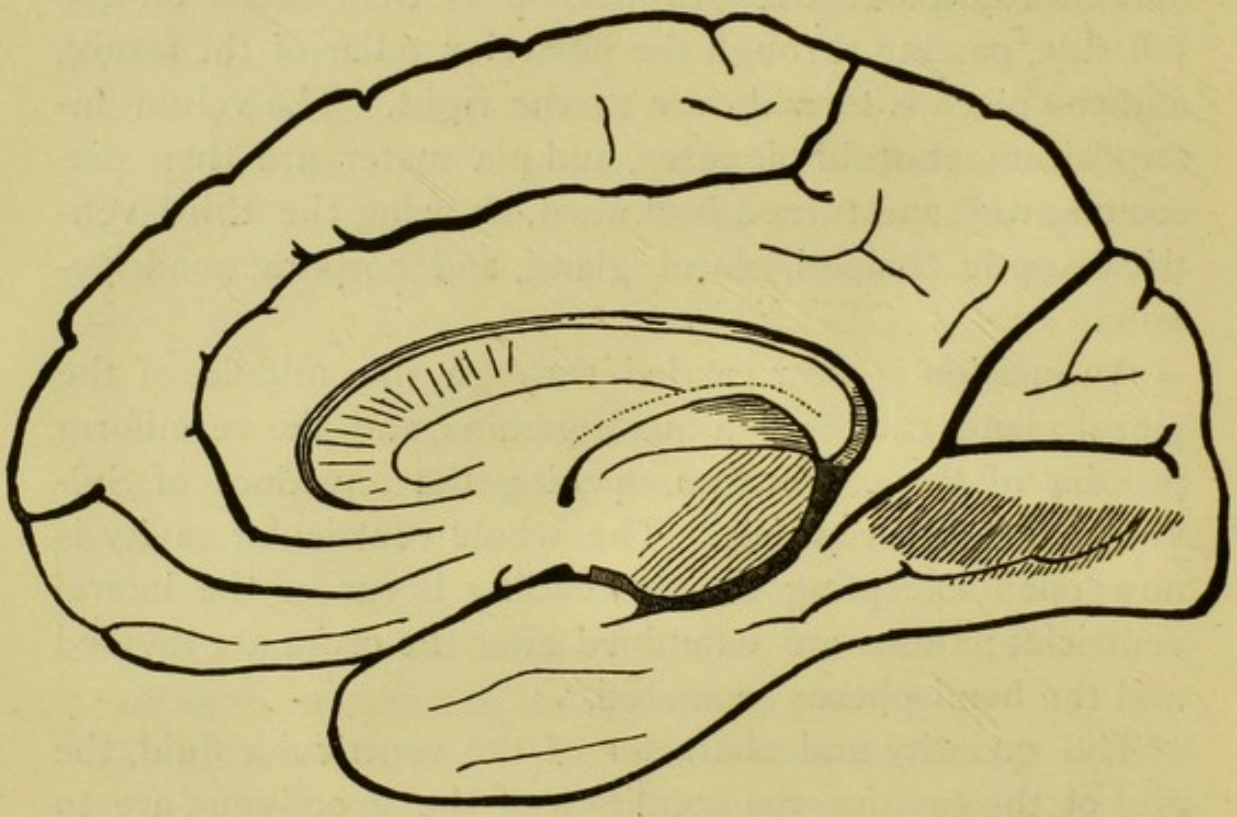
Examine the **fourth ventricle** carefully for extravasations, pigmentation, and granulations of the ependyma.

The crura are now divided in a plane extending from the upper border of the pons to the lower border of the

corpora quadrigemina, and the hemispheres are separated by cutting the remaining connections in the median line.

The ventricles having been emptied, the brain is now to be weighed, the hemispheres separately, if desired.

Some authorities recommend that the brain should be weighed immediately after removal, and again after it is dissected. The object seems to be to determine the



View of the Median Surface of the Right Hemisphere.

amount of cerebral fluid by subtracting one weight from the other.

It must be remembered that some of the fluid drains from the pia, and often some is lost from the ventricles during the removal of the brain; and for this reason the difference between the two weights will not exactly represent the quantity of fluid originally present.

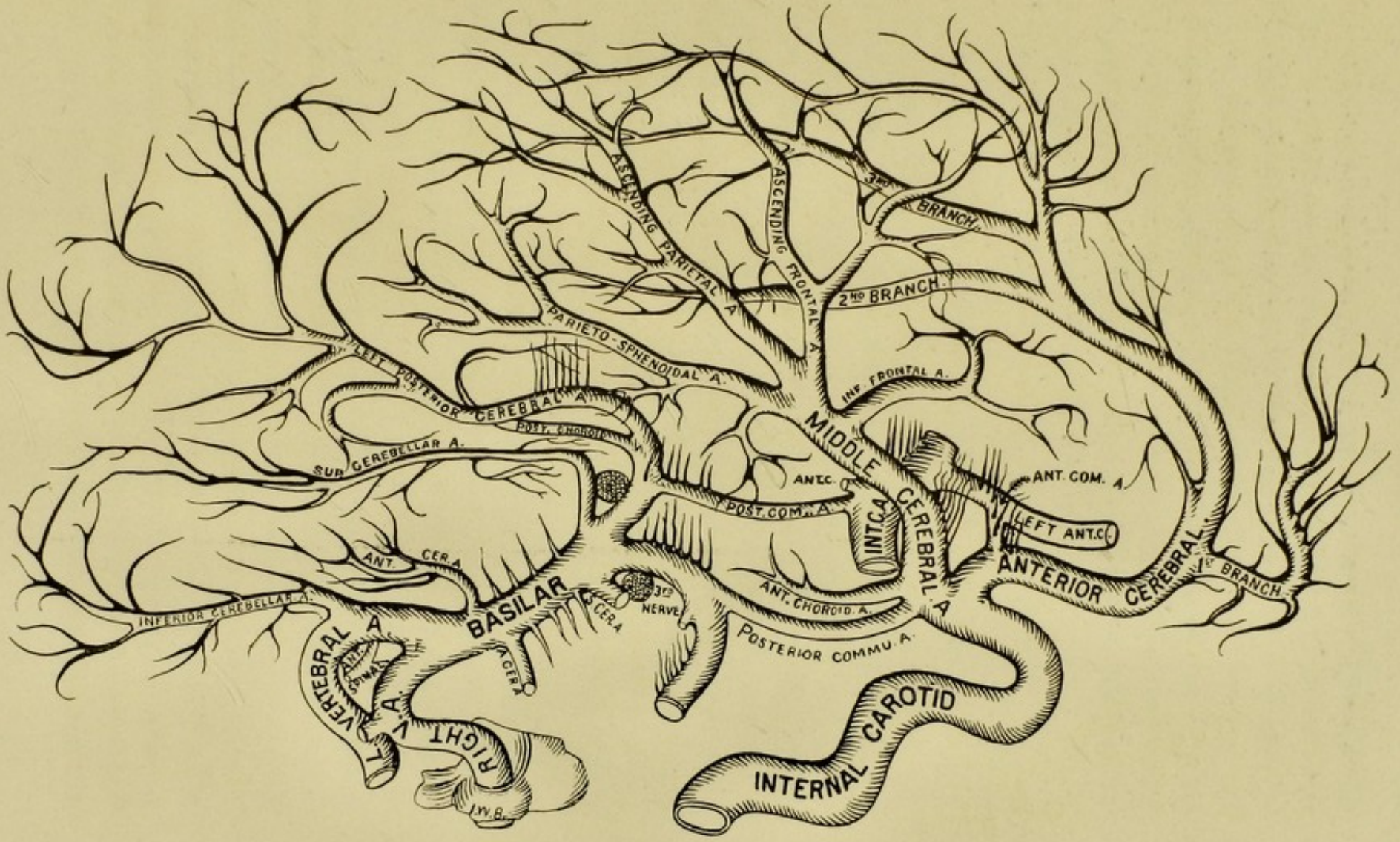


DIAGRAM OF THE CEREBRAL ARTERIES.

If the exact quantity is to be ascertained, that which escaped while removing the brain must be added to what collected during its dissection, and the whole must be measured or weighed.

The absolute weight of the brain can only be determined after emptying the ventricles and removing the membranes. If weighed with the pia mater about an ounce should be subtracted for the weight of the latter.

SECTION OF THE HEMISPHERES.

The hemispheres may be incised in any way desired by the operator, but perhaps the most useful sections are those of M. Pitres; they are made as follows :—

A section of the hemisphere made at right angles to the long axis of the brain, and in the præ-frontal region, is called the **præ-frontal section.** It exposes the white substance of the frontal lobes, showing sections of the three frontal convolutions at their anterior portions. The white substance is divided into fasciculi which correspond with the convolutions,—the præ-frontal fasciculi.

The next section passes through the bases of the three frontal convolutions, two centimetres in advance of the fissure of Rolando. It is known as the **pediculo-frontal section,** and the white matter exposed is divided into three pediculo-frontal fasciculi, corresponding with the frontal convolutions, and an orbital fasciculus. The anterior extremities of the insular lobe, the lenticular and caudate nuclei and the internal capsule are seen in the section.

The third section is carried through the ascending frontal convolution, parallel to the fissure of Rolando, and is called the **frontal section.** It is divided into four fasciculi: the superior, middle, and inferior frontal, and the

temporo-sphenoidal. The optic thalamus, lenticular and caudate nuclei, claustrum, external and internal capsules, anterior portion of the descending horn of the lateral ventricle, and the insular lobe, appear in this section.

A section parallel with this passing through the ascending parietal convolution, is the **parietal section.** It is also divided into four fasciculi: superior, middle, and inferior parietal, and the temporo-sphenoidal. It shows portions of the same structures as the preceding, and a transverse view of the hippocampus.

The next is the **pediculo-parietal section.** It is carried through the parietal lobe three centimetres posterior to the fissure of Rolando, and parallel with it. Here we find three fasciculi: superior and inferior pediculo-parietal, corresponding to the two divisions of the parietal lobe, and a temporo-sphenoidal. The tail of the caudate nucleus appears in two places; the optic thalamus is seen, but the lenticular nucleus is anterior to this section.

The last of the series is the **occipital section**; it is made through the occipital lobe and shows the occipital fasciculi not separately designated.

As the **frontal** and **parietal** sections of Pitres pass longitudinally through two very important convolutions, and the paracentral lobule—regions very interesting for microscopical study—I would suggest that two other sections be substituted.

Instead of the **frontal,** a section is made parallel with the ascending convolution, passing through the **præ-central fissure.** It shows the bases of the three frontal convolutions, the posterior extremities of the orbital convolutions, the insular lobe, and the parts of the corpus striatum. This may be named the **antero-central section,** being anterior to the central or Rolandic fissure and convolutions.

The section substituted for the **parietal** passes through the retro-central fissure, posterior to the ascending parietal convolution. It will show sections of the anterior extremities of the parietal lobules, of the temporo-sphenoidal lobe, the insular lobe, the caudate and lenticular nuclei, the optic thalamus, claustrum, and capsules. For reasons similar to those given above this is called the **postero-central section**. The white substance of these sections may be divided into fasciculi corresponding with the convolutions and lobes divided.

The advantages of having a series of sections such as the above, with division of the white substance into definite areas, are increased by using diagrams of the same, on which the pathologist may map out the exact seat and extent of any lesion. In addition he may use the name of the section and the fasciculus in his written description. Taken in connection with the use of diagrams of the exterior of the brain, and of its arterial system, it is believed that the localization of lesions will be much facilitated. The engravings which accompany this Manual show the situations where the sections are to be made.

It is not intended that the pathologist should limit the sections of the hemispheres to those described. The incisions should be made in any way that the nature of the case demands, and in sufficient number to fully expose the interior. This is especially important in the region of the basal ganglia, where it is necessary to make numerous cuts in order to be sure that no lesion has been overlooked.

Transverse incisions may be made of one hemisphere and horizontal incisions of the other, or one-half may be preserved without section for the study of gross lesions, shape, convolutions, fissures, etc. The basal ganglia, how-

ever, should rarely be neglected; transverse or longitudinal incisions may be made without interfering materially with the value of the specimen.

SECTION OF CEREBELLUM.

The **cerebellum** is divided by a horizontal section separating it into two equal portions. These lateral portions are then subdivided by radiating cuts from the surfaces exposed outward to the pia mater. The one-half may be cut into wedge-shaped pieces by sections radiating from the peduncles. To avoid injury to the fourth ventricle by stretching during the examination of the cerebellum, remove the latter by cutting through its peduncles.

SECTION OF PONS, MEDULLA, AND CERVICAL CORD.

The **pons**, and other portions of the brain stem, are to be divided by transverse incisions, which may be as numerous as desired, all the parts being held together by remnants of the pia mater. In the study of nerve lesions the cuts should be made to expose the nerve nuclei, and, as a rule, the incisions should pass through regions of greatest interest.

The small portion of the cervical cord removed with the brain may be incised transversely if desired, but it should always be preserved for microscopical study, whether the lower portions are removed or not. If an examination of the whole cord is not necessary, at least two inches of the cervical portion may be safely removed from the upper end, through the foramen magnum. To do this the cord should be divided transversely just below the medulla,

when removing the brain; it is then dissected free from its attachments and divided as far down in the spinal canal as possible.

OTHER METHODS OF DISSECTING THE BRAIN.

Of the many methods of dissecting the brain that of Meynert is much used by neurologists. The original object of this method seems to have been the separation of the brain into three great portions (**brain-mantle, brain-axis,** and **cerebellum**), in order to ascertain their relative weights. The method is also an excellent one for demonstration of the coarser anatomy of the fresh brain, and for localization of lesions in the internal capsules and basal ganglia.

The section is sometimes slightly modified from the original plan of Meynert; it may be made as follows:—

The brain is placed with its base upward and the cerebellar end toward the operator. The cerebellum is lifted up and the pia mater is cut through above the corpora quadrigemina, around the crura, and along the inner margins of the temporal lobes until the middle cerebral arteries are reached. The Sylvian fissures are now opened to their entire extent, the opercula are raised and the insular lobes exposed to their limiting furrows.

The apices of the temporal lobes are now raised, and with the knife held nearly horizontally, their junction with the base is cut through until the anterior extremities of the descending cornua are opened. The knife is now inserted into the descending horn, and the incision is carried backward as far as the posterior angle of the insula, or even some distance beyond it, severing some of the convolutions at the posterior extremity of the Sylvian fissure.

The next incision is made to separate the basal piece from the posterior extremities of the frontal lobes. It connects the anterior boundaries of the islands, and opens the anterior horns of the ventricles. The incision may be a slightly curved, transverse one, connecting the anterior borders of the islands; or, by a little care and a double-crescentic cut the exact boundaries of the convolutions may be followed.

The cerebellum is now raised and the knife is entered at the posterior angle of the island, and the incision is carried along the outer limiting furrow until it meets the cut previously made through the anterior border. Care must be taken to keep the knife in the angle between the roof of the ventricle and the basal ganglia, to avoid injuring the latter. The basal piece is now lifted until the anterior crura of the fornix and the septum lucidum may be severed, and the basal section thereby completed.

The basal piece thus separated includes the islands of Reil, the basal ganglia, the crura, pons, medulla, and cerebellum. The brain-mantle includes the convolutions, the corpus callosum and fornix, and the olfactory tracts.

The cerebellum may be separated from the brain-axis by cutting through its peduncles, and the lobes may be incised as in other methods. The basal ganglia, pons, and medulla are best examined by transverse incisions. The brain-mantle may be incised if desired by Pitres' method, or hardened without further section.

VIRCHOW'S METHOD.

Virchow's method of dissecting the brain is used by many pathologists. It differs from the first method given, mainly in the section of the hemispheres; the opening of

the ventricles and the dissection of the cerebellum and basal parts being about the same in both methods.

After opening and examining the ventricles an incision is made in each hemisphere, extending outward and downward from the outer angle of the lateral ventricle to the pia mater of the lower part of the convexity. The portion thus turned outward is now divided into wedge-shaped pieces by incisions made from within outward to the pia mater, leaving the membrane to hold the parts together. The remainder of the dissection is practically the same as that already described.

SECTION OF THE BRAIN AFTER HARDENING.

In some cases it may be desirable to harden the brain before making sections through it. Lesions accompanied by much softening, hemorrhages, tumors, etc., may by this means be more accurately localized. The brain must be carefully removed, so as to preserve the arteries intact, and the dura should not be detached from the margins of the longitudinal fissure. To secure the best results the hardening agent (preferably Müller's fluid) should be injected into both carotid arteries, one vertebral, and into the ventricular cavity through the infundibulum. Large quantities of fluid should be used in hardening, and the organ should be protected from pressure by absorbent cotton or by suspending it in a gauze sling. As the appearances of the lesion and of the brain tissue in the fresh condition are often of great importance, this method is not generally useful in the study of mental disease. If the contents of the vessels are to be studied the brain must, of course, not be injected.

During the dissection of the brain the most minute attention should be paid to all the normal, as well as to the abnormal, appearances. It is only by an accurate knowledge of the normal that the senses of sight and touch are able to appreciate those delicate changes which may be all-sufficient to account for cerebral disease.

All gross lesions should be accurately described, the various forms of local softenings, hemorrhages and their effects, cicatrices of former lesions, tumors, etc. Their situations should be described as well as mapped upon the diagrams.

The consideration of the minute changes in the structure and composition of the brain, belonging, as they do, to works on pathology, are out of the range of the present subject. For their study and for special methods of determining abnormal conditions of the brain the reader is again referred to the list of works at the end of the Manual.

SPINAL CORD.

Unless the examination of the spinal cord is of especial importance, it may be deferred until the thoracic and abdominal organs have been examined and the cavities closed.

The body must be turned over and a block placed under the chest, while the head hangs over the end of the table. An incision is then made from the occiput to the sacrum, exactly over the spinous processes of the vertebræ. The skin and muscles are neatly dissected from the processes and spinal grooves the whole length of the incision, and the vertebral laminæ are sawn, or cut through near their junction with the transverse processes. The most rapid and usual way of exposing the spinal canal is as follows:

After the soft parts have been cleared away from the processes, the inferior lumbar vertebræ are separated with a large knife or chisel sufficiently to admit the points of the large curved bone forceps; the laminæ of the vertebræ are cut close to the transverse processes, first on one side and then on the other. The spinous processes remain connected by the ligaments, and are raised with a strong pair of forceps as the dissection is proceeded with, until the superior cervicals are reached, when the whole mass is laid over the neck, to be replaced in position after the meninges and nerve roots have been examined.*

The cord may be examined *in situ* by opening the posterior surface of the dura, but it is usually better to remove the two together. Beginning at the lower end the spinal nerves are severed on both sides as near to their foramina as possible. The dura is seized with the forceps and lifted from the canal while it is freed from its attachments, care being taken not to bend sharply or press upon the cord within. The dura mater is now opened on the anterior and posterior surfaces over its whole length and examined for inflammatory lesions, tumors, hemorrhages, etc. The spinal pia mater should receive like attention, and the size, shape, color, and consistence of the cord should be noted. If the cord is to be incised at this time, attention should be given to changes in shape and color of columns and cornua; but as a naked eye examination is never conclusive, good authorities recommend that sections should not be made until the cord is hardened.

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* By means of a long, curved chisel made for this purpose, the spinal canal may be opened and the cord removed from the front, after the thoracic and abdominal organs have been taken out.

Whether incised or not the cord should be suspended in a jar long enough to contain it without bending; and it should still remain attached to the dura.

THE VERTEBRAL COLUMN.

After examination of the cord and its membranes, attention should be directed to the condition of the spinal canal and the vertebræ. Notice any arrest of development of the bones, injuries of any kind, which may not have visibly affected the cord or its membranes. Note unusual curvature or other deformity of the column, especially when associated with asymmetry of the skull.

OPENING AND INSPECTION OF THORACIC AND ABDOMINAL CAVITIES.

The **incision** to open the thoracic and abdominal cavities should extend from the upper end of the sternum, or where circumstances permit, from the chin to the pubes, passing to the left of the umbilicus to preserve the round ligament of the liver. The cut should be made with the whole edge of the knife, and the arm movement should be mainly from the shoulder, making the entire primary incision with one sweep of the knife. Over the sternum the tissues should be divided down to the bone; the abdominal portion should extend to the sub-peritoneal tissue, but not penetrate the cavity. To complete the abdominal incision carefully dissect through the peritoneum just below the ensiform cartilage, introduce the fore- and middle fingers of the left hand, spread them apart, and with the knife between them complete the abdominal incision.

Lateral incisions in the abdominal walls are unnecessary, but additional room may be gained by cutting, subcutaneously, the recti and pyramidales muscles at their insertions into the pubic bone.

In cases where gas is suspected in either the pleural or abdominal cavity, its presence may be determined by making a little cup-like fold of the skin, filling it with water, and making the first puncture into the cavity through the liquid; if gas escape it may be seen bubbling through the water; if not, the fluid will disappear through the opening.

The **abdominal cavity** is now to be inspected before the thorax is opened. The condition of the peritoneal surfaces is to be noticed before their color is changed by contact with the air; abnormal contents of all kinds must be carefully described, and if fluid, collected and measured. The position of the organs, including the diaphragm, is to be noted, especially if abnormal, and the location of wounds, perforations, adhesions, limited inflammations, and other conditions which would be disturbed by subsequent steps of the operation.

The **thoracic cavity** is now to be opened. The muscles are neatly dissected from the sternum, cartilages, and ribs, for some distance beyond the costo-chondral articulations, and the abdominal muscles are cut away from their attachments to the arch of the ribs. The cartilages are then divided by oblique cuts near the ends of the ribs, the knife being held nearly horizontally to avoid injuring the organs within. If the cartilages are at all calcified, or in any case, the costotome may be used as a safer instrument.

The cartilage of the first rib will often require the use of the saw or costotome, when the others are readily divided

with the knife; and the instrument used should be directed well outward in dividing this rib.

It is often not permissible to disarticulate the sternum on account of disfigurement of the body. In such cases the diaphragm, the intercostal muscles, and the mediastinal attachments are dissected away and the sternal piece is bent backward until it breaks near the upper end. A notch with the saw on the inner surface of the manubrium will make this easier; and, to avoid dangerous splintering of the broken ends, the bone may be nearly severed, leaving the periosteum of the anterior surface to serve as a hinge.

When the organs of the neck and mouth must be examined, it is necessary to continue the primary incision almost up to the symphysis of the jaw, and to disarticulate the sternum.

Some care is required in the disarticulation of the sternum from the clavicles. The attachments of the sternomastoid muscles at this point should be severed and a narrow-bladed scalpel inserted into the joint, and the incision made in the direction required by the shape of the articulating surfaces. While disarticulating and removing the sternum care should be taken not to injure the great veins which lie beneath the upper end.

The next step after exposing the thoracic organs is to notice the position of the lungs and heart, the condition of the pleural surfaces, and the contents of the cavities. If liquid be present in abnormal quantity it should be measured and its character described. Distinguish the serous exudate of pleuritic inflammation from that of hydrothorax.

The **pericardial cavity** should now be opened. An incision is made along the margin of the right lung, and another meeting it at an angle is carried along the diaphragmatic border of the pericardium. The V-shaped flap

thus made will expose the heart, and at the same time any fluid contained will be retained and may be collected and measured.

The appearances of the pericardial surfaces, the degree of distention of the heart cavities, and, if unusual, the size, shape, and position of the heart, should be noted at this time.

DISSECTION OF THE THORACIC ORGANS.

THE HEART.

The heart is usually the first organ examined after the preliminary inspection.

A complete examination cannot be made without removing the organ, but in certain cases it is necessary to open the cavities and great vessels *in situ*. It may be important to determine the exact quantity of blood in the heart chambers, or the presence and situation of thrombi; if so, this can only be done with certainty before removal. In most cases the organ may be removed at once and examined out of the body.

The first step in the examination of the heart will depend upon whether the competence of the valves is to be tested, as the incisions have to be governed accordingly.

It is not common to test the competence of the **auriculo-ventricular valves,** but it may be done in the following manner:—

First lay open the auricles to remove the blood and clots, and to expose the upper surfaces of the valves; then introduce the nozzle of a large syringe beyond the semilunar valves of the pulmonary artery, or aorta, as the case may be, and send a stream of water downward into the ventricle.

The segments will be floated upward and their degree of sufficiency may be observed from the auricle. The test for these valves is far from reliable, as it is impossible to place the valves under natural conditions, and it may be omitted. To test the **semilunar valves** an opening is first made in the ventricle, and blood and clots are removed. The vessel must now be held so that the orifice is exactly horizontal and not distorted in any way, while a stream of water is poured in to float out the valves. If they are competent the valves will retain the water; if it flows away cut the vessel down until the place of leakage may be seen. It is well to remember that if the incision into the ventricle has been large, the water may escape through the severed coronary arteries.

Having tested the valves the diameters of the various orifices should be taken. This may be roughly done by introducing the fingers into the orifices, but a better way is to use the graduated cones. These should be gently pushed into the orifice in the direction in which the blood flows; no force should be used, and care must be taken not to detach vegetations from the valves. In fact, on account of this danger it is often better not to thrust the fingers or any object through the valvular orifices in order to test their size.

INCISIONS USED IN OPENING THE HEART.

It is desirable that all the incisions into the heart cavities and great vessels in the examination *in situ*, and in testing the valves, should be but portions of those used in the complete examination after removal. The organ is thus mutilated as little as possible and the specimen presents a better appearance if preserved for a museum specimen.

The incisions given are those used by the writer; they are slightly modified from those of Virchow and others.

The **right auricle** is opened by an incision carried from

a point midway between the venæ cavæ to the end of the appendix; the **left auricle** by an incision which starts midway between the two right pulmonary veins, extends onward between the left pair, and on to the extremity of the appendix. By these incisions no important structures are divided and the orifices of the veins are preserved.

The **right ventricle** is opened by an incision made along the right border of the heart, beginning at a point just below the auriculo-ventricular ring and ending near the apex; and a second cut, which begins about the middle of the former, and passes out into the pulmonary artery. The operator must be careful that his knife passes in front of the papillary muscle attached to the anterior wall; and, also, that by cutting well toward the left, it passes between the left anterior and the posterior segments of the pulmonary valve. These incisions will generally be sufficient to examine the valves, but if desired, the tricuspid valve may be fully exposed by cutting through the auriculo-ventricular ring between the right anterior and posterior segments of the valve.

The first incision for the **left ventricle** is made along the left border of the ventricle beginning just below the auriculo-ventricular sulcus and ending at the apex. The second incision begins at the apex and extends close to, and parallel with, the anterior border of the septum into the aorta. As a rule, one of the segments of the aortic valve is cut, though it is possible, by some care, to pass between the left posterior and the anterior segments.

A good view of the valves and the interior of the left ventricle may now be obtained, but if desirable to more completely expose the mitral valve the first incision may be extended through the auriculo-ventricular ring into the auricle.

After opening the ventricles and great vessels the **coronary arteries** are to be opened with the small probe-pointed scissors and thoroughly searched for thrombi, atheroma, and other disease.

The heart must be fully cleared of clots and blood and then weighed. The thickness of the walls, the condition of the heart muscle, the size of the cavities, and the appearance of the endocardium should be carefully noticed.

The valves should be examined for vegetations, chronic thickening, contraction, adhesions, perforations, and all other lesions of the various forms of endocarditis. Do not mistake the fenestration of the semilunar valves above the line of contact for evidence of disease.

THE LUNGS.

Having in the preliminary examination determined the position and external appearances of the lungs, they may now be removed. If pleural adhesions exist they are to be torn or cut away, unless very strong, when it is better to make an incision at the anterior portion of the parietal layer, work the fingers behind it, and take out the two layers together with the lung. When the root of the lung is fully exposed it is divided with care, so as to avoid injury to the aorta and œsophagus.

The surface is then more fully inspected, and the interior is examined by making long, smooth incisions from apex to base; from the convex surface toward the root of the lung. The bronchi and the pulmonary vessels are to be opened up as far as necessary with the probe-pointed scissors. The bronchial glands and trachea are now examined, though to complete the latter will require an extension of the primary incision.

The lung tissue should be gently pressed to detect crepitation, the presence of an exudate, or the downy feel of emphysema. If solidified the tissue will sink in water; it will be more friable than normal, and it will not crepitate. By somewhat harder pressure over larger areas, fluid contents may be forced out of the bronchi before incision of the lung.

Notice the amount of blood in the organs and where distributed; note the œdema and post-mortem settling of the blood so often found in the posterior portions, and distinguish from actual congestion. The weight may be taken as an indication of the amount of serum, blood, or other exudate.

For examination of the lungs of the new-born the reader is referred to special works given in the list appended.

After removal of the heart and lungs the mediastinum, parietal layers of the pleura, and chest walls are to be examined.

LARYNX, PHARYNX, AND ORGANS OF THE NECK AND MOUTH.

To examine the structures of the neck and floor of the mouth the primary incision is extended onward to near the symphysis of the jaw; the skin and fascia are reflected and the sternum must be disarticulated.

The organs of the neck may be examined *in situ* by exposing one after another in their anatomical order, but if a thorough examination is to be made, and to include the structures of the floor of the mouth, the whole mass must be removed together and dissected from behind forward. The incision to remove the organs follows the inner surface of the inferior maxillary bone, passes above the tonsils and through the upper part of the pharynx.

The organs are then drawn downward and dissected free from their attachments until the lower end of the œsophagus is reached; this is ligated and the mass is removed.

The pharynx and œsophagus are laid open on their posterior surfaces; the larynx and trachea in the same way. The thyroid gland is dissected off and weighed, incised, and examined.

The mucous membrane of the pharynx and œsophagus is to be searched for evidences of inflammation, stricture, injury, etc.; the interior of the larynx and trachea, for œdema, disease of cartilages, foreign bodies, tumors, and the specific inflammations.

In cases of sudden death the examination of the larynx and pharynx should never be neglected.

Other organs of the neck, the arteries, veins, and nerves, may require examination in some cases, and the tongue and other structures of the mouth occasionally. The cervical ganglia of the sympathetic should always be examined when permissible. Anomalies in the formation of the arteries should be looked for, and noted. In the examination of these the operator must suit his methods to the requirements of the case.

It may be mentioned here that examination of the parotid gland and other organs of that region may be made with least mutilation by extending the incision from the scalp downward to the side of the neck, and reflecting the integuments until the organs are exposed.

DISSECTION OF THE ABDOMINAL ORGANS.

OMENTUM.

The omentum is the first abdominal organ to be examined. It may be overloaded with fat, or atrophied; it is sometimes matted together by inflammation and adherent to the abdominal walls; it may enter into the contents of a hernial sac, or it may have looped adhesions through which the intestines may find their way and become incarcerated. The omentum may be removed, if desired, before proceeding to other organs.

SPLEEN.

The spleen is next examined. Its position has already been observed, and it is now drawn out of the abdomen until the structures entering the hilus may be seen. These are noticed, and if abnormal, described, and the organ is then removed. It is weighed and then incised longitudinally from the convexity to the hilus. The color, consistence, amount of blood, fibrous tissue, and the appearance of the Malpighian bodies are to be noted. The iodine test for amyloid change should be applied to all enlarged spleens. Supernumerary spleens are sometimes found in the gastro-splenic omentum; they are found to correspond in structure and in morbid changes with the main organ.

KIDNEYS.

The kidneys with their supra-renal bodies and ureters are next examined, beginning with the left. To fully expose these organs *in situ* it is necessary to dissect away the colon very freely, but simply to remove the kidneys and their supra-renal capsules an incision behind the upper part of the ascending and descending colon is sufficient.

The position, size, shape, color, and weight of the kidney should be noted, and the organ is then incised from the convex border to the hilus, leaving some of the structures of the latter to hold the parts together. The capsule is then stripped from the surface, with the exception of those portions reserved for microscopical examination, and the degree of adhesion to the cortex and the condition of the surface of the latter are noted. Observe the amount of blood on the cut surface; the relative thickness of cortex and medulla (normally about as one to three); study the glomeruli; the different regions of the cortex, for cysts, tubercles, and deposits in the tubules. Open the pelvis and ureter, and if necessary trace the latter on into the bladder.

Portions with the capsule still adherent are to be hardened for microscopical examination.

The **supra-renal capsule** is to be weighed, incised, and its condition noted. Softening of the interior must not be considered pathological.

The corresponding organs of the right side are now examined in a similar manner.

In cases where there are important associated lesions of the urinary organs it may be necessary to examine the whole tract *in situ*, and afterward to remove the organs. To do this it is better to remove the intestines first. The colon is double-ligated at the rectum, the small intestine at the lower part of the duodenum. The colon is then dissected free, the mesentery cut across near its origin, the two extremities divided between the double ligatures, and the organs are placed aside for the present.

A piece is now sawn from the middle of the pubic bone, large enough for examination of the parts beneath it; and now, by dissecting away the peritoneum, fat, and other overlying structures, the whole urinary tract is exposed and

may be laid open from the meatus urinarius to the pelves of the kidneys.

To examine the **prostate gland,** the **seminal vesicles** and **ducts,** and the deep-seated parts of either sex, it is best in all important cases to remove the whole genito-urinary system of organs and examine them outside of the body. The external organs may be removed with the internal by including the skin and muscles of the pelvic floor in the incision. This, however, is seldom necessary, and as a rule the important parts may be removed and the integuments left so as to cause little apparent mutilation.

The **penis** may be examined and the greater portion of the organ removed, if desirable, by dissecting away its attachments to the pubic bone, drawing the body backward beneath the pubic arch, and finally cutting it off subcutaneously just behind the glans.

The **testicles** may be examined and removed without injury to the scrotum by opening the internal abdominal rings and pushing the organs up through the inguinal canals.

After removing the organs from the pelvis the deeper seated parts are exposed by dissection and examined.

The **female organs** may be very advantageously examined by making a median section through the bladder, urethra, vagina, uterus, and rectum. With a little care this section may be carried exactly in the median line and the relation of the parts perfectly shown.

The **ovaries** are to be examined for atrophy, hypertrophy, cysts, tumors, corpora lutea, and signs of inflammation.

The **Fallopian tubes** for obstructions, dilatation, adhesions to other structures, and abnormal contents.

The position, size, and shape of the **uterus** should be

noticed before removal. The state of its mucous membrane, the presence of tumors, lacerations of the cervix, thromboses of the uterine veins, etc., should be noted on incision.

The **vagina** is to be examined for injuries, new growths, malformations, inflammation, and hemorrhage. In medico-legal cases the examination of the vagina precedes that of the uterus.

The **rectum** should be searched for strictures, fissures, hemorrhoids, tumors, and forms of inflammation.

THE DUODENUM AND STOMACH.

The **duodenum** is the next organ examined. If its contents have not been too much disturbed it is an advantage to open it *in situ* to determine presence of bile above and below the entrance of the bile duct. Ligatures are placed upon the upper and lower ends and an incision is made along its anterior surface. The contents are to be inspected, and the biliary papilla found and examined. Press gently upon the intestinal portion of the bile duct, and observe what exudes from it. Now, by gently pressing upon the gall bladder, it may be seen if obstruction exists within the gall ducts. If no bile escapes the location of the obstruction must be found; it may be in the cystic duct while the hepatic and common ducts are open.

If in the subsequent examination the stomach is to be removed, the structures of the **hepatico-duodenal ligament** should be examined at this time.

The **gall ducts** and the **gall bladder** are opened, and the **portal vein, hepatic artery,** and **vena cava** should be examined.

The **stomach** may be opened *in situ* if desired, by an incision carried preferably along its greater curvature.

There can be no objection, however, to the much neater way of examining the organ, by ligating both extremities and removing it.

The contents should be inspected, the diameters of the orifices taken, and the condition of the mucous membrane carefully studied. Care must be taken not to mistake post-mortem staining, or softening of the mucous membrane, for pathological changes.

THE LIVER.

The structures of the hepatico-duodenal ligament are to be examined if this has not been done, and we are now ready to remove and examine the liver. Cut through the diaphragm on the left side of the suspensory ligament, as far back as the spine; divide the ligament, and raise the right and left lobes in turn and sever the lateral ligaments. Then turn the under surface upward and divide the hepatico-duodenal ligament; and finally seize the left lobe, drag the organ downward, and cut away the remaining attachments.

The surface is then examined, the organ is weighed, and the interior is exposed by long, smooth cuts in the longest diameter, and from the superior toward the inferior surface.

Observe the amount of blood on the cut surface; the color and consistence of the tissue, and the appearances of the hepatic lobules. Wash the cut surface and apply the iodine test for amyloid degeneration. Note dilatation of the bile ducts in cases of calculous or other obstruction to the flow of bile. Note the presence of primary or secondary tumors.

If the **gall bladder** has not been examined in a previous stage of the operation, it is to be opened, the contents

examined, and the mucous membrane searched for signs of disease.

Occasionally the gall bladder is totally obliterated and its site occupied by a mass of cicatricial tissue.

PANCREAS AND SEMILUNAR GANGLIA.

The pancreas is next removed and examined; for, though commonly neglected, it is occasionally the seat of disease. It may be incised transversely or longitudinally, and its duct should be examined. We may find hemorrhages; simple and specific inflammations; degenerations, tumors, and in the peri- and para-pancreatic tissues foci of fat necrosis.

The **semilunar ganglia** will require examination in special cases only.

MESENTERY AND INTESTINES.

The greater portion of the mesentery may have been removed with the intestines, in order to examine the urinary tract. Examine the lymphatic glands, especially in conditions which may cause degeneration or irritation of these organs. Notice the blood-vessels and lacteals.

The **small intestine** should always be examined externally, and in most cases it should be opened. The mesentery must be dissected away, and the bowel opened along the line of its attachment, to avoid the Peyer's glands, which lie opposite the mesentery. Examine the mucous membrane for ulcers of all varieties, especially those of tubercular or of typhoid origin. Distinguish the tubercular ulcer from the typhoid, by the presence of tubercular disease elsewhere, by the character of the lesion, or by microscopical examination. Examine the contents of the bowel, especially for foreign bodies, parasites, etc.

The **large intestine** is to be opened along one of its longitudinal muscular bands. The same may be said of this as of the small intestine; its internal examination is highly important in many cases. It should be searched for local and general lesions, and for the presence of abnormal contents.

In cases of hernia, incarceration, intussusception, etc., describe the condition and the parts involved. Do not neglect to examine the **vermiform appendix.**

AORTA AND ADJOINING STRUCTURES.

The aorta may be removed or examined *in situ*, as the removal of the other organs renders this easy. Deposits of atheroma may often be found in the abdominal aorta when the arch is comparatively free. Aneurism may be present; anomalies of its trunk or branches should be recorded.

The **vena cava** occasionally requires examination.

The **receptaculum chyli, thoracic duct** and **retro-peritoneal lymphatic glands** should not be neglected. The latter may be found enormously enlarged and matted together in cancerous disease of the abdominal viscera; and they may be irritated and inflamed by the products of specific or simple inflammation. In conditions accompanied by changes in the lymphatic system generally, these are, of course, liable to be affected and should be examined.

CONCLUSION.

Having now finished the examination, the organs are returned to their respective places. For the sake of decency alone the viscera should not be tumbled back promiscuously; but another reason may be given besides this. Occasionally a reëxamination must be made, and

sometimes in the presence of witnesses. In such cases it would be far better to find each organ in its place, and not needlessly mutilated. Of course the reservation of portions, or even whole organs, for scientific purposes is legitimate and proper; but in private cases it is questionable whether it should be done without the knowledge and consent of some trustworthy friend of the deceased.

The incisions are now carefully closed with continuous sutures, and the body is washed and reclothed.

In a private post-mortem the physician should see that all traces of the operation are removed before the friends are permitted to view the body. Consideration for the feelings of the family should always be shown, however absorbed the operator may be in the scientific aspects of the examination.

WEIGHTS OF ORGANS.

For the convenience of the pathologist the following have been compiled from Gray's Anatomy and other sources:—

Brain. Average weight in the adult male, 49½ ounces avoirdupois (1403 grammes).

Average weight in the adult female, 44 ounces avoirdupois (1247 grammes).

Prevailing weight in adult males, 46 to 53 ounces avoirdupois (1304 to 1502 grammes).

Prevailing weight in adult females, 41 to 47 ounces avoirdupois (1162 to 1332 grammes).

Maximum weight in adult males (278 cases), 65 ounces avoirdupois (1842 grammes).

Minimum weight in adult males (278 cases), 34 ounces avoirdupois (964 grammes).

Maximum weight in adult females (191 cases), 56 ounces avoirdupois (1587 grammes).

Minimum weight in adult females (191 cases), 31 ounces avoirdupois (878 grammes).

According to Luschka the average weight of a man's brain is 1424 grammes (about 50 ounces avoirdupois); of a woman's, 1273 grammes (about 44¾ ounces avoirdupois).*

The brain reaches its maximum weight between the ages of thirty and forty. Beyond this period, as age advances, it slowly diminishes in weight, at the rate of about an ounce for each subsequent decennial period.

The weight of Cuvier's brain was 64⅓ ounces (1823 grammes); Abercrombie's, 63 ounces (1786 grammes); Dupuytren's, 62½ ounces (1771 grammes); Webster's, 53½ ounces (1517 grammes); Agassiz's, 53⅖ ounces (1513 grammes).

One of the heaviest brains on record was that of an ignorant bricklayer; it weighed 67 ounces (1899 grammes). A congenital imbecile had 70½ ounces (1998 grammes) of brain substance.

The brain of an idiot seldom weighs more than 23 ounces (652 grammes).

The lowest weight of brain compatible with ordinary intelligence is, according to Gratiolet, 900 grammes (about 31.7 ounces), and, according to Broca, 907 grammes (about 31.9 ounces) for the female, and 1049 grammes (about 37 ounces) for the male.

Spinal Cord. 1 to 1½ ounces (28 to 42 grammes).

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* In Gray's Anatomy the metric weights given by Luschka have been converted into their equivalents in troy ounces; to correspond with the others they are here changed to avoirdupois.

Heart. Prevailing weight in male adults, 10 to 12 ounces (283 to 340 grammes).
Prevailing weight in female adults, 8 to 10 ounces (227 to 283 grammes).

Lungs. Weight of both lungs together, about 42 ounces (1190 grammes). The right is about 2 ounces (56 grammes) heavier than the left. Much variation is met with according to the amount of blood or serous fluid they contain.

Thyroid Gland. 1 to 2 ounces (28 to 56 grammes).

Thymus Gland. At birth, ½ ounce (14 grammes).

Liver. 50 to 60 ounces (1417 to 1701 grammes).

Spleen. 7 ounces (198 grammes).

Pancreas. 2 to 6 ounces (56 to 170 grammes).

Kidneys. In the adult male, 4½ to 6 ounces (127 to 170 grammes).
In the adult female, 4 to 5½ ounces (113 to 156 grammes).
The left is usually 2 drachms (3.54 grammes) heavier than the right.

Supra-renal Capsules. 1 to 2 drachms (1.77 to 3.54 grammes).

Prostate Gland. 6 drachms (10 grammes).

Testicles. 6 to 8 drachms (10 to 14 grammes).

Uterus. 1 to 1½ ounces (28 to 42 grammes).

Ovaries. 1 to 2 drachms (1.77 to 3.54 grammes).

Stomach. 4½ ounces (127 grammes).

ON HARDENING TISSUES FOR MICROSCOPICAL EXAMINATION.

GENERAL DIRECTIONS.

1. The pieces of tissue to be hardened should be as small as the nature of the subject for examination will admit; as a rule they should not be over half an inch in thickness for most hardening fluids, and some tissues have to be cut much thinner to insure perfect hardening of the interior portions. If the sections must be large, the pieces should be cut thin and hardened carefully to prevent distortion. Whole organs must be injected to insure successful hardening. The pieces should be cut smoothly, without unnecessary pressure, and they should not be washed before being placed in the hardening fluid.

2. The pieces should always be cut from the most interesting portion of the lesion or organ, and, if possible, some of the normal or less affected tissue should be included in the piece selected. The exact locality from which the piece was taken should be noted with other data on the label of the jar.

3. The specimens should be placed in the hardening fluid as soon as the naked-eye examination of the part is completed, while the autopsy is still in progress. If decomposition has commenced the hardening will require extra care; the fluid which will best arrest the change should be used; portions should be hardened in different kinds of fluid; and, if possible, the tissues should be examined in the fresh condition by frozen sections. In fact, no microscopical examination can be absolutely relied upon which does not include a study of the tissues in the fresh condition supplemented by careful hardening and examination by other methods.

4. Protect the pieces from pressure by using absorbent cotton in the bottom of the jar and between the pieces. Large pieces of brain may be hardened by making deep incisions and keeping the cut surfaces slightly apart with absorbent cotton.

It is an advantage to turn the pieces over at each change of the fluid; this is especially necessary in hardening entire organs, such as the brain. Large pieces, or whole organs, may be suspended in gauze slings.

5. Use a large quantity of all hardening fluids, and change frequently. The proportion of tissue to fluid should not be greater than 1 to 10, or 20, according to the fluid used; and, as a rule, the fluid should be renewed on the second, third, fourth, and seventh days, and at the end of each week thereafter until hardening is completed. The sediment should always be washed from the surfaces of the specimens, and the bottom of the jar at each renewal of the fluid.

6. When the autopsy is finished the jars should be put away in a cool, dark place, preferably an underground cellar, or an ice box. The number of the case, the date, the supposed morbid condition, the hardening fluid used, and other important data should be recorded on the label.

7. At each change note the consistence of the tissues, and do not allow specimens to be over-hardened by remaining too long in solutions of chromic acid and its salts. The usual practice is to transfer chrome-hardened tissues to alcohol after completion of the hardening, but they will keep for some time in pure water. If the specimens are to be kept for a considerable length of time without transferring to alcohol, the hardening may be slowly completed and the tissues preserved by using dilute solutions toward the end of the process.

Specimens preserved in alcohol may remain almost

indefinitely, though the spirit slowly dissolves some of the fatty and other constituents of the tissues.

8. The hardening fluid to be used will depend upon the nature of the tissue, the object of the investigation, and the degree of rapidity required. When the tissue is hard and firm, and not likely to be injured by the abstraction of water, fat, or other constituents, alcohol may be used as a hardening agent. For rapid hardening, alcohol must be used in some part of the process, and decomposition is best arrested by the use of strong alcohol. It must be used where the elements of the tissue would be injured by the action of the chromic acid solutions.

Tissues to be studied for bacteria must be hardened in absolute alcohol from the first.

9. When the tissue contains much blood which it is desirable to preserve; when it is soft, œdematous, myxomatous, or fatty, Müller's fluid or bichromate solutions should be used. For the nervous system use the solutions containing chromic acid, or its salts, preferably Müller's fluid. This is especially important, as hardening in solutions containing the bichromates is an essential part of some of the most valuable staining methods.

10. For very delicate structures, nerve fibres, retina, renal epithelium, etc., use osmic acid solutions, Delafield's osmic acid mixture, or Flemming's fluid.

HARDENING AGENTS.

ALCOHOL.

For some tissues alcohol is an indispensable hardening agent, but on account of the shrinkage and distortion it causes, and the injurious action of alcohol on the constituents of the tissue, it is unsuitable for the nervous

system. It is, however, used to complete the hardening process, and to preserve the specimens, after using other agents to fix the tissue elements.

The tissues should be cut in small pieces and put into 50 per cent. alcohol for twenty-four or forty-eight hours; at each change the strength should be increased until the 95 per cent., or absolute alcohol, is used. Some tissues must be placed at once in strong spirit, even at the risk of injury to the tissue elements. By the time the water is removed, the tissue will be hardened sufficiently for interstitial embedding, and by frequent changing this may be done in a few days; very small pieces may be dehydrated and hardened by absolute alcohol in thirty-four to forty-eight hours. Slow hardening will injure the tissues less and is always to be preferred when time will permit.

CHROMIC ACID.

Chromic acid in weak solutions is much used as a hardening agent. It is used in $\frac{1}{6}$ to $\frac{1}{2}$ per cent. solutions. It acts with great vigor but has little penetrating power, especially in strong solutions, as the surface is soon hardened and rendered impermeable to the fluid, and the interior is apt to spoil. For this reason the pieces to be hardened must be very small, and the solution used at first should not be stronger than $\frac{1}{6}$ per cent. The strength may be gradually increased as the hardening proceeds, though it should not exceed $\frac{1}{4}$ to $\frac{1}{2}$ per cent. Large quantities of the fluid should be used and it should be changed frequently, the consistence of the tissue each time being noted. Care must be taken not to over-harden, as most tissues become very brittle in chromic acid solutions. Hardening will require from one to six weeks, according to the size and nature of the specimens. When they have acquired

the desired consistence, the fluid is replaced by alcohol, using 50 per cent. for twenty-four hours, and then 95 per cent. alcohol to preserve until wanted. Some prefer to wash the specimens out in water for twenty-four or forty-eight hours before putting them into the alcohol.

CHROMIC ACID SOLUTIONS AND ALCOHOL.

A hardening fluid in some respects superior to the last, is made by adding alcohol to the chromic acid solutions. It is commonly known as the chromic acid mixture. It is usually made by adding one part of common alcohol to two parts of a $\frac{1}{6}$ per cent. solution of chromic acid, though some use equal parts of the two fluids.

This fluid has greater penetrating power than the chromic acid solutions and hardens with greater rapidity and certainty. It will harden moderately small pieces of most tissues in one or two weeks; like all other solutions large quantities should be used, it should be frequently changed, and when the specimens are sufficiently hardened they should be transferred to alcohol.

MÜLLER'S FLUID.

Müller's fluid is more used than any other hardening agent. It is admirably adapted for hardening nearly all the tissues, normal and abnormal, and it is especially useful for those containing much water, blood, fat, or other substances which would be extracted by the action of alcohol. In the study of the nervous system it is of the greatest value both as a hardening agent and as a preliminary to valuable staining processes.

It is composed of bichromate of potash, 2½ parts; sulphate of soda, 1 part; water, 100 parts; by weight. It may be used for all purposes for which the simple solutions

of the chromic acid salts are recommended, and in some respects is preferable to any of them.

The pieces should be small, to insure perfect hardening, but they may be larger than for most other fluids, and by means of interstitial or arterial injection whole organs may be safely hardened in it.

The only objection to Müller's fluid is its slowness, as two or three weeks are required to harden small pieces, and whole organs, such as the brain, will take two to six months, even when injected. The process may be hastened by transferring to alcohol after the tissue is partly hardened, if the special staining methods are not to be used.

It is best to transfer the specimens to 50 per cent. alcohol at first, and gradually increase the strength to 95 per cent., in which they may be preserved indefinitely.

If for any reason it is undesirable to transfer the specimens to alcohol, the hardening must be completed in the Müller's fluid, and the specimens kept in a dilute solution of the same, or in pure water until ready for study.

For Weigert's method of staining the tissues of the nervous system, the specimens should not be brought in contact with water, and for the carmine methods of Schultze and Piersol they should be transferred directly from the bichromate solutions to the staining fluid.*

MÜLLER'S FLUID AND ALCOHOL.

The difficulty of hardening large pieces of tissue in Müller's fluid, and its slow action, has led to the mixture of alcohol with it in various proportions. It may be added in equal volume; one of alcohol to three of Müller's; and in other proportions.

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* *American Monthly Microscopical Journal*, December, 1889.

This mixture acts more rapidly than Müller's fluid, and large pieces may be hardened in it. A whole brain, with the membranes intact, may be successfully hardened, especially if the fluid be injected into the vessels and the ventricles. When the contents of the vessels are of no importance this is an excellent method of hardening any whole organ.

Specimens will harden in the mixture in about half the time required by Müller's fluid. A whole brain will harden in about three months; small pieces of brain or spinal cord in two weeks. After partial hardening in the mixture the specimens may be transferred to 95 per cent. alcohol to complete the process.

This method is rather expensive on account of the large quantity of alcohol used, but a great deal of the fluid may be used again by filtering it and adding a few crystals of the salts and some fresh alcohol. The discolored alcohol resulting from the second part of the process may be filtered and used for making the mixture.

POTASSIUM BICHROMATE AND CUPRIC SULPHATE (ERLICKI'S FLUID).

This is a valuable hardening fluid made by substituting one half part of sulphate of copper for the sulphate of soda in Müller's fluid. It hardens more rapidly, but has less penetrating power than Müller's; the pieces must, therefore, be smaller. Small pieces of tissue will be hardened in a week or two, sufficiently to transfer to alcohol. Tissues of the nervous system hardened in this solution are ready for staining by Weigert's method. It sometimes produces dark precipitates in the tissues which may prove sources of error.

POTASSIUM AND AMMONIUM BICHROMATE.

These two salts are used in solutions of 2 to 5 per cent. They are used in the same way as Müller's fluid and have no additional advantages except cheapness.

AMMONIUM CHROMATE,

A 5 per cent. solution of ammonium chromate is a rapid hardening agent used especially for studying cell structure. The tissues must be cut into very small pieces, not more than $\frac{1}{6}$ to $\frac{1}{4}$ inch in diameter. They should be placed in ten to fifteen times their volume of the fluid, and left from twenty-four to forty-eight hours, when they should be washed thoroughly in water and cut at once, or transferred to weak alcohol for twenty-four hours, and then to strong alcohol to preserve.

OSMIC ACID.

Osmic acid in $\frac{1}{6}$ to 1 per cent. solution is a useful fixing and hardening agent for small portions of delicate tissues. The tissues must be cut into small pieces and placed in the solution for twelve to twenty-four hours; they are then washed in water, and preserved in a mixture of equal parts of glycerine, alcohol, and water.

Such preparations are better adapted for teazing or other methods than for section cutting. To harden sufficiently for sections the specimens must be washed in water and then placed in strong alcohol to complete the process.

To harden larger pieces in osmic acid solutions the organ must be injected, or the fluid introduced by interstitial injection. Better results are attained by diluting the 1 per cent. solution of the acid with equal parts each of alcohol and water.

Tissues should not remain too long in solutions of osmic acid or they will become brittle and too deeply stained. The jars containing the specimens should be kept from the light; and, as the acid is very volatile, they should be well closed.

DELAFIELD'S OSMIC ACID MIXTURE.

One per cent. solution of osmic acid,	10 c.c.
One-fifth per cent. solution of chromic acid,	100 c.c.
Ninety-five per cent. alcohol,	100 c.c.
Acetic acid,	1 c.c.

Specimens are allowed to remain in this mixture for twenty-four hours, and are then transferred to 80 per cent. alcohol to complete the hardening and to preserve. The pieces to be hardened in this mixture should be small, or the fluid should be introduced by interstitial injection. The fluid is recommended for the cells of the kidney, liver, and other glands.

FLEMMING'S FLUID.

This fluid and its modification by Fol are highly recommended as rapid fixing and hardening agents for small pieces of tissue; it consists of:—

Two per cent. solution of osmic acid,	16 c.c.
One per cent. solution of chromic acid,	60 c.c.
Acetic acid, glacial,	4 c.c.

The pieces must be very small, and should remain in the solution twenty-four to forty-eight hours; they are then washed in water forty-eight hours, and finally transferred to alcohol to complete the hardening and preserve.

Fol's modification of this fluid is made as follows:—

One per cent. solution of osmic acid,	2 c.c.
One per cent. solution of chromic acid,	25 c.c.
Two per cent. solution of acetic acid,	8 c.c.
Water,	68 c.c.

This fluid is used in the same way as the original, but it acts with less rapidity.

The pieces of tissue should be flat—not more than 1 to 2 mm. in thickness. It makes little difference as to the size. When placed in the fluid they should rest on cotton or be turned over several times, otherwise they stick to the bottom of the vessel and the fluid only acts on one side.

CAJAL'S FIXATION FLUID.

The penetrative properties of this fluid are superior to that of Flemming; it also has the advantage of not making the medullary tissues too brittle. It has the following composition:—

Potassium bichromate,	3 parts.
One per cent. solution of osmic acid,	25 parts.
Distilled water,	100 parts.

The pieces of tissue should remain in this fluid from twenty-four to forty-eight hours, and the medium should be changed at least once. The method is especially adapted to the modification of Golgi's silver stain.

NITRIC ACID.

Nitric acid in 2 to 10 per cent. solution is used as a fixing, hardening, and decalcifying agent. It requires two or three weeks to act, and hardening is then completed and the acid at the same time removed with alcohol. Nitric acid is used more in embryology and in the preparation of naked-eye specimens than in ordinary histological work.

For decalcifying it may be used in solutions of 2 to 10 per cent., or it may be combined with chromic or picric acid solutions.

PICRIC ACID.

A saturated solution of picric acid is recommended as a useful decalcifying and hardening agent.

The pieces are allowed to remain in the solution for twenty-four to forty-eight hours, and are then transferred to weak alcohol for twenty-four hours, and finally to strong spirit to complete the hardening.

To decalcify tissues will require two or three weeks. The fluid need not be changed often, but should be kept saturated by the addition of some of the acid from time to time. When the specimens are decalcified (which may be determined by passing a needle through them) they are transferred to weak and then to strong alcohol to finish the hardening.

CORROSIVE SUBLIMATE.

A cold, saturated, aqueous solution of this salt is highly recommended as a fixing and hardening fluid. The solution is allowed to act on the tissues until they are well permeated with it; they are then transferred to weak alcohol for twenty-four hours, and finally to strong alcohol to further harden. It is a rapid and certain method for small pieces of tissue.

HARDENING OF SPECIAL TISSUES.

Brain. The hardening agents of greatest value for the brain are Müller's fluid, and the mixture of Müller's fluid and alcohol.

The pieces should be cut from all the principal regions of the organ, and each piece should be, by some means, accurately localized. For this purpose it is an advantage to leave the pieces large, and to make deep incisions into

them to admit the hardening fluid. To secure the best results the pieces should not be over half an inch in **thickness**, though the other dimensions may be larger. It is usually best to make transverse sections of the convolutions and to leave the pia mater attached.

The specimens must be carefully protected from pressure by the free use of absorbent cotton, and when the fluid is changed the cotton must be washed and replaced.

Directions as to time required to harden, changing of fluids, etc., need not be repeated here.

Spinal cord. The fluids recommended for the brain are also used for the cord. If the spinal dura is opened the cord may be safely hardened without being cut into sections.

Heart. Parenchymatous and fatty degeneration of the heart-muscle should be studied by teazing in one-half per cent. salt solution, or in equal parts of glycerine and water. Frozen sections may be made and examined in the same reagents. For other lesions of the heart-muscle and of the valves use Müller's fluid, chromic acid mixture, or alcohol. For the study of diseases of bacterial origin harden in absolute alcohol.

Lungs. If the contents of the bronchi and alveoli are of no importance the lung may be filled with the hardening agent. Use Müller's fluid, Müller's and alcohol, chromic acid mixture, or alcohol. If the organ has been dissected, pieces may be hardened in any of the above fluids. To study the tubercle bacilli use absolute alcohol.

The **larynx, trachea,** and **bronchi** are best hardened in the chromic acid mixture, completed by alcohol.

Spleen. Examine all important cases in the fresh condition. Harden in Müller's fluid.

Kidneys. Harden in Müller's fluid, or in Delafield's osmic acid mixture. As the renal epithelium is very perishable, cut the pieces small and use great care in hardening. Study the degenerations by the fresh methods.

Supra-renal capsules. Use Müller's fluid, the chromic acid mixture, or alcohol.

The **bladder, urethra, vesiculæ seminales, prostate, testicles, ovaries, uterus,** and **vagina** are best hardened in Müller's fluid, or the chromic acid mixture. Great care must be taken not to rub the epithelium from the surfaces of the organs. For tumors of these organs use the same hardening agents.

Liver. The degenerations should be studied in the fresh condition in one-half per cent. salt solution. For general purposes and tumors of the organ, use Müller's fluid. To study the cells harden small pieces in the osmic acid mixtures.

Intestines and stomach. Stretch gently on pieces of cork with the mucous membrane outward, immerse for a few minutes in strong alcohol, and then place in 80 per cent. alcohol to complete the hardening. For tumors of stomach and intestine use Müller's fluid.

Pancreas. The chromic acid solutions and Müller's fluid act injuriously upon the cells of this gland. Use strong alcohol, and cut the pieces small.

The **thymus, thyroid, mammary, salivary,** and **lachrymal glands** harden best in Müller's fluid and alcohol, or in alcohol alone.

The **lymphatic glands** and **marrow** of **bone** are hardened in the same fluids, but in the diseases of the blood accompanied by changes in these organs they should always be examined in the fresh condition.

The various structures of the **eye** are best hardened in Müller's fluid.

The organs and tissues not mentioned may be safely hardened in Müller's fluid, or in the mixture of this fluid and alcohol.

LIST OF WORKS CONSULTED.

The writer wishes to acknowledge his indebtedness to the following works:—

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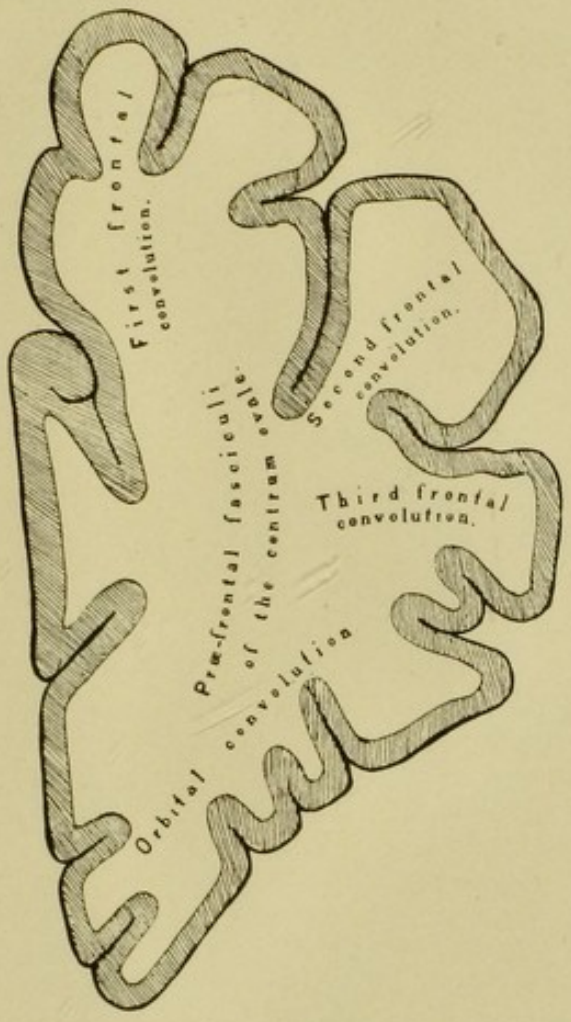

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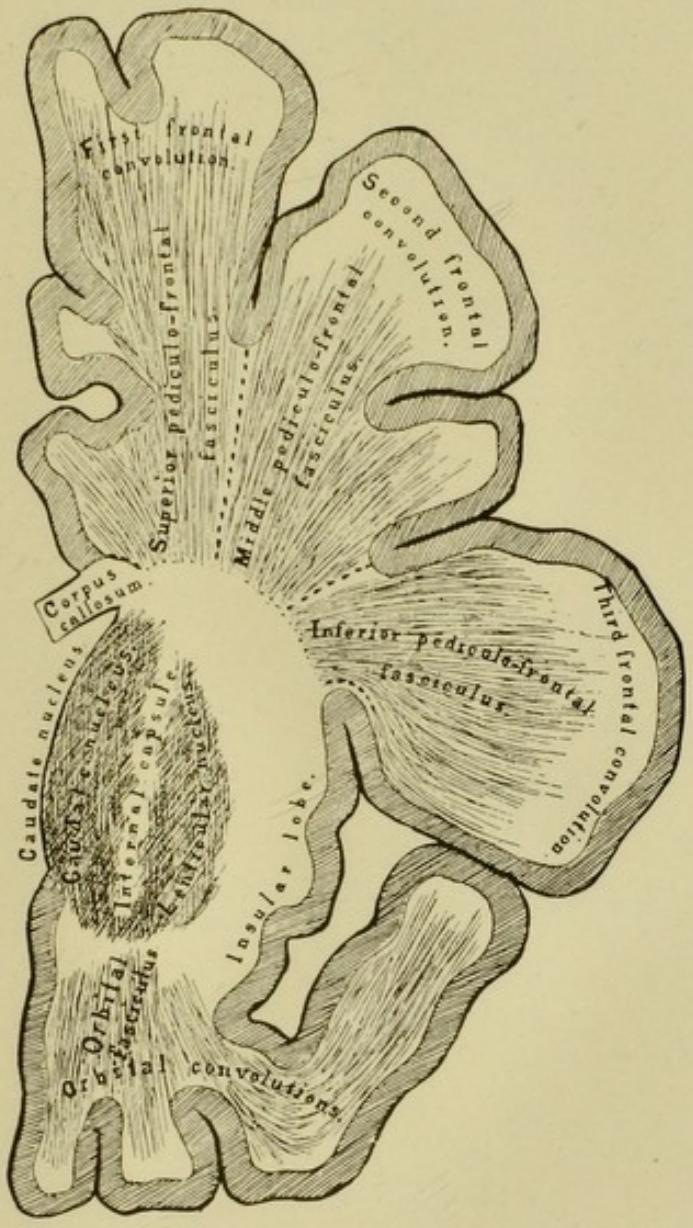

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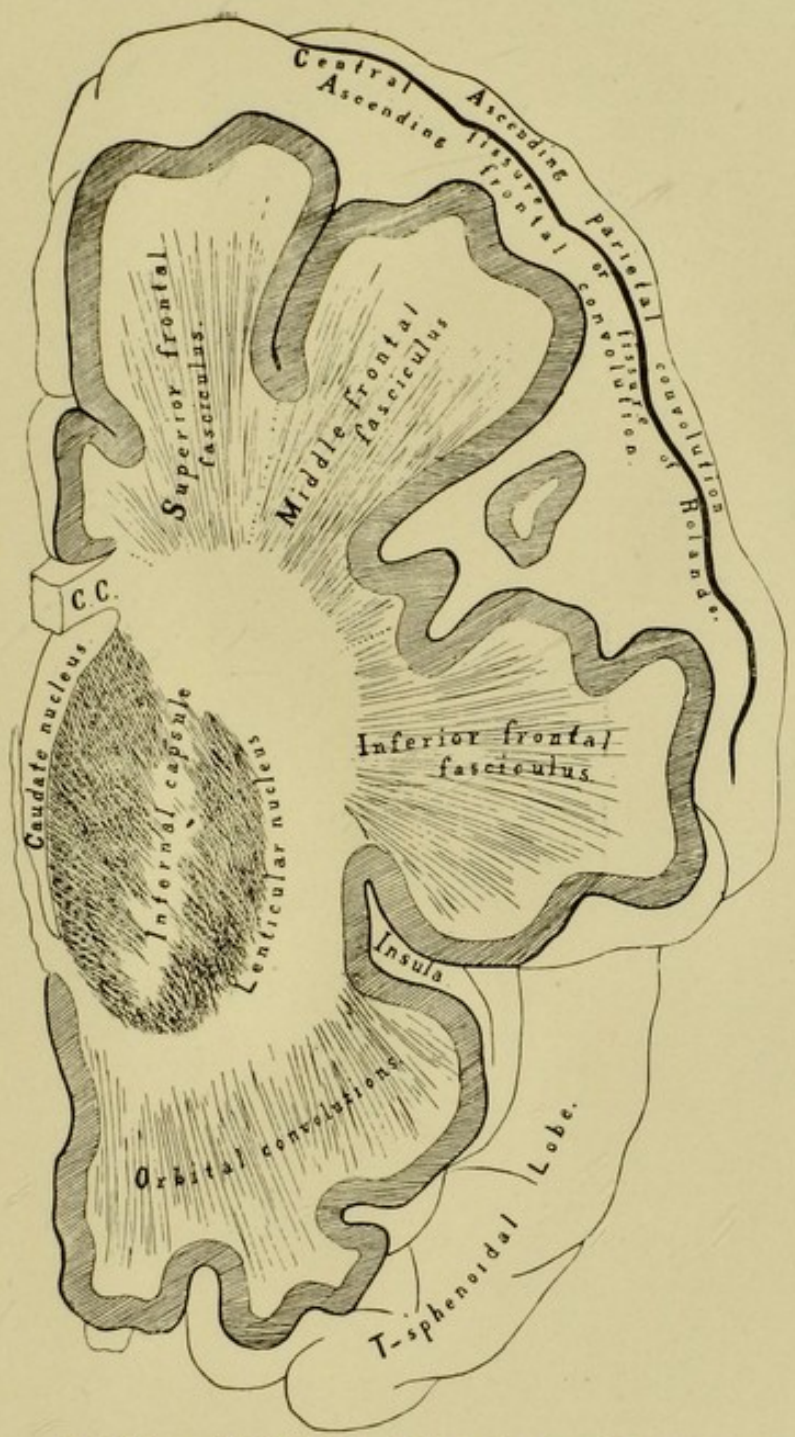

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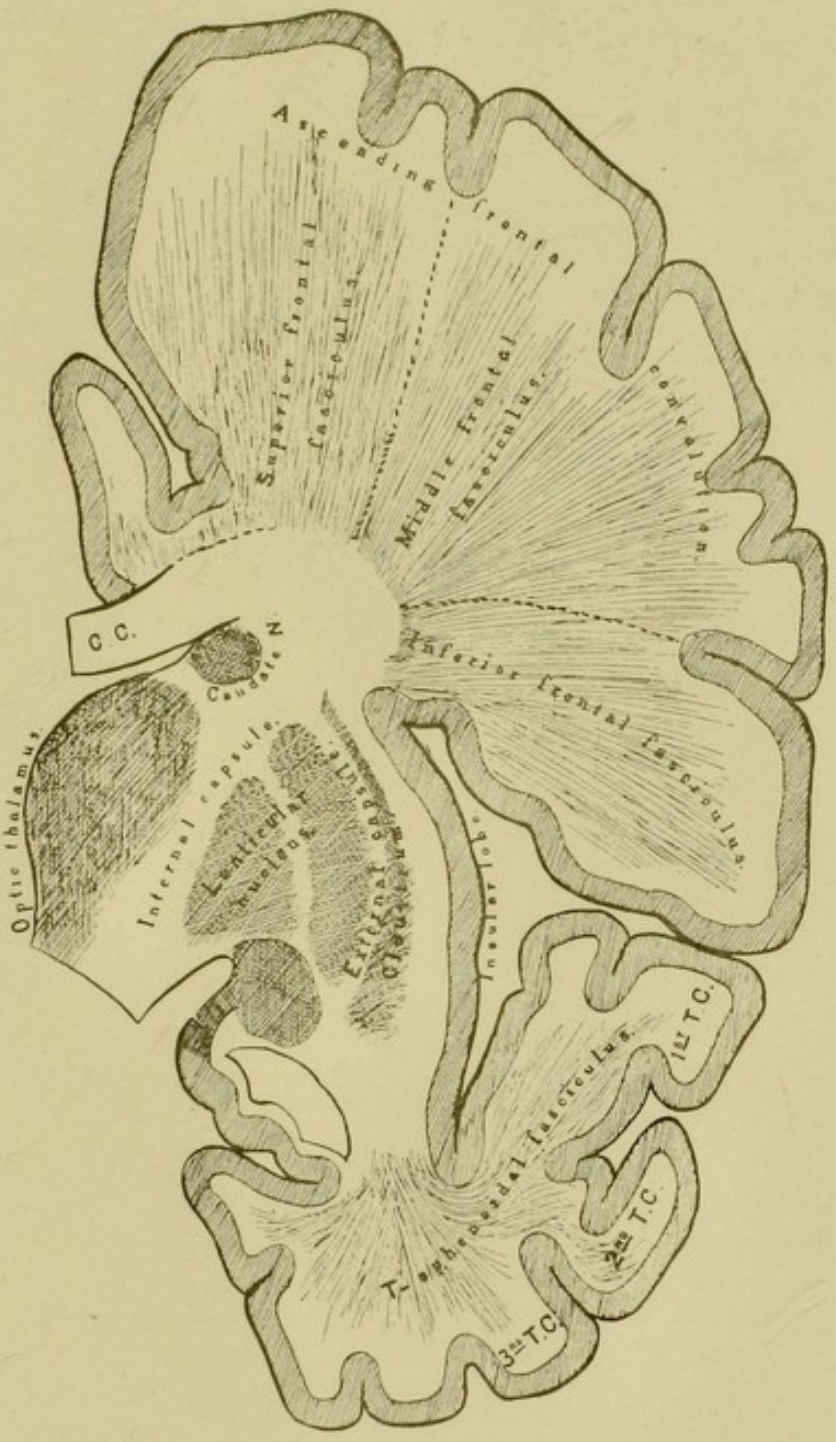

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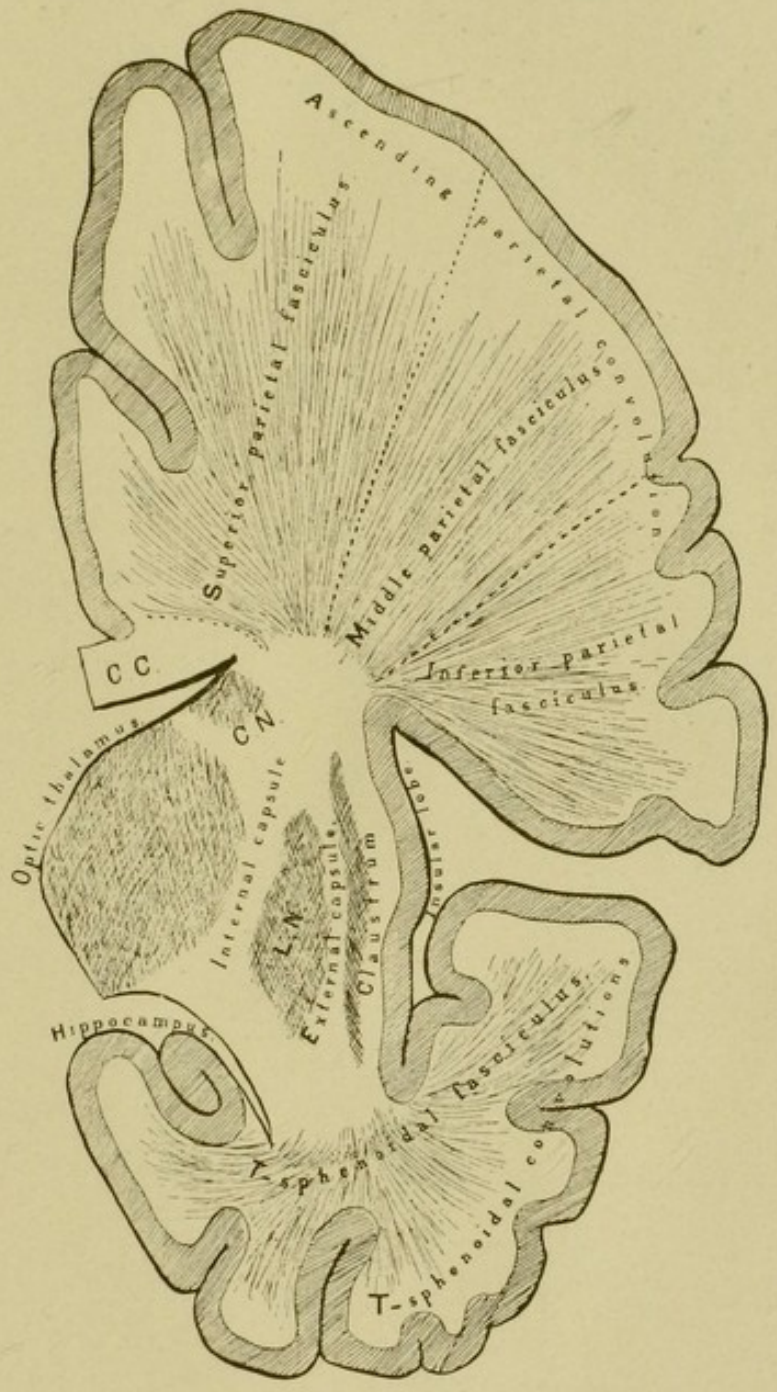

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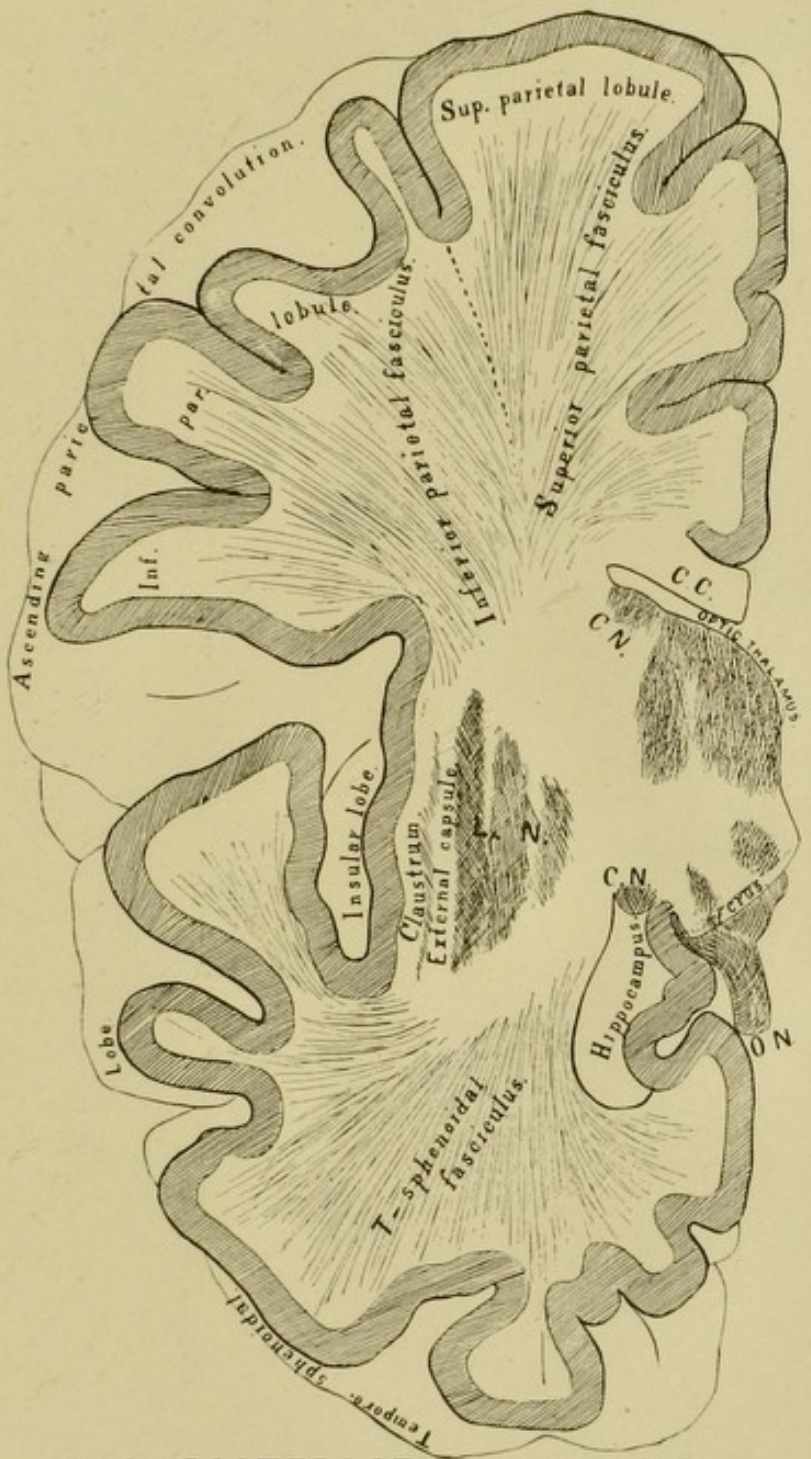

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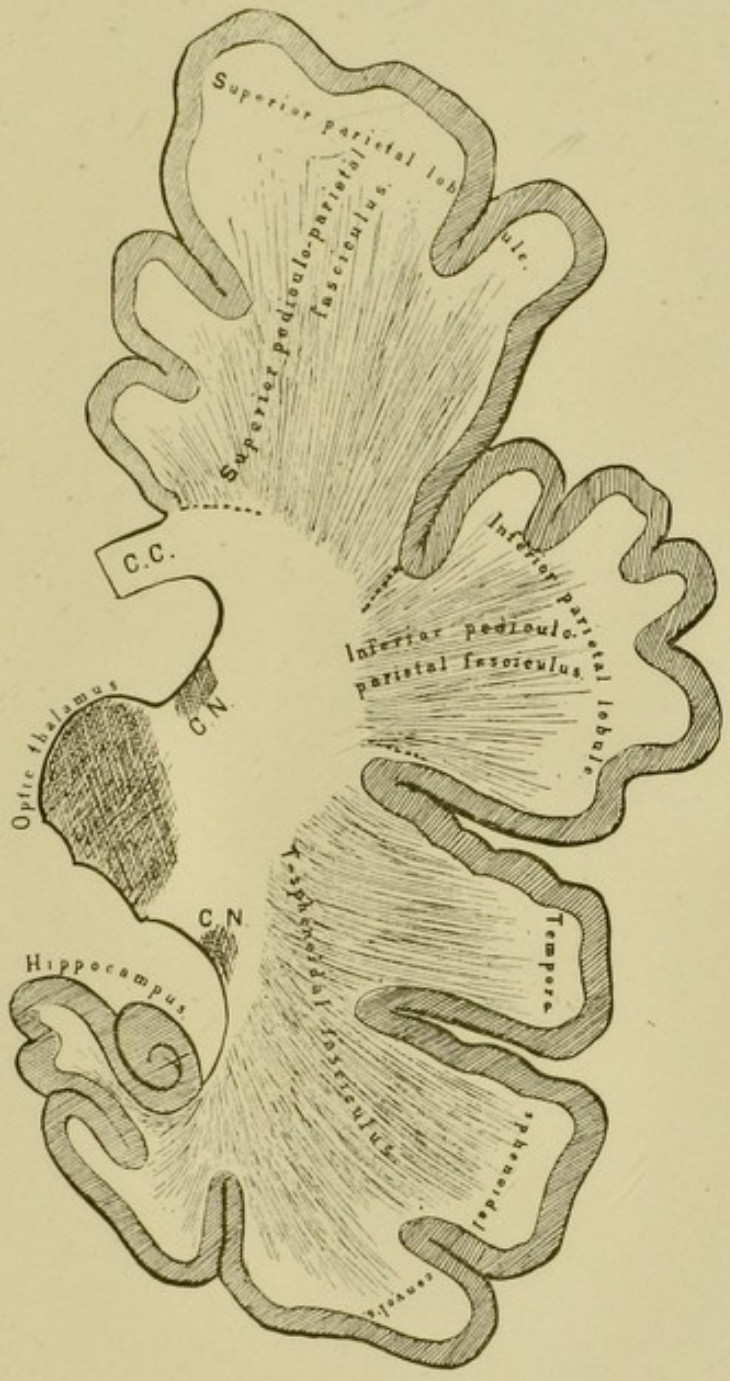

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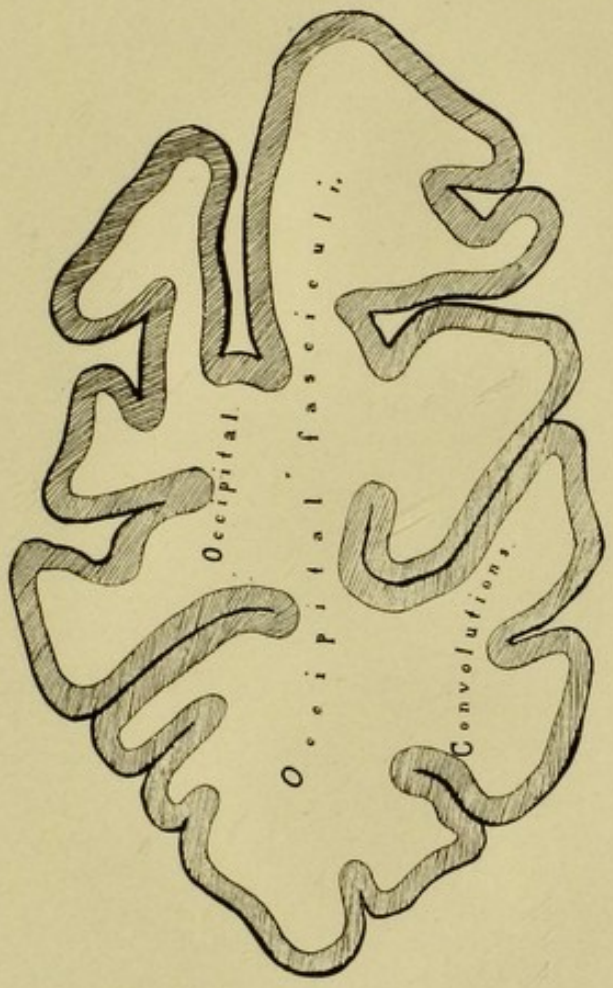

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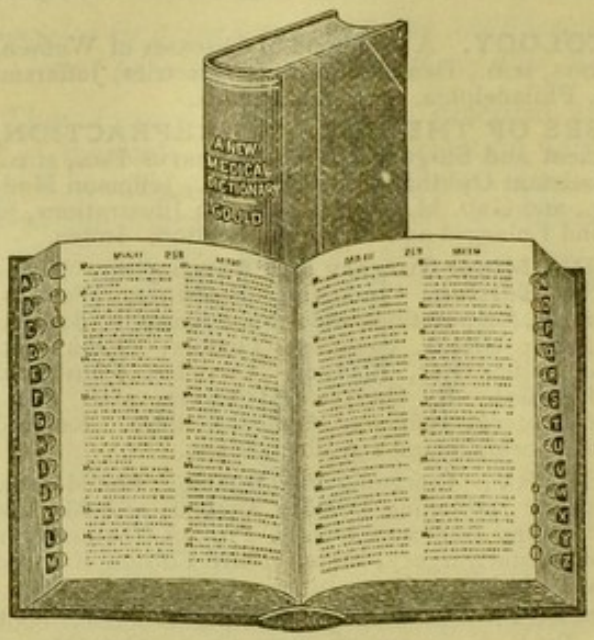

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