It is claimed that paræsthesia may be detected with the æsthesiometer. Generally the pupil is contracted. This has been noted in the greater proportion of cases. Paralysis of the dilator or irritation of the sphincter is met with. Photophobia, ocular spectra, and ringing in the ears are symptoms peculiar rather to cerebral anæmia or to the venous variety of hyperæmia. The ophthalmoscope teaches but little in regard to cerebral hyperæmia. Its use has, however, justified the supposition of a transitory vaso-motor paralysis during frequent and severe attacks of cerebral congestion in a case of hysteria with paralysis and other symptoms. Diplopia and illusive transformations of hearing are often present with the other derangements of the special senses. Recent observations point to the connection between tympanic congestion and cerebral hyperæmia. Examination of the membrana tympani appears to indicate the state of the cerebral circulation, a fact demonstrated by comparing the state of this membrane before and after the administration of quinia or amyl nitrite. It is remarked, in connection with this circumstance, that evidences of congestion are noticed in the vessels over the handle of the malleus, and that the membrana tympani is of a light pinkish color. There is also a rise of temperature in the external auditory canal.

Motor disorders are seen in the agitations and struggles of the patient. There may be numbness and formication of the extremities, but paralysis does not in any way belong to arterial hyperæmia. Convulsions are most common in infants, and belong rather to anæmia or venous stasis than to arterial hyperæmia, and they may be confounded with epilepsy. The vomiting sometimes met with belongs also most often to anæmia. The circulatory apparatus is more or less disturbed in cases of active congestion. There are palpitation and a sense of oppression; the pulse is full and rapid and the carotids pulsate. This morbid excitability of the heart is particularly influenced by emotional disturbance. There is, however, a difference of opinion as to its symptomatic importance. Reflex excitability is preserved.

The phenomena of *venous or passive congestions* are in reality those that commonly relate to anæmia of the brain, and in a given case of anoxhæmia it is difficult to recognize whether the condition be owing to want of blood in totality or to venous stasis. In a venous stasis from thrombosis of the sinuses or from embolism the symptoms present are similar to those of congestion, namely, derangements of the intelligence, the sensibility, and the motility, and sometimes there is an agitated state of mind, with dilated pupils. Vertigo, photophobia, auditory subjective phenomena, and incoherence of ideas exist, however, to a less degree in this form than in the fluxionary, and in the case of delirium it is rather of the mild or demented kind. The symptoms may vary according to age, sex, and other circumstances. Men are more subject than women. The different periods of life known as increase, maturity, and decline are modifying influences, but it does not appear that season exerts any influence. The symptoms may be light or severe, and they may be acute or chronic.

In a case of acute *fluxionary hyperæmia* the patient may, after a short premonitory headache and dizziness, fall senseless, with or without convulsive movements. The face is red, the conjunctivæ are injected, the pupils contracted, the temporals and carotids pulsate vehemently, the pulse is hard and strong, the respiration stertorous. There are often convulsive movements and twitchings, especially in children, combined with slight paresis, and the condition often ends in stupor and death. If the case does not terminate fatally, the symptoms decrease in severity and disappear entirely, or they may pass into the chronic form. The latter is characterized by a sense of fulness and heaviness in the head, by continuous or paroxysmal headache, dizziness, and pulsations of the temporal and carotid arteries. These symptoms become worse by lowering the head, and by the influence of alcohol, if the hyperæmia is still active. The frame of mind is rarely serene, the patient is morose,

excitable, and explosive. There is a disinclination to mental labor, with confusion of thought, the combinations of which are illogical, morbid, and exaggerated; and symptoms of morbid apprehension, like those common to agoraphobia, are often present. A morbid fear of impotence is a predominant idea in this condition. Other symptoms arrange themselves according to the fundamental conditions that originate the exaggerated distention of the cerebral vessels.

The symptoms of *passive hyperæmia* are not entirely identical with the foregoing. There is more apathy, and the patient is more depressed. It should be taken into account that the poisonous influences of carbon dioxide obtain in this condition: it is the defect of oxygen in the venous blood, and not its quantity, which causes the characteristic phenomena.

DIAGNOSIS.—The diagnosis of cerebral hyperæmia is often not clear, because of the likeness of the symptoms to those of anæmia. The question here concerns the symptoms that have already been mentioned in connection with the excitements of the three great faculties of the nervous system, another enumeration of which would be tedious. In the delirium of anæmic origin, as in grave fevers and inanition, the aspect of the patient is quite the opposite of the flushed face, the brilliant eye, and general rugged appearance so often associated with hyperæmic delirium. The essentially transitory character of the excitement met with in these cases, the syncope and convulsions, leave no doubt as to the anæmic cause of the delirium. Delirium tremens and a certain kind of delirium from lead-poisoning resemble in some points the delirium of cerebral hyperæmia, but the discrimination is easy when attention is directed to the history of the case and a knowledge of the patient's habits. Elevation of temperature is of use in distinguishing inflammatory diseases of the brain from hyperæmia. The latter condition is usually apyretic, but at times it is possible to detect an elevation of one or two degrees above the normal by means of the differential calorimeter applied to different regions of the head. Vertigo, epilepsy, uræmia, embolism, thrombosis, softening, and hemorrhage may be confounded with cerebral hyperæmia; but each of these affections may be distinguished after careful examination into the condition of the urine, heart, lungs, and blood-vessels, and on comparing the symptoms of the afore-mentioned diseases with those of hyperæmia.

PROGNOSIS.—The prognosis of cerebral hyperæmia depends upon the intensity and duration of the symptoms as well as on individual circumstances. Children are more liable to succumb to the intensity of congestion, and in old people cerebral congestion is particularly dangerous because of the tendency to rupture in the degenerated vessels. Strong cerebral congestions are as grave as cerebral hemorrhage, and may lead to death. They may also prove the immediate cause of death in such chronic conditions as tumor of the brain and senile degeneration of its vessels. The tendency to such secondary lesions as hemorrhage, softening, cerebritis, and the like is greatly increased by the frequency of the paroxysms. Active cerebral hyperæmia, being more amenable to treatment, is consequently more favorable to recovery than is the passive variety.

TREATMENT.—The chief therapeutic indication in acute fluxionary hyperæmia is to diminish the sanguineous afflux, and this is perhaps best done by judicious inaction and careful watching of the symptoms. The condition is not one either of pressure or of œdema, but of an over-active circulation, and the treatment must vary according as the causes are primary or secondary. The nature of the treatment of active congestion from such causes as extremes of temperature, insomnia, or an irritable condition of the brain will, of course, differ from that required by the secondary congestions caused by suppression of the menses, by gout, or by rheumatism. Rest and position are of primary importance during an attack. The head should be elevated and the arms stretched upward. Quiet surroundings, fresh air, and a

darkened room are advisable. Local bleeding is recommended by most practitioners, but it should be done with a certain amount of discretion and caution. As a rule it is contraindicated in children and old people, and in hysteric or chlorotic persons. The so-called derivation and revulsion, in which a considerable congestion of the whole or part of the intestinal canal is produced by the administration of a drastic purgative, may diminish the afflux of blood to the brain. In fact, main reliance is to be placed upon the derivative effects of croton oil, colocynth, and irritating enemata, as of vinegar; the irritation of hot or mustard baths for both the hands and feet; and the production of diuresis. Reflex action is further brought about by the application of a mustard plaster to the epigastrium, and of the actual cautery to the nape of the neck. Cold vigorously applied to the head, in the form of ice, or cold douches upon the head, combined with a hot bath, are adjuncts in the treatment too valuable to be overlooked. When there is a heart complication it may be met with cardiac medicaments. Among the internal remedies that it is advisable to employ as agents in relieving the cerebral congestion are the bromides, ergot, oxide of zinc, eucalyptus, and hydrobromic acid. When the symptoms of congestion have disappeared, strychnia, phosphorus, and cod-liver oil may be administered with advantage, and at the same time the patient's nervous system is to be carefully nursed. This is particularly to be enjoined in the case of chronic hyperæmia. Complete intellectual rest, fresh air, regular habits, and the disuse of tea, coffee, alcohol, and tobacco should form part of the hygienic treatment. The milk cure and the grape cure may be mentioned as valuable dietetic measures. If the congestion arises from stoppage of a hemorrhoidal flow, leeches may be applied to the anus. Wonderful effects have been thus brought about. Like results have been obtained by applying leeches to the mouth of the uterus in secondary hyperæmia caused by suppression of the menses. In this condition the electric brush applied to the thighs, with douches to the loins and perineum, has been found efficacious in restoring the menses. Galvanization of the head and of the sympathetic nerve, having the power to contract the cerebral blood-vessels, may often be used with good effect. A systematic course of hydrotherapeutics is often advantageous.

In passive hyperæmia the causes are to be made the special objects of treatment. Generally, it is a question of restoring vascular tonicity and combating symptoms that in many respects resemble those of cerebral anæmia. Stimulants may be administered in many cases. Satisfactory results have been obtained from ether inhaled in small quantities. The use of cardiac tonics, as digitalis, when the stasis results from some vascular or cardiac lesion, or when there is cirrhosis of the kidney, is a question that still admits of a satisfactory solution.

Irving C. Rosse.

BRAIN: LESIONS OF THE CORPORA QUADRIGEMINA.—In discussing the lesions of the corpora quadrigemina in man our material is scanty, and it is often impossible to distinguish between the results due to injury of one portion of the brain and those due to the destruction or irritation of neighboring parts.

The corpora quadrigemina of mammals correspond in structure to the optic lobes of frogs, birds, and fishes. Little is known about purely destructive lesions of the corpora quadrigemina in man. Experiments on animals would lead us to suppose that destruction of the whole corpora quadrigemina would result in complete blindness, and unilateral lesion in hemianopsia. In man, however, this does not always occur. In a case related by Eisenlohr, a revolver bullet entering through the forehead passed directly into the right corpus quadrigeminum and there remained. The power of sight was only partially lessened at first—R. $\frac{20}{30}$, L. $\frac{20}{20}$; later, R. $\frac{20}{20}$, L. $\frac{20}{30}$ (Monakow). Monakow concludes that the destruction of a whole anterior corpus quadrigeminum in man causes only moderate affection of sight and leaves the color

sense intact. Local lesions of the corpora quadrigemina may cause dilatation of the pupils in one or both eyes and the pupillary reaction to light and accommodation may be much impaired. As the process advances toward the base, disturbances of the ocular muscles become prominent. Total ophthalmoplegia is rare, but there is paresis of the various muscles, not homologous, incomplete, and developing unevenly. The posterior corpora quadrigemina have nothing to do with sight; after isolated lesion of them no effect on vision is observed. Paralysis of the fourth nerve (unilateral or bilateral) and disturbances of chewing have been found in such cases. Lesions of the corpora quadrigemina also produce both ataxia of movement and cerebellar ataxia. Tremor resembling that of paralysis agitans and sometimes choroid movements either of the opposite extremities or bilateral may exist.

An important symptom in cases of lesion of the *posterior corpora quadrigemina* is a *diminution of hearing* in the opposite ear.

In cases of tumor or foreign growth in the corpora quadrigemina or their neighborhood the adjacent regions are liable to be affected and symptoms strictly referable to the disturbance of these regions are apt to occur. These symptoms, as well as the general, that is non-localizing, symptoms of cerebral tumor cannot be discussed here, but must be considered as of much importance in forming the diagnosis. *William N. Bullard.*

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BRAIN: LESIONS OF THE CORPORA STRIATA.—By corpora striata is designated the lateral portion of the collection of gray matter called basal ganglia; these are further subdivided into two parts, the nucleus caudatus and nucleus lenticularis.

These parts of the brain are rarely if ever the seat of independent states of disease. The lesions found in this region of the brain are almost exclusively vascular or tumors.

The symptomatology of disease of the corpora striata is very obscure, and reports of pathological without distinct clinical findings are often met with.

The main symptoms to be expected from lesions in this neighborhood will be dependent upon implication of the adjacent capsular structures. As symptoms pointing with some probability to involvement of the corpora striata, these motorial irritation phenomena are cited: choreatic and athetotic twitchings and spasms or convulsive laughter or crying. *Joseph Fraenkel.*

BRAIN: MALFORMATIONS. See *Teratology.*

BRAIN: METHODS OF REMOVING, PRESERVING, DISSECTING, AND DRAWING.—§ 1. This article has no direct reference to microscopical or pathological requirements, which are provided for elsewhere in this work and in special papers.* Neither is it designed for neurological specialists, or for those who may have the benefit of their counsel, or access to large libraries; but physicians and students at a distance from medical centres, who desire to attain a real and personal acquaintance with the gross anatomy of the human brain as an aid to the comprehension of its minute structure, its functions, diseases, and mental relations, may profit from an account of the methods found useful in a laboratory where many students have prepared for a medical course.

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* For example, that of Donaldson, 1894; see the Bibliography at the close of this article.

§ 2. *Need of More Attention to the Subject.*—In the large city schools considerable time is now devoted to the anatomy and physiology of the nervous system, and instruction is given especially in histological methods; but even there the gross anatomy is not always adequately worked out by the student himself upon good material, and it is to be feared that in some institutions the conditions described seventeen years ago (W., 1884, *a*) may still prevail.

§ 3. Inasmuch as he is permitted to clean scrupulously the abdominal muscles before examining the vastly more important viscera, the average first-year student is at least consistent in deferring the removal of the organ that wrinkles the forehead. With saw and chisel he lacerates the brain, tears it in the effort to save entire the sacred skull-cap; injures it yet more in the process of extraction,* and places it upon a hard, flat surface, where its own weight completes the rupture of delicate connections and hopelessly distorts its shape. Here he leaves it (having to clean some bones), perhaps for a day or two, probably drying, and either freezing or decomposing according to the temperature. He then transfers it to a basin or pail, covers it with strong alcohol, notes with satisfaction that the surface hardens rapidly, feels sure of finding out all about the brain, and sees himself a future neurological expert, perhaps even an asylum superintendent. In due time, armed with his "Gray" and a big knife, he succeeds in identifying the cerebellum, the chiasma, and the pons. Upon the cerebrum he recognizes the Sylvian fissure, but is doubtful about the central; moreover, the effort to detach the dried-on pia creates so many undescribed depressions and fissural confluences that he imagines, *à la* Benedikt, that it belonged to some hardened criminal. Lifting the occipital lobes, his fingers readily enter cavities which must be the "descending horns of the lateral ventricles," a triumphant refutation of the opinion of certain "theoretical" anatomists that there is no such thing as a "great transverse fissure" till artificially produced. He then slices the brain *secundum professoris artem*, and is so pleased at demonstrating the "*centrum ovale majus*" that he is not seriously disturbed at the presence of an unexpected rent in the callosum and an irregular orifice at either side. Continuing his operations, he finds the interior of the brain a mass of amorphous pulp; suspects that the names in the books have much the same significance as those of the heavenly constellations; modestly admits that he may not be sufficiently advanced to comprehend the brain, and resolves that, when this branch is undertaken again, his *armamentarium* shall consist not of a scalpel but a spoon.

§ 4. The more important of the macroscopical methods of studying the brain, pursued in the Neurologic Laboratory of Cornell University, are summarized in §§ 7–52. From the nature of the case a strictly logical sequence is impracticable; certain of them are subsequently described in detail.†

§ 5. *Acknowledgments.*—Did space permit, I would gladly specify the sources of such of these methods as are not original, and the points in which efficient aid has been rendered by my students, past and present, in either carrying out my own ideas or in improving upon them; the following deserve particular mention: P. A. Fish, S. H. Gage, F. L. Kilborne, B. F. Kingsbury, W. C. Krauss, B. L. Oviatt, M. J. Roberts, M. G. Schlapp, Theobald Smith, H. E. Summers, B. B. Stroud, and F. L. Washburn.

*The article "Anatomy" in the last edition of the Encyclopedia Britannica (i., 876) seems to acquiesce in the present state of things as beyond remedy: "In taking the brain out of the cranial cavity this commissure [the medicommissure] is usually more or less torn through, and the cavity [diocele] is consequently enlarged."

† That these methods are fairly successful may be concluded from the facility with which those who practise them receive the most advanced or specialized instruction imparted at the great medical schools, and from the nature of these methods that it is not susceptible of change for the better; indeed, the constant effort to improve them has been a serious hindrance to the completion of this article.

§ 6. *Order of Treatment.*—Introduction and Acknowledgments, §§ 1–6.
  Summary of Principal Methods, §§ 7–52.
  Preliminary Work upon Certain Animal Brains, §§ 53–59.
  Removal of the Adult Human Brain, §§ 60–71.
  Removing the Brains of Infants and Fetuses, §§ 72–80.
  Preservative Liquids, §§ 81–90.
  Injection into the Cavities and Arteries, §§ 91–115.
  Dry Preparations, §§ 116–119.
  Injection Mixtures, §§ 120–121.
  Economics of Alcohol, §§ 122–127.
  Storage and Transportation of Brains, §§ 128–131.
  Dissection, §§ 132–136.
  Instruments and Apparatus, §§ 137–144.
  Labelling and Recording, §§ 145–151.
  Methods of Representation, §§ 152–171.
  Bibliography.

§ 7. Before dealing with the human brain, the various processes of removal, preservation, and dissection are practised upon the more accessible brains of the sheep (pp. 153, 173, 208, 209, 372, 374, 382) and the domestic cat (pp. 149 and 151): "*Fiat experimentum in corpore vili.*"

§ 8. Fetal and infant brains are utilized not only for what is learned from them as such (pp. 136 and 185–189), but also as preliminary to dealing with the adult organ when, as is sometimes the case, the latter is less readily procured and removed.

§ 9. Although, in most cases, the ultimate object of neurologic study is the comprehension of the structure and functions of the human brain, yet it is held to be desirable that students should understand the general pattern of the organ and recognize both the conformity of the human thereto and the degree of its departure therefrom; for this purpose are studied the brains of certain lower vertebrates, especially the green turtle (*Chelone mydas*, p. 148) and the sheep (pp. 209 and 374).*

§ 10. Although the pattern of the cerebral fissures of man and the other primates differs widely and perhaps irreconcilably from that of the other mammals (p. 198, § 303), yet the methods of fissural study apply equally to all, and the comparative simplicity of the fissures in dogs and especially cats renders them convenient subjects upon which to commence a difficult branch of neurology (pp. 187–206).†

§ 11. Still other animal brains may be found useful in the illustration of special points (*e.g.*, pp. 140, 148, 150, 170, 204, and 207); but I strongly deprecate the extent to which merely curious or startling facts of comparative anatomy are sometimes introduced into medical publications.

§ 12. Before the *detailed* study of the contours of the masses there is gained a general idea of the cavities, their connections and their circumscription.

§ 13. Skulls—which may be purchased or easily prepared under nearly all circumstances—are less esteemed than brains; the "kernel" is more highly valued than the "shell."

§ 14. The infant cranium is divided with scissors and nippers (Fig. 986), or softened by ten per cent. nitric acid so as to be cut with the knife.

§ 15. The common method of dislodging the adult calva (calvaria or skull-cap), after the circular cut with the saw, by "inserting a strong hook and giving a quick jerk," is held to be artistically brutal and anatomically futile; a second, sagittal, section is made, a little way from the meson (middle line) and the calva removed in two pieces; § 60, *E.*

§ 16. Excepting for special reasons the dura is retained

*Were opossums as common as cats in most civilized lands the less preponderance of the cerebrum and cerebellum over other parts would warrant the general study of their brains.

†I desire to reiterate here the conviction expressed on several previous occasions as to the inutility of the brains of ordinary monkeys for the elucidation of human fissural problems; indeed, our present comprehension and nomenclature of cerebral elevations and depressions would be far better than they are had neither Gratiolet nor any other anatomist ever examined a monkey brain.

until the calva is removed, and it is sometimes extracted with the brain.

§ 17. The fresh brain is removed over brine (saturated and filtered), supported in it during the operation, and kept in it until its final disposition is made.

§ 18. A fresh brain in the dura is lifted by the latter and supported in liquid by attaching cords to the dural edges, the other ends of the cords being carried over the rim of the pail or other vessel and wound about hooks, or otherwise attached.

§ 19. A fresh brain deprived of its dura, if it is to be either studied from any aspect or injected into the arteries or the cavities, is supported and steadied in a pail of brine by passing under it a towel or broad strip of cloth, the ends of which are secured to the pail by hooks, tacks, or otherwise; the brain may thus be kept at any height in the brine, and rotated without touching it.

§ 20. The fresh brain is never allowed to bear its own weight or to rest upon a flat surface, but is supported in the calva or in a bowl of appropriate shape, or in a liquid of equal specific gravity, or on a bed of *ordinary* cotton.*

§ 21. The use to be made of a brain is, if possible, determined upon in advance. If only part is to be employed for a specific purpose, the rest is cut away and preservative effort concentrated upon the selected portion.†

§ 22. When the brain is to be preserved entire, especially for the elucidation of membranous attachments and the circumscription of the cavities, alcohol (or other active preservative liquid) is injected into the arteries by continuous pressure, and thus carried directly to the tissues; §§ 99 and 114.

§ 23. When a separated head is obtained the brain is sometimes hardened in place by the continuous injection of alcohol (§ 99); it shrinks somewhat, but retains its natural proportions. Such a head, medisected with a sharp saw, is instructive in many respects (Fig. 670, p. 141). Sometimes sections are made in other directions, or the calva removed as with the fresh brain (§ 60).

§ 24. For macroscopic purposes freezing is avoided, as tending to leave the mass friable.

§ 25. If a specimen is to be used especially for the elucidation or demonstration of the contours and circumscription of the cavities and the lines of attachment of membranes and plexuses, strong alcohol, or an alcoholic solution of zinc chloride, is injected into the cavities and the arteries.

§ 26. If certain portions of the cavities are in question, free access of the preservative is gained by widely opening some other region, as, *e.g.*, by cutting off a frontal, temporal, or occipital lobe.

§ 27. Unless there are special reasons to the contrary, brains are transected in the narrow region of the mesencephal (gemina or optic lobes) (Figs. 689 and 756); the cerebral and cerebellar portions are then removed separately with greater ease and less risk of laceration (§ 60, *J.*). Each of these regions is medisected, if desired, more accurately than the entire brain can be, whether before or after hardening, and the two divisions of either half are subsequently apposed for study, or even attached for exhibition.

§ 28. When the mesencephalic region itself is to be preserved intact, by lifting the occipital lobes a little more the transection is made through the diencephal (thalami) (Fig. 707).

§ 29. For the study of fissures and gyres, the cerebrum (with the thalami) is commonly medisected (§ 61), and each half hardened by placing it on its mesal surface in the preservative.

*So general has become the use of absorbent cotton that one does not always realize that its very excellence for certain purposes renders it less appropriate for others; when wet it packs very closely, whereas, in any liquid, the ordinary cheap cotton retains its elasticity much longer.

†The city neurologist has perhaps only to decide that a brain is needed; but others, like the writer, may find it advantageous to keep in a portfolio slip memoranda of what he wishes to do with fresh brains, or heads, adult or young, as the case may be; when the opportunity occurs he has only to decide among several things that might be done, and little time is lost.

§ 30. So far as possible, incisions of the brain are made in liquid or while the scalpel is irrigated; with hardened brains alcohol is used; with fresh a salt solution.

§ 31. Specimens which have become dry and distorted are immersed for a day in weak spirit (twenty-two per cent.), and then replaced in the strong alcohol.

§ 32. When part of a thin brain preparation (*e.g.*, a hydrocephalous cerebrum like that shown in Fig. 715) has dried, it is restored by placing on the spot a bit of absorbent cotton wet in water.

§ 33. To remove a delicate specimen from a vial, the vial is immersed in a dish of alcohol and the specimen floated out; to replace it, if the alcohol is clear, the vial is immersed and the specimen floated in; if turbid, the specimen may be transferred upon a bit of paper, a watch glass, spoon, or *upon—not between*—the points of the fine, curved forceps (Fig. 985).

§ 34. Friable specimens are infiltrated with paraffin; see the paper by W. C. Krauss (Buffalo *Medical and Surgical Journal*, November, 1888) and publications referred to.

§ 35. Defibrillation—the tearing of brain substance in the direction of the least resistance so as to make "cleavage preparations"—is not regarded as affording conclusive evidence of tract arrangement; but it is practised in illustration of facts determined by more exact methods, microscopical, pathological, and experimental.

§ 36. For the decided maintenance or increase of the color differentiation of the two kinds of nervous tissue, alba and cinerea (p. 139, Fig. 66), specimens are immersed in, or injected with (or both), a solution of potassium dichromate (§ 85); or Müller's liquid (§ 86).

§ 37. When the color and microscopic structure are subordinate to purely morphologic considerations a choice is made between four compound liquids devised by past or present assistants in the laboratory, the zinc-glycerin (§ 88) or the zinc-formalin (§ 89) of Fish, the saline-alcohol (§ 90) or the simplified saline-alcohol (§ 90) of Stroud.

§ 38. Dry (mummified) preparations are made according to the improved method (turpentine and castor oil) of P. A. Fish (§ 117).

§ 39. When the larger vessels are to be studied, Gage's modification of Pansch's starch mixture is employed (§ 120); if the ultimate vascular supply is in question, a fine gelatin mass is used (§ 121).

§ 40. When practicable the leptomeninges (pia and arachnoid) are removed as soon as they loosen from the surface, which is commonly within two days after immersion; but this is not essential, for they may be removed at any subsequent period, with merely somewhat more care against breaking or wounding the hardened brain.

§ 41. Alcoholic brains are examined before fresh ones.

§ 42. The size and form of the cavities are maintained and the preservation of their immediate parietes is insured by injecting alcohol into them; Fig. 731.

§ 43. The forms of cavities are ascertained by making solid casts; Fig. 718.

§ 44. Encephalic fragments, and poorly preserved or distorted specimens serve for preliminary dissections, so that the perfect material may be more readily utilized.

§ 45. Before attempting to comprehend large sections, involving perhaps several parts but distantly related excepting by topographical contiguity (Fig. 732), the beginner makes dissections for the exposure of parts in their structural continuity; Figs. 681, 682, and 801.

§ 46. To facilitate discrimination of natural from artificial surfaces, especially upon permanent preparations, incisions always follow straight lines and meet at angles rather than join by curves; see Figs. 708 and 733.

§ 47. Specimens that might be injured by falling upon a hard surface from the height of even a decimetre (four inches) are held during examination over a pad of cotton or a dish of alcohol, and carried from room to room in a vessel and not in the hand.

§ 48. Embryos and delicate brain preparations are dissected under alcohol, and sometimes pinned to a piece of

cork loaded with sheet-lead; see Fig. 734. Preparations including the medicommissure (Fig. 709) are supported upon cork while making and for exhibition.

§ 49. In brain dissection, as in surgery, the knife is made the last resort; blunt points and blowpipes are employed as long as possible. When cutting is to be done the aphorism of Dr. Holmes is recalled: "Let the eye go before the hand, and the mind before the eye."

§ 50. Delicacy of manipulation is cultivated and a prompt check put to all forms of anatomical Philistinism, whether in word or deed; the student is urged to practise self-control, to restrain what Hyrtl calls the "*furor secandi*," and never touch his specimen except for a good and sufficient reason. From the ecclesiastical standpoint, perhaps, the "laying on of hands" cannot be overdone, but in practical anatomy its excess is likely to prove the reverse of a blessing. These cautions are called for in
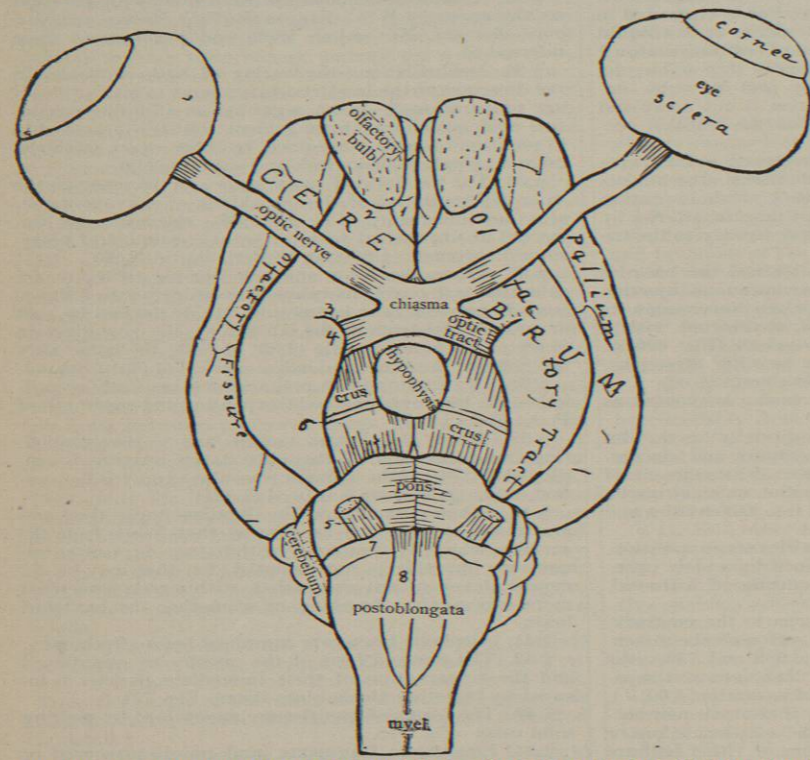
FIG. 978.—Base or Ventral Aspect of the Sheep's Brain with the Eyes Attached. Slightly enlarged. (From "Physiology Practicums.") 1, Frontal portion of pallium mesad of olfactory bulb; 2, narrow portion of olfactory tract (compare Fig. 688, p. 153); 3, precibrum ("anterior perforated space") just cephalad of the optic tract; 4, tip of temporal lobe overhanging optic tract; 5, root of trifacial (trigeminus or fifth cranial nerve); 6, opposite the narrow band of fibres crossing the crus, called by von Gudden "tractus peduncularis transversus," cimbia by the Ass'n Amer. Anatomists; 7, trapezium, concealed in man by the overhanging margin of the pons; 8, pyramid. Compare Figs. 672 and 689, pp. 143 and 154. Most of the nerve roots and many other details are omitted.

respect to the dissection of muscles, etc., to which the examination of the brain is as watchmaking to the wielding of hammer and tongs.

§ 51. All specimens are numbered as soon as received (§ 146), and the essential data preserved in the form of a card catalogue (§ 151).

§ 52. From the beginning students are required to make outline drawings, accurate if not artistic, and clear rather than shaded.

§ 53. *Preliminary Work upon Animal Brains.*—I cannot too strongly emphasize the view indicated in § 7 as

to the desirability of gaining from the comparatively inexpensive brains of lower mammals the manipulative dexterity and the familiarity with parts and their names so essential to making the best possible use of the precious and costly brain of man. The two particularly recommended are of the sheep and the domestic cat; but the methods of removal and dissection appropriate for the latter may be applied to the rabbit and to small dogs, while larger dogs, the pig, the calf, and cattle may be dealt with substantially as indicated for the sheep.

§ 54. *Removal of the Sheep's Brain.*—Unless already familiar with the general form and size of the organ it will be well to consult the representations of it on pp. 153, 173, 208, 209, 372, 374, 382, or a plaster cast such as may be had for a small sum at Ward's Natural History Establishment, Rochester, N. Y. The mode of extraction recommended was devised by Prof. P. A. Fish while instructor in my department in 1890, and is indicated, perhaps sufficiently, in Figs. 979 and 980. In brief, the cranium, containing the brain, is removed from the facial portion of the head by sawing in a plane coinciding with the ventral margins of the orbits and of the foramen magnum. The corners of the cranium are then sawn off and the brain exposed with nippers, beginning with the base. The nerve roots must be divided with the scissors, the dura must be divided about the hypophysis, and special pains taken to dislodge the olfactory bulbs from their fosse (§ 60, H).

§ 55. *Instruments Required.*—In addition to a stout knife, coarse forceps, and coarse curved scissors, strong nippers, and a medium-sized saw, the sawing will be easier and more expeditious if the head can rest against the edge of a board or in an oblique sort of miter-box; the form of this will readily suggest itself if the operation is repeated several times.

§ 56. *Removal of the Cat's Brain.*—The following directions are condensed and modified from W. and G., pp. 428–432. The brain only is considered here and other parts are disregarded. Consult Figs. 682 and 686, pp. 149 and 151. The head is supposed to have been cut off.

A. *Instruments and Materials.*—Arthrotome or stout scalpel; coarse curved scissors and forceps; nippers of medium size.

B. *Removing the Skin.*—With arthrotome or knife, divide the dorsal skin from near the nose to the caudal free margin. Remove the skin in the easiest way by putting the connective tissue on the stretch and cutting. Note the third eyelid or plica at the mesal angle, represented in man by a vestigial fold of mucosa.

C. *Removing the Mandible.*—Dissect the temporal muscles from the side of the cranium. Divide the zygoma with the nippers, its cephalic end by pushing a point

* According to the view expressed on p. 209, § 371, the part marked 3 and the olfactory tract cephalad of it, are parts of the rhinencephal, while 4 and 6 are portions of the prosencephal.

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ventrad, between it and the eyeball; its caudal end by pushing a point ventrad from the temporal fossa just cephalad of the auditory meatus. The mandible may now be moved up and down so as to indicate the location
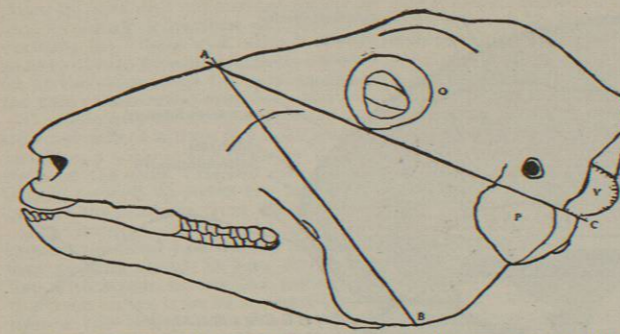
FIG. 979.—Left Side of Head of Sheep, Skinned. (From my paper, 1896, g.) Along the line A–B the butcher may cut with saw or cleaver so as to remove most of the face; it extends from the angle of the jaw to a point about midway between the nose and the prominence of the head between the eyes. The rest of the face is then to be separated from the cranium by sawing somewhat accurately along the line A–C, intersecting the ventral margins of the orbit O, and of the occipital condyles V. See § 54.

of the joint; open this with the arthrotome; cut the soft parts about the mouth and throat and remove the mandible together with the larynx, esophagus, etc.

D. *Remove the eyes* by cutting the muscles, etc., with curved scissors. The white cylindric optic nerve at the bottom of the orbit is to be cut, not torn.

E. *Remove the cervical muscles* by cutting lengthwise at either side of the cervical spines and then dissecting off the muscles. With the nippers cut off the spines; the atlas, of course, has none. Note the occipital crest for attachment of the strong muscles.

F. *Opening the Cranium.*—Rest the head on either side. Apply the nippers at nearly right angles to the convex temporal region and "gnaw" through the cranium till the dura is reached, taking care not to plunge the points into the brain. The dura may be recognized by toughness and non-vascularity. It may adhere so closely to the bone as to come off with it, but should be left on the brain for the present if possible. Continue to expose the brain by nipping off successive fragments, by breaking rather than by direct cutting. Before crossing the meson expose the entire lateral aspect of the cerebrum and continue cautiously cephalad to the olfactory bulb.

G. *The Cerebellum.*—Expose this from the same side. Between it and the cerebrum is a bony tentorium, which may be removed without injuring the brain if the nippers are introduced sidewise for about 1 cm. between the cerebellum and the cerebrum at the meson and just above the meatus. Continue caudad by nipping the sides of the atlas and axis so as to expose a portion of the myel.

H. *The other half* of the brain is most easily exposed by passing the nippers-point between the cranium and dura at the meson, and nipping or breaking off fragments as before; but constant care will now be needed lest the fingers crush the side already exposed.

I. *Remove the maxilla* by cutting with the nippers across the spongy ethmoid region about 1 cm. cephalad of the cerebrum, and then dividing the base and sides of the maxillary bone. The olfactory bulbs may now be exposed; at the first trial one or both is almost sure to be torn or crushed.

J. *Remove the base of the cranium,* in fragments, using both nippers and coarse scissors cautiously until at about the middle of the cerebrum is seen the chiasma; try to expose the optic nerves for a few millimetres; avoid pulling upon them lest the brain be torn. The hypophysis lies just caudad and is to be saved if possible.

K. Hold the specimen, ventral side up, the brain just

resting in a dish of brine. By raising the base of the cranium carefully there may be recognized successively the pairs of cranial nerves; each is to be cut with the scissors as far as possible from the brain. Continue caudad as far as the myel was exposed; then divide the myel.

L. The ventral dura has probably been removed with the base of the cranium. Remove the remainder as convenient, noting the mesal fold between the two hemicerebrums, constituting the falx, and its connection with the layers of dura between which was the bony tentorium.

§ 57. *Endymal Continuity and Celian Circumscription.*—A detailed account of these features of the mesal cavities of the human brain occurs on pp. 151–152 in connection with Fig. 687. In connection with it, and preferably as preliminary to it, the mesal aspect of the sheep's brain may be studied by the aid of Fig. 981.

§ 58. *Transections.*—Before transecting or dissecting the human brain it is well to make and study carefully transections of the sheep's brain at levels such as are indicated in Fig. 981; and at others as preferred. They are more instructive in some respects if the alba and cinerea are differentiated as by some chromic acid compound (§§ 84–86).

§ 59. *Fig. 981 illustrates:* A. The general similarity to the corresponding aspect of the human brain as shown on pp. 141, 189, and 213.

B. The slighter cranial flexure; p. 142, § 36.

C. The smaller relative size of the cerebrum, permitting the cerebellum and even the olfactory bulbs to appear in a dorsal view of the organ; p. 144, § 40.

D. The large size of the medicommissure; p. 166, § 151.

E. The distinctness of the crista in the adult sheep; p. 208, § 366.

F. The non-extension of the callosal rostrum, as a copula, to join the terma, as in man and the chimpanzee, and the consequent closure of the narrow pseudocele by the pia only; p. 184, § 223.

G. The absence, as in mammals generally, of small foliums upon the lingula; p. 160, § 119.

H. The absence, as in mammals generally, of a metapore (foramen of Magendie); p. 154, § 78.

I. The completeness of the endymal continuity or celian circumscription; p. 151, § 63.

J. The possibility of transecting several of the segments without cutting others. A–A crosses the myel;
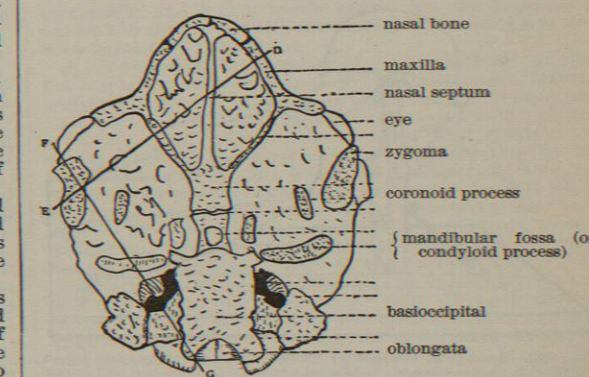
FIG. 980.—Ventral or Cut Surface of the Cranium as Separated from the Face Along the Line A–C (Fig. 979). If the parts outside the lines D–E and F–G are sawn off, the brain may be exposed by removing with the nippers the base and one or both sides of the cranium.

B–B the postoblongata, metencephal, overhung by the cerebellum; C–C, the epencephal (cerebellum, preoblongata, and pons); D–D, the mesencephal (crura and quad-

rigeminum); E–E, the diencephal (tuber, medicommissura, thalami, etc.), overhung by the cerebrum; F–F, prosencephal (cerebrum) just cephalad of the chiasma
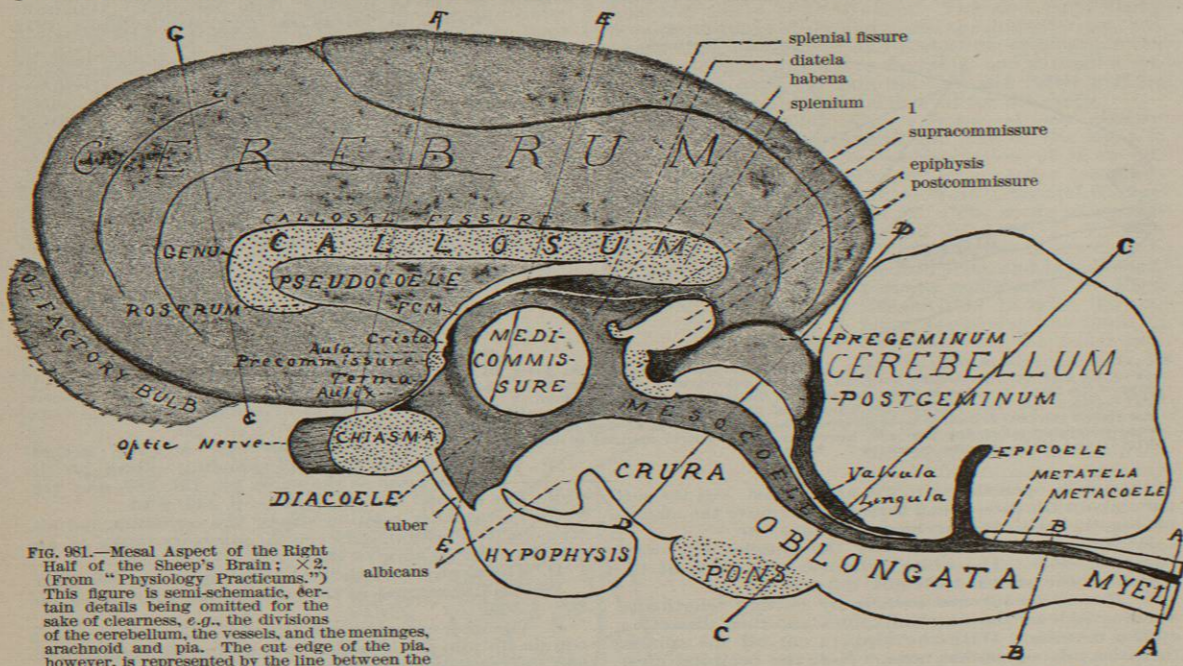

FIG. 981.—Mesal Aspect of the Right Half of the Sheep's Brain; × 2. (From "Physiology Practicums.") This figure is semi-schematic, certain details being omitted for the sake of clearness, e.g., the divisions of the cerebellum, the vessels, and the meninges, arachnoid and pia. The cut edge of the pia, however, is represented by the line between the rostrum and the crista. The names of the cavities, Diacoele, etc., should be spelled Diacoele, etc. The lines A–A to G–G represent planes of instructive transections. See § 58, J.

G–G, the rhinencephal, at the junction of the olfactory bulb and tract (pp. 153, 173, 208, 209) overhung by the cerebrum.

§ 60. Removing the Adult Human Brain.*—The method here recommended and described differs from those sometimes employed in three respects: First, since the brain is
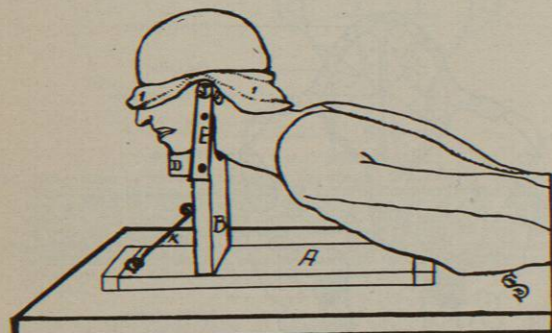
FIG. 982.—Head-Rest Devised by Stroud, in Use. (From his paper, 1900, b.) A, Baseboard; B, upright board; D, chin-rest; E, lateral iron bar. For details see Figs. 988–989, and §§ 142–143. 1–1, Reflected portions of the scalp.

not to be sliced or cut into small pieces for histologic examination, but preserved entire or in large divisions for morphologic investigation and demonstration, the

removal is done leisurely * and with care so as not to distort form or rupture membranous connections. Secondly, the calva (calvaria or skull-cap) is divided sagittally 1 to

2 cm. from the meson and removed in two pieces. Thirdly, the subject lies upon the belly with the head supported and steadied in the "head-rest" devised by Dr. Stroud (Figs. 982, 988).

A. Instruments and Materials.—In the absence of a well-equipped post-mortem case (see the article Autopsies) the following should be provided: Scalpel, medium size; arthrotome (Fig. 985) or a similar stout knife; syringotome (Fig. 985); probe-pointed bistoury (§ 138); coarse scissors and forceps; fine scissors and forceps; tracer; bone-chisel (§ 139); mallet or hammer; strong hook, for catching on the divided margin of the calva and dislodging it; † saw (§ 140); drill or awl or wire nail; wire and cutting pliers (p. 385); ‡ surgeon's needles and silk; absorbent cotton; common cotton; plaster of Paris; towels and Japanese napkins; scales; several pans of water and of brine, one large enough for mediaection of the cerebrum. The beginner will do well to have at hand for consultation a hardened brain and a preparation of the dural folds (falx and tentorium) or models or good figures of the same (Fig. 800).

B. Dividing the Scalp.—Between the roots of the ears carry a cord over the highest region of the head. Wet the hair along this line over a zone 2–3 cm. wide.§ With

* See also the articles Autopsies and Brain, Surgery of.

* Commonly an hour and a half is allowed for the operation; but on one occasion, in an emergency, with the aid of a single assistant, Dr. Stroud removed a brain and made the head presentable for waiting friends within forty minutes.

† In the absence of one made for the purpose it may be made from stiff wire; some large pocket knives have a hook of suitable size and strength.

‡ The pliers used by the linemen of the telegraph and telephone answer admirably for both cutting and twisting.

§ This and some other details presuppose that the body may be viewed by friends or that there are other reasons for the minimum of disfigurement. Under certain circumstances they may be disregarded, although I think it well to maintain an almost esthetic and artistic attitude toward all dealings with the human brain.

a narrow scalpel handle or any convenient instrument part the hair along the cord so that none remains crossing the line of incision. Mark the proposed line with a soft pencil or a fine point, and remove the cord. Insert a scalpel point at the top of the head with the edge away from the head and cut toward either ear along the chosen line, avoiding deflections and the division of hairs. Divaricate the edges and repeat the incision if necessary so as to divide fat and connective tissue to the periosteum, or, at the sides, over the ears, to the firm fascia covering the thin (temporalis) muscle in that region.

C. Reflecting the Scalp.—Dissect up the scalp at either side and reflect it over the neck and the face to a level, if possible, a trifle lower than the first incision between the roots of the ears. Before reflecting the frontal portion it may be well to cover the face with a pad of cotton to protect the features from undue pressure.

D. Circular Division of the Cranium.—Tie a cord around the head just dorsad of the ears, the frontal portion passing about 15 mm. from the brows; mark this line with a pen, or cut the periosteum to the bone. If the fresh calva is to be secured in place after the extraction of the brain, leave the fibrous cephalic and caudal margins of the temporal muscles for the stitches to be taken in; otherwise these muscles may be removed entirely.

In sawing,* three points are to be observed: (1) The thicker frontal and occipital regions should be taken first; (2) at four places, preferably what might be called the four corners of the cranium, the bone is not to be divided completely until the calva has been sagittally divided (§ 66); (3) if the ectal features of the cranium should be preserved intact, a sectioned cranium should be consulted in order to estimate the thickness at variable points, and frequent trials should be made by pushing a point, like the probe end of the tracer, into the kerf (saw-cut) at the middle of that part of the convexity; when it can be pushed through, the sawing should proceed with care in each direction.

E. Sagittal Division of the Calva.—After the circular kerf has been completed, but before the calva has been loosened by the chisel,† carry a cord from the brows to the occipit, over the head, at about 13 mm. (half an inch) from the meson; along this line cut or mark the periosteum, and saw completely through the bone. Then, with taps of the hammer upon the chisel, sever the remaining attachments of the circular kerf. Sometimes that piece will come off readily; if not, introduce the spatula in the temporal region, where the bone is thin, keep its point pressed against the bone and so detach the piece; in some cases the spatula must be introduced at other points, always with the minimum amount of pressure upon the brain.

The mesal adhesions along the sinus are now directly accessible, and a sharp edge may be employed if necessary. The location of any other adhesions may commonly be inferred from what existed upon the first piece, and the removal of the larger side of the calva is completed without difficulty.

F. The Dura.‡—Unless it is desired to retain the calval dura entire the longitudinal sinus should be slit to let out the blood. Commonly, notwithstanding all precautions, the saw has cut the dura at some point. There—or at any other point—commence with the scissors or probe-pointed bistoury, and cut the dura along a line about 2 cm. from the margin of the cranium and turn

it outward so as to protect the delicate brain from the sharp or rough edges of the cranium.* Lift the sides of the dura in turn, cutting with scissors any vessels or fibrous connections between the dura and the cerebrum; near the meson there are several veins entering the longitudinal sinus. Unless the entire calval dura is to be preserved the two sides may now be cut away along the margins of the sinus.

G. The Falx.—On Figs. 800, 801, and 804 (pp. 212, 213, 215) note its form and its relations to the crista galli, the tentorium, and the callosum. In a good light divaricate the frontal lobes so as to expose the narrow cephalic portion of the falx and transect it with scissors. Lift the end slowly, dividing membranous and vascular attachments as they appear; at its wide occipital end there will be need of especal care lest the traction dislocate the important relations of parts about the splenium. The wide end of the falx may now be divided along its attachment to the tentorium.

H. Freeing the Ventral Attachments of the Cerebrum.—These are (a) the entocarotid arteries ("internal carotids," Fig. 803, p. 214) and some smaller vessels and fibrous bands; (b) the optic nerves (Fig. 672, p. 143), the hypophysis (Fig. 689, p. 154), and the filamentary olfactory nerves passing from the ventral side of the bulb (Fig. 672, p. 143) through the cribriform plates. Unless these filaments are divided the bulbs or their tracts are likely to be torn. The head should be tilted a little so as to permit some recession of the frontal lobes. Raise these and allow a good light to enter between them and the cranial floor. With the syringotome or other small curved instrument, divide or tear the soft olfactory nerves as they enter the cribriform plate so as to free the bulbs; sometimes it may be done most easily with fine curved scissors.

The carotids are easily recognized at the sides of the chiasma and should be cut with the scissors.

The optic nerves are tough and not apt to tear, but the slender infundibulum is very easily broken; hence, before dividing the nerves, it is well to cut the dura at the margins of the hypophysial (pituitary) fossa and so dislodge the hypophysis as completely as possible. When this is accomplished divide the optic nerves close to the cranium.

Now tilt the head first to one side and then to the other so as to permit the division of some veins connecting the temporal region with the cranium.

I. The remainder of the operation will differ according as the brain is to be removed entire or in two portions, cerebral and cerebellar. For most purposes the latter is preferable, and it is so much easier that the beginner is advised to adopt it until familiarity with the parts has been gained by experience.

J. Transecting the Mesencephal.—Tilt the head so that the cerebrum tends to slide somewhat cephalad. Lift the occipital lobes and with the scissors cut the vessels and connective tissue and membranes just caudad of the splenium (Fig. 801) so as to expose the gemina, the dorsal lobes of the mesencephal corresponding to the crura ventrad (Figs. 707, 708). This is the narrow region connecting the wider cerebellar mass with the still wider cerebral portion, and hence called sometimes the "isthmus." With the probe-pointed bistoury or sharp, narrow scalpel cut this just caudad of the epiphysis; the knife should point almost directly at the tip of the nose if the pons is to be wholly avoided. It is sometimes well to make two cuts, one from either side, directed slightly cephalad as well as mesad so as to avoid the caudal margin of the pons. The trochlearis and oculomotor nerves will probably be cut during the transection. If not, they are to be watched for and divided during the next step.

The cerebrum may now be lifted out with both hands and weighed (§ 62) or otherwise dealt with as desired (§ 61).

K. Tentorium.—This is to be cut, with the blunt-pointed bistoury or the coarse-curved scissors, along its

* Most of the sawing should be done by an assistant, that the chief may better accomplish the later operations.

† If the conditions are such that the calva must be kept entire there seems to be no other way than to remove it by pulling upon either the frontal or occipital edge with a hook as is commonly done at post-mortems; but this is almost certain to tear the brain or its telas or plexuses so as to render them unsuited for morphological eluciclations.

‡ Space will not permit detailed directions for removing the brain in the dura; suffice to say that with care and patience and anatomical knowledge it may be accomplished so that only a small part of the dura is absent from the central region of the base. For the safe handling of the brain and for alinjection purposes even the dorsal half of the dura is worth saving. See pp. 171 and 213, Figs. 720 and 801.

* For this valuable suggestion I am indebted to Dr. Stroud.