of a persistent bitter taste. It is very insoluble in water ($\frac{1}{5000}$), but dissolves rather freely in alcohol, and more freely in chloroform. A second alkaloid, *parabuxin*, was found by Pavia to accompany the buxine in box; and it is still probable that some other principle may be found to explain the poisonous qualities it has been occasionally observed to have.

USES.—Box has had some reputation as a febrifuge and tonic; in large doses it is purgative and emetic. It is suspected of being sometimes used to replace hops in beer; but it is little employed in medicine to-day. The alkaloid *buxine* (bebeerine), either from box or bibiru, has been offered as a substitute for quinine in intermittents, but is much inferior; in the same large doses it deranges the stomach and digestion; in small doses it, however, is an excellent tonic. *Buxine* has been found in several plants of entirely different orders, and is probably, like berberine, a rather extensively distributed alkaloid. The bebeerine of bibiru (*Nectandra Rhodiœi* Schomb.), the pelosine of pareira (*Chondodendron tomentosum* R. et P.), as well as of the false pareira, have been shown by Flückiger and others to be identical with this alkaloid, although it is not quite certain that the physiological effects of buxine from all these sources are the same. The *sulphate* and *hydrochlorate* of buxine are in the market. Dose, as a tonic, from 5 to 10 cgm. (0.05–0.10 = gr. i. ad ij.); as a febrifuge, eight or ten times as much (0.5–1 = gr. viij. ad xvi.).

W. P. Bolles.

BRADFORD MINERAL SPRINGS.—Merrimac County, N. H.

POST-OFFICE.—East Washington. Hotel.

ACCESS.—From Boston viâ the Lowell Railroad to East Washington; thence one mile to hotel at springs. Stages await trains during the season from May 15th to October 15th.

This spring became known to the white settlers in 1770, and since early in the present century its waters have been used for medicinal purposes. An analysis by Dr. Jackson, of Boston, subsequently confirmed by Dr. Richards, of Poughkeepsie, New York, showed the presence of the following ingredients: Sodium chloride, potassium chloride, sodium carbonate, calcium carbonate, magnesium carbonate, calcium phosphate, iron oxide, aluminum oxide, organic matter, sulphur, carbonic acid gas.

We are unable from this analysis to assign the water to its proper class, although it is probably a sulphureted chalybeate. The spring yields twenty-one hundred gallons hourly. The water is clear and sparkling, and emits an odor of sulphureted hydrogen gas. It has been successfully used by the residents of the neighborhood in the treatment of certain cutaneous diseases, especially eczema. It is said to be a very efficient diuretic and tonic, and seems to be well adapted for rheumatism and diseases of the alimentary tract, and for conditions in which the urine is scanty and high-colored. As a douche in nasal catarrh and in catarrhal states of the vagina and uterus it has been found useful. There are bathing facilities for guests who wish to take hot or cold sulphur baths. The surroundings of the place are very attractive, and ample amusements and diversion are afforded the visitor in the way of bowling, shooting, fishing, driving, etc.

James K. Crook.

BRAIN. (ANATOMICAL.)—I. INTRODUCTION. § 1. *Scope of this Article.*—The development of the brain, its growth, histology, functions, blood-vessels and surgery, and the methods of its removal, etc., are presented under appropriate titles. In this article the organ will be considered mainly from the standpoint of normal morphology, with occasional elucidations from embryology, comparative anatomy, and teratology.

I regret that so many points remain undetermined and so many problems unsolved. These relate especially to the meninges and the olfactory region of the brain.

§ 2. *Order of Treatment.*—I. Introduction, §§ 1–13.
II. General Constitution of the Brain, Segments, etc., §§ 14–69.
III. The Metencephal (postoblongata), §§ 70–90.
IV. The Epencephal (preoblongata, cerebellum, and pons), §§ 91–128.
V. The Mesencephal (gemina and crura), §§ 129–141.
VI. The Diencephal (thalami), §§ 142–157.
VII. The Prosencephal, its cavities, parietes, commissures, fissures, and gyres, §§ 158–356.

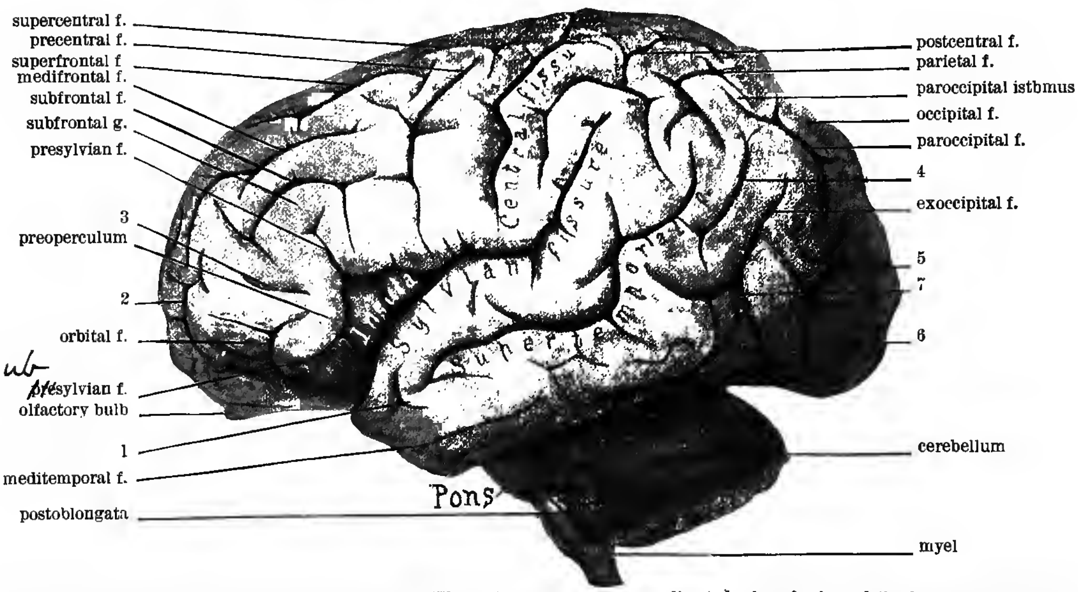


FIG. 663.—Left Side of the Brain of a Male Child at Birth; 478. × 1. The brain was medisected when fresh, and the hemicerebrum spread and flattened considerably while hardening. The specimen is really the right half, but for readier comparison with other specimens and figures a diagram was made (by Mrs. Gage) reversed so as to represent the left half. This figure is based upon a photograph of the diagram. The cerebellum is correct in outline, but no details are shown. Other aspects of the same specimen are shown in Figs. 702, 756, 774, 775. Just ventrad of the narrow isthmus, between the overlapping branches of the subfrontal and precentral fissures, is a white x; 1, 2, 3, 4, 5, 6, undetermined fissures; 7, an isthmus between 6 and the exoccipital which is nearly concealed by the adjoining gyres. See § 4.

VIII. The Rhinencephal (olfactory bulbs, etc.), §§ 357–372.
IX. The Meninges (dura, arachnoid, pia), §§ 373–409.
X. Bibliography.

§ 3. *Method.*—The text consists largely of commentaries upon the points illustrated by the figures. What seem to me the more important facts and fundamental ideas of encephalic morphology are embodied in concise propositions. Unless otherwise stated these propositions apply to the human brain, and may not always hold good for those of other vertebrates, or even other members of the mammalian class.*

§ 4. *Fig. 663 illustrates:* A. The general aspect of a brain from the side; its continuity with the myel (spinal cord) through the oblongata; the existence of a smaller mass (the cerebellum) and a larger (the cerebrum); the overlapping of the former by the latter more extensive at birth, and in earlier than adult brains; the existence of other parts, the olfactory bulb, the pons, and the oliva (the elliptical elevation of the postoblongata upon which the line from that word ends); the fissures of the cerebrum; the subdivisions of the cerebellum (foliums) are not indicated.

(The remaining points illustrated refer to the cerebral fissures, and may be considered more advantageously in connection with Part VII.)

B. The simple, almost schematic, relations of the fissures demarcating the several operculums (compare Fig. 784); the preoperculum only is named. The suboperculum is the region ventrad of the subsylvian fissure. The operculum is between the presylvian and Sylvian fissures; and the postoperculum is the overlapping margin of the temporal lobe, the region on which is the word *Sylvian* and ventrad of it.

C. The incomplete covering of the insula (see Fig. 788)

D. The presence of a distinct medifrontal fissure, subdividing the medifrontal gyre.

E. The independence of the postcentral, parietal, and paroccipital fissures.

F. The presence of the exoccipital (the "ape fissure" of some writers).

G. The frequency of the zygal or H-shaped form of fissure—*e.g.*, paroccipital, parietal, postcentral, subfrontal, orbital, and fissure 2; see § 307.

§ 5. *The Facts.*—Most of the statements are parts of common anatomical knowledge, and special references are seldom given in this connection; therefore the following extract from the preface to Huxley's "Anatomy of Vertebrated Animals" may be appropriately added:

"The reader, while he is justly entitled to hold me responsible for any errors he may detect, will do well to give me no credit for what may seem original, unless his knowledge is sufficient to render him a competent judge on that head."

§ 6. *The Ideas.*—Unfortunately, the facts of anatomy are susceptible of various interpretations according to the relative weight assigned to them. In particular there are divergent views respecting the segmental constitution of the entire brain and the normal pattern of the cerebral fissures.

§ 7. *The Illustrations.*—Of the one hundred and forty-five figures, one hundred represent preparations made by me for the museum of Cornell University; these preparations are designated by their catalogue numbers. The drawings have been executed, from the specimens and from photographs, by Prof. E. C. Cleaves (C.), Mrs. S. H. Gage (G. or S. P. G.), and Mrs. Wilder. The twenty-five borrowed figures are credited to their sources. The remaining illustrations are original diagrams or drawings, or direct reproductions of photographs.

§ 8. *Terminology.*—The general subject will be discussed in the article *Terminology, Anatomical,* in another volume; meantime those interested are referred to the article under that title in Vol. VIII., of the first edition, pp. 515–537; to "Anatomical Technology" (Wilder and Gage, 1882); to the Reports, during the last ten years, of Committees of the American Association for the Advancement of Science, the American Neurological Association, the Association of American Anatomists, and the Anatomische Gesellschaft; to the article, "Anatomical Nomenclature," by F. H. Gerrish, in "Progressive Medicine," for 1899, pp. 327–346; to G. M. Gould's "Suggestions to Medical Writers," 1900, chap. iv.; and to my address, "Some Misapprehensions as to the Simplified Nomenclature," Assn. Amer. Anat., Proceedings, 1898, pp. 15–39, and *Science,* April 21st, 1899. The principal publications prior to 1896 are included in the bibliography of my "Neural Terms, International and National," *Jour. Comp. Neurology,* December, 1896, vol. vi. Here, therefore, it is necessary only to comment briefly upon the two groups of terms employed in this article.

§ 9. *Terms of Position and Direction* (*Toponyms*).—In place of the more or less ambiguous terms *upper, lower, anterior, posterior, inner, outer,* etc., will be employed terms referring to the regions of the vertebrate body in whatever attitude it may be—viz., *dorsal, ventral, cephalic, caudal, mesal, lateral, ental, ectal,* etc., constituting an intrinsic toponymy. The adverbial forms are *dorsad, mesad, ectad,* etc.

§ 10. *Terms of Designation* (*Organonyms*).—Each part is designated uniformly by one and the same name. Where two or more names are already in use, the simpler or shorter has been chosen. In some cases simple names have been formed by the omission of unessential words or by the combination of two, or by the coinage of words from the Latin or Greek. Where the English form (paronym) differs from the classical the former is often preferred. For examples, "pneumogastric" becomes *vagus;* "pons Varolii," *pons;* "corpus callosum," *callosum;* "commissura anterior," *precommissure;* "aquæductus Sylvii" and "iter a tertio ad quartum ventriculum" give place to *mesocœlia* (the cavity of the mesencephal), Eng. *mesocele.**

§ 11. *Fig. 664 illustrates:* A. The general form and appearance of the cerebrum of an educated and moral distinguished man, rapid in thought and movement.

B. The general symmetry as to form and especially as to certain fissures, central, occipital, paroccipital, inflected, associated with some decidedly asymmetric conditions—*e.g.*, the relations of the postcentrals to the paracentrals.

C. The bifurcation of the dorsal end of both central fissures and the bifurcation of the caudal branch on each side.

D. The coexistence of the more common relation of the paracentral to the postcentral on the right with the inclusion, on the left, of both branches of the postcentral within the curve of the paracentral; see § 285 and Fig. 769.

E. The great depth of both occipital fissures; this is their real depth, and is not due to a superficial extension.

F. The distinctness and simplicity of the paroccipital fissures, and the existence of the more usual combination —*i.e.*, continuity with the parietal on the left and independence on the right; see Fig. 778.

G. Nevertheless, the difficulty of deciding how this case should be entered upon a Table. On the right the isthmus between the parietal and the paroccipital is perfectly distinct and visible in any direct view; yet it is below the level of the adjacent gyres and might perhaps be regarded as a vadum. On the left the vadum (at the point marked 13) is much more depressed, and hidden from easy view by the overlapping gyre just cephalad of it.

H. The unusual complexity of the fissures representing the parietal and the postcentral. On each side there are recognizable three irregular fissures caudad of the central; the most dorsal of each group is triradiate and

* The uses of certain animal brains as aids in the study of the human organ are set forth in the article, *Brain: Methods,* etc., and in my paper, 1896, *g.*

* Orthographic discrepancies between this article and my recent papers (*e.g.*, in the retention of certain diphthongs and of the ultima of *anatomical, morphological,* etc.) are due to the necessity of conforming to the plan of the entire work.

perfectly distinct, and is marked *postcentral;* on the right one of the rays (4) cuts the margin of the hemicerebrum deeply. The most ventral (2 and 9) joins the Sylvian fissure. The middle one (3 and 10) is continuous with the parietal on the right, but on the left a vadum may be recognized.

I. The unusual location, depth, and symmetry of the inflected (?) fissures.

§ 12. *References.*—In the Bibliography at the close of this article the names of authors and editors are arranged alphabetically. The date after the name is the year of publication, and the following letter, if there is one, designates a particular paper or book out of two or more published within a single year. My own name is abbreviated in the text to W. My papers on the structure and nomenclature of the brain prior to 1897 are enumerated in the Bibliography of "Neural Terms," 1896, *h*, which is probably accessible to most anatomists either as a reprint or in the *Journal of Comparative Neurology.*

§ 13. *Acknowledgments.*—For assistance in the making of preparations or photographs, for suggestions as to methods, for helpful criticism of the former edition, or for the loan of figures, I am indebted to the following former students, of whom several are present colleagues: P. A. Fish, S. H. Gage, Mrs. Gage, G. S. Hopkins, O. D. Humphrey, B. F. Kingsbury, W. C. Krauss, B. D. Myers, and B. B. Stroud.

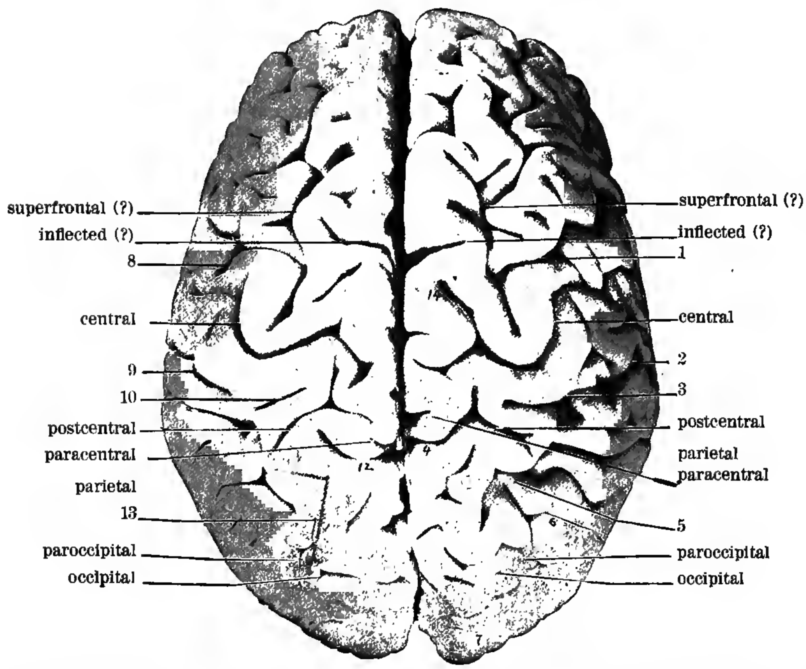


FIG. 664.—Dorsum of the Cerebrum of James Edward Oliver, Professor of Mathematics in Cornell University; aged sixty-six; 3,334. × .57. When removed the brain was firm in texture and weighed (with the piarachnoid but without the dura) 1,416 gm. (49.94 ounces), approximately 50 ounces. It was transected at the mesencephal; the cerebrum was medisected and each half hardened while resting in a mixture of alcohol, formal, zinc chloride and water, of specific gravity equal to that of the brain; later it was transferred to increasing strengths of alcohol. The cerebrum is believed to retain very nearly its natural form. The diacele ("third ventricle") was unusually wide and the medicommissure wholly absent (see § 152). There were no obvious signs of diseased conditions beyond a slight opacity of the piarachnoid about the dorsal ends of both central fissures. Professor Oliver was a man of the purest character and a philosophic thinker, in not only the higher mathematics, but other sciences and ethics. He was left-handed and absent-minded, but rapid in thought and action. For an account of his life and a list of his writings, see the memoir by G. W. Hill, read before the National Academy of Sciences, April, 1896; also *Science*, April, 1895, and the Ithaca *Journal*, March 28th, 1895. 1 (right) and 8 (left), fissures parallel with the centrals and representing, perhaps, both precentrals and supercentrals; they unite with the longitudinal fissures (superfrontals ?); but a vadum exists on each side; 2 (right) and 9 (left), the most ventral of the postcentral groups; 3 and 10, the middle of each group (subcentral ?); 4, a ray of the postcentral cutting the margin of the precuneus; 5, the right paroccipital isthmus; 6, an incision; 7, a distinct diagonal fissure; 8, see 1; 9, see 2; 10, see 3; 12, a fissure cutting the margin of the precuneus deeply but connected with neither the paracentral nor the postcentral; 13, location of the paroccipital vadum. Inadvertently no guide lines indicate the parietal fissures, but they may be recognized from their relations to the paroccipitals. See § 11.

II. GENERAL CONSTITUTION OF THE BRAIN.—§ 14. *Definition.*—The *brain* (Gr., ἐγκέφαλος; Lat., *cerebrum;* late Lat., *encephalon;* It., *cervello, cerebro;* Sp., *cérebro;* Fr., *cerveau;* Ger., *Gehirn;* Eng., *encephalon, encephal*) is the enlarged, segmented, cephalic ("anterior") portion of the neuron or cerebro-spinal axis.

§ 15. The neuron* is that one of the great mesal (median) organs which is nearest the dorsal surface of the body, and farthest from the heart (Fig. 665). The other two are the *enteron* (alimentary canal), and the *axon* (skeletal or body axis; notochord in early embryos, but in later stages and adults the series of centrums or bodies of the vertebræ), Fig. 670, *odontoid process*, etc. The enteron is in the ventral (hemal) cavity; the neuron occupies the dorsal (neural or cerebro-spinal) cavity; the axon forms a partition between the two.

§ 16. *Fig. 665 illustrates:* A. The existence, in man as in other vertebrates, of two parallel body cavities, a dorsal or neural, and a ventral or hemal, separated by the axon, the skeletal axis.

B. The presence, in the ventral cavity, of the *heart*, a hollow muscular organ, rhythmically contractile during life.

C. The presence, in the ventral cavity, of a muscular tube, the *enteron* (alimentary canal).

D. The presence, in the dorsal cavity, of a subcylindrical rod, the *neuron* (cerebro-spinal axis), itself containing a cavity, the neurocele ("central canal" and "ventricles").

§ 17. Excepting at its first formation (when it is a rod with a dorsal furrow) the entire neuron is a tube, a subcylindrical mass enclosing a cavity. This cavity is the *neurocele*, and the enclosing material constitutes the celian parietes. The existence of the neurocele may be demonstrated by the transection

* Certain points relating to this word will be discussed in the article *Terminology, Anatomical.* The following brief statement is the abstract of my paper, 1899, *d*, as printed in *Science*, March 16th, 1900, 420: "*Is neuron available as a designation of the central nervous system? Neuron* (from τὸ νεῦρον) was proposed by me in this sense in 1884 (*N. Y. Med. Journ.*, August 2d, p. 114), and employed in the same journal, March 28th, 1885, p. 356; in addresses before the Amer. Neurol. Assn. (*Journ. Nerv. and Ment. Dis.*, July, 1885); Amer. Assn. Adv. Sci. Proceedings, 1885, and in the second edition of 'Anatomical Technology,' 1886. It has been employed by McClure, Minot, Waters, and others. The reasons for its abandonment in 1889 for *neuraxis*, as stated in the Proceedings of the Assn. Amer. Anatomists for 1895, p. 44, and REF. HANDBOOK OF MED. SCI., ix., 100, now seem to me inadequate. *Neuron* is the basis of *neural* (as applied to aspect, folds, furrow, and canal) and of *neurenteric* and other compounds. and it is the natural correlative of *enteron* (entire alimentary canal) and of *axon* (notochord or primitive skeletal axis). Not until 1891 did Waldeyer propose *neuron* for the nerve cell and its processes; not until 1893 did Shäfer apply it to the axis-cylinder process. As with *tarsus* and *cilium*, the context would commonly avert confusion between the macroscopic and microscopic significations of the word in a given case. The compounds *macroneuron* and *microneuron* might be employed if necessary, or (as suggested by Barker, 1899, p. 40), the histologic element might be designated by *neurōne*, as if from νευρών. The question is now further complicated by Van Gehuchten's adoption of *Neuráxe* as the title of a new journal of neurology."

of any part of the neuron in any other vertebrate, and in an immature human being; but with the adult, in certain regions, the olfactory bulbs (Fig. 672) and most of the myel (spinal cord, Fig. 670), the cavity is more or less completely obliterated.

§ 18. *Location.*—The brain is contained mainly within the cranium, although part of the postoblongata or even,

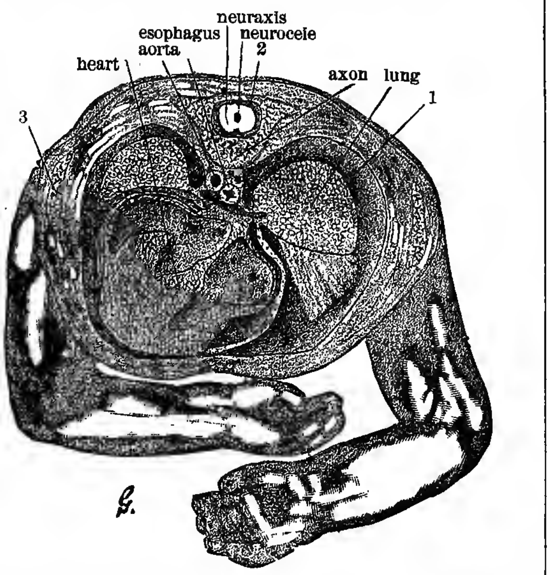


FIG. 665.—Caudal Aspect of a Thoracic Transection of a Fetus About 3.9 cm. from Nates to Bregma, and Estimated at Ten Weeks; 2,139. × 4. 1, Thorax, part of the ventral or hemal cavity; 2, spinal canal, part of the dorsal or neural cavity; 3, scapula.

Defects.—The fetus was badly shrunken by immersion in too strong alcohol, and the parts here shown dried somewhat while photographing. Certain details as to the pleura, spinal nerves, and arachnoid are omitted, the object of the figure being mainly diagrammatic. See § 16.

as appears in Fig. 670, a little of the cerebellum, may extend beyond the limits of the *foramen magnum.* It is remarkably sheltered and clothed by the cranial bones and by the soft parts ectad and entad of them, the scalp and the meninges (dura, arachnoid, and pia) (Figs. 795, 796, 798).

§ 19. *The Brain a Modified Tube.*—In its simplest expression the brain, like the remainder of the neuron, may be represented as a tube of nervous tissue lined by a nonvascular, ciliated* epithelium, the endyma ("ependyma"), and covered by a vascular membrane, the pia ("pia mater").

§ 20. In what may be regarded as an approximately typical condition, the parietes consist of three layers or strata, viz., an ental, mainly cellular, adjoining the endyma, the *entocinerea* ("central tubular gray"); an ectal, mainly cellular, adjoining the pia, the *ectocinerea* (cortex); an intermediate, fibrous, between the other two, the *alba* or medulla; see Fig. 666. In some regions, particularly the epicelian and paracelian roofs, the entocinerea is dislocated or crowded as it were from its normal position next the endyma by albal or fibrous intrusions, commissures, especially the callosum. Parts of the ectocinerea (*e.g.*, claustrum and lenticula, Fig. 781) are also separated more or less completely from the rest.

§ 21. *Unequal Thickness of the Parietes.*—In the earliest

* There is considerable divergence of statement among authors as to the presence of cilia, especially in adults. P. A. Fish has described (1890, 256) the ciliated cells in the encephalic cavities of the cat, both old and young. He urges the importance of thorough preservation by the injection of the preservative into the cavities; states that a magnification of not less than six hundred diameters must be employed, and intimates that the failure to recognize them in man may be due to defective methods of preparation or examination. See also the recent paper of Studnička: "Ueber das Ependym des Centralnervensystems Wirbeltiere," *Sitzungsber. K. Böhm. Ges. Wiss.*, Math. Nat. Cl., 1899, xiv., p. 7.

stages the celian parietes are of approximately equal thickness throughout, although certain portions of the roof, *e.g.*, of the metacele, are never so thick as portions of the floor. With some low or generalized vertebrates—*e.g.*, *Scymnus*, a shark (T. J. Parker); *Necturus*, a salamander (W., 1884, *a*, Fig. 16); *Ceratodus*, a Dipnoan (W., 1887, *a*)—this condition prevails throughout life, at least with certain regions.

With man, until the fetus attains a length of at least 6 cm., and an estimated age of twelve weeks (see Fig. 667), the cerebral parietes are almost uniformly thin; when 24 cm. long, and about twenty weeks old, certain regions are considerably thicker than others, as seen in Fig. 716; in the adult brain of man, and indeed of mammals generally (Figs. 686 and 735), the difference between even closely adjacent portions of the parietes is simply enormous; compare, *e.g.*, the mesencephalic floor (crura) with the caudal part of its roof, valvula (Figs. 670 and 687); the two divisions of the epicelian roof, cerebellum and lingula (Figs. 670, 687, 702); the diacelian sides, thalami, with the floor, tuber or terma (Figs. 670 and 687); the thin or membranous parts (fimbria, tenia, pala, etc.) adjoining the rima with the adjoining hippocamp and caudatum (Figs. 716 and 732).

§ 22. *Telas.*—Where the proper nervous constituent of the parietes is wanting the endyma and the pia are in contact and constitute a membranous area or zone, a tela. Among vertebrates the most constant and extensive of these is the roof of the metacele, the caudal portion of the "fourth ventricle," here called metatela (Figs. 675, 680, 686).

A similar portion of the roof of the "third ventricle" is the diatela (Figs. 675, 681, 682); its cephalic continuation as the roof of the aula is the autatela; finally, in man and apes, a part of the floor of the paracele ("lateral ventricle") is a membranous zone, the paratela (Figs. 733, 735).

§ 23. *Fig. 667 illustrates:* A.—The large size of the paracele, the thinness of the parietes and their nearly uniform thickness.

B. The extent of the paraplexus, and its fulness as compared with that in the adult. Possibly when fresh it

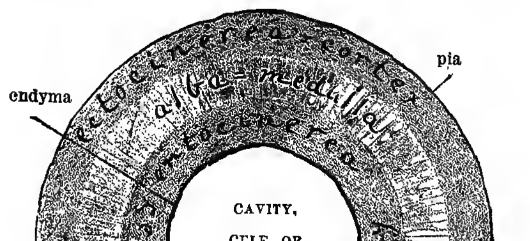


FIG. 666.—Schematic Transection of the Brain, representing the topographical relations of the two kinds of nervous substance, the white, which is fibrous and conducting, and the gray, which is cellular as well as fibrous and dynamic in function. The entocinerea is primary, and alone exists in the myel: the ectocinerea is secondary; it constitutes the mesencephalic cappa, and the cortex of the cerebrum and cerebellum. The cilia are omitted.

more nearly filled the paracele, but was contracted by the alcohol (compare Figs. 716 and 735).

C. The similarity of the precornu and medicornu.

D. The absence of distinct indication of the postcornu, indicating that this may be formed eventually not by a special protrusion caudad, but by the thickening of the parietes in such a way as to leave an occipital space of variable size.

E. The commencing formation of the hippocamp as a corrugation of the mesal wall of the medicornu.

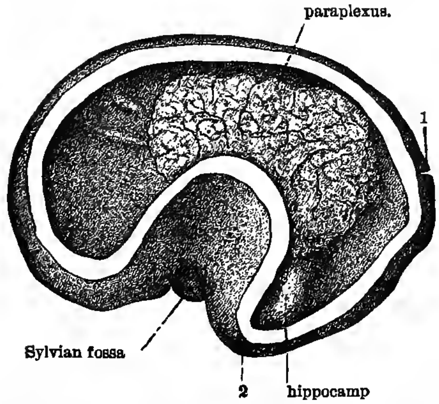


FIG. 667.—The Left Hemicerebrum of a Fetus (Measuring 6 cm. from Bregma to Heel, and Estimated at Twelve Weeks), Opened from the Lateral Aspect; 340. × 3. 1, A fissure; 2, tip of temporal lobe.

F. The non-extension of the paraplexus and thus of the rima to the extremity of the medicornu.

G. The presence of at least one distinct transitory fissure (1).

H. The evidences of some mesal fissures as slight corrugations just cephalad of the plexus.

I. The formation of the Sylvian fossa, with as yet no trace of the insula.

§ 24. *Plexuses.*—As already stated the endyma is nonvascular; but provision is made for the practical introduction of blood-vessels into the encephalic cavities by

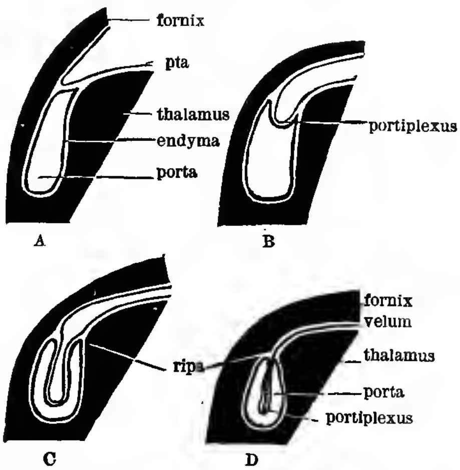


FIG. 668.—Schematic Representations of Four Stages in the Formation of the Portiplexus, as a Type of Plexuses. At A the porta is seen to have the following boundaries: cephalad, the fornix; caudad, the thalamus: ventrad, the junction of the two; dorsad, however, there is merely the endyma passing from fornix to thalamus, and the ectal pial fold, one of its laminæ being fornical and the other thalamic. The first step in the formation of any entocelian plexus is represented at B, where the pial fold (or vessels therefrom) pushes the endyma before it into the cavity. At C the process is carried a step farther, and at D the parts are represented as in the adult, with the plexus apparently inside the porta, and yet really excluded from the cavity by the unbroken covering of endyma.

the formation of plexuses at various points. A plexus is an apparent intrusion of a fold of pia, or of vessels from the pia, into one of the cavities; but the endyma is carried before the intruded portion, and covers it completely so that, strictly speaking, neither the pia nor its vessels are in the cavity. The conditions are comparable with the relations of the abdominal viscera to the peritoneum. If one takes a closed sack of flexible material and pushes the fist against one side it may be carried so far as apparently to be within the sack; yet all the while it is covered by the material of the sack and strictly excluded from the true cavity. Simple examples of the plexus formation are presented by the epiplexus (Fig. 695), and portiplexus (Fig. 668). The metaplexus is seen in Fig. 686; the diaplexus in Figs. 686 and 732; and the paraplexus in Figs. 718, 726, and 732. The disproportionate size of the paraplexus at early stages (Figs. 667 and 747) indicates that it is intimately related to the growth of the cerebrum. The structure and diseases of the paraplexuses are discussed by Findlay, 1889.

§ 25. *Ripa.*—Where the endyma leaves the nervous parietes either at the margin of a tela or for reflexion upon a plexus, there is a sort of shore line which I have called ripa. The name was originally given to the ragged edge left when a tela or plexus is torn from the nervous parietes (see Figs. 692, 699).

§ 26. *Fig. 669 illustrates:* A. The effect of the cranial flexure (§ 36), the two segments, mesencephal and epencephal, with their cavities, appearing upon the same section surface.

B. The triplicity of the epicele, consisting as it does of a mesal portion and two lateral extensions, the lateral recesses (§ 60). In Fig. 695 the lower part of the figure is still more enlarged, and commented upon.

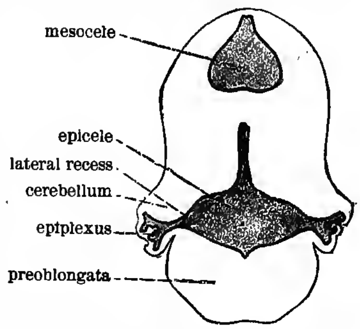


FIG. 669.—Transection of the Brain of an Embryo Rabbit, Sixteen Days Old. × 9. (From Kölliker.)

§ 27. *The Brain as a House.*—Within certain limits the brain may be likened to an edifice, and the comparison has been carried out in some detail on p. 413 of Wilder and Gage, 1882. Architectural terms, *floor, roof, sides,* may be employed appropriately to indicate the general locations of the parts relatively to each other and to the common cavity, and I have proposed two specific terms, *aula* (a hall) and *porta* (a doorway), for the designation of certain portions of the cavity.

§ 28. *Irregularities of Contour.*—In the brain straight lines and plane surfaces are infrequent, and the spiral form is not uncommon; hence dissections are often more instructive than mechanical sections, and normalization, actual or ideal (§ 38), is sometimes desirable.

§ 29. *Commissures, etc.*—Of the parts connecting lateral masses across the meson, whether cellular or fibrous, whether direct (true commissures) or oblique (decussations), some are merely specializations of pre-existing floors or roofs; *e.g.,* precommissure, postcommissure, supracommissure, pons; others, the callosum and commissure of the fornix, are marked extensions of pre-existing lines or areas of conjunction (Fig. 741). The medicommissure, finally, as well remarked by Spitzka, is rather a fusion of contiguous surfaces than a commissure in the usual sense of the word.

§ 30. *Atrophic Parts.*—Certain parts (terma, hemiseptum, valvula, tuber) which are very thin and apparently functionless, nevertheless serve to contain the neurolymph (cerebrospinal liquid), and may have a morphological significance as representing parts more developed in other forms. Two other parts, the epiphysis ("pineal body") and the hypophysis ("pituitary body") are rather thick than thin, but are not known to have definite functions; their peculiarities will be considered in connection with the diencephal (§§ 146, 154), of which they are appendages.

§ 31. *Riparian Parts.*—Along the ripas, or lines of reflection of the endyma upon telas or plexuses, the substantial nervous parietes are commonly reduced in thickness, so as to resemble the terma, valvula, and tuber in some degree. Such are the obex at the end of the metacele (Fig. 702); the fimbria along the hippocampal margin of the rima, the tenia along its caudatal margin, and the pala at its extremity (Figs. 730, 732, and 735).

§ 32. The riparian condition may not be incompatible

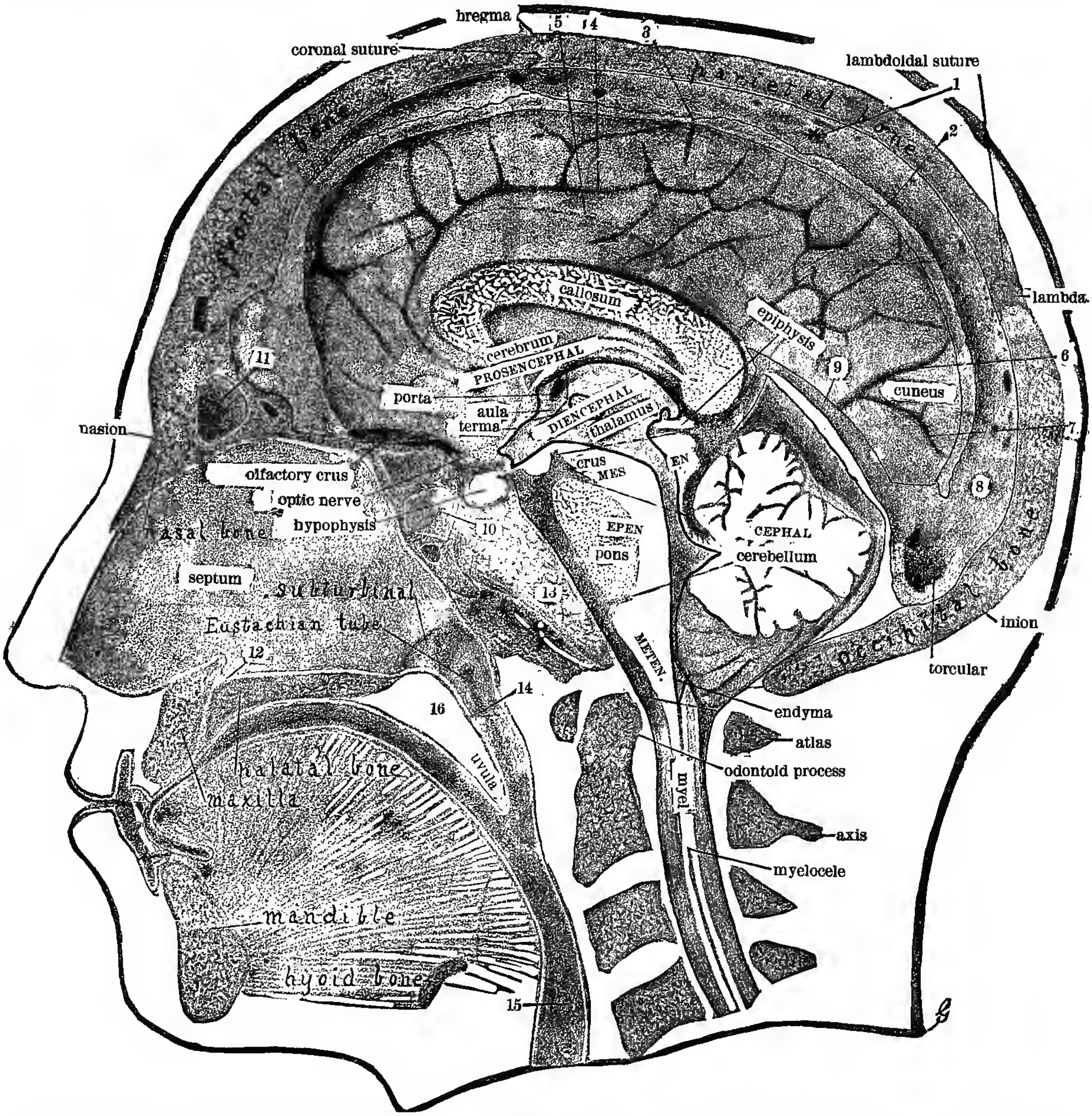


FIG. 670.—Mesal Aspect of the Right Half of an Adult Head, the brain hardened in place by continuous alinjection; 811. × .7. (This was the head of William Menken, who was hanged for murder in July, 1885; the specimen was shown at the American Neurological Association in 1886, and at the American Laryngological Association in 1888 [see article by Dr. Harrison Allen, in *New York Medical Journal*, February 2, 1889]; the mode of preparation is described in the article *Brain: Methods*, etc.). 1, The star upon the mouth of a vein opening into the longitudinal sinus indicates the location of the dorsal end of the central fissure; 2, caudal part of the paracentral fissure; 3, inflected fissure; 4, supercallosal fissure; 5, callosal margin of the falx, indicated by the interrupted line; 6, occipital fissure; 7, calcarine fissure: 8, in the longitudinal sinus just dorsad of the torcular; 9, tentorial sinus; 10, a sphenoidal sinus (not vascular, but a cavity in the sphenoid bone); 11, a frontal sinus; 12, naso-palatine canal; 13, bssioccipital bone; the basisphenoid has 10 upon it, but the two hones are continuous: 14, naso-pharynx; 15, oro-pharynx; 16, soft palate. The heavy black line bounding the shaded mesal cavities is the endyma.

Defects.—The planes of section of the brain and of the other parts are not absolutely identical, although perhaps nearly enough so for most purposes. Many of the boundary lines aré too faintly indicated, *e.g.*, that of the section of the chiasma. A continuous line representing the pia should have surrounded all the cut surfaces in close contact therewith. Another line representing the arachnoid should follow the general contours, as stated more fully in connection with Fig. 801. The segmental name *diencephal*, hides most of the oval area indicating the medicommissure; this last should have been named and should not he dotted. The heavy black line representing the endyma should extend farther into the stem (infundibulum) of the hypophysis, and into the epiphysis, as in Fig. 687. At the second *e* of the abbreviation MESEN the endymal line should not be interrupted. The interruption opposite the *n* of the abbreviation METEN represents the metapore (foramen of Magendie), and should have been so designated as in Fig. 687. Notwithstanding the minuteness of the myelocele ("central canal of the cord") in the human adult its location should have been indicated by the continuation of the endymal line. The neck, scalp, features, and all the soft, vascular parts are swollen by the alinjection; the margins of the tongue are moulded upon the teeth; the soft palate and dorsal wall of the pharynx are obviously thickened, and the subturbinal projects beyond the true margin of the septum into the naso-pharynx, as is perhaps the case temporarily during the congestion attending a severe "cold in the head." No attempt has been made to indicate the blood-vessels, the structure of the skin, the exact direction of the lingual muscles, or the details of the nuchal region.

with distinct and even important functions. The supracommissure and the habena (Fig. 707), for example, are, in one sense, parts of transition from substantial to membranous parietes; but they doubtless, like the fimbria, have some distinct use.

§ 33. *Marginal Cinerea.*—The riparian parts mentioned in § 31 consist of alba; but with the cerebrum and cerebellum the cortical margins have a special morphological interest, and are but little known.

§ 34. Physiologically the intermediate portions of organs are commonly most important, as well as most easily recognized and examined; but morphologically the extremes have great significance, and present unsolved problems for future investigators.

§ 35. *Fig. 670 illustrates:* A. The relative location and extent of the cranial and facial regions of the head so far as they appear at the meson.

B. The continuity of the two portions of the neuron, the myel ("spinal cord"), and the brain (encephal), at or near the junction of the cranium with the spine.

C. The obvious subdivision of the brain into several regions, represented, for example, by the cerebellum, the cerebrum, and the intervening narrower part, which is sometimes called *isthmus cerebri*.

D. The possibility of recognizing in the adult brain smaller divisions or definitive segments, corresponding with the divisions of more nearly equal size in certain other vertebrates.

E. The difficulty of assigning exact limits to the brain and myel or to the regions of the brain, since they are continuous and do not present arthra (articulations or joints) as with the skeletal segments.

F. The representation of each segment at or near the meson by some well-known part: the metencephal by the postoblongata; the epencephal by the cerebellum and pons; the mesencephal by the crura and geminal lobes; the diencephal by the thalami; the prosencephal by the cerebrum; and the rhinencephal by the olfactory bulbs.

G. The existence of a mesal series of communicating cavities surrounded by the endyma.

H. The insignificance of the aula, the mesal cavity of the prosencephal, as compared with not only the other cavities but the cerebrum itself.

I. The presence of an orifice, the porta ("foramen of Monro"), evidently leading laterad from the mesal aula into a cavity within the right hemicerebrum.

J. The relations of the masses to the cavities, as are related the floors, roofs, and side walls of an edifice to the apartments.

K. The great difference in the thickness of the roofs and floors at different points.

L. The continuity of the side walls, floors, and (excepting at one point) of the roofs.

M. The existence of certain fibrous masses, commissures, extending across the meson, and therefore divided in this preparation.

N. The lodgment of a subspherical appendage of the base of the brain (the hypophysis) in a deep pit in the floor of the cranium (the "pituitary" or hypophysial fossa).

O. The change in direction of the cranial floor at about this point, the remnant of the embryonic cranial flexure.

P. The similar angle formed by the base of the brain.

Q. The still more decided angle formed by the general outlines of the floors of the encephalic cavities at a point nearly corresponding with the cephalic orifice of the mesencephalic cavity.

R. The liability of misapprehension from the employment of the ordinary descriptive terms, *vertical, horizontal, anterior, posterior, upper,* and *lower,* since each of these words would have one meaning for the myel and postoblongata, and another for the diencephal. It is as if two adjoining houses faced, one to the east and the other to the south. The employment of *eastern* and *southern* as designating structural features common to the two would be likely to cause misapprehension.

S. The convenience of regarding the entire floor as ventral, the entire roof as dorsal, any region of the brain nearer the myel as relatively caudal, and any region farther therefrom as relatively cephalic.

T. The dorsal expansion of most of the segments. The wedge-like shape of the mesencephal is easily recognized; the thalami are not wholly exposed, but the region is more extended dorsally than ventrally; the cerebellum is much larger than the pons, while the disproportion of the cerebral hemispheres to their strictly basal, mesal part, the aula, is one of the many remarkable features of the adult human brain.

U. The tendency of certain segments to overlap adjoining parts, especially in the caudal direction.

V. The lack of exact collocation between the encephalic regions and the cranial bones; the cerebellum corresponds to less than half of the superoccipital bone, and extends a little beyond its margin at the *foramen magnum.*

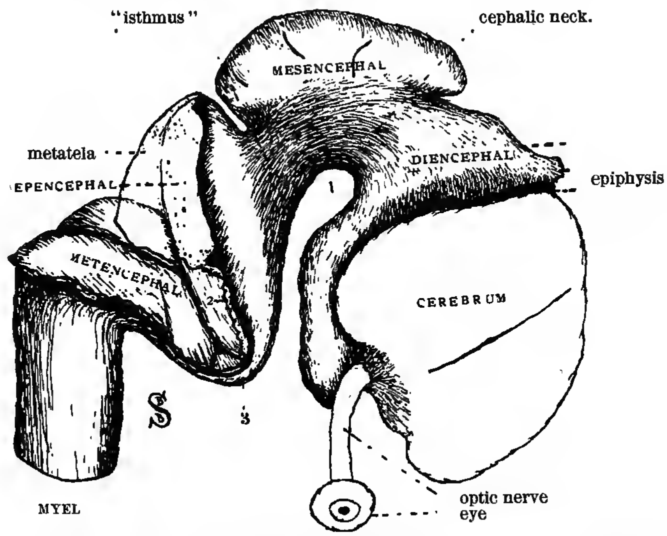


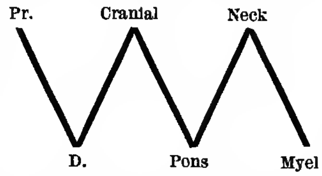
FIG. 671.—Right Side of the Brain of an Embryo 22 mm. Long and Estimated at Eight Weeks; 2,652. × 7. Prepared and drawn by B. B. Stroud (1899, *a*). 1, Cranial flexure; 2, torn edge of the metatela; 3, pons flexure. The olfactory bulbs are not shown. See § 37.

W. The collocation of the lambdoidal suture with the dorsal end of the occipital fissure.

X. The location of the mesal craniometric points, nasion, bregma, lambda, and inion.

§ 36. *The Encephalic Flexures.*—These are commonly described as three, the *cranial,* the *pons,* and the *neck.* The second and third are temporary in man, respectively indicating the junction of the myel with the postoblongata and of the latter with the preoblongata. The cranial or mesencephalic flexure is a permanent feature of the human brain, as seen in Figs. 670 and 687. There is, in addition, a flexure, likewise permanent, in the diencephal so that the prosencephal is dorsad instead of cephalad of it; this persists in man and other Mammals, and in Birds and Reptiles, but with Amphibia and "fishes" the prosocele and diacele are on approximately the same level; see my papers, 1887, *b,* and 1896, *d.*

The relative positions of the several encephalic flexures, although not their relative sharpness or the length of the intervening parts of the brain, may be indicated to the eye approximately by a capital **W**, with an oblique line (half of a **V**) for the myel. In the accompanying diagram the three flexures commonly named are indicated by the words cranial, pons, and neck; Pr. stands for the prosencephalic region, and D. for the diencephalic flexure. In this diagram, in accordance with my custom, the cephalic ("anterior") end is at the left. Unfortunately, however, the two figures which illus-



D. The presence of corrugations on both the mesencephal and the cerebrum. The former appear in many of our preparations; the latter may be artifacts.

§ 38. *Normalization.*—This term is used to include all processes by which modified or morphologically abnormal forms and relations may be reduced, either actually or ideally, to their known primitive and presumed normal conditions. *Rectification* would have nearly the same significance; it denotes the reduction of complex structures to simple, of irregular to regular, of crooked to straight, and of rough to plain. Examples of this process are the representation of the segments as subequal in size and on the same plane (Figs. 674 and 675); the lateral extension of the various outgrowths of the mesal

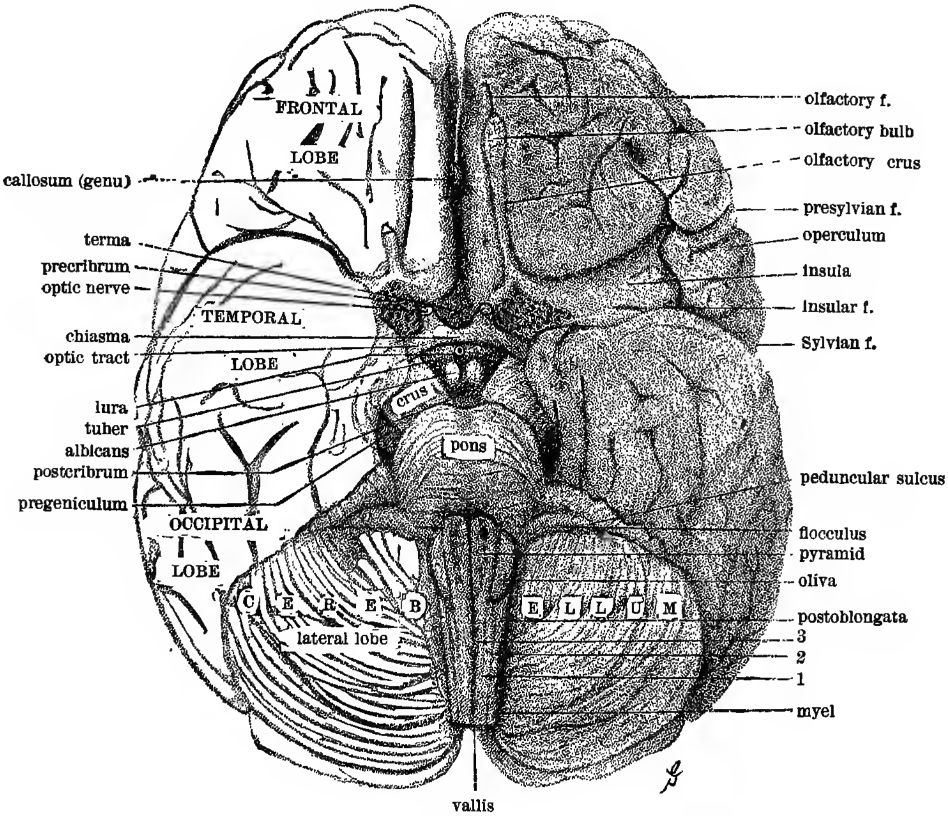


FIG. 672.—Base (Ventral Aspect) of the Brain. From Henle, Edinger, and nature. × .7. 1, Ventral ("anterior") column; 2, line between the ventral and lateral column; 3, ventrimesal fissure.

Preparation.—The cerebellum has been allowed to fall dorsad by its own weight; thereby the occipital lobes are divaricated somewhat, the encephalic curvature is reduced, and the crura are more fully exposed. The hypophysis and infundibulum have been severed from the tuber, and the pia removed, together with the cranial nerve roots, excepting the optic. The right olfactory crus has been divided near its attachment. On the left the operculums are divaricated somewhat, so as to expose the ventro-lateral aspect of the insula.

Defects.—As may be seen from profile views of the brain (Figs. 670 and 687), in the normal condition of the organ the pons and the chiasma are naturally nearly in contact, and the intervening regions, crura, etc., are practically invisible; the ventral surface of the metepencephal also forms little more than a right angle with that of the prosodiencephal; consequently in a direct view of either region the other is greatly foreshortened, and even the equal division of the obliquity between them shows neither to advantage. The fresh or imperfectly preserved brain, when resting upon the dorsal aspect, will, however, straighten itself, as it is commonly represented. To include so large a surface within a figure of moderate size certain details must be inadequately presented or omitted altogether. The fissures in the present figure, substantially as given by Henle, need not be regarded as signifying anything more than the general aspect of the cerebrum. The two crura should be equal in width. The pyramid decussation is inadequately indicated (see Fig. 689). See § 41.

trate the flexures most perfectly (671 and 676) have the reversed position, so that comparison with the diagram is less readily made.

§ 37. *Fig. 671 illustrates:* A. The general form of the brain at this stage, especially the sharpness of the several flexures.

B. The size and prominence of the mesencephal and its extension over the adjoining regions.

C. The distinctness of the constriction cephalad of the mesencephal as compared with that caudad, and the apparent absence of reason why the latter should be regarded as a definitive segment any more than the former.

parts (Figs. 683 and 714); the straightening of the medicornu (Fig. 729); the schematic representation of the fissures (Figs. 757 and 758), and the designation of the human geniculums as pre and post rather than external and internal (§ 62, K).

§ 39. *The Brain a Segmented Organ.*—A fundamental morphological idea * of the brain is that it consists of a *series of segments*, comparable, although not, probably,

* Like other symmetrical organs it consists of right and left halves, approximately identical. It is also regarded by some as divisible into dorsal and ventral zones; but this has not, I think, been demonstrated for the entire brain.

strictly equivalent. The development and comparative anatomy of the organ can hardly be treated upon any other basis; it is recognized in the discussion of encephalic physiology and of psychology, and the descriptive anatomy of the organ is most conveniently based thereon.

§ 40. The segmental constitution of the human brain is invisible from the dorsal aspect (Fig. 664); hardly suggested when the cerebellum as well as the cerebrum is in view; more obvious from the lateral aspect (Fig. 663); still more so from the ventral side (Fig. 672); clearer still from the mesal aspect (Figs. 670, 687, and 756), and unmistakable with early embryos (Figs. 671, 673, and 679), which therefore, but for practical difficulties as to procuring, preserving, and dissecting, would form a natural introduction to human encephalic morphology.

§ 41. *Fig. 672 illustrates:* A. The enormous preponderance of the visible parts of the prosencephal and epencephal over the other segments, thereby occasioning the common and not unnatural though very unphilosophical division of the entire brain into cerebrum (cerebrum proper, olfactory bulbs, and thalami) and cerebellum (with pons and postoblongata), the intervening narrow region, the crura and the quadrigeminum, being regarded as merely an isthmus.* From the morphological standpoint, however, the statement would be nearly reversed. The mesencephal is at one period the most prominent and distinct region (Figs. 671 and 676). The cerebellum may be characterized as an hypertrophied bridge over the "fourth ventricle," and there are some grounds for regarding the olfactory bulbs as primary, and the cerebral hemispheres as their secondary appendages (see my paper, 1887, *a*).

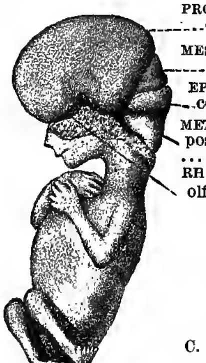


FIG. 673.—Fetus Measuring 49 mm. from Nates to Bregma, and Estimated at Twelve Weeks; 1828. × 1. The specimen was received in alcohol, still enclosed by the membranes. After removal it was pinned to loaded cork and kept under alcohol during the exposure of the brain. The attitude and expression are noteworthy, and have been faithfully reproduced by the photograph and drawing; the right side of the brain is shown in Fig. 746, and the dorsal aspect was published in the *New York Medical Journal*, February 16th, 1884, p. 177.

B. The extension of the cerebrum beyond all other parts of the brain, the occipital lobes overlapping the cerebellum even when the latter is allowed to displace the former. For the relations of these parts in the anthropoid apes, see my paper, 1884, *g*.

C. The lapping of the temporal lobe over the optic tract, as shown by the two interrupted, curved lines on the right (left of the figure).

§ 42. *Fig. 673 illustrates:* A. The general form of the body and limbs at this period.

B. The visibility of all the encephalic segments, excepting the diencephal; even this may be regarded as represented by the optic nerve, dimly seen through the indentation at the ventral margin of the cerebrum.

C. The marked preponderance of the cerebrum.

D. The absence of the transitory fissures; compare, however, the right hemicerebrum, as shown in Fig. 746.

E. The simplicity of the other regions, better shown in Fig. 746; the cerebellum is a narrow and undivided mass; the mesencephal presents a slight transverse depression between the pregeminum and postgeminum.

§ 43. The recognition of the brain as a segmented organ is not dependent upon the determination of the exact number of segments, their equivalency, or their boundaries. The postoblongata represents several *potential* segments or neuromeres, but practically it may be regarded as one. Some even regard the entire oblongata together with the cerebellum and pons as a single segment.

§ 44. Some idea of the diversity of opinion and usage among anatomists with respect to the number and designations of the definitive segments may be gained from the table published in the first edition of this work (viii., 114), which is substantially the same as in my paper, 1885, *b*, and in Wilder and Gage, 1882, 405. The appended Table I. indicates the difference between the verbal schemas adopted by the Anatomische Gesellschaft in 1895, and by the Association of American Anatomists in 1897; the second is followed in the present article.

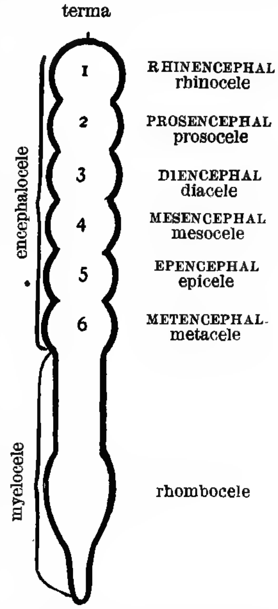


FIG. 674.—Schema of the Neuron (Cerebro-Spinal Axis), as if the cavity were exposed by the removal of the roof. The six encephalic segments are given a conventional spherical form, but without intending to imply that this is their actual shape or that all are separated by constrictions. The main object of the diagram is to associate the encephalic segments with their names and the names of their cavities.

§ 45. *Commentaries on the Schematic Medisected Brain, Fig. 675.*—A. No two original workers in comparative neurology would be likely to construct schemas identical in all respects; the one here presented is not satisfactory to me and I can hardly expect it to suit others. But with all its defects I believe it may serve three useful ends—viz.: (*a*) indicate the relative position of certain parts in the floor or the roof of the general cavity; (*b*) facilitate the recognition of the essential identity of the brains of all vertebrates with that of man; (*c*) stimulate efforts toward the construction of a more perfect schema.

B. Only mesal parts are presented, *i.e.*, such as are divided in a medisection.* This excludes the cerebral hemispheres and olfactory bulbs, the lateral lobes of the cerebellum, and the elevations of the crura and quadrigeminum at the side of the ventral and dorsal mesal furrows.

C. The parietes present four degrees of thickness, viz.: (*a*) thin, *e.g.*, the terma and the tuber in the floor, and in the roof the valvula and the lingula between the thickened quadrigeminum and cerebellum; (*b*) thick, *e.g.*, the two just mentioned, the crura, and the oblongata caudad of the pons; (*c*) reinforced, *e.g.*, the pons, chiasma, and precommissure; (*d*) membranous, consisting only of the endyma and the pia, constituting a tela, *e.g.*, the roofs of the metacele (metatela), of the diacele (diatela), and of the prosocele. The plexuses (metaplexus, etc.) are special modifications of the telas (§ 24). The metapore is here represented as an interruption of the metatela. If, as now seems probable (§ 83), it is an evagination, there still remains the difficulty of determining its extent, and the best mode of representing it.

D. For the sake of comprehensiveness certain features are included which do not occur in all vertebrates—*e.g.*: the metapore (in man and a few others); the pons (mammals only); the medicommissure (mammals and some

* This, the "isthmus cerebri" of some writers, must not be confounded with the "isthmus rhombencephali" of others, which includes a portion only of the mesencephalon (see Table I.).

* The callosum and fornix are omitted because their inclusion would have caused undesirable complications.

TABLE I.—COMPARATIVE VIEW OF THE SEGMENTAL SCHEMAS ADOPTED BY—

THE ANATOMISCHE GESELLSCHAFT IN 1895.

Partes ventrales.	*Partes dorsales.*
VI. TELENCEPHALON.	
Pars optica hypo-thalami.	Corpus striatum; rhinencephalon; pallium.
V. DIENCEPHALON.	
Pars mamillaris hypo-thalami.	Thalamus; metathalamus; epithalamus.
IV. MESENCEPHALON.	
Pedunculi cerebri.	Corpora quadrigemina.
III. ISTHMUS RHOMBENCEPHALI.	
Pedunculi cerebri.	Brachia conjunctiva; velum medullare anterius.
II. METENCEPHALON.	
Pons.	Cerebellum.
I. MYELENCEPHALON.	
Medulla oblongata.	
Pars ventralis.	*Pars dorsalis.*

THE ASSOCIATION OF AMERICAN ANATOMISTS IN 1897.

I. RHINENCEPHALON.	Bulbi olfactorii with their tracts, part of the aula and of the precommissure.
II. PROSENCEPHALON.	Palliums, connected by part of the aula and part of the precommissure.
III. DIENCEPHALON.	Thalami, including the chiasma; genicula.
IV. MESENCEPHALON.	Crura and quadrigeminum.
V. EPENCEPHALON.	Cerebellum; pons; preoblongata.
VI. METENCEPHALON.	Postoblongata.

reptiles); the paraphysis (not found in mammals*); the chiasma (absent in teleosts).

E. The dotted areas represent fibrous parts crossing the meson whether directly (precommissure) or obliquely (chiasma); the similar representation of the medicommissure is not warranted by its cellular structure in mammals.

F. Other differentiations of the substance of the parietes are not indicated, *e.g.*, into the alba (white substance) and the cinerea (gray).

G. The hypophysis is notched and crossed by the broken line to indicate its twofold source, neural (*n*) and

J. The two indentations of the cerebellum, ental and ectal, represent respectively the fastigium (§ 95) and the furcal sulcus (§ 117), but without implying their exact collocation.

K. The crista has been observed in comparatively few vertebrates and its morphological significance is undetermined (§ 366).

L. *The Absence of Flexures.*—Granted that no brain is perfectly straight and that many are strongly flexed in one or more places, how many flexures shall be represented and what shall be their extent? The only impartial condition of the axis is straight (§ 38).

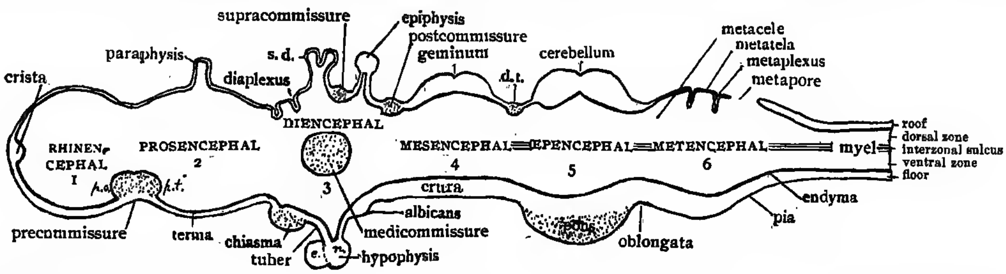


FIG. 675.—Provisional and Imperfect Schema of the Brain as if Medisected; intended to approximate the "least common multiple" of the brains of vertebrates above the lancelet.

Abbreviations:—In the floor, at the sides of the precommissure, *p. o.* designates the olfactory division (*pars olfactoria*) and *p. t.* the cerebral or temporal division (*pars temporalis*) of that commissure. In the hypophysis, *e*, designates the portion derived from the enteron (prehypophysis), and *n.* the strictly nervous portion (posthypophysis). In the roof, *s.d.* designates the dorsal sac (*saccus dorsalis*), and *d. t.* the decussation of the trochlear nerves (*decussatio trochlearis*). The numerals indicate the six definitive segments beginning with the most cephalic (compare Fig. 680).

enteric (*e*) § 146. The ectal line which elsewhere represents the pia enveloping the brain should not be so interpreted for the enteric portion.

H. The indentation of the precommissure merely emphasizes the relations of its two portions to the rhinencephal and the prosencephal respectively (§ 364).

I. The indentation of the mesencephalic roof represents the transverse furrow which—in mammals only—demarcates the quadrigeminum into a pregeminum and a postgeminum; the former, I believe, is always the larger, but the ratio is not known to me. No attempt is made to indicate the intergeminum ("interoptic lobes" of Spitzka).

M. On the same principle the dorsal and ventral outgrowths, paraphysis, dorsal sac (*s.d*), epiphysis, and hypophysis, are made to project nearly at right angles with the brain axis. In many vertebrates the hypophysis tends caudad, but in man it tends rather in the opposite direction, and in the goose-fish (*Lophius*) it lies far cephalad of the rest of the brain.

N. *The Dorsal and Ventral Zones.*—It is conceded that the myel is demarcated by an interzonal sulcus ("*sulcus limitans ventriculorum*" of His) into a dorsal zone which is sensory and a ventral which is motor; also that the sulcus and zones are represented more or less distinctly in the caudal half of the brain. On the figure the sulcus is conventionally indicated by the segmental names, *mesencephal*, etc., and by the three lines connecting them. But I have as yet been unable to satisfy myself of the

* See the turtle's brain Fig. 680. The part is briefly discussed by Minot, 1892, 690, and by Studnička, 1895.

continuance of these features in the cephalic half of the brain (see § 153).*

O. Comparisons will be made naturally and justly with (*a*) representations of the primary neural segments or true neuromeres like, *e.g.*, that of Charles Hill (1899, 1900); (*b*) the schema of Prof. Wilhelm His (1893) which was adopted in 1895 by the Anatomische Gesellschaft (His, 1895); (*c*) that of Huxley (1871); (*d*) my own successive attempts, especially that in the first edition of this work, vol. viii., p. 114, which was substantially identical with that in the last four editions of Quain's "Anatomy." From all four it differs in the recognition of the olfactory region of the brain as a definitive segment; from the first it differs also in regarding adult rather than early embryonic conditions—thus in recognizing the final, actual, or definitive segments rather than the primitive or potential neuromeres; from the second, in addition to minor points that may be mentioned later, it differs also in the greater regard for the conditions in the lower vertebrates; in the non-recognition of the "*isthmus rhombencephali*" as a definitive segment; in the method of numerating the segments and in the names of some. See also my papers, 1897, *e*, and 1899, *c*.

P. *The Number of Segments.*—On this point the differences of opinion and usage are wide and radical; my own views have changed more than once and may change again. No one admits more fully the need of further information and of more logical interpretation. The practical question that now confronts us—investigators, teachers, and students alike—is this: In the present state of our knowledge, ignoring no known conditions of the brain, adult or developmental, and assigning at least equal weight to the lamprey and to the hag as to man, what number of transverse divisions shall be recognized, so as to facilitate the exposition and comprehension of the main features of a highly complex organ while not hindering the elucidation of the mysteries as yet unsolved? These divisions must be natural, not necessarily identical but at least comparable, and neither so few as to be useless nor so many as to be inconvenient. The practical requirements are met by the numbers five and six. Five definitive segments were recognized in Quain and in the first edition of this work. Six are now recognized by both His and myself; but, as will be seen later, the first of mine (rhinencephal) is not admitted by him, while I am unable to see a definitive segment in the "isthmus rhombencephali."†

Q. In regarding the olfactory bulbs, their tracts or crura, the *pars olfactoria* of the precommissure, and the corresponding portion of the aula, as constituting a definitive segment, the rhinencephal, I may be unduly influenced by the conditions in certain other vertebrates (Figs. 680, 790, 791, and 794) and by the considerations briefly outlined in 1897, *e*; but I feel that scant justice has been dealt hitherto to this probably primitive portion of the brain.

R. *The Developmental and Structural Disparity of the Segments.*—Whatever number of definitive segments any anatomist admits, he will hardly claim that they are identical in either structure, mode of development, or relation to the primitive neuromeres. According to Charles Hill the mesencephal represents two neuromeres, and there certainly are several in the oblongata.

S. *The Relative Size of the Segments.*—This point is analogous to that respecting the direction of the axis of the entire brain (L). Even were the preponderance of the cerebrum in man and other mammals to be indicated the precise ratio would not be easy to fix. But in some sharks the cerebellum is very large; in Teleosts the mesencephalic lobes are most conspicuous; in *Chimaera* the dieucephal is greatly prolonged (W., 1877, *a*); in the electric ray the postoblongata (metencephal) equals in size the remainder of the brain. Finally, to offset the relative insignificance of the olfactory bulbs in the Primates and their total absence in certain Cetacea, they compare favorably with the other segments in many Reptiles and Amphibia, in the hags (Fig. 790) they are as wide as the cerebrum, and in the lamprey (Fig. 789) they surpass it in bulk. There seems to be no escape from the conclusion exemplified in the schema, viz., that the definitive segments are potentially equal in size.

T. *The Numerical Designation of the Segments.*—In accordance with the rule (to which there is, so far as I know, but a single exception*)—viz., that the members of any cephalo-caudal series of similar parts, *e.g.*, ribs and vertebræ, should be numbered beginning with the one next the head—anatomists have hitherto generally designated the segment next the myel as last and the one at the other extreme as first. That plan is adhered to in Fig. 674, and throughout this article. The contrary enumeration was introduced by Professor His in 1893. It has been adopted by the Anatomische Gesellschaft, and there is likely to result confusion such as would attend the reversal of the universal method of enumerating the cranial nerves.

U. *The Segmental Names.*—As may be seen from the table of His reproduced in the latter part of the article *Brain, Development of*, and from the abstract of it in Table I., the most radical differences concern the two segments next the myel. The Association of American Anatomists follows Quain in designating the most caudal *metencephalon* and the next *epencephalon*. The Anatomische Gesellschaft follows Huxley in applying *metencephalon* to the penultimate segment and designating the ultimate by *myelencephalon*.†

§ 46. *Fig. 676 illustrates:* A. The great relative bulk of the head, constituting about one-half of the entire body.

B. The indications of encephalic segmentation by slight furrows, represented by the converging lines upon the side of the head.

C. The prominence of the mesencephal at this period, forming the "top of the head."

D. The sharpness of the cranial flexure, whereby two of the segments appear in a dorsal view, and two in a ventral, while the fifth appears partly in both views, as shown by Figs. 677 and 678.

E. The conditions of the eye and ear; the greater differentiation of the manus than of the pes; the presence of a short but distinct tail.

§ 47. *Fig. 677 illustrates:* A. The distinctness of the myelocele ("central canal") even to the root of the tail.

B. The sudden and great expansion to constitute the metepicele ("fourth ventricle").

C. The marked constriction between the mesocele and the metepicele.

D. The existence, on the contrary, of the greatest

* Burckhardt has represented the zones and other features by an elaborate system of colors; 1895.

† Should the "isthmus rhombencephali" be regarded as a definitive segment? In the early fetal brain of man, the cat, and perhaps some other mammals, there is a neck-like region just caudad of the mesencephal. Professor His names this region "isthmus rhombencephali," and apparently regards it as co-ordinate with the other five segments recognized by him (1893, 173–174; 1895, Suppl. Bd., 157). But these same specimens, and indeed many of the figures of Professor His, present an equally distinct constriction cephalad. Even if the former represents the second of the two neuromeres which Charles Hill credits to the mesencephal, it is not easy to see why one of these regions, so insignificant in the later stages, should be reckoned as a definitive segment rather than the other. This point has been formulated independently by Dr. Stroud in the title of his paper, 1899, *a*, "If an Isthmus Rhombencephali, Why Not an Isthmus Prosencephali?" from which Fig. 671 is borrowed.

* Dr. Gerrish informs me that in the famous work of Albinus, "Tabulæ sceleti et musculorum corporis humani," 1747, the vertebræ, lumbar, thoracic, and cervical, are numbered from the caudal to the cephalic end of each series; nevertheless, curiously enough, the ribs are enumerated in the more usual way.

† Undesirable results or concomitants of the application of *myelencephalon* to the last (most caudal) segment, and of *metencephalon* to the next (cerebellar) segment, are the following: (*a*) Disregard of the prior association of *epencephalon* with the cerebellar segment by Owen and Quain. (*b*) Disregard of Owen's prior application of *myelencephalon* to the entire cerebro-spinal axis. (*c*) Inconsistency, since the *myel* of *myelencephalon* obviously refers to the "spinal cord" which, however, is termed *medulla spinalis*. (*d*) The apparent impossibility of having an appropriate or correlated convenient word term for the cavity of the last segment. *Myelocœlia* (Eng. *myelocele*) was applied by me to the cavity of the myel (canalis centralis); *myelencephalocœlia* would be cumbersome; likewise *ventriculus myelencephalicus*.

width of the metepicele opposite the ventral transverse furrow which is regarded by me as demarcating the cephalic portion (epicele) from the caudal (metacele).

E. The slightness of this transverse depression of the floor. With some human embryos of this and later stages (Fig. 671) there is a marked flexion (the pons flexure) of this entire region, at about the middle of its length, so that the two segments are easily distinguished.

§ 48. *Fig. 678 illustrates:* A. The greater width of the mesocele than of the diacele, so that the latter might be described as merely a passage between the former and the prosocele.

B. The absence of any distinct thickening of the diacelian walls to indicate the formation of the thalami.

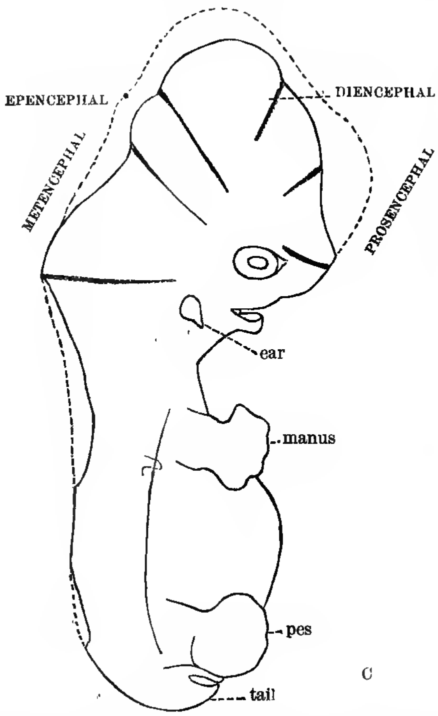


FIG. 676.—Right Side of a Human Embryo, 18 mm. long, and Estimated to be Four Weeks of Age; 274. × 6.
Preparation.—The embryo was received in its membranes, and had apparently lost much of the neck curvature, so that the head is more nearly than usual in line with the body. The encephalic cavities were exposed by removing their roofs; the original outline is indicated by the broken line.

C. The mesal depression in the diacelian floor, probably representing the infundibulum.

D. The lateral extension of the paraceles, the cavities of the future hemicerebrums.

E. The presence of an elevation of the paracelian floor, probably representing the caudatum.

F. The continuity of the parietes at the junction of the prosencephal with the diencephal, and the absence of any indication of plexal intrusion at this period.

§ 49. *Commentaries upon Fig. 679.*—A. This figure is a combination of parts of Figs. 677 and 678, as if the encephalic curvature were obliterated. This ideal straightening, a form of normalization (§ 38), may be illustrated as follows: Flex the index finger upon itself as far as possible; let the nail represent the prosocele, the knuckle the metepicele, and the prominent middle joint the mesocele. From either the dorsal or palmar aspect only parts of the convex surfaces are visible; but if the finger is extended all fall into one view.

B. The main object of this figure is to facilitate a comparison between the encephalic cavities of this early embryo and those of the adult cat as shown in Fig. 686. The differences are much greater in appearance than in

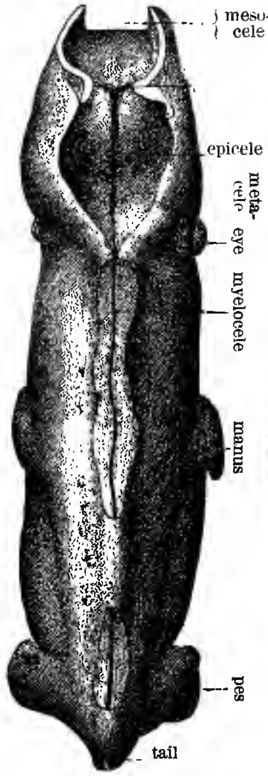


FIG. 677.—Dorsal Aspect of the Embryo Shown in Fig. 676; 274. × 6. This and three of the following figures (678, 679, 681) are too deeply shaded. See § 47.

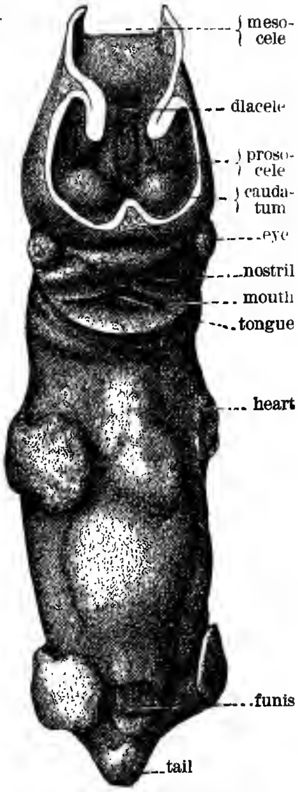


FIG. 678.—Ventral Aspect of the Embryo Shown in Figs. 676, 677, and 679; 274. × 6. The left arm has been removed. See § 48.

reality, consisting mainly in the reduction of most of the cavities, the thickening of most of the parietes; the great and irregular extension of the lateral masses, hemicerebrums, containing the paraceles ("lateral ventricles").

C. The resemblance of this figure to the appearance presented by the brain of *Necturus* (a salamander) after the removal of the roof is almost startling; see my paper, 84, *a*.

§ 50. The adult human brain presents great and perhaps peculiar departures from the general type as based upon embryology and comparative anatomy, and while anatomically admirable and physiologically nearly perfect, it may fairly be characterized as a morphological monstrosity. Among other general features, the segmental constitution of the organ is more apparent in many lower or more general-

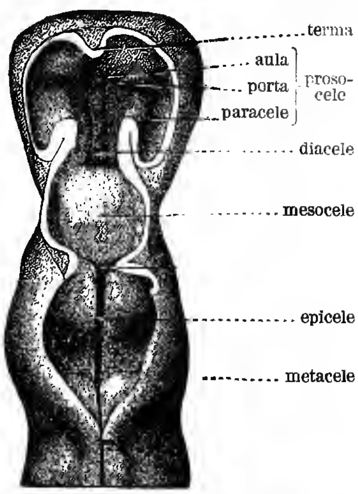


FIG. 679.—The Encephalic Cavities of the Embryo Shown in Figs. 677 and 678 Represented upon One Plane.

ized vertebrates, *e.g.*, the turtle (Fig. 680) and the hag (Fig. 782), and even in mammals where the cerebrum is less preponderant than in man. But with mammals the other segments are more easily recognized if the cerebrum and cerebellum are either tilted in opposite directions as in the rabbit preparation (Fig. 681), or the former is also medisected as in the cat (Fig. 682), or both partly cut away as in the sheep (Fig. 794).

§ 51. *Fig. 680 illustrates:* A. The availability of this reptilian brain for the exemplification of certain features of the organ; it is large as compared with that of amphibia and most other reptiles; the cerebrum and cerebellum do not overtop the other parts so as to obscure their serial relations; excepting the pons and callosum most of the commissures are represented; and the cranial flexure is slight (Fig. 671).

B. The departure from the schematic brain in two respects: (*a*) the reduction of the mesal portion of the rhinocele and prosocele to a slight cavity, the aula, opening laterad by the porta; (*b*) the crowding of the cephalic segments caudad, occasioning the diencephalic flexure, and bringing the aula and porta dorsad of the diacele instead of cephalad of it.

C. The elongation and close apposition of the three dorsal outgrowths, paraphysis, dorsal sack, and epiphysis.

D. The relatively large size of the olfactory bulb, and the duplicity of the olfactory nerve.

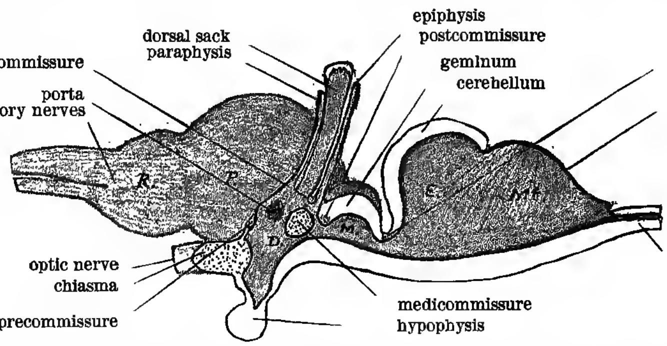


FIG. 680.—Mesal Aspect of the Medisected Brain of the Green Turtle, Chelone midas. × 1. From nature and from the paper of O. D. Humphrey, 1894. The letters R., P., D., M., E., and Mt., designate respectively the six segments, rhinencephal, prosencephal, diencephal, mesencephal, epencephal, and metencephal. The first and second are placed on the pial surfaces of the olfactory bulb and hemicerebrum; the other four are within the cavities.

§ 52. *Fig. 681 illustrates:* A. The greater obviousness of the segmental constitution than with the adult human brain from any point of view.

B. The smaller relative size of the cerebrum than in man or the cat (Fig. 682).

C. The much less extent of the callosum than in man or the cat, making it possible to uncover the diencephal without the medisection required in the cat (Fig. 682).

D. The presence of a distinct roof of the diacele, the interthalamic space, notwithstanding the cerebrum has been tilted.

E. The relation of this roof, the diatela, to the habenas, the ridges demarcating the dorsal and ectocelian from the mesal or entocelian surfaces of the thalami.

F. The non-adhesion of the thalamus to the hemicerebrum in any way such as to indicate that the former enters into the composition of the paracelian floor.

G. The more nearly equal size of the lateral (pileums) and mesal (vermis) lobes of the cerebellum, and the concomitant absence of the vallis which is so obvious on the caudal aspect of the adult human cerebellum (Figs. 672 and 697).

§ 53. *Fig. 682 illustrates:* A. The possibility, even with so high a mammal as the cat, of making a preparation that, without disturbing the essential morphological features of the organ, may exhibit portions of all of the encephalic segments excepting the last, the metencephal.

B. The tendency of three of the encephalic segments to overlap those caudad of them. The cerebellum, the epencephalic roof, partly conceals the postoblongata, metencephal, in its natural attitude; in the present figure it is tilted caudad. The mesencephal (gemina or optic lobes) is covered partly by the cerebellum and partly by the cerebrum, and also at the sides overlapped somewhat by the postgeniculums, elements of the diencephal; in the figure these bodies are in deep shadow, crossed by the line 3 on the right, and on the left by the line leading to the postgeminum. Finally, the cerebrum conceals the diencephal and mesencephal, part of the rhinencephal, and even the cephalic slope of the cerebellum in the cat, while in man it alone is visible when the brain is viewed from the dorsal aspect (Fig. 664).

C. The relations of the callosum and fornix to the two hemicerebrums, as lines of secondary adhesion between the two, the one dorsal and the other ventral.

D. That the triangular area, hemiseptum, is really only a portion of the mesal wall of either hemicerebrum, which has been intercepted between the two lines of junction above named.

E. That the interval, pseudocele ("fifth ventricle") between the two hemiseptums, has no connection with the true encephalic cavities.

F. That the callosum and fornix are in no sense parts of the roof of the diacele (third ventricle): this is constituted by (1) its proper endyma, (2) the pia covering this, as all other parts of the brain, (3) the pia pertaining to the fornix, which layer of pia, with the layer (2) and the intervening vessels, constitutes the velum.

G. Incidentally it may be remarked that the cruciate fissure in cats and dogs constitutes, as it were, a gash

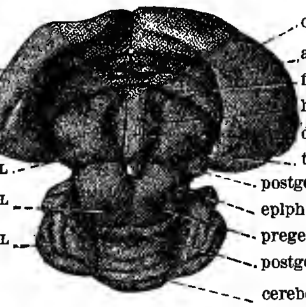


FIG. 681.—Dorsal Aspect of the Brain of a Young Rabbit, the Cerebrum and Cerebellum Pushed in Opposite Directions.

Preparation.—While fresh, the cerebellum was tilted caudad and the hemispheres cephalad, and the velum removed; the brain was then placed in strong alcohol so as to retain the desired shape. The segmental names are at the left, the names of parts at the right. The specimen has been lost or destroyed.

across the mesal margin near the cephalic end of the hemicerebrum; it appears, therefore, upon both the mesal and the dorso-lateral aspects. The well-known and easily experimented-upon motor areas of the limbs occupy the U-shaped gyre between the cruciate and coronal fissures. It does not follow, however, that the cruciate fissure and the human central fissure are homologous (§ 303).

§ 54. *Relative Size of the Segments in the Embryo and the Adult.*—In the embryo at one period the mesencephal is the most prominent region, and it remains the largest in some fishes; in the adult human brain it is one of the least conspicuous.

§ 55. *Segmental Overlapping.*—Although originally subequal in size, certain segments early manifest a tendency to extend beyond their neighbors in one or more directions. In man and the mammals generally this overlapping is in inverse ratio to the original size of the parts. The mesencephal, at one period most prominent, is encroached upon by the diencephal at the sides, by the pons ventrad, the cerebellum dorsad, and all are eventually covered by the cerebrum, primarily a comparatively insignificant portion of the brain.

§ 56. This segmental overlapping is, upon the whole, greater caudad than cephalad, most of the segments presenting something like the "rake" of the mast of a ship. The cerebellum, for example, not only extends both cephalad and caudad from its connections with the epencephalic floor, but is tilted distinctly caudad (Figs. 670, 687, and 693).

§ 57. Transections at any level caudad of the aula usually affect two or more segments. This is illustrated in the following diagrams (Fig. 683).

§ 58. *The Caudato-thalamic Fusion.*—The relations of the prosencephal to the diencephal are further complicated by the intimate fusion of the sides of the latter (thalami) with the floors of the former (caudatums). Although, therefore, in the early embryonic stages (Fig. 671) it is very easy to distinguish between the two segments, there is some difficulty in the adult. For convenience, in the present article, the capsula ("internal capsule") is adopted provisionally as the boundary, so far as regards the thalamus and the lenticula (part of the striatum). But the same medullary stratum intervenes between the lenticula and the caudatum, both prosencepalic parts, and the whole subject requires further elucidation.

§ 59. *The Segments Primitively Mesal and Single.*—This view is generally accepted with regard to the diencephal and the parts caudad of it on account of the familiar

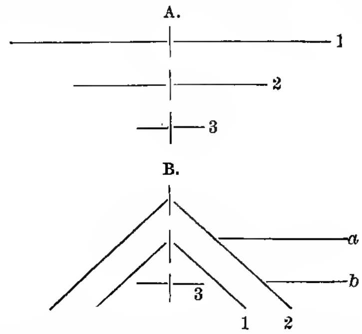


FIG. 683.—Diagrams Illustrating the Lateral Overlapping of the Mesencephal by the Two Segments Cephalad of It. The transverse axes of the prosencephal, diencephal, and mesencephal are indicated by the lines 1, 2, 3, respectively; in A they are directed laterad, as in the early embryonic stages; at B they are inclined caudad, and transections at *a* or *b* would cut two or three segments instead of one.

conditions of early development. The prosencephal likewise, although commonly described as a pair of lateral masses, is single in "fishes" (see the figures and statements in connection with that segment, §§ 158–162). The case of the rhinencephal is less readily disposed of, and will be stated in connection with that segment (§ 370).

§ 60. *Potential Triplicity of the Encephalic Segments.*—Although primarily mesal and simple, each segment presents at some period and in some vertebrates a dis-

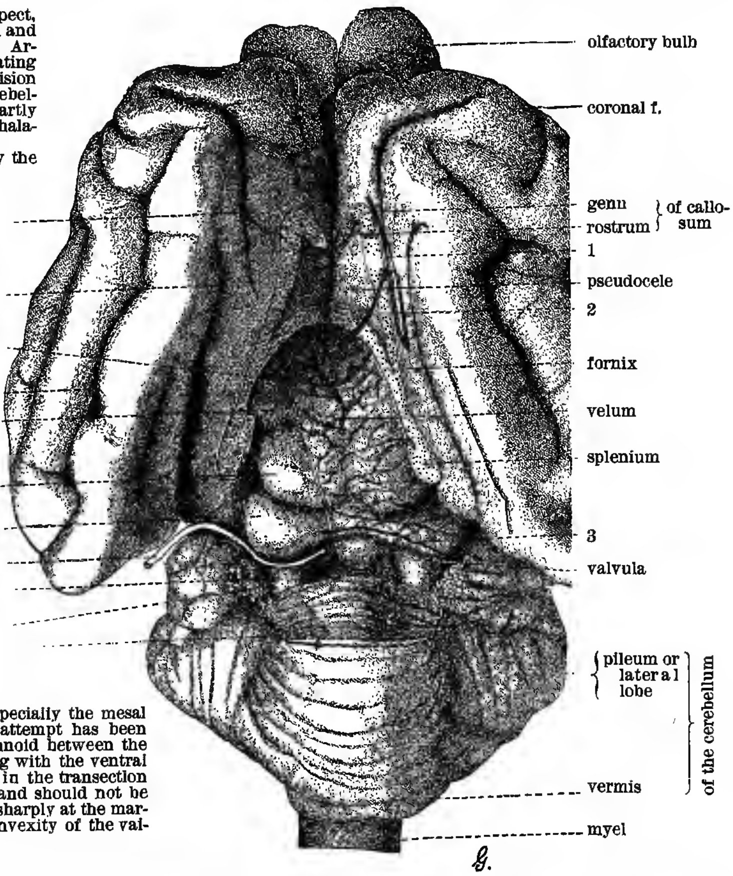


FIG. 682.—The Brain of a Cat from the Dorsal Aspect, After the Callosum and Fornix had been Divided and the Hemicerebrums Divaricated; 474. × 2. 1, Artery (precerebral ?); 2, artery joining 1, perforating the callosum from the velum; 3, 4, lines of division of the arachnoid, between the cerebrum and cerebellum; 5, line of division of the velum, which is partly removed on the left side so as to expose the thalamus and gemina of that side.

Preparation.—While fresh and supported by the *basis cranii*, the hemicerebrums were carefully separated so as to expose the callosum; this was divided, beginning with the splenium; then the fornix until the incision reached the point of attachment of the velum. The cerebellum was tilted caudad and the arachnoid between it and the postgeminum divided; the cerebellar edge of the arachnoid is represented by the line 4. The valvula is shown as if inflated with air. On the left side, along a line (5) extending obliquely caudo-mesad from under the margin of the fornix, the two layers of pia constituting the velum were divided, and the part at the left removed so as to expose more distinctly the postgeminum, pregeminum, and thalamus. The cerebral pia was removed. A similar preparation of the human brain is very desirable, but difficult to make, on account of the weight of the cerebrum.

Defects.—The arteries should have been injected with a red mass, for the better exposition of the pia, the plexuses, and especially the mesal artery (2) which penetrates the callosum. No attempt has been made to show the lines of reflection of the arachnoid between the two hemicerebrums, along a line corresponding with the ventral margin of the falx and indicated approximately in the transection (Fig. 732). The fornix is represented too thick and should not be dotted. The trochlearis nerve (N. tr.) stops too sharply at the margin of the valvula, from which it arises. The convexity of the valvula is too sharply defined.

tinctly threefold condition, with one mesal and two lateral portions. The prosencephalic triplicity is exhibited in all air-breathing vertebrates and some aquatic forms (Dipnoans, etc.); with birds and frogs the mesencephal is markedly tripartite (Fig. 682); with man and other mammals, and likewise with some other vertebrates, the epicele presents more or less extensive "lateral recesses" (Figs. 669, 684, 698). The embryonic diencephal protrudes at either side an optic vesicle that becomes the retina and optic nerve.

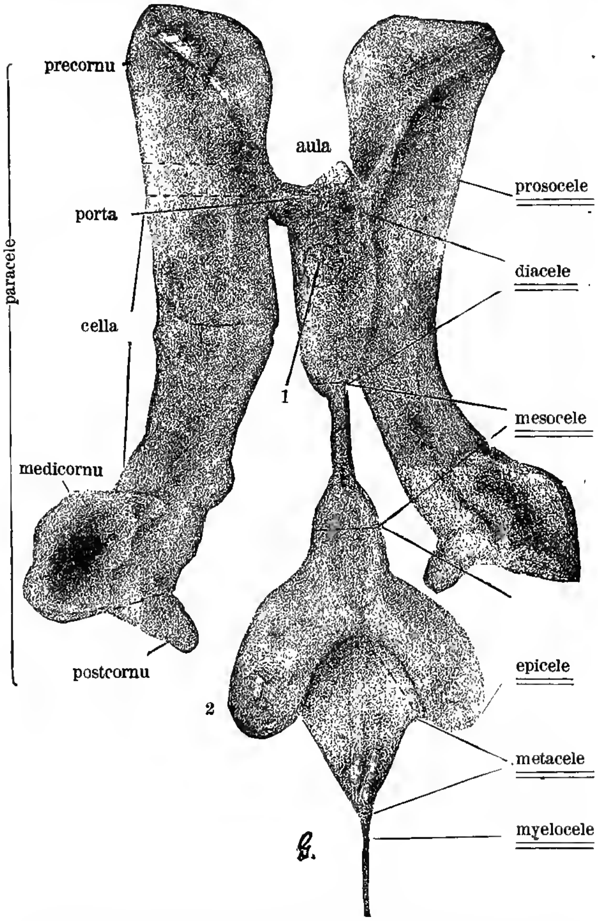


FIG. 684.—Cast of the Encephalic Cavities, Ventral Aspect; approximately correct. × 1 (?) (From Weisker, modified.) The names at the right, doubly underlined, designate five divisions of the encephalocele, together with the slender myelocele (central canal of the spinal cord). The metacele and epicele together constitute the "fourth ventricle" of the text-books; the mesocele corresponds to the aqueduct or iter; the diacele equals the "third ventricle" less the aula, which is the mesal part of the prosocele; prosocele includes all not already specified, viz., the mesal aula, the lateral paraceles ("lateral ventricles"), and the two portas through which they are continuous. The names at the left designate the parts of the paracele, viz., the cella, extending caudad from the porta; the precornu, extending cephalad; the medicornu, extending in a spiral direction laterad, ventrad, cephalad, and mesad, successively; and the postcornu projecting caudad from the cella. 2 is placed near the tip of the right lateral recess of the epicele. The larger part of the figure is modified from a photograph of the wax model made by Weisker, of Freiburg. The metacele, myelocele, and part of the epicele are from a cast of the cavities in a child. The ventral aspect was chosen in order to display to better advantage the uninterrupted series of mesal cavities, and the portas.

Defects.—I doubt whether any part represents the corresponding cavity accurately. The portas are too long (compare Fig. 718). The diacele presents neither the orifice for the medicommissure (the presumed location of which is indicated by the dotted circle (1) just caudad of the portas) nor the marked ventral extension toward the hypophysis. The medicornua are not sufficiently curved; in reality the extremity of each approaches the diacele within about 2.5 cm.; the postcornua are too short; the boundaries of the epicele are vaguely and perhaps incorrectly indicated, and the lateral recesses (2) should be longer.

§ 61. *Fig. 684 illustrates:* A. The continuity, general form, and relative size of the several divisions of the adult human encephalocele, as viewed obliquely from the ventro-dextral aspect.

B. The obvious triplicity of the prosocele, and the existence of lateral extensions of the epicele.

C. The slenderness of the mesocele as compared with its relative size in the embryo (Fig. 680) and in the adults of some other vertebrates (Fig. 685).

D. The general modifications of the primitive and typical condition of the encephalic cavity which led the older anatomists, and still lead some of their modern successors, to regard the whole as comprising four "ventricles," a first and second (lateral), a "third," and a "fourth," the aula being ignored and the mesocele considered merely as a "passage from the third ventricle to the fourth."

§ 62. *Fig. 686 illustrates:* A. An arrangement and circumscription of the encephalic cavities in the adult cat (an accessible mammal), essentially identical with that in the human adult (Fig. 735) and fetus (Fig. 716), and in vertebrates generally.

B. The great differences in size and shape between the various divisions of the encephalocele; the mesocele is little larger than the myelocele, and is tubular; the diacele is narrow but high; the metacele wide but shallow; the epicele is very irregular; the myelocele is patent throughout, while in man it is nearly obliterated. The epicelian lateral recesses are not exposed, so the triple constitution of a typical segmental cavity is exhibited only by the prosocele, with its mesal, aula, and lateral paraceles.

C. The different constitution of the celian parietes. The roofs of the aula, portas, and metacele are membranous telas, with plexuses on the ental surface.

D. The reduced thickness of the parietes near the rima, constituting the fimbria, one of the riparian or marginal parts.

E. The apparent interruption of the wall of the medicornu at the rima ("great transverse fissure"). On close examination, however, although the proper nervous parietes are absent, the intruded pial fold (paraplexus) is seen to be covered by the endyma reflected from the adjoining parts, so that the injected alcohol was completely confined.

F. The not very obvious relation of the ectal furrow, hippocampal fissure, to the ental elevation or colliculus, hippocamp; on the right the line from *postgeniculum* crosses the end of the fissure, which is not otherwise indicated.

G. The relations of the alba (medulla) to the ectocinerea (cortex) and the entocinerea ("central tubular gray"); the metepencephalic entocinerea has been removed in exposing the cavities, but it is distinct and abundant at the sides of the mesocele (aqueduct), of the diacele, consti-

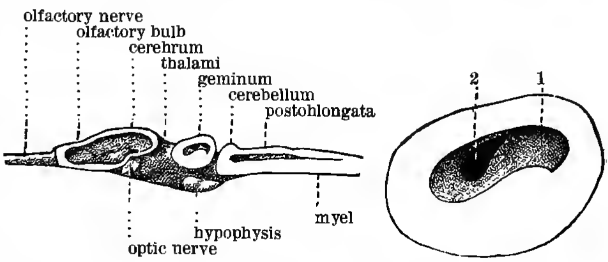


FIG. 685.—Left-hand figure: Brain of Frog Seen from the Left After Removal of Parts of the Left Side; 654. × 1.5. Right-hand figure: Enlargement of the Geminum (Mesencephal), so as to show more distinctly the lateral cavity of the mesocele and the orifice (comparable with the porta) by which it communicates with the mesal cavity.

tuting the thalamus, and of the prosencephalic precornu, constituting the caudatum and—unexpectedly—the hemiseptum and column of the fornix, all which were distinctly gray in the fresh preparation.

H. The caudal extension of the cerebrum so as to reach the cerebellum, and thus conceal the lateral aspect of the intervening segments, diencephal and mesencephal.

I. The fusion of the thalamus with the caudatum, of the diacelian side wall with the paracelian floor. The line of junction of the two segments may be regarded as indicated approximately by the word *dien.*

J. The absence or inconspicuousness of the lenticula, claustrum, and insula (compare Fig. 782).

K. The less width of the diencephal than in man, so that the geniculums maintain their proper morphological relation of cephalic (pre) and caudal (post), rather than of lateral, or "external," and mesal, or "internal," as in man.

L. The extension of the paraceles, the proper cavities of the hemicerebrums, caudad from the aula even farther than cephalad, thereby warranting the diagrammatic representation of the paraceles as lateral extensions, not cephalic only.

M. The absence of a postcornu in the cat as in most other mammals, the exceptions being man, monkeys, seals, porpoises, and some dogs.

N. The distinctness of the crista in the cat. It is not named on the figure, but may be seen as a conical elevation at the cephalic side of the aula; the line from *aula* points at it.

§ 63. *Celian Circumscription.*—The facts of development and comparative anatomy, and analogy with other hollow organs warrant the presumption that the encephalic cavities communicate only with one another and with the myelocele. Any communication with the ectal surface is presumably artificial, excepting, perhaps, at the metapore ("foramen of Magendie") and the lateral recesses (§§ 78, 98).

§ 64. *Endymal Continuity.*—The endyma is the essential and absolutely constant constituent of the celian parietes; hence in all figures purporting to illustrate celian circumscription the line representing the endyma should be distinct and uninterrupted, excepting where discontinuity has been demonstrated.

§ 65. *Fig. 687 illustrates:* A. The sharpness of the cranial or mesencephalic flexure in man. Compare the sheep (Fig. 794) and the turtle (Fig. 680).

B The continuity of the endyma lining the mesal series of cavities excepting at the metapore, and the concomitant completeness of the celian circumscription.

C. The non-communication of the pseudocele with the true cavities. (The meninges and blood-vessels are considered under Fig. 801.)

§ 66. In tracing the continuity of the endyma at the meson it is best to begin with a region where a rupture could hardly occur in either floor, roof, or sides, and where also a transection is most readily effected when the entire brain is to be studied in two parts, a cerebral and a cerebellar portion. This "place of election" is the mesocele ("aqueduct" or "*iter a tertio ad quartum ventriculum*").

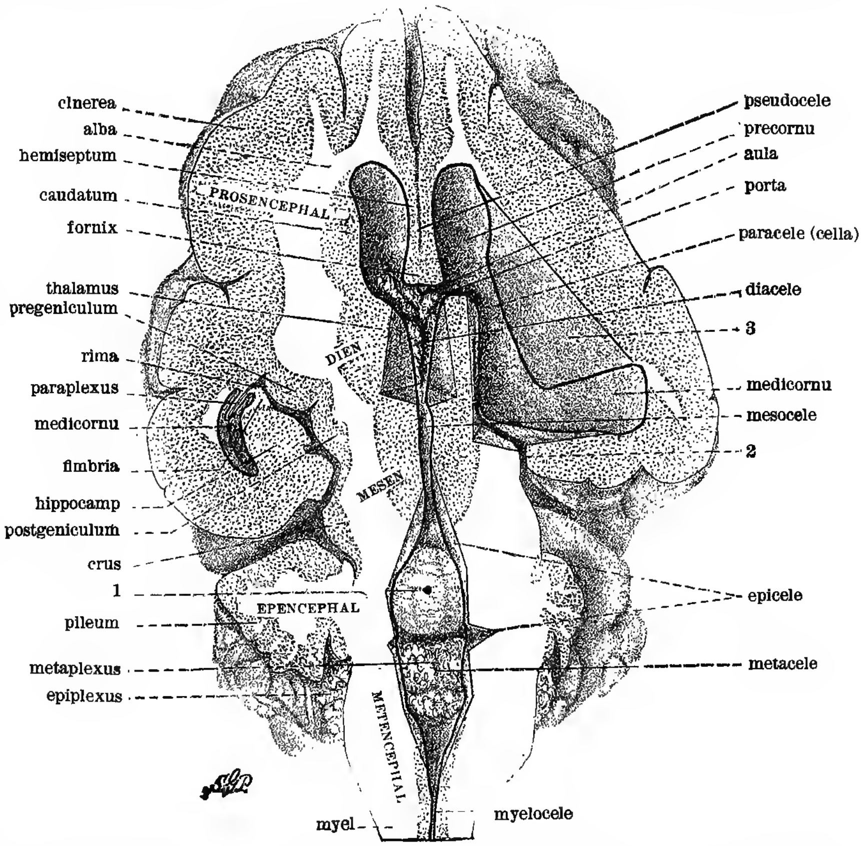


FIG. 686.—The Encephalic Cavities of a Cat, Exposed from the Ventral Side; 479. × 2. 1, The valvula, which is so thin in the cat that the cerebellar folia show dimly through it (the line is interrupted just above the L of EPENCEPHAL); 2, the narrow space between the lateral aspect of the mesencephal and the overlapping hemicerebrum; in anthropotomy this is commonly reckoned as part of the "great transverse fissure"; 3, obliquely cut surface, left by the removal of the caudatum and adjacent parts of the left hemicerebrum.

Preparation.—The brain was exposed from the ventral side and left in the calva for better support. the cavities were alinjected so as to harden the parietes and keep them apart. Successive slices were removed until the portas and aqueduct (mesocele) and myelocele were exposed. With a narrow-bladed knife the walls of the diacele (including the medicommissure), epicele, and metacele were cut away obliquely; also on one side (the right of the preparation, but the figure is reversed so that it appears on the left) the caudatum, hippocamp, and part of the thalamus, so as to expose the continuity of the precornu and medicornu. The olfactory bulbs were removed with the ventral portion of the cerebrum. The boundaries of the cinerea (cortex, etc.) and alba (medulla) were ascertained by comparing the similarly exposed surface of a fresh brain; some of the differences between the two sides are due to a slight difference of the section-levels.

Defects.—The braiu should have been prepared in a chromic-acid solution, or injected with the red mixture, so as to differentiate the alba and cinerea.

A. The endyma covering the floor of the mesocele may be traced caudad (actually almost directly ventrad) with slight depressions and elevations through the oblongata to the myel where it lines the slender myelocele, the "canal of the cord."

B. Recommencing at the same point in the mesocele, the floor endyma turns quite sharply ventrad over the cephalic curvature of the crus, passes the albicans, and reaches a region where the floor is thin and frequently torn in removing the brain. This is the tuber, commonly called "*tuber cinereum*," which is continuous with the infundibulum, and thus with the hypophysis. The cephalic part of the tuber is reinforced by the chiasma,

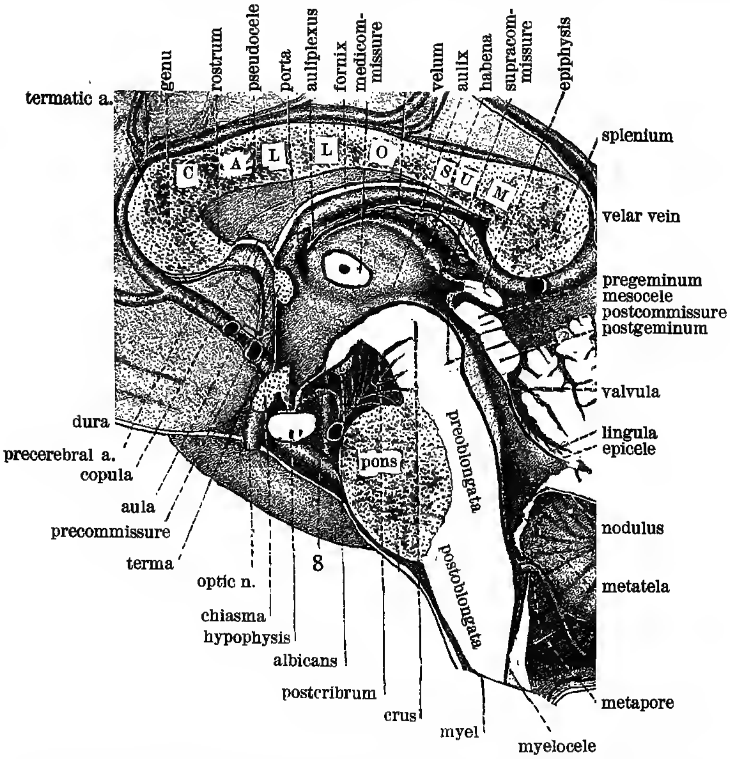


FIG. 687.—The Mesal Cavities of an Adult Brain Exposed from the Left, with Their Immediate Parietes. × .65. Fig. 801 represents the entire meson of the same specimen on a smaller scale, and its mode of preparation is there described.

Defects.—In addition to those specified under Fig. 801, the most serious are: (*a*) the non-representation of the postpontile recess, the mesal depression just caudad of the pons, shown in Fig. 702, 2; (*b*) the presence of the line curving dorso-caudad from the rostrum of the callosum; (*c*) the imperfect indication of the membranous parietes of the dorsal sac, the pouch lying upon the epiphysis; (*d*) the non-designation of the diacele.

the ental margin of which presents a marked transverse ridge, sloping caudad into the tuber and cephalad into the optic recess. In Figs. 689 and 708, the chiasma and tuber are shown with the hypophysis attached; but in Fig. 672 it is detached, leaving an orifice, the lura.

C. Directly dorsad from the chiasma, the cephalic wall of the diacele is the terma (*lamina terminalis*, or *l. cinerea*), so thin and delicate as not infrequently to be ruptured during the removal or manipulation of the brain. The proper nervous material of the terma seems hardly more substantial than the lining endyma and the covering pia, here represented by the ental and ectal lines. The ectal aspect of the terma is shown in Fig. 711.

D. Suddenly there is a marked thickening of the cephalic wall, from the reinforcement, so to speak, of the terma by a fibrous cord, oval or elliptical in section. This, the precommissure, connects the olfactory bulbs and portions of the cerebrum upon opposite sides, and hence belongs to both the rhinencephal and prosencephal; the cavity just caudad and dorsad of it is the aula, the mesal portion of the rhinocele and prosocele; §§ 362–364.

E. From the precommissure caudad to the roof of the mesocele the course of the endyma is extremely irregular, and the nature and shape of the roofs are very diverse. The immediate roof is largely membranous, and the condition is further complicated by blood-vessels large and small, and by plexuses. Finally, the parts lying directly upon the meson differ materially from those just laterad of it, and as the chances are altogether against a medisection being exactly mesal in the whole of its course, there is nearly a certainty that upon the first inspection one will miss anticipated features and see what one does not understand.

F. The recognition and comprehension of the actual facts in a given preparation will be facilitated by consulting the diagram (Fig. 725), and the representations of the brains of the cat and rabbit (Figs. 681 and 682). The important point to bear in mind is that the complete circumscription of the mesal encephalic cavities would be unaffected were the entire cerebrum removed, including the callosum, hemiseptum (the lateral wall of the pseudocele), and fornicommissure (the mesal continuity of the fornix), down to the point where the heavy line representing the endyma leaves the narrow, white area representing the fornicommissure to cross the convex surface of the fornicolumn and be reflected upon the auliplexus. The details of this, the aulic and portal region, are more clearly seen in the enlarged figures of the porta (Figs. 721 and 719).

G. From the auliplexus (at or very near the meson) or from the portiplexus (if the section plane passes through the right or left porta instead of the mesal aula) the endyma may be traced caudad upon the ventral surface of a membranous fold, the velum. Strictly speaking, between the endyma and the velum, which is a fold of pia, intervenes the remnant of the primitive nervous roof of the diacele. This may persist in some animals, but in the adult cat and in man, so far as I am aware, there is practically nothing between the pia constituting the velum and the endyma. At each side of the meson there depends a more or less distinct vascular fringe, the diaplexus, continuous with the auliplexus, the portiplexus, and thus with the paraplexus, these last three being successive members of the prosoplexus.

H. The relations of the endyma to the velum and plexuses are more clearly shown in Fig. 732, representing a transection of the diacele. There also are shown the relations of the habena. This is a low ridge following a curved line along the mesal aspect of the thalamus from the dorsal end of the porta to near the epiphysis; it is covered by endyma, but just dorsad of it, dimly seen in the figure, is a shallow furrow, the habenal sulcus, from which the endyma is reflected first dorsad, and then mesad, upon the velum and the diaplexuses. The habena unites with its opposite (fellow of the other side) at the supracommissure. The endyma line is seen to leave the velum, and descend to the dorsal (really cephalic) surface of the epiphysis, whence it extends cephalad to and over the margin of the supracommissure, then into and out of the epiphyseal recess, and over the convex cephalic surface of the postcommissure; thence it enters the mesocele, where the tracing of its continuity was begun, only it is now the lining of the roof, the geminal bodies, instead of the floor.

I. Continuing caudad, there is but slight change in the direction of the roof of the mesocele; a great reduction in its thickness occurs in the transition from the postgeminum to the valvula. The succeeding part, the lingula, is somewhat thicker and trends slightly dorsad, to become continuous with the cerebellum proper. The cavity here resembles a gable roof, with a sharp dorsal angle. The caudal slope is formed by the nodulus, a comparatively massive mesal lobe; but from its margin, commonly more rounded than appears in this figure, the endyma

Brain.

TABLE II.—PROVISIONAL GROUPING OF SOME NEURAL PARTS ACCORDING TO THEIR SEGMENTS AND SOME OTHER CHARACTERS.

	1. Segment.	2. Chief constituent.	3. Cavity.	4. Membranous portion.	5. Plexuses.	6. Thin and riparian parts.	7. Commissures, etc.	8. Some other parts.
I.	Rhinencephalon.	Bulbi olfactorii.	Rhinocœlia. ...	Rhinotela (in some "fishes")	....	....	Præcommissura (pars olfactoria).	Præcribrum, limen, criata.
II.	Prosencephalon.	Cerebrum....	Prosocœlia (including the mesal aula and lateral paracœliæ).	Prosotela (including the mesal aulatela and lateral paratelæ).	Prosoplexus (including the mesal auliplexus and lateral paraplexus).	Tænia, fimbria, pala, terma.	Præcommissura (pars temporalis), callosum, fornix.	Pallium, insula, lenticula, caudatum, paraphysis.
III.	Diencephalon.	Thalami	Diacœlia	Diatela........	Diaplexus	Habena	Supracommissura, medicommissura, chiasma.	Postcribum, tuber, hypophysis, epiphysis, genicula.
IV.	Mesencephalon.	Quadrigeminum.	Mesocœlia	Mesotela (in the lamprey).	....	Valvula	Postcommissura, decussationes tegmentorum.	Crus, tegmentum, crusta, lemniscus, intercalatum.
V.	Epencephalon.	Cerebellum ..	Epicœlia......	....	Epiplexus	Lingula........	Pons	Præoblongata, vermis, flocculus, dentatum.
VI.	Metencephalon.	Postoblongata.	Metacœlia	Metatela.......	Metaplexus	Metaporus, ligula, obex.	Decussatio pyramidum.	Pyramis, oliva, trapezium.
VII.	Myelon	Myelon	Myelocœlia....	Myelotela (in lumbar enlargement of birds).	....	....	Commissura ventralis, c. dorsalis.	Conus, filum.

is abruptly reflected, together with the pia which had covered its caudal surface; these two membranes, closely united, and with apparently little or no trace of the primitive nervous roof, constitute the metatela. This is interrupted or modified at the orifice here called metapore, but commonly known as "foramen of Magendie"; in the present figure it is at the point where an artery appears. Later observations indicate that the above accounts of the metatela and metapore do not apply to all specimens; see §§ 77–83.

§ 67. *Encephalic Variations.*—Excepting as to the fissures and gyres, and the pyramidal decussation, treatises upon anatomy seldom refer to variations or anomalies of the surfaces or ental structures of the brain,* yet they are frequent, and sometimes significant, morphologically if not physiologically. So far as I can determine from my own materials, and from figures and descriptions, there is hardly a feature of the human brain respecting which it can be stated confidently what is normal, or how frequently certain peculiarities occur.

§ 68. *Classification of the Parts of the Brain.*—The foregoing account of the brain as a whole constitutes an introduction to the description of each of the six segments, beginning with that immediately succeeding the myel.

§ 69. *Commentaries upon Table II.*—A. It is substantially identical with Table VII. in my paper, 1896, *h.* Compare the tables in the first edition of this work (1889, *a*),

* The subject is treated with unusual fulness by Krause, 1889, 192–195.

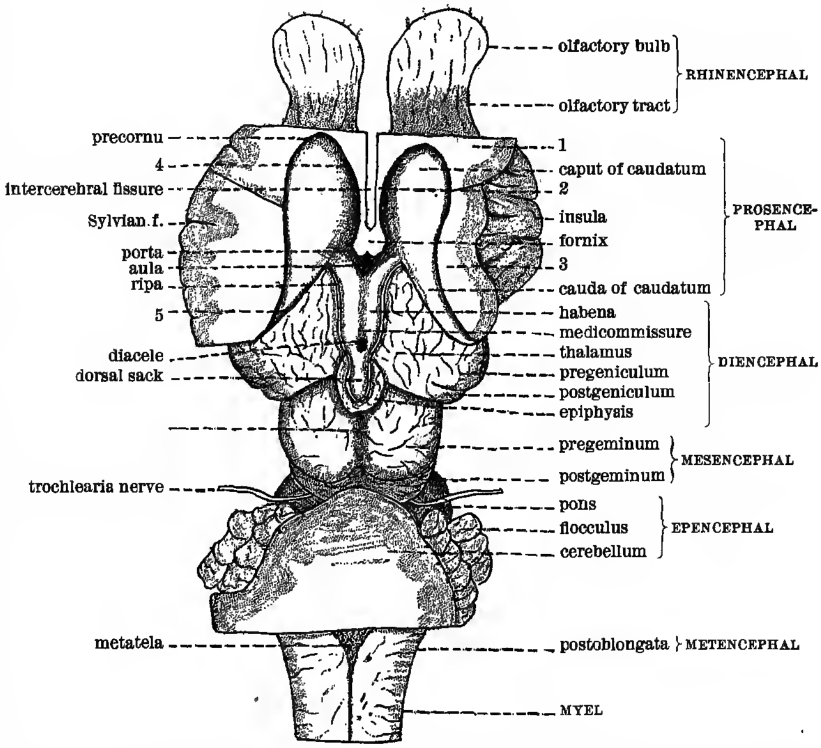


FIG. 688.—Brain of the Sheep, dissected so as to exemplify the segmental constitution of the organ in mammals. From "Physiology Practicums." 1, Cephalic slope of the cut surface of the cerebrum; 2, mesal wall of the paracele—at a higher level this would be one of the hemiseptums; 3, horizontal cut surface of cerebrum; 4, the mesal, vertical portion of the paracele; 5, indicates the location of the ripa between the thalamus and caudatum, but it is overhung by the latter so as not to appear in this view; 6, mesal furrow of the pregeminum.

From the cerebellum have been cut both caudal and dorsal parts. On the cut dorsal surface are seen the central alba and the peripheral cinerea, but the outline of the latter is diagrammatic only. At the sides are the tiers of foliums constituting the flocculus.

From the cephalic end of the cerebrum have been cut the parts projecting over the olfactory tracts, but part of the cephalic slope is here marked 1. With the dorsal portion were removed the entire callosum and the fornix excepting the cephalic vertical part. This and the mesal walls of the paracele are really cut at a lower level than the larger cut surface on the left. On the right the insula has been exposed by pushing up and breaking off the overhanging parts. The ectal surfaces, covered by pia, are indicated by irregular lines representing the blood-vessels.

The ental surfaces, covered by endyma, are those of the caudatums in the paraceles, the habenas, medicommissure, and dorsal pouch; and the floor of the aula and portas.

The irregular line laterad of the habena and extending around the endymal area on the epiphysis represents a ripa (shore line). It consists of the cut or torn edges of the pia from the dorsum of the thalamus and of the endyma from the habena which united to form a membranous roof of the diacele, the diatela, which has been removed.

Similarly the pial, dorsal surface of the thalamus is demarcated from the endymal surface of the caudatum by a ripa which meets the other at the porta.

The epiphysis, although a constituent of the diencephal, is tilted caudad so as to rest upon the pregeminum, and the mesal part is covered by the dorsal sack.

and in Wilder and Gage, 1882, 409. From the tables of Schwalbe (1881, 397) and His (1893 and 1895) it differs especially in the absence of any attempt to indicate the relative "values" of the several segments upon embryologic or other grounds.

B. Its purpose is twofold: (*a*) To indicate, according to my present information and belief, the number and constitution of the definitive encephalic segments. (*b*) To illustrate the verbal correlations between the names of the segments themselves (column 1), and those of (3) their major cavities, (4) their membranous parietes, and (5) their vascular plexuses.

C. The Latin form of the names is employed (see § 10).

III. METENCEPHAL.—§ 70. Synonyms: Metencephalon, after-brain, myelencephalon, macromyelon.

§ 71. *Tabular Arrangement of Parts.*—Chief part: postoblongata (caudal portion of "medulla oblongata"). Cavity: metacele (caudal portion of "fourth ventricle"). Floor: postoblongata. Sides: restes ("restiform bodies") and ligula. Roof: metatela and obex. Plexuses: metaplexuses. Orifice or evagination: metapore ("foramen of Magendie"). Decussation: Dec. of the pyramids. Other ectocelian parts and features: Ventral sulcus; ventral column; pyramid; oliva; arciform fibres; lateral column; funiculus of Rolando; tubercle of Rolando; cuneate funiculus; *funiculus gracilis;* clava; ligula; obex. Other entocelian parts and features: Mesal sulcus; *ala cinerea;* postfovea; *eminentia cinerea.*

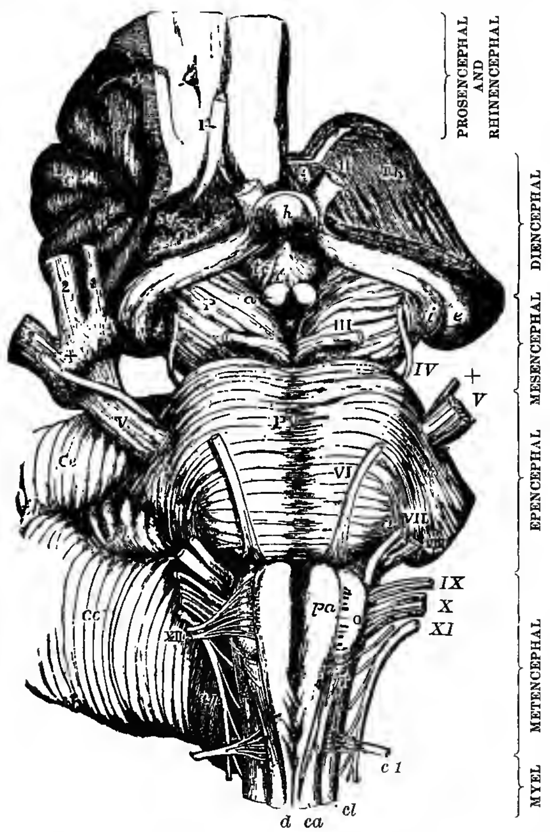


FIG. 689.—Ventral Aspect of the Entire Brain Stem. × 1. (From Quain.) Compare Fig. 672. The Roman numerals I.–XII. designate the twelve pairs of cranial nerves; *ii*, the optic tract, more completely exposed than in Figs. 672 and 728; *a*, albicans; *c*, insula; *ca*, ventral column; *c* 1, first cervical, or suboccipital nerve; *ce*, cerebellum; *cl*, lateral column; *d*, ventral fissure of the myel, just cephalad of which is seen the decussation of the pyramids; *e*, pregeniculum; *f*, lemniscus; *fl*, flocculus; *h*, hypophysis; *i*, postgeniculum; *o*, oliva; P, crus; *pa*, pyramid; PV, pons; *r*, "lateral tract of oblongata," direct cerebellar tract; *Sy*, at the ventral margin of the insula, indicates where the basisylvian fissure begins; *tc*, tuber ("*tuber cinereum*"), between which and the hypophysis is the infundibulum; *Th*, thalamus, cut surface; ×, postcribrum ("posterior perforated space"); × ×, precribrum ("anterior perforated space"); +, motor root of trifacial nerve.

Preparation.—The entire left hemicerebrum has been removed by an incision described as passing (in the capsula?) between it and the thalamus; on the right side are left the insula, the adjacent part of the frontal lobe, the olfactory tract, and the precribrum.

Defects.—Several parts, notably the albicantia (*a*) and the flocculus (*fl*), are represented in a somewhat conventional way, and the cimbia ("*tractus peduncularis transversus*") is omitted. The crura, especially the left, are shaded so as to appear twisted.

§ 72. The postoblongata (Figs. 670, 688, 689, etc.) is so obviously a continuation of the myel that if there were no parts cephalad of it, and if it were wholly contained within the spinal canal, it would probably be regarded as merely a somewhat modified region of the myel, comparable with the lumbar enlargement near its other extremity, which also in birds contains a distinct and thin-roofed dilatation, the rhombocele.* There is, therefore, ample etymological warrant for the name *macromyelon* (large myel region), applied by Owen, and for *myelencephalon* (myel-like brain region), employed by Huxley, His, and others. On account, however, of its equally obvious continuity with the preoblongata (especially in animals lacking the pons, *e.g.*, the turtle, Fig. 680); its location, mostly within the cranium; and the number, peculiarity, and vital importance of the nerves connected with it, the postoblongata is conveniently regarded as a definitive segment† of the brain under the title, *metencephal.*

§ 73. Nevertheless both the macroscopic and the microscopic structure of the postoblongata are much better understood in connection with those of the myel. For more details the reader is referred to the articles *Spinal Cord* and *Brain, Histology of the.*

§ 74. *Fig. 689 illustrates:* A. The ectal origins of the cranial nerves.

B. The ventral aspect of the adult insula (comp. Figs. 672 and 781).

C. The continuity of the optic tract with both geniculums.

D. The decussation of the pyramids (see under Fig. 672).

E. The representation of all six segments upon the ventral aspect of such a preparation, including the parts of what is commonly called the "brain stem."

§ 75. The postoblongata differs from a corresponding length of the myel in size, shape, amount of alba, amount and arrangement of cinerea, the extent and form of the cavity, and the nature of its roof.

§ 76. In the myel the two halves dorsad of the commissures are in contact; this is the case also with the caudal extremity of the postoblongata; but for most of its length the originally mesal surfaces are separated by a rapidly widening interval, so that what was mesal becomes successively dorsal, and finally lateral, while what was lateral becomes approximately ventral. These changes materially increase the width of the segment.

§ 77. *Metacele.*—The cavity, a tube in the myel and caudal part of the postoblongata, is expanded into an irregular triangular fossa, the metacele or caudal part of the "fourth ventricle." The roof of this cavity consists of only the lining endyma and the covering pia, constituting the metatela.

§ 78. *Metapore (foramen of Magendie).*—In 1826–27 Magendie described (1827, 1–29) an orifice in the roof of the "fourth ventricle" by which that cavity communicates with the subarachnoid space. Magendie designated the orifice as *entrée des cavités du cerveau* or *entrée des ventricules cérébraux.* In 1855 Luschka published a description and figure of the orifice, which he renamed *foramen Magendii.* In the present article these and various other polyonyms are replaced by the mononym *metapore,* Latin *metaporus,* signifying an orifice in the metatela, the membranous roof of the metacele, the cavity of the metencephal.

* This dilatation of the myelocele has also been called *sinus rhomboidalis;* and this name has likewise unfortunately been applied to the "fourth ventricle," the continuous cavity of the metencephal and epencephal; furthermore, there have come into use derivatives like "rhomboidal lip" and "secondary rhomboidal lip."

† As stated in § 43, this region represents several potential segments or neuromeres.

§ 79. Most later anatomical writers have admitted the existence of the metapore, but the descriptions are commonly brief and the figures unsatisfactory. That by Key and Retzius is suspiciously symmetrical, although

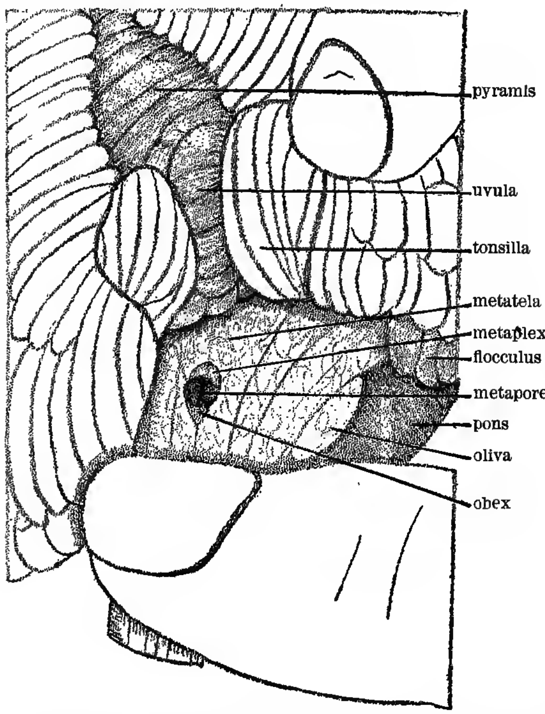


FIG. 690.—The Metapore (Foramen of Magendie) as Exposed by the Divarication of the Cerebellum and Oblongata; 318. × 1.

Preparation.—The brain of an adult Swedish carpenter was removed with great care, by dividing the calva sagittally at the left of the meson, so as to avoid tearing membranous adhesions. The brain was supported on a bed of cotton; the arteries and the arachnoid extending from the cerebellum to the oblongata were cut away and the two parts held asunder with fingers so as to expose the region of the metapore. A photograph was then taken, upon which the drawing is based. After hardening, however, most of the cerebellum was cut away and another photograph taken of the reduced mass. The specimen and both photographs were shown at the meeting of the Association of American Anatomists, December 28th, 1892.

Defects.—The right side of the cerebellum was displaced more than the left, giving rise to the marked obliquity. The metapore itself should be shown on a larger scale. The postcerebellar arteries are omitted; they do not appear distinctly in the first photograph, and no record was made of their locations. This is unfortunate, since in all the cases in which they are preserved their relations to the metapore are close. Had more of the caudal aspect of the cerebellum been included, there might have been shown the line of attachment of the arachnoid at the boundaries of the postcisterna. The wavy lines on the dorsum of the oblongata hardly do justice to the vascularity of the pia covering that region.

it is copied by Schwalbe; Henle's (Fig. 691) is more natural. The best figures and the fullest description are those of Carl Hess, 1885, but few figures have the appearance of having been based upon photographs.

§ 80. My own earlier scepticism was based partly upon the absence of any such orifice in the cat and sheep, and upon the presumption in favor of endymal continuity and celian circumscription. The steps of my conversion to the more common view are stated in the first edition of the REFERENCE HANDBOOK and in the papers there referred to. The examination of specimens carefully prepared for the purpose showed that:

(1) The metapore is a normal and nearly constant feature of the human brain at and after birth.

(2) It exists also in apes and some monkeys.

(3) There are two human types, viz.: (*a*) definite, as shown in Fig. 690; (*b*) indefinite, Fig. 691. The latter is the more common.

§ 81. *Fig. 690 illustrates:* A. The existence of a natural orifice in the membranous roof of the "fourth ventricle."

B. The simplicity of the form and relations of the metapore in this specimen. It is mesal, symmetrical, and oval.

C. The appearance of the metaplexuses just within the cephalic margin of the metapore with no such extension upon the cerebellum as is shown in Fig. 691.

§ 82. *Fig. 691 illustrates:* A. The admission of the normal existence of the metapore in the adult by so expert an anatomist as Henle.

B. The attachment of an extension of the metatela from the cephalic border of the metapore upon the uvula and pyramis of the cerebellum.

C. The extension of the metaplexuses upon the thus everted ental aspect of the metatela, whereas in the specimen represented in Fig. 690 they barely appeared at the margin.

D. The topographical relation of the contorted postcerebellar arteries to the metapore.

E. The relation of the flocculus to the lateral recess (Fig. 698).

§ 83. *The Metapore the Outlet of an Evagination.*—In accordance with the general morphological relations of the germ layers Minot published (1892, 676) this passage:

"Several writers have thought that the membrane [endyma] was broken through at certain points, but it prob-

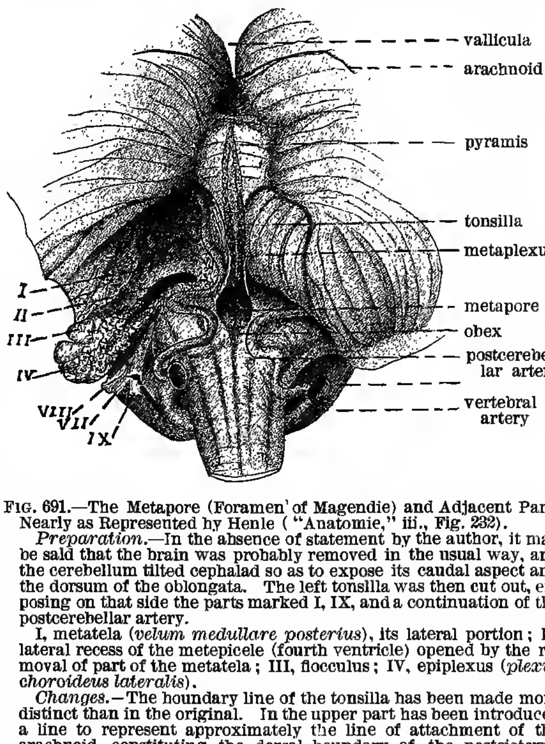


FIG. 691.—The Metapore (Foramen of Magendie) and Adjacent Parts Nearly as Represented by Henle ("Anatomie," iii., Fig. 232).

Preparation.—In the absence of statement by the author, it may be said that the brain was probably removed in the usual way, and the cerebellum tilted cephalad so as to expose its caudal aspect and the dorsum of the oblongata. The left tonsilla was then cut out, exposing on that side the parts marked I, IX, and a continuation of the postcerebellar artery.

I, metatela (*velum medullare posterius*), its lateral portion; II, lateral recess of the metepicele (fourth ventricle) opened by the removal of part of the metatela; III, flocculus; IV, epiplexus (*plexus choroideus lateralis*).

Changes.—The boundary line of the tonsilla has been made more distinct than in the original. In the upper part has been introduced a line to represent approximately the line of attachment of the arachnoid, constituting the dorsal boundary of the postcisterna (see Fig. 806).

Defects.—The margins of the metapore are too sharply defined; this is, perhaps, unavoidable when the parts are upon so small a scale; it cannot be said to bear either way upon the question of the naturalness of the orifice, for the effect of tearing a tough membrane like the metatela would be to leave ragged edges. The relations of the plexuses and accompanying strip of metatela are inadequately indicated, and the writer regrets his present inability to elucidate them. The postcerebellar arteries are represented as if distributed only between the oblongata and cerebellum, and between the lobes of the latter (compare Fig. 806).

ably is really continuous throughout life. The fourth ventricle is to be regarded, then, as an expansion of the central canal permanently bounded by the original medullary walls."

In the following year, in a letter which he authorized me to publish in my paper (1893, *d*), Minot made the important suggestion that the metapore represented the mouth (proximal orifice) of an evagination of the endyma. Mrs. Gage found (1893) an evagination in *Amia*, and in *Diemyctylus* a distal orifice. Recently J. A. Blake has gone over the whole subject and shown (1898, 1900) by an admirable series of sections that in cats and dogs and other mammals there is a caudal protrusion of the metatela in the form of a closed sac, but that in man and apes, and (with modifications) in other primates, the larger part of the sac disappears so as to leave a free communication between the "fourth ventricle" and the postcisterna, a subarachnoid space. Blake's paper is accessible to American anatomists, and the bibliography is very complete; much, however, remains to be done.

§ 84. The increased cinerea of the postoblongata consists of (1) the continuous expanded masses of the ventral and dorsal cornua, especially the latter, which, with the modified ventral commissures, constitute the metacelian floor; (2) special masses of cinerea, more or less completely separate, the *nidi* of Spitzka, the niduli of Herrick, the "nuclei" of most writers, constituting the ental or deep origin of certain cranial nerves, and presumably representing detachments of the cornua; (3) the *dentatum olivæ*, or olivary nucleus, a capsule of cinerea within the oliva, resembling the cerebellar dentatum.

§ 85. *Fig. 692 illustrates:* A. The insensible transition from the myel to the postoblongata, and thus from the myel as a whole to the brain as a whole.

B. The apparently sharp demarcation between the epencephal, represented here mainly by the pons, and the adjoining segment. In reality, however, not only do the cephalic and caudal margins overhang the adjoining surfaces to a certain extent (see Fig. 702, 1 and 2), but it is by no means certain that the pons covers no more and no less than the epencephalic portion of the oblongata. In the sheep and cat, for example, the trapezium, here invisible, is exposed (Fig. 794), while with many lower vertebrates the pons is rudimentary or absent altogether, and the boundaries between metencephal and epencephal must be otherwise determined; *e.g.*, the turtle, Fig. 680.

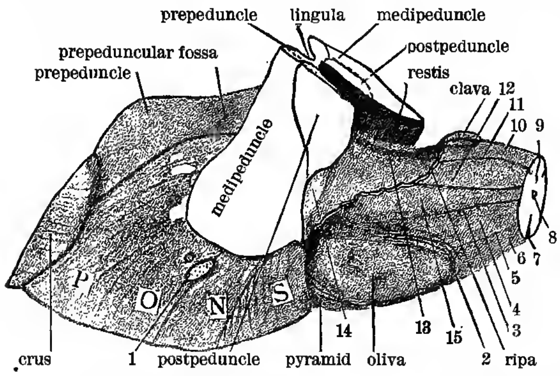


FIG. 692.—Left Side of the Metepencephal (After the Removal of the Cerebellum); 2,136. × 1.5. 1, Emergence area of the trifacial nerve, the larger the sensory root, the smaller the motor; 2, the *fibræ arciformæ* partly encircling the oliva; 3, line of emergence of the accessorius and of the dorsal roots of the spinal nerves; 4, continuation of the lateral column of the myel; 5, line of emergence of the ventral roots of the spinal nerves; 6, ventral column; 7, ventral (mesal) fissure; 8, myelocele; 9, dorsal (mesal) fissure; 10, *funiculus gracilis*, the oblongatal continuation of the myelic dorsomesal ("posterior median") column, enlarging cephalad into the clava; the clava and funiculus together are sometimes called "posterior pyramid"; 11, "posterior median fissure"; 12, *funiculus cuneatus*; 13, the shaded band represents the mesal portion of the metacele (caudal part of the "fourth ventricle") between the restes ("restiform bodies") of the two sides; 14, acoustic tubercle, over which run the acoustic striæ, which are not shown; 15, tubercle of Rolando, the continuation of the unspecified funiculus of Rolando, interpolated between the *funiculus cuneatus* and the emergence line of the dorsal roots.

Defects.—Although good in general form and showing the oliva and its arciform fibres (2) with unusual distinctness, the specimen does not exhibit the several columns very clearly, and the lines of demarcation, excepting the "posterior median fissure," are taken from other preparations and from figures; this applies also to the lines upon the pons indicating the passage of the caudal fasciculi entad of the cephalic. The dotted lines demarcating the sectional areas of the peduncles are only approximately accurate. The facial and acoustic nerves are not shown, or the acoustic striæ (see Fig. 693).

C. The lapping of the cephalic portion of the pons over the caudal, giving the appearance of a twist or rotation of the medipeduncle upon its own axis to the extent of the fourth of a circle.

D. The relation to the oliva of the arciform fibres (2), which appear to be derived from the pyramid and to pass around the caudal end of the oliva to enter into the composition of the restis and postpeduncle.

E. The projection of the right clava beyond the left, a marked lack of symmetry in this specimen.

F. The ripa, or line of demarcation between the general, pial surface of the myel and oblongata, and the endymal, metaceliau surface. The ripa consists of the pia and endyma with, in some specimens (Fig. 702), a thin intervening lamina of nervous substance.

G. The prepeduncular fossa, a shallow depression on the dorso-lateral surface of the prepeduncle, near the medipeduncle.

§ 86. The visible longitudinal divisions of the postoblongata do not correspond altogether with the myelic columns. The ventral column (Fig. 672, *i*, Fig. 689, *ca*, Fig. 692, 6) continues cephalad partly in the pyramid of the same side, as would naturally be expected, but mostly dips entad of the pyramid and oliva and forms longitudinal fasciculi near the meson farther dorsad.

§ 87. Of the lateral column (Fig. 689, *cl*, and Fig. 692, I) a large part crosses at the decussation (shown in Fig. 689, but not always visible) to constitute mainly the pyramid of the opposite side. Some of the fibres join the restis of the same side, constituting the "direct lateral cerebellar tract." The rest of the lateral column dips entad of the oliva and "forms the longitudinal fibres of the *substantia reticularis grisea.*"

§ 88. The dorsal column of the larger portion of the myel is displaced in the cervical region by the dorsomesal ("posterior median") column (Fig. 692, 10); this, in the postoblongata, is called *funiculus gracilis.* Near the apex of the metacele it presents a distinct enlargement, the clava (Fig. 692), cephalad of which the funiculus is no longer distinct. Between the *funiculus gracilis* and the lateral column (Fig. 692, 4) there intervene, in the postoblongata, two funiculi, of which the more lateral (15) is regarded as the direct continuation of the dorsal column of the myel, but is commonly called funiculus of Rolando, sometimes "lateral cuneate"; between it and the dorso-mesal column (*funiculus gracilis*) intervenes another interpolated funiculus, the cuneate (12); this and the funiculus of Rolando appear to enter into the composition of the restis ("restiform body") which is continued as the postpeduncle into the cerebellum; but, according to *Quain*, this relation is rather apparent than real, the components of the restis and postpeduncle being (*a*) the arciform fibres (Fig. 692, 2) from the ventral column, and (*b*) the "direct cerebellar tract" of the lateral column.

§ 89. The increased bulk of the postoblongata is due also in part to the entrance (or exit) of the roots of the accessory, hypoglossal, vagus, and glosso-pharyngeal nerves, which are more numerous than the spinal nerve roots upon a similar length of the myel (see Figs. 672 and 689).

§ 90. *Fig. 693 illustrates:* A. The general topographic relation of the cerebellum to the segments just cephalad and caudad, and to the ventral portiou of its own segment, through the three pairs of peduncles, prepeduncle (5), postpeduncle (3), and medipeduncle (the cut area crossed by line 5 on the right and by lines 3, 4, and 5 on the left).

B. The tendency of anatomical writers to ignore the existence or traces or morphological significance of the thin or membranous portions of the encephalic parietes (see my paper, 1891, *b*).

IV. EPENCEPHAL.—§ 91. *Synonyms.*—Epencephalon; metencephalon; cerebellar segment; hindbrain.

§ 92. *Principal Parts.*—Floor: preoblongata and pons. Roof: cerebellum and lingula. Sides: peduncles. Cavity: epicele with lateral recesses. Ectocinerea: cortex. Entocinerea: dentatum, fastigatum, embolus, globulus. Chief cerebellar divisions: (mesal) vermis; (lateral) pileums ("hemispheres"). Flocculus and parafiocculus.

§ 93. *Boundaries.*—The epencephal may be defined as including as much of the brain tube as intervenes be-

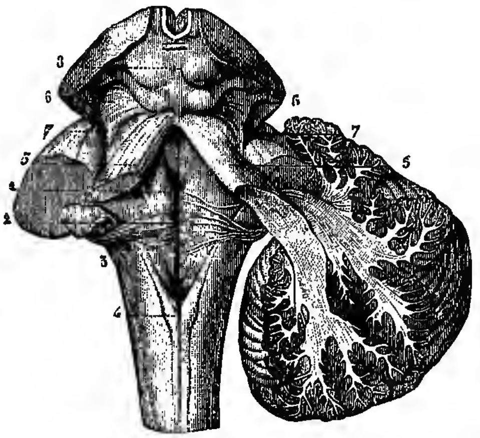


FIG. 693.—Dissection of the Peduncles. × 0.5. (From Quain, after Sappey, and Hirschfeld and Levielié.) 1, Mesal sulcus; the line crosses the middle of the wide cut surface of the medipeduncle; 2, mesal sulcus at the place of emergence of the acoustic striæ; 3, postpeduncle, continuous with the restis; the cut end of the postpeduncle is crossed by the line, 2; 4, the clava, the swollen portion of the funiculus gracilis; 5, prepeduncle; 6, lemniscus; 7, lateral sulcus of the crus; 8, pregeminum, the postgeminum just caudad.

Preparation.—On the left, the three peduncles are cut short; the right half of the cerebellum is cut obliquely, and tilted laterad, so as to show the connections of the prepeduncle and postpeduncle.

Defects.—There is no evidence of the lines of division, ripas, of the endyma in exposing the metepicele ("fourth ventricle"), or of the existence of the valvula and lingula between the prepeduncles.

tween the membranous portion of the roof (metatela) and the decussation of the trochlearis nerve, together with the corresponding regions of the floor and sides and the encompassed cavity, the epicele.

§ 94. *Fig. 694 illustrates:* A. The general aspect of the adult cerebellum from the side.

B. The location of three main sulci, furcal, cacuminal, and peduncular.

§ 95. *Epicele.*—The epencephalic cavity includes the cephalic ("anterior") portion of the "fourth ventricle" together with its dorsal extension (fastigium) into the cerebellum, more or less triangular in form. According to Blake (1898–1900, 89–90) the cavity of the cerebellum has at first a greater dorso-ventral extension which is reduced by the fusion of the opposed walls.

§ 96. *Lateral Recesses.*—By this name are commonly known the pair of extensions of the "fourth ventricle" laterad and ventrad (Figs. 684, 695, and 698). Their walls are partly membranous (metatela) and partly substantial (sides of oblongata, peduncles of flocculus, and certain nerve roots). They might with equal appropriateness, perhaps, be described under the metencephal, and the difficulty in determining the segmental assignment is very naturally included by Blake (1898, 104) among the reasons for the non-recognition of two segments in this region.

§ 97. *Fig. 695 illustrates:* A. The embryonic continuity of the endyma and more substantial elements of the parietes around the lateral recesses at this stage (see § 98).

B. The corrugation of the thin portion of the parepicelian parietes preparatory to the formation of the epiplexus.

§ 98. *Outlets of the Lateral Recesses.*—Although closed in the embryo (Fig. 695) the ventral ends of the recesses are commonly described as open, constituting communications with the subarachnoid space even when the metapore does not exist. I have been disposed to regard these

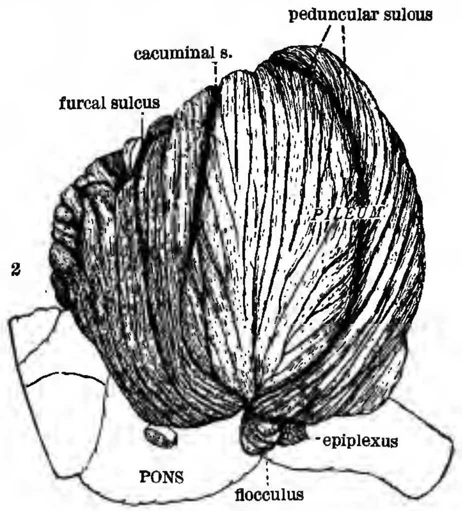


FIG. 694.—Left Side of the Cerebellum of an Aged White Man; 3,434. × 1. (From Stroud, 1897, *a.*) The outlines were drawn with the camera lucida.

orifices as artifacts from the readiness with which the membranous adhesions of that region are torn during the removal and examination of the brain according to customary methods. But the histological and embryological researches of Blake seem to show that in man and in mam-

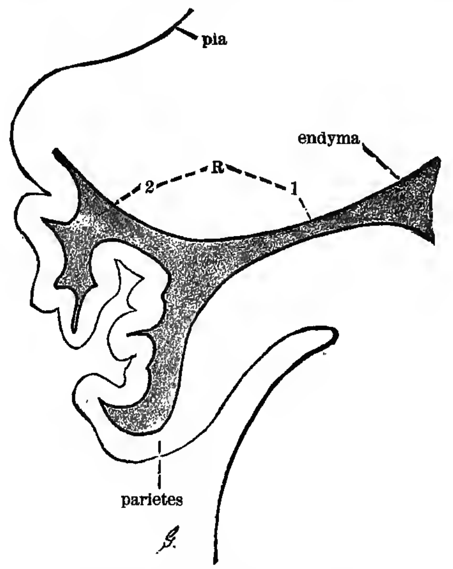


FIG. 695.—Transection of the Brain of an Embryo Rabbit, Sixteen Days Old. (From Kölliker.) × 65; enlargement of part of Fig. 669.

mals generally the ends of the recesses are opened by the more or less extensive disappearance of the membranous parietes.

§ 99. *Fig. 696 illustrates, in addition to points also shown in Fig. 694:* A. The great depth of the furcal sulcus.

B. The absence of the lingular foliums (§ 119).

§ 100. *Preoblongata.*—The floor of the epicele is the preoblongata, continuous with the postoblongata and with the crura. In the turtle (Fig. 680) and other nonmammals there is no obvious line of demarcation.

§ 101. *Pons.*—In mammals the preoblongata is so markedly reinforced by a transverse fibrous mass, the pons, that it is easily recognized; but the width of the

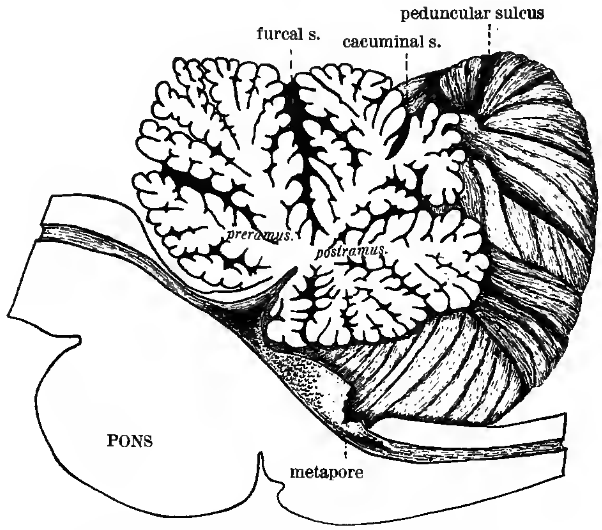


FIG. 696. Mesal Aspect of the Cerebellum of an Adult Male Negro; 3,118. × 1. Traced from a photograph. (From Stroud, 1897, *a.*)

pons varies so greatly that its margins can hardly be accepted as the boundaries of the entire segment. Compare the turtle (Fig. 680) with the sheep (Fig. 794) and man (Figs. 672 and 689).

§ 102. *Peduncles.*—At and near the meson the connections of the cerebellum with the adjoining segments are thin; the lingula is relatively atrophied (Fig. 702) and the metatela wholly membranous (Figs. 670 and 687); but laterally the cerebellum has massive continuations, constituting three pairs of peduncles: a cephalic (prepeduncles) to the mesencephal; a caudal (postpeduncles) to the metencephal and myel, and an intermediate (medipeduncles) to the pons, part of the same segment.

§ 103. The peduncles constitute a continuous mass of alba at either side, but their relative positions and extent are pretty well determined by various methods, anatomical, microscopical, and experimental. The medipeduncle is the largest and most lateral; it is mainly continued from the lateral lobe of the cerebellum to the pons, where the fibres cross the meson, interdigitating with their opposites, and forming a relation with the cinerea. The postpeduncle mainly connects the vermis with the restis, while the prepeduncle connects chiefly the dentatum with the mesencephal and parts farther cephalad. The dorso-lateral aspect of the prepeduncle presents a distinct shallow depression, the prepeduncular fossa (Fig. 692).

§ 104. The relative location and direction of the three peduncles on the right side may be illustrated by the digits of the right hand. Hold the hand with the fingers down, the thumb pointing backward, the index forward, and the other three fingers, slightly overlapping, outward between them. The palm may then represent the cerebellum, the pollex the short and sharply curved postpeduncle, the index the longer and less curved prepeduncle, and the other three fingers the intermediate and thickest medipeduncle, continuous with its opposite through the pons.

§ 105. *Fig. 697 illustrates:* A. The lapping of the tonsillæ over the uvula.

B. The location of the flocculus and the commencement of the peduncular sulcus.

C. The relative position and size of the three peduncles.

§ 106. *Flocculus and Paraflocculus.*—Attached to the medipeduncle by short peduncles of their own are small foliated masses, the flocculus (in two lobes) and the paraflocculus (in one) (Figs. 698 and 701). Contrary to the implication of the names, the paraflocculus is really attached mesad of the flocculus; in Fig. 698 they are twisted so that the reverse appears to be the case. The peduncle of the flocculus forms part of the wall of the "lateral recess" (Fig. 698). Little is known of the functions of these parts or of their homologues in other animals. According to Stroud (p. 96) the paraflocculus is much larger in the cat and capable of division into a supraflocculus and mediflocculus.

§ 107. *Fig. 698 illustrates:* A. The location and form of the flocculus, with its two divisions and rounded folia, and of the smaller paraflocculus, presenting but slight traces of foliation. All are attached to the medipeduncle, and the flocculus is sometimes called the peduncular lobe.

B. The general location of the lateral recess (2), or parepicele, between the peduncles cephalad, the restis and other parts of the postoblongata mesad, and the flocculus stem laterad; its peculiar relations with the glosso-pharyngeal and vagus nerves are inadequately shown and need special preparation and study.

C. The twisting of the peduncles of the flocculus and paraflocculus whereby their real attachments are apparently reversed. The paraflocculus, although its name

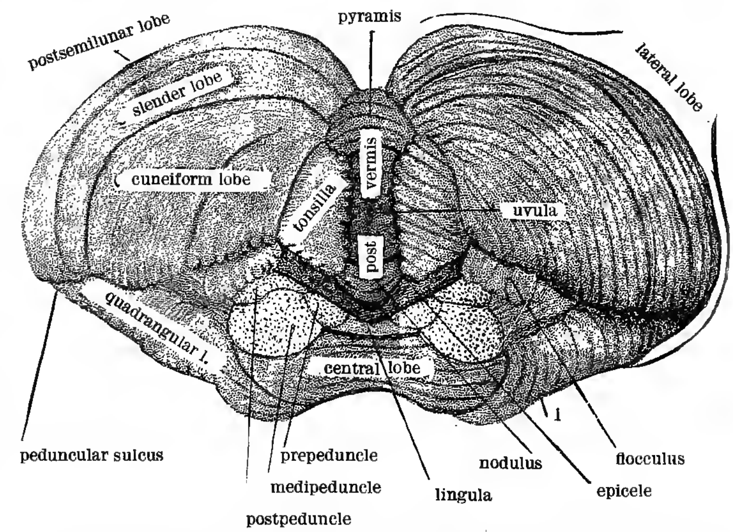


FIG. 697.—Caudal ("Lower" or "Posterior") Aspect of the Adult Cerebellum. A little less than natural size. (From Edinger, inverted and slightly modified.) 1, Part of the right quadrangular lobe. The cut ends of the peduncles are dotted; the large medipeduncles extend latero-dorsad into the lateral lobes; the flocculi are attached to the medipeduncles. The continuity of the vermian divisions with those of the lateral lobes is not apparent upon this aspect.

Defects.—In addition to the general remark made under Fig. 700 the following special deficiencies are to be noted: (1), There is no line to represent the divided endyma of the metatela along the caudal (here upper) side of the cavity (epicele); all this region requires elucidation in respect to celian circumscription; (2), the omission of the plexuses and nerve roots; (3), the postvermis should be more deeply shaded to indicate its depth below the level of the tonsillæ, which also are really almost in contact; (4), on this, or on Fig. 700, the vermis should present a line indicating the reflexion of the arachnoid.

suggests a lateral position, really is attached mesad of the flocculus; see Fig. 701.

§ 108. The *cerebellum* is essentially an arch over the epicele (cephalic part of the "fourth ventricle") (Fig.

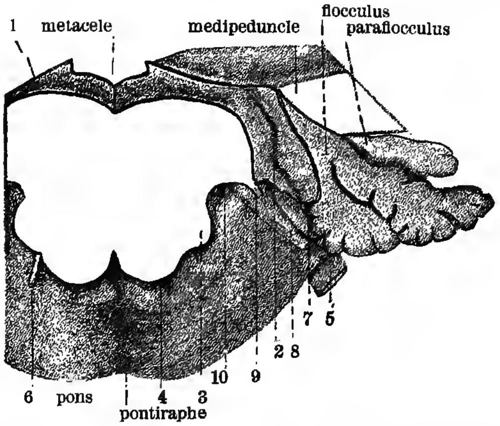


FIG. 698.—Caudal Aspect of the Right Flocculus and Adjacent Parts; 2,238. × 2. 1, Endyma at the left side of the epicele; 2, right lateral recess, laid open; 3, oliva; 4, pyramid; 5, trifacial nerve; 6, abducens; 7, facial; 8, acoustic; 9, glosso-pharyngeal; 10, recess latero-dorsad of oliva.

Preparation.—The cerebellum was removed by division of the peduncles to near the floor of the epicele, and the postoblongata by a transection just caudad of the pons; the lateral recess (2) had already been torn open, as usual, in removing the brain, and its entire extent and exact form are not determinable from this preparation (see Fig. 684).

699). This condition exists in the embryo, and persists in many of the lower vertebrates. The adult human organ, however, is a foliated mass of complex fibrous and cellular structure, well meriting the adjective *hypertrophied*, applied to it by E. C. Spitzka.

FIG. 699.—Caudal Aspect of the Cerebellum and Oblongata of a Fetus. (Size and age and magnification uncertain, specimen and notes having been lost; it probably resembled quite nearly the specimen shown in Fig. 373.) *a*, The kilos.

§ 109. *Fig. 699 illustrates:* A. The large size of the epicele at this period, as compared with the thickness of the parietes.

B. The extensions latero-ventrad constituting the parepiceles or "lateral recesses" (compare Figs. 384 and 395).

C. The non-appearance of the mesal lobe, vermis, at this period and the absence of sulci upon the lateral masses, pileums.

D. The continuity of the riparian part, *a*, the kilos ("posterior velum"), along the line of junction of the ectal pia and ental endyma, they not being represented distinctly; if their torn edges were distinct they would constitute the cestus. The cestus and kilos indicate the line of attachment of the metatela.

§ 110. *Aspects of the Cerebellum.*—In the natural condition of the adult brain the rounded margin of the cerebellum demarcates two surfaces looking respectively "upward" and "downward." But in accordance with the general principle of normalization (§ 38) and by analogy with the simpler case of the epiphysis (§ 154) the cerebellum is here regarded as if projecting dorsad at right angles with its supporting portion of the brain-axis, the oblongata (Fig. 702). The two main surfaces become therefore cephalic and caudal, but they are not sharply delimited.

§ 111. *Pileums and Vermis.*—The adult cerebellum comprises a mesal lobe, the *vermis*, and two *lateral* masses, the pileums, commonly called "hemispheres." On the cephalic aspect, the vermis (prevermis) is prominent (Fig. 700); but on the caudal the lateral lobes project decidedly beyond the postvermis, the surface of which is thus at the bottom of a deep mesal crevice, the vallis ("vallecula") (Fig. 697).

§ 112. *Foliums, Sulci, and Lobes.*—The entire surface of the adult cerebellum presents numerous lines, for the most part parallel and having a generally transverse direction. These lines represent crevices of greater or less depth, the sulci, and the intervening thin plates are the folia. Certain of the interfoliar crevices are so constant, deep, or distinct as to warrant the recognition of the intervening groups of folia as lobes.

The commonly received division of the two regions of the cerebellum into lobes is indicated upon the figures. I am free to admit, however, that I am by no means fully satisfied therewith.

§ 113. *Fig. 700 illustrates:* A. The natural tilt caudad of the cerebellum, so that its normally cephalic surface looks dorso-cephalad, even when the oblongata is held in the cephalo-caudal plane.

B. The extension of the cerebellum, so as to overhang the postoblongata.

C. The enormous preponderance of the pileums (lateral lobes) over the vermis (mesal lobe) in the adult; compare however, Fig. 699.

D. The slight demarcation between the vermis and pileums on this aspect.

E. The appearance of part of the postsemilunar lobes, and of the peduncular sulcus, both these appearing partly also upon the caudal surface.

F. The connection of the two cacuminal (presemilunar) lobes by means of a single folium, the cacumen.

§ 114. *Cortex* (ectocinerea).—Each folium consists of a central lamina of alba and a covering of cinerea having a peculiar cellular structure; see the article *Histology of the Brain.*

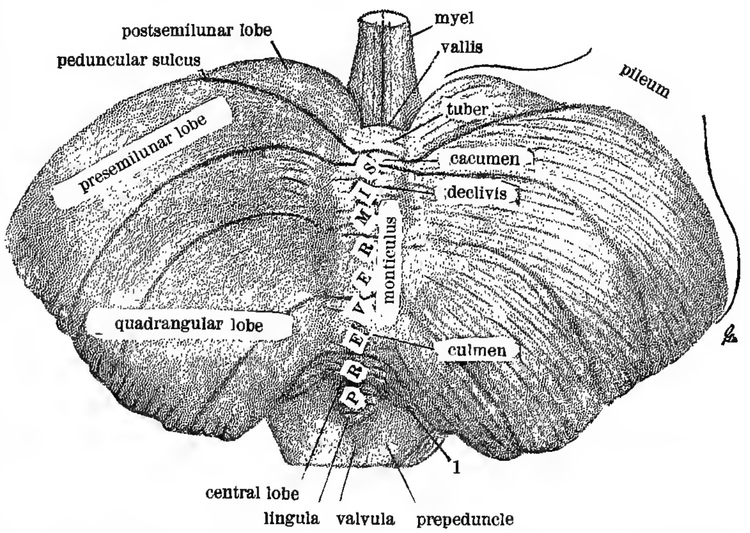


FIG. 700.—Cephalic ("Upper" or "Anterior") Aspect of the Adult Cerebellum. From Edinger, inverted and slightly modified; a little less than natural size. 1, The ala or lateral portion of the central lobe.

Defects.—The original figure is obviously diagrammatic; it was selected as more clear than usual, and as representing the general interpretation of the foliar arrangement on this aspect of the cerebellum; I am not, however, satisfied in all respects, and regret that I cannot determine certain points upon my own preparations, so as to base the figures upon them entirely. These remarks apply equally to Fig. 697.

§ 115. *Peduncular Sulcus* ("*great horizontal fissure*").—When the flocculus and paraflocculus are removed, or the overlapping foliums of the cerebellum are separated from them and from one another by the removal of the pia, the non-foliated lateral surface of the medipeduncle is easily seen to continue laterad and dorsad for about 1 cm. between the tiers of foliums on the cephalic and the caudal aspects. This interval is the beginning or stem of what is commonly called the "great horizontal fissure," but which, from its obvious relation to the medipeduncle, I have called peduncular. By most writers it is represented as continuing along the dorsal ("posterior") margin of the cerebellum and as demarcating the cephalic and caudal aspects of the entire organ. In particular it is regarded as meeting its opposite at the meson just caudad of the cacumen, a single thin folium which, at either side of the meson, enlarges and becomes a subdivided cacuminal ("presemilunar") lobe.

§ 116. *The Peduncular Sulcus Incomplete as a Landmark.*—But, while it is perfectly possible, with most specimens, to recognize a deep sulcus of the pileum which passes caudad of the cacumen and trends laterad in the direction of the medipeduncle, an inspection of the depths arouses doubts of its essential continuity and morphological significance.

§ 117. *Furcal Sulcus.*—On various grounds, especially comparative anatomy and development, Stroud has concluded (1897, *a*, 6) that the primary and most constant sulcus, and the one which should be held to demarcate the two main regions of the cerebellum, is one which leaves the stem of the peduncular sulcus opposite the attachment of the paraflocculus and passes at right angles across the cephalic surface, dipping between the adjacent foliums so deeply as to more nearly reach the cavity than any other of the sulci. As seen in Table III. the furcal is the preclival sulcus of Schäfer.

§ 118. The region cephalad of the furcal sulcus is divided by the culminal sulcus (postcentral of Schäfer) into the culminal lobe and the central lobe.

§ 119. *Lingula.*—When the central lobe is lifted or removed there will be exposed the valvula, the thin zone of the mesocelian roof, and caudad of it, completely overhung and concealed by the adjacent parts of the cerebellum, a series of three, four, or five transverse diminutive foliums; see the medisection (Fig. 702). At birth the lingular folia are rounded and distinct, but in the adult they are relatively smaller, often flattened as if by pressure of the overhanging cerebellum, and sometimes (at least in certain negro and insane brains) nearly or completely absent.* The cephalic folium is narrowest and has a rounded outline (Fig. 700): the pia adheres quite firmly to these folia, so that they are liable to be torn off.

§ 120. *Fig. 702 illustrates:* A. The mesal topography of the cerebellum and adjacent parts when brought into nearly their "normal position," *i.e.*, when the metepencephalic floor is nearly horizontal (cephalo-caudal) and when the longer axis of the cerebellum is nearly dorso-ventral; this is nearly their condition in a body lying prone, with the axon and longer portion of the neuron (myel) approximately horizontal, as with most quadrupeds and the majority of walking and swimming vertebrates (see § 9, and the article on *Terminology, Anatomical*). For comparison with Figs. 670, 687, and 756, this or they must be regarded as turned about one-fourth of a circle.

B. The exact number and form of the cerebellar folia and subfolia at birth, so far as they appear upon an approximate medisection.

C. The combination of the folia to form lobes, more or less well defined.

D. The arboriform arrangement, whence the name *arbor vitæ* (herein mononymized to *arbor*).

E. The topographical relations of the mesal lobe (vermis) to the lateral lobes; caudad, dorsad, and at the ventro-cephalic region the lateral lobes project beyond the vermis, but the latter is the more prominent with the culmen at the cephalic side and with the nodulus at the caudo-ventral angle. The interval between the lateral lobes on the caudal aspect constitutes the vallis.

F. The enormous size of the cerebellum as compared with its cavity, even had the dorsal part of the latter been maintained at its natural size by alinjection.

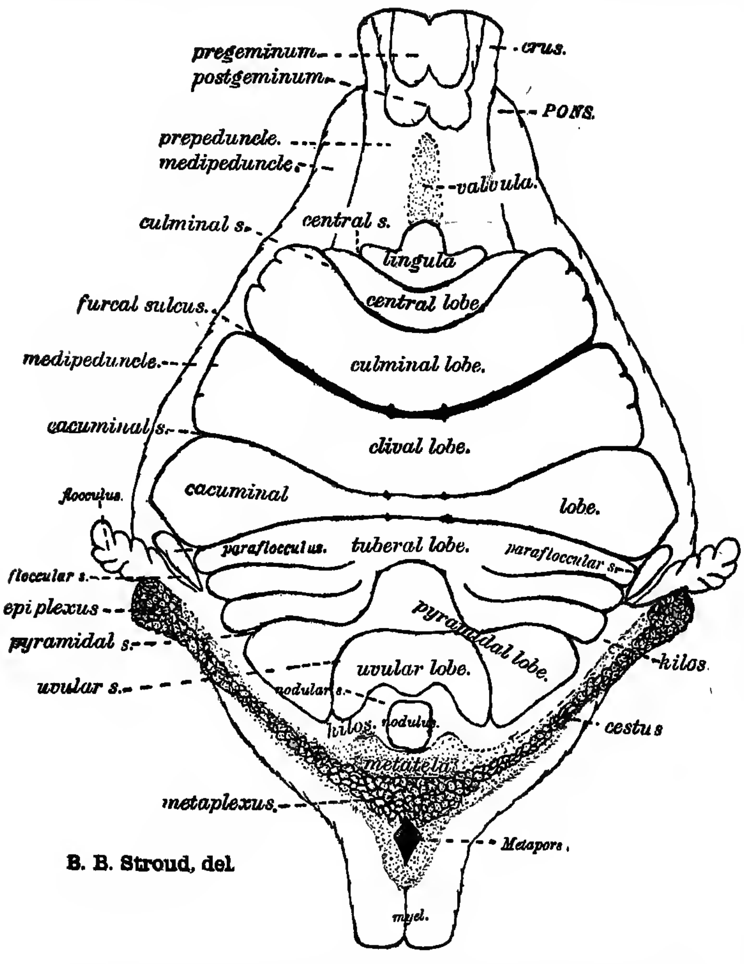


FIG. 701.—Diagram Showing the Divisions of the Human Cerebellum as If Extended in One Plane. (From Stroud, 1897, *b*, 108.) The line between the cacuminal lobe and the tuberal lobe should be designated *peduncular sulcus* ("horizontalis magnus").

G. The projection of the cerebellum beyond its attachments and proper cavity. Cephalad, it overhangs not only the valvula, but the postgeminum, these being parts of the mesencephal; caudad, whatever exact limit be as-

* The lingula has not been recognized in the apes, but Stroud is inclined to regard as its homologue what he described (1897, *b*, 120) as a "cephalic" lobe in apes and in certain human brains, *e.g.*, Fig. 698.

signed to the epicele, the vermis covers the entire "fourth ventricle."

H. The distinctness of the four lingular folia, constituting the transition from the massive cerebellum to the atrophic (?) valvula.

I. The prominence of the cephalic and caudal margins of the pons, and the concomitant depth of the prepontile and postpontile recesses.

J. The merging of the dorsal commissure of the myel and postoblongata into the obex, and of this into the ligula; in the adult this latter seems to be hardly more than the combined pia and endyma (see Fig. 692), but in the child's brain from which this feature was derived, although the meninges had been removed, there was, nevertheless, a distinct lamina of nervous substance.

§ 121. The divisions of the caudal region of the cerebellum cannot be seen completely unless the postoblongata is forcibly bent ventrad or cut away; indeed the entire oblongata and pons may advantageously be removed by transection of the peduncles ventrad of the flocculi as in Fig. 697.

§ 122. When the pileums are divaricated the postvermis caudad of the cacumen is seen to be at first narrow, then wider, and then decidedly compressed. The wide portion is the pyramis; the short region between it and the cacumen, the tuber; the longer portion of the remainder is the uvula crowded between subglobular divisions of the pileums, the tonsils. Finally, and seen with some difficulty, is the nodulus, a group of three or four foliums, connected at either side by the kilos with the flocculus. The relations of these parts to one another and to the lateral masses and to the sulci are indicated upon Table IV.

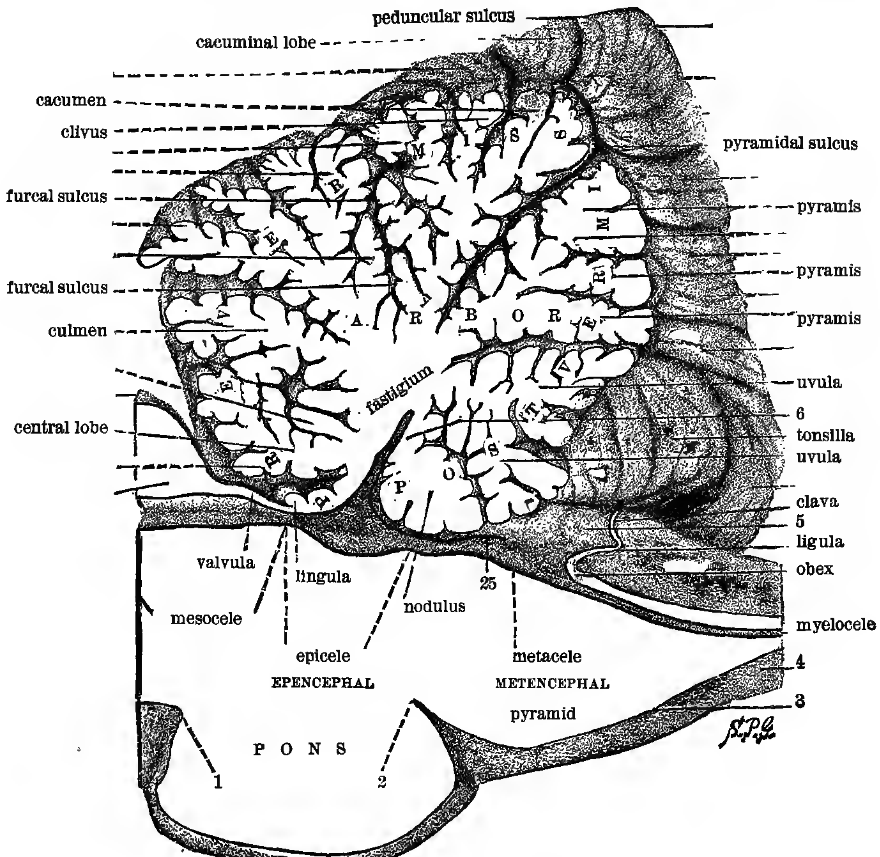


FIG. 702.—The Metepencephal (Cerebellum, Oblongata, and Pons) of a Child at Term, Showing the Approximately Mesal Aspect of the Right Half; 478. × 3. Traced from an enlarged photograph. (This is the same specimen that is shown in Fig. 756, where, however, no attempt was made to represent details, and the cerebellum is more nearly in its "natural attitude." 1, Prepontile recess; 2, postpontile recess (*foramen cæcum*); 3, presumed caudal end of the pyramid; between 3 and 4 there might be—but were not seen—indications of the pyramid decussation (Figs. 672 and 689); 5, slight elevation of the metacelian floor; the triangular darker area just ventro-cephalad represents the postfovea; 6, the dorsal extension of the epicele into the cerebellum; 25, metatela (diagrammatic).

Defects.—The plane of section passed slightly sinistrad of the meson; hence certain features are not exactly what would have appeared upon a precise medisection. On the cut (unshaded) surfaces the alba and cinerea are not distinguished, the latter having been bleached by the alcohol. The pons section does not show the fibres of the raphé. The cavities were not alinjected and hence are unnaturally small. The meninges were removed; so there is no indication of the dorsal attachment of the arachnoid to limit the subarachnoid space, and the obex, ligula, and metatela are supplied from other specimens, but the extent of the metapore (foramen of Magendie) is not shown.

When the drawing was made, the significance of the furcal sulcus had not been recognized. Dr. Stroud has kindly revised the identifications. He would limit the prevermis to so much as is cephalad of the furcal sulcus; but for the present I retain the original designations of the two regions of the vermis. The sulcus just cephalad of the cacumen is the cacuminal; that just caudad is the peduncular, deep in the pileum (lateral lobe) but shallow at the meson. The tuber is the part between the peduncular and tuberal sulci. See § 120.

TABLE III.—SYNONYMS OF THE PRINCIPAL SULCI OF THE CEREBELLUM; STROUD, 1897, *a*.

Preferred.	Schäfer.
1. Central sulcus.	1. Sulcus precentralis.
2. Culminal sulcus.	2. Sulcus postcentralis.
3. Furcal sulcus.	3. Sulcus preclivalis.
4. Cacuminal sulcus.	4. Sulcus postclivalis.
5. Peduncular sulcus.	5. Sulcus horizontalis magnus. *a*. Sulcus postgracilis. *b*. Sulcus intragracilis.
6. Pyramidal sulcus.	6. Sulcus pregracilis. } s. postpyramidalis. }
7. Uvular sulcus.	7. Sulcus prepyramidalis.
8. Nodular sulcus.	8. Sulcus postnodularis.

TABLE IV.—SYNONYMS OF THE LOBES OF THE CEREBELLUM; FROM STROUD, 1897, *a*. SLIGHTLY MODIFIED.

TERMS PREFERRED.		SCHAFER.	VARIOUS AUTHORS.
Vermis.	Vermis and pileum.	Worm and hemisphere.	Hemisphere.
		Lobus lingulæ......	Frænulum lingulæ.
1. (Lingula?), Cephalic lobe, *variable*	1. Lingular lobe..	1. Lobus centralis..	Ala lobuli centralis.
2. Central lobe.	2. Central lobe ...	2. *Not recognized as a distinct lobe.*	
3. Culmen..	3. Culminal lobe .	3. Lobus culminis ..	Lobus lunatus anterior.
Furcal sulcus.			
4. Clivus ...	4. Clival lobe.....	4. Lobus clivi	Lobus lunatus posterior.

TABLE IV.—SYNONYMS OF THE LOBES OF THE CEREBELLUM; FROM STROUD, 1897, *a*, SLIGHTLY MODIFIED.—*Continued.*

TERMS PREFERRED.		SCHAFER.	VARIOUS AUTHORS.
Vermis.	Vermis and pileum.	Worm and hemisphere.	Hemisphere.
5. Cacumen	5. Cacuminal lobe	5. Lobus cacuminis.	Lobus postero-superior. Presemilunar lobe.
6. Tuber ...	6. Tuberal lobe ...	6. Lobus tuberis....	Postsemilunar lobe. Lobus postero-inferior.
	a. pretuberal lobe.	....	*a*. L. semilunaris inferior.
	b. medituberal lobe.	....	*b*. Slender lobe. L. gracilis posterior.
	c. posttuberal lobe.	....	*c*. L. gracilis anterior.
7. Pyramis..	7. Pyramidal lobe.	7. Lobus pyramidis.	Cuneiform lobe. L. biventralis.
8. Uvula....	8. Uvular lobe....	8. Lobus uvulæ	Tonsilla. Amygdala.
9. Nodulus.	9. The nodulus does not extend laterad into the pileum. The flocculus is a separate division. It is not a part of the pileum (or hemisphere).	9. Lobus noduli.....	Flocculus.

§ 123. *Fig. 703 illustrates:* A. The constitution of the dentatum as a corrugated capsule of cinerea, open cephalo-ventrad.

B. The entrance of the fibres of the prepeduncle through the hilum of the dentatum to connect with its cells.

§ 124. *Entocinerea.*—Upon a medisection of the organ there would appear to be only alba and ectocinerea, the former branching in a tree-like manner, whence the name *arbor* (*vitæ*). But in the central part of the cerebellum, near the apex of the epicele, are four pairs of masses of cinerea sometimes called roof-nuclei or tectal nidi. There are reasons for thinking that the primitive cerebellar entocinerea has been displaced, and is represented by these masses enumerated in their order from the meson laterad: Fastigatum; globulus; embolus; dentatum.

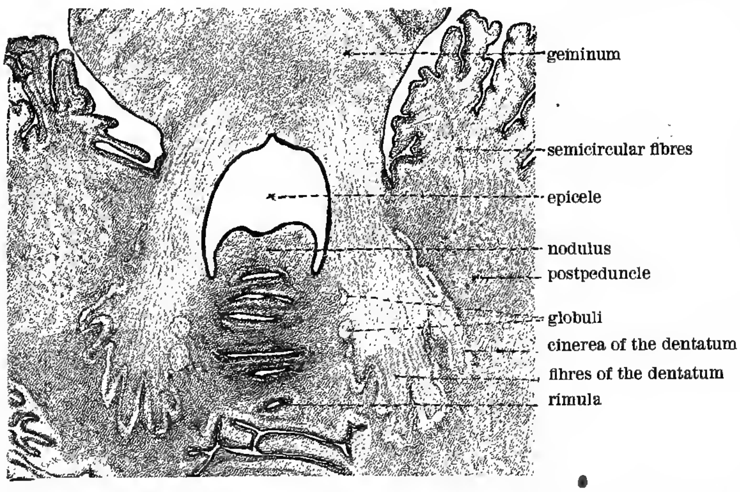


FIG. 703.—The Dentatums and Prepeduncles. (From Stilling, somewhat modified.) × 2 –.
Preparation.—The plane of section was oblique, so as to coincide with the general direction of the prepeduncles as shown in Figs. 692 and 693.
Defects.—By an inexcusable oversight the prepeduncles are not indicated by a line and the name; but they are readily recognized as the fibrous tracts at the sides of the epicele, converging from the dentatums to the geminum. There is no representation of the "fleece," the layer of fibres radiating from the ectal surface of the dentatum.

§ 125. *The Dentatum.*—This is the largest and most easily recognized of the four masses; (see Figs. 703 and 704). It has the form of a corrugated capsule, open meso-ventro-cephalad, for the reception of the fibres of the prepeduncle (Fig. 703). In any cerebellum, whether fresh, or hardened in chromic acid compounds, or even alcohol, it is readily recognized upon transections or upon sagittal sections begun about 1 cm. either side of the meson and continued laterad for 2 or 3 cm. The dentatum has received the following additional names, of which the last only is used with any frequency: *Nucleus dentatus; corpus denticulatum, s. fimbriatum, s. lenticulatum, s. ciliare;* Eng., ciliary body.

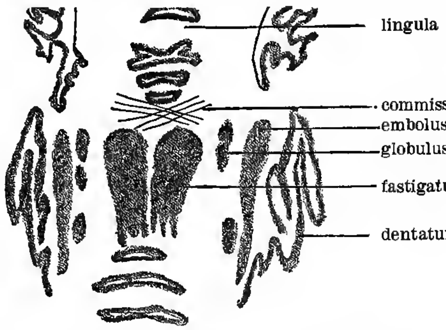


FIG. 704.—The Dentatum and Other Masses of Cinerea in the Central Part of the Cerebellum. From Stilling, somewhat modified. × 2 –.
Preparation.—This is commonly designated as a "horizontal" section. Really, the plane cannot be indicated in such simple terms. The central part of the figure, including the cinereal masses, is through the fastigium, the roof of the apex of the epicele.
Defects.—No attempt has been made to represent the fibrous constitution beyond the purely diagrammatic indication of the cephalic (anterior) decussating commissure.

§ 126. *The Fastigatum.*—This, more often called "fastigial nucleus," is close to the meson, directly in the roof (fastigium) of the epicele; Fig. 703. It is rounded cephalad, but the caudal end presents two or three projections.

§ 127. *The Embolus* and *Globulus.*—These smaller masses of cinerea lie between the dentatum and the fastigium, and somewhat dorsad of the latter. Their forms are indicated by their names, and are well shown in Stilling's figure as reproduced in Fig. 704. More common (and cumbersome) titles are *nucleus globosus* or *globuliformis*, and *nucleus emboliformis.*

§ 128. *Fig. 704 illustrates:* A. The existence, near the apex of the epicele, of four pair of cinereal masses, representing, perhaps, dislocated portions of the cerebellar entocinerea.

B. The lack of precise symmetry in the forms of these masses; of the globuli there are three on the left and two on the right, the more cephalic probably representing two.

V. MESENCEPHAL.—§ 129. Synonyms: Mesencephalon; midbrain. Tabular arrangement of parts: Chief parts: quadrigeminum and crura. Cavity: mesocele (aqueduct or iter.) Floor: crura. Sides: gemina. Roof: gemina and valvula. Ectocinerea: cappa. Entocinerea ("central tubular gray"). Commissures: postcommissure, trochlear decussation.

§ 130. In early embryonic stages the mesencephal is the most conspicuous region of the entire brain, but consists of a single, thin-walled vesicle, with a relatively large cavity (Figs. 671 and 677). As the parietes thicken, two furrows appear upon the dorsal aspect; a mesal, demarcating the left elevation from the right, and a transverse, subdividing each of these into a cephalic and a caudal portion (Fig. 673); there results, in the adult mammalian brain, the formation of four approximately similar elevations, whence the names, *corpus quadrigeminum, corpora quadrigemina, optic lobes*, etc. In the present article they are called *gemina* (twin bodies), pregeminum and postgeminum (Figs. 693 and 707). They constitute the larger part of the mesocelian roof.

§ 131. *Valvula.*—A caudal portion of the mesocelian roof retains nearly its primitive tenuity as a transparent lamina, the valvula, between the gemina and the lingula (Fig. 702). Its cephalic part presents some slight corrugations, either a mesal furrow and a pair of lateral ridges, the frenulums (Fig. 706), or a mesal ridge in addition.

§ 132. The fibres of the trochlearis nerve decussate in the valvula. It is practically convenient, although not perhaps quite correct, to regard the tróchlear decussation as the boundary between the mesocelian valvula and the epicelian lingula (see Fig. 675).

§ 133. *Mesocele.*—In all mammals what Tiedemann picturesquely described as a "vast and spacious cavity" becomes relatively an insignificant tubular passage, which has been called "aqueduct" and *iter a tertio ad quartum ventriculum*. As may be seen from Figs. 670, 687 and 756, it is expanded or trumpet-shaped at the cephalic end, and irregular in form at the caudal; the intermediate, longer part varies considerably in different individuals, being sometimes nearly cylindrical, but usually a transection presents points in two, three, or four directions, lateral, ventral, dorsal; the departures from the cylindrical shape are more frequent and distinct in the postgeminal and valvular portion (see Figs. 687, 706, and 708), and may be regarded as vestiges or suggestions of the potentially tripartite condition which is actually present with birds and frogs (Fig. 685).

§ 134. *Lemniscus and Brachia.*—The lateral slope of the mesencephal presents three megascopic features, the lemniscus, postbrachium, and prebrachium, shown in Fig. 706; in the former the fibres run approximately cephalo-dorsad, in the latter obliquely dorso-ventrad; their course and connections are considered in the article *Brain, Histology of the*, as is also the extent of the ectocinereal lamina called *cappa*. The lemniscus and its connections have been discussed at considerable length by E. C. Spitzka, 1884, *c.*

§ 135. *Entocinerea.*—This is the least modified of all portions of the encephalic "central tubular gray"; it forms a layer 2 to 3 mm. thick surrounding the mesocele.

§ 136. *The Crura* (*crura* or *pedunculi cerebri*).—Excepting the parts already named, the mesencephal consists mainly of a pair of fibrous masses (Figs. 672 and 689) containing the compacted motor and sensory conductors between the regions caudad, whose relations are mainly with the body, and the regions cephalad, which are the organs of the mind. Each crus consists of two regions, a ventral, the crusta, and a dorsal, the tegmentum (Figs. 706 and 708).

§ 137. *Intercalatum* (*substantia nigra, locus niger*).—A transection through the crus at almost any level reveals a dark mass (Figs. 706 and 708) of crescentic outline, approximately dividing the section into a ventral third and a dorsal two-thirds. Its lateral and mesal borders correspond to the furrows called *sulcus lateralis* and *s. oculomotorius*. The name commonly employed refers to the distinctly dark color (due to pigment in the cells) of the mass in man and some apes; but the absence of color in other mammals has led E. C. Spitzka to propose a name referring to its more constant character of *intercalation* between the ventral crusta and the dorsal tegmentum; the locative mononym was adopted by the Association of American Anatomists in 1897.

§ 138. *Postcommissure.*—The cephalic margin of the mesocelian roof is of moderate thickness, and curved

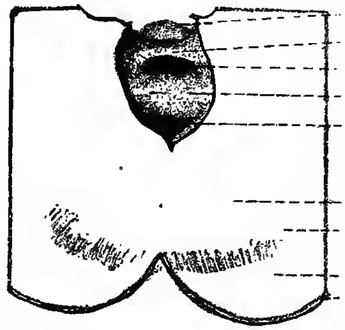


FIG. 705.—The Postcommissure and Adjacent Parts; 2,239. × 1.5.
Preparation.—The diencephal was transected just cephalad of the postcommissure; the diatela was torn away to admit more light; the space just above the epiphysis was occupied by the dorsal sack. The figure should be compared with the medisections (Figs. 670 and 687), and with the dorsal aspect of the region (Figs. 707 and 708).

dorsad so sharply as to present a cephalic convexity (Fig. 705) and a caudal concavity (Fig. 687). Osborn has suggested that it is intersegmental like the trochlear decussation (Fig. 675).

§ 139. *Fig. 705 illustrates:* A. The appearance of this aspect of the postcommissure as a cylinder.

B. The considerable size of the epiphyseal recess; although a mere diverticulum within an apparently functionless organ, it is larger than the cephalic orifice of the mesocele in this specimen.

C. The distinctness of the supracommissure (*commissura habenarum*).

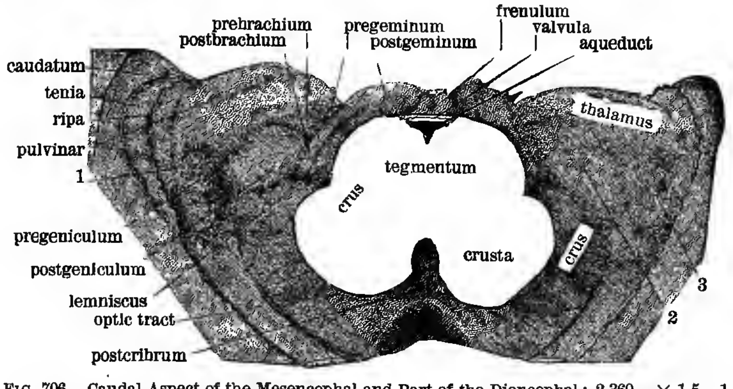


FIG. 706.—Caudal Aspect of the Mesencephal and Part of the Diencephal; 2,360. × 1.5. 1, Tenial sulcus; 2, right postgeniculum; 3, right pregeniculum.
Preparation.—A well-hardened, alcoholic, adult brain was transected just cephalad of the pons, at a level indicated nearly by the line from *crus* in Fig. 707. A block containing the thalami and adjacent parts was then cut out by incisions in various directions, the fornix peeled off, and the velum and other parts of the pia removed; the ink lines near the sides marked *ripa* indicate the lines along which the lateral margins of the velum, the paraplexuses, were torn away.
Defects.—More should have been left at the sides and ventrad. On the left, the roughly indicated curved line just laterad of the tenia was due to inadvertence, and may be disregarded. See § 140.

D. The location of the dorsal sac upon (morphologically, cephalad of) the epiphysis; see Fig. 687.

E. The modified relative position of these parts. In a less modified condition of things, the two commissures and the epiphysis should all lie nearly in one plane; but the pressure of the superincumbent cerebrum has made the long axis of the epiphysis cephalo-caudal instead of dorso-ventral, and left the two commissures and the two orifices in a dorso-ventral series instead of a cephalo-caudal.

§ 140. *Fig. 706 illustrates:* A. Segmental overlapping. The thalami and geniculums project caudad beyond the intersegmental line, and the caudatum is here directly laterad of the thalamus instead of cephalad; consequently a transection through the pregeminum would divide not only the mesencephal, but also both the diencephal and the prosencephal.

B. The caudal extension of the thalamus as a rounded eminence, the pulvinar, on which, at the right, the word *thalamus* is placed.

C. The existence of two other eminences on this aspect of the diencephal, the postgeniculum, mesad and more distinct, and the pregeniculum, laterad and less distinct. With lower mammals the general mass of the thalamus is less developed than in man, and the pregeniculum is not only still less prominent, but also decidedly cephalad, so that the prefixes *pre* and *post* are much more appropriate.

D. The continuity of the optic tract with both the geniculums, more obviously with the pregeniculum.

E. The nearly complete concealment of the pregeminum, in this view of the parts, by the postgeminum; the former is seen at the left to project slightly.

F. The location and forms of the postbrachium and prebrachium; the former is between the two geminums, the latter just cephalad of the pregeminum; as they pass ventrad they embrace, as it were, the postgeniculum.

G. The location of the lemniscus, just caudad of the postbrachium.

H. The T-shape of the mesocele in this specimen.

I. The thinness of the mesocelian roof, here constituted by the valvula, with a mesal furrow and lateral ridges, the frenulums.

J. The relatively extreme thickness of the mesocelian floor, constituted by the crura.

K. The division of each crus into a ventral crusta and a dorsal tegmentum, the boundary between these two regions being defined partly by the lateral furrow, opposite the word *crus*, on the left, and partly by a pigmented tract, the intercalatum, not here seen, but shown in Figs. 705 and 708.

L. The deep ventral depression between the crura, constituting an intercrural area.

M. The presence, at the cephalic end of this area, of several rather large foramina for the transmission of arterial branches, whence this part is called postcribrum ("posterior perforated space").

N. The trefoil outline of the mesencephalic transection due to the mesal and the two lateral depressions.

O. The obviously and unquestionably pial and ectocelian character of all the natural mesocelian surfaces.

P. The equally unquestionable continuity of these surfaces over the geniculums to the pulvinar.

Q. The absence of anything like a ripa on the visible surface of the thalamus until we reach the sharp and irregular line so marked at the left.

R. The endymal and entocelian character of the slender natural surface of the caudatum.

S. The continuation of this endymal surface upon the visible length of the tenia.

T. The significance of the ripa as not only a boundary between contiguous pial and endymal surfaces, but as indicating where the margin of the paraplexus or some membranous continuation of it has been torn away.

§ 141. *Fig. 707 illustrates:* A. The segmental overlapping of the diencephal at the side of the mesencephal and of the prosencephal at the side of that (see § 55).

B. The division of the caudatum (the entocelian portion of the striatum) into a cephalic, enlarged *caput* and a caudal, slender *cauda*.

C. The unlike topographical relations of these two parts, in that the caput is uncomplicated, while the cauda has a slender, marginal (riparian) band at its mesal side, the tenia, having peculiar relations with other parts.

D. The location of the diacele between the two thalami and its continuity with the aula.

E. The presence of the medicommissure (seen somewhat better in Fig. 709).

F. The relation of the callosal genu to the intercerebral fissure and the pseudocele; but for the callosum the

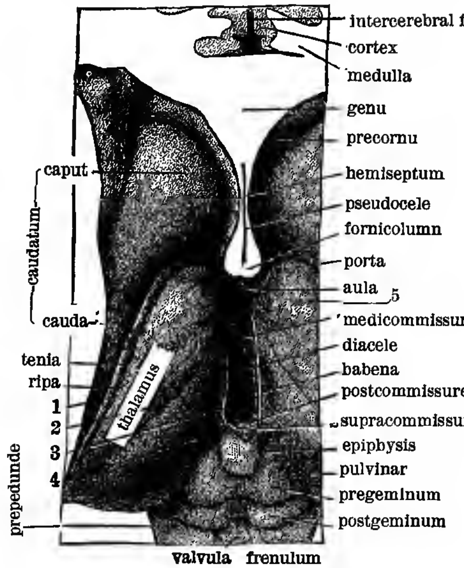


FIG. 707.—Dorsal Surfaces of the Caudatum, Thalamus, and Gemina. (From Henle, reduced and slightly modified.) 1, Tenial sulcus; 2, fimbrial sulcus; 3, habenal sulcus; 4, trigonum; 5, "anterior tubercle" of the thalamus.

Preparation.—The dorsal portion of the cerebrum has been removed, including the callosum, fornix, velum, paraplexuses, and diatela; also the pia covering the epiphysis and mesencephal.

Defects.—The shading is too deep and does not indicate the distinction between the pial and the endymal surfaces. The caudal parts of the thalami are crowded mesad, and the gemina are not well shaped.

fissure and the pseudocele would be continuous, as would also the hemiseptum with the general mesal wall of the precornu.

G. The demarcation of the mesal, entocelian surface of the thalamus from the dorsal, entocelian surface by a rough edge just dorsad of the habena; here it is represented by the narrow, white line between the two black ones, and designated as the habena; it is really a ripa along the dorsal side of the habena (see also Figs. 687 and 739).

H. The presence of three shallow furrows on the dorsal surface of the thalamus; a dorso-mesal, just dorsad of the habena, the habenal sulcus; a lateral, corresponding nearly with the mesal edge of the tenia, the tenial sulcus; an intermediate and oblique, corresponding with the lateral margin of the fimbria (removed), the fimbrial sulcus.

I. The demarcation of the dorsal surface of the thalamus, which is pial and ectocelian, from the adjoining surface of the caudatum and tenia, which is endymal and entocelian, by a sharp, irregular line at the mesal edge of the tenia, constituting a ripa. This line was introduced into the figure; it is absent in the original, as in all similar figures known to the writer, excepting Fig. 16, in Meynert's "Psychiatry," where it is called "*linea aspera,*" without, however, any reference to its morphological significance.

J. The vague and unsatisfactory representation of the parts at the porta. This region has yet to be cleared up in respect to the relation of the pial and endymal surfaces; it was my inability to show these relations clearly upon original preparations that led me to employ the present figure provisionally.

K. Incidentally it may be remarked that both this and the previous figure exemplify the advantages of that feature of the simplified nomenclature which consists in the designation of members of natural or artificial groups of parts by words compounded of the generic terms and prefixes indicating relative position; *e.g.*, pregeminum and postgeminum; pregeniculum and postgeniculum; precommissure, medicommissure, postcommissure, and supracommissure.

V. DIENCEPHAL.—§ 142.—Synonyms: Diencephalon, deutencephalon, thalamencephalon, interbrain, 'tween-brain. Tabular arrangement of parts: Chief parts: thalami. Cavity: diacele. Floor: tuber, chiasma, and diaterma. Sides: thalami. Roof: diatela (practically the velum). Plexuses: diaplexuses. Commissures and decussations: medicommissure, supracommissure, chiasma. Ectal elevations: albicantia, pregeniculums, and postgeniculums. Perforated areas: precribrums and postcribrum. Ental elevations: habena. Ectal depressions: trigonum, habenal, tenial, and fimbrial sulci. Ental depression: aulix ("sulcus of Monro"). Appendages: hypophysis, epiphysis, and dorsal sac.

With the adult of man and all other mammals the primitively thin sides of the diencephal are greatly thickened and become the *thalami*, with the *geniculums* (pre- and post-) as latero-caudal elevations. The relations of the diencephal to the entire brain are well indicated in the young rabbit (Fig. 681).

§ 143. The *pregeniculum* and *postgeniculum* are represented in Figs. 706 and 707, and described in connection therewith; the *optic tract* and the *chiasma* are shown in Figs. 689 and 711, and considered in connection with the optic nerves in the article, *Cranial Nerves.*

§ 144. *Fig. 708 illustrates:* A. The form, direction, and complete separation of the albicantia; they are usually represented (as in Figs. 672 and 689) as hemispherical elevations; here they are seen to be elliptical in outline, their longer axes converging caudad, and the caudal ends overhanging the postcribrum; in the sheep (Fig. 794) and in mammals generally the albicantial sulcus is a shallow depression or wholly absent.

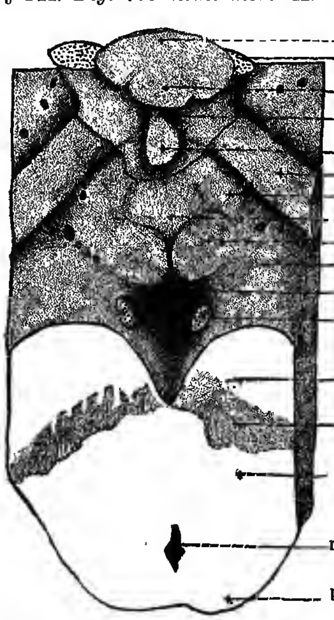


FIG. 708.—The Tuber (*tuber cinereum*) and Adjoining Parts; 706. × 1.5. (The same region is shown in Figs. 672 and 689, upon a smaller scale.) 1, Expanded proximal end of the infundibulum, covering the lura, which is exposed in Fig. 672; 2, a slight elevation between the tuber and the optic tract. The irregular line across the tuber and optic tracts represents the cut or torn edge of the pia, which adheres quite firmly to the chiasma. The black spots represent the foramina in the postcribrum and elsewhere through which vessels passed; the triangular region laterad of the chiasma is a part of the precribrum ("anterior perforated space").

Preparation.—The brain was removed with great care, the hypophysis being extricated from its fossa by dividing the dural folds in several directions with the sharp point of a scalpel, and then introducing the blunt-pointed syringotome.

Defects.—The natural surfaces of the crura should have presented a more fibrous appearance (somewhat as in Fig. 689), and another preservative than alcohol would have differentiated the cinerea on the cut surface. The albicantia have perhaps the appearance of overhanging the postcribrum too far, but this is more nearly correct than the usual representation, as, for example, in Figs. 672 and 689. The left intercalatum should be shown more nearly like the right.

B. That the hypophysis is wider than long, and consists of two parts, conveniently called *prehypophysis* and *posthypophysis;* the latter is the smaller and partly as it were let into an emargination of the former.

C. The expanded base of the infundibulum (1).

D. The raised, unnamed area (2) at either side of the tuber.

E. The demarcation of the crusta from the tegmentum by the intercalatum.

F. The slight, angular extensions of the mesocele, which sometimes is almost circular in outline.

§ 145. The diacelian floor is various in direction and composition. Beginning with the mesencephalic floor, the crura (Fig. 687), there is a marked decrease in thickness in the region of the postcribrum (which may really be common to the two segments), as well as a deflection of the floor ventrad; the albicantia (Figs. 672, 689, and 708) constitute lateral thickenings, and then the floor is reduced to an atrophied lamina comparable with the valvula; this, with the shorter, thin part just cephalad of the intervening and dependent hypophysis, constitutes the tuber (*tuber cinereum*) and infundibulum. The fusion of the stems of the primitive optic vesicles to form the chiasma, and the fusion of this with the otherwise thin diacelian floor, confers upon the latter in this region considerable thickness and firmness, but this part is again succeeded by the atrophied terma (Figs. 687 and 711), strictly the diaterma, in distinction from the prosoterma dorsad of the precommissure. Although the diaterma has a nearly dorso-ventral direction, it should properly be regarded as part of the floor, since the aula, the mesal division of the prosocele, is constructively cephalad of the diacele, although actually more nearly dorsad.

§ 146. *Hypophysis* (pituitary body or gland, Figs. 670, 687, and 708).—This has a twofold origin, viz., from the neuron (posthypophysis) and from the enteron (prehypophysis); see the article *Brain, Development of.* Herdman thinks it may have been an ancestral sense organ (*American Naturalist*, 1888, p. 1127). At present, notwithstanding its constancy throughout the vertebrates, its function is still in doubt, but the not infrequent coexistence of acromegaly with lesion of the hypophysis merits careful consideration.*

§ 147. In marked contrast with the massive sides the diacelian roof is, for the most part, very thin, consisting apparently of the endyma only, closely attached to the ventral or diencephalic layer of the velum, from which are developed the parallel diaplexuses (Figs. 716 and 732) dependent at either side. Cephalad, the diatela is continuous with the aulatela, or perhaps directly with the fornix dorsad of the aula and portas; caudad, it extends for some distance beyond the proper diencephalic boundary, is reflected ventrad upon the dorsal (properly cephalic) aspect of the epiphysis to constitute the dorsal sac, and is then continuous with the supracommissure, and the epiphysis itself (Fig. 687).

§ 148. *Fig. 709 illustrates:* A. The size, form, and connections of the medicommissure; it is relatively smaller than in other mammals (Fig. 688), and slightly constricted about its middle; if isolated it would have the form of a pulley-wheel with a shallow groove.

B. The relations of the mesal aula to the portas and to the diacele (see § 163).

C. The thinness of the lamina uniting the two halves (columns) of the fornix. This lamina must be regarded as the primitive prosocelian terma as high as the dorsal limits of the porta, and may, therefore, be called the *prosoterma.*

* On this subject articles have been published by Woods Hutchinson in the New York *Medical Journal* for July, 1900.

§ 149. *Habena* (habenula); (Fig. 687).—At the dorsal margin of the mesal surface is the *habena*, a slight ridge, with a dorsal convexity, extending from the porta to the supracommissure, which unites it with its opposite.

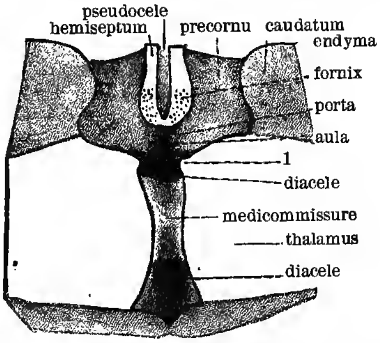


FIG. 709.—The Medicommissure and Adjacent Parts; 2032. × 1.3. (Compare Fig. 707, where some of the same parts are shown on a smaller scale.)

Preparation.—The brain was removed with care so as not to tear the medicommissure, and alcohol was injected *per luram* so as to harden the parietes and keep them apart. The prefrontal lobes were then removed, thus opening the precornua and exposing the caudatums; with these as guides the block containing the medicommissure was safely isolated; the thalami are cut away almost to the level of the commissure. See § 148.

Along the dorsal side of the habena is the habenal sulcus, and the two represent nearly the line of reflection of the endyma from the mesal surface of the thalamus upon the roof of the diacele (see Figs. 681, 687, 707, and 732).

§ 150. *Fig. 710 illustrates:* A. The overlapping of the cerebrum upon the diencephal, so that the transection of one includes the other.

B. The folding of the pia covering the now apposed dorsal surface of the thalami and the ventral surface of

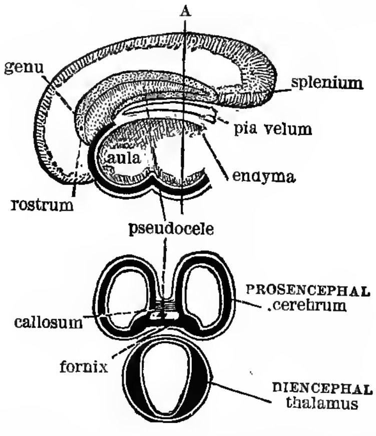


FIG. 710.—Diagrams Illustrating the Relations of the Callosum, Fornix, and the Pseudocele, the Constitution of the Velum, and the Superposition of the Prosencephal. The upper figure represents the mesal aspect of the right half of the schematic brain; the lower, a transection of both right and left halves at the level indicated by the line A in the upper. In the lower figure the thickening of the black line representing the fornix may indicate the hippocamp, but strictly it should be corrugated, presenting an ectal furrow—the hippocampal fissure. The relations of the fornix to the rest of the parietes would also be more completely shown had the black line been interrupted a little laterad of the hippocamps.

Defects.—The aula, the mesal part of the prosocele, is shown of equal size with the diacele, and on the same level; this is not the case, so far as the writer is aware, with any vertebrate in which the callosum and fornix attain dimensions such as are indicated in the figure (see Fig. 725); but so far as concerns the special objects of this figure, the above inconsistency may be ignored. Unlike most of the figures, the substantial nervous parietes are represented by the heavy black line, the pia and endyma by lighter ones.

the cerebrum so as to constitute the velum (see Fig. 732); but since this figure does not represent the lapping of the prosencephal upon the diencephal at the *sides*, or the formation of the rima and paraplexus, the pia of the two segments is continued independently around each.

C. The theoretical constitution of the diacelian roof by (1) the possible, though not always actual, continuation of the thicker nervous material at the sides, (2) the lining endyma, (3) the covering pia, one or both layers according to the closeness of their adhesion.

D. The relations of the callosum, fornix, and pseudocele; the two former represent two lines of extended junction between the apposed mesal surfaces of the hemicerebrums; they are continuous at the splenium and likewise in man at the cephalic end; the space thus circumscribed like the hollow of a partition is the pseudocele or "fifth ventricle"; it is really narrower, but the relations are as indicated.

E. The general constitution of the fornix is more fully described in § 197.

§ 151. *Medicommissure* (commissura media, s. grisea, s. cinerea, s. mollis, s. thalamic fusion).—Primarily separate, the apposed, mesal surfaces of the thalami unite (at about the fifth month of gestation according to Mihalkovics), giving rise to what is commonly called the "middle commissure" (Figs. 670, 687, 707, and 709). It is in a direct line between the porta and the aqueduct, considerably nearer the former, and just dorsad of the aulix. The shorter, dorso-ventral, diameter, is 4–5 mm., the longer, cephalo-caudal, 6–7. It is relatively larger in all other mammals (*e.g.*, sheep, Fig. 688); it is present in turtles (Fig. 680) but absent in birds and other immammalia. Its functions are experimentally unknown, but in a man and a cat lacking the callosum, it was larger than usual.

§ 152. *Anomalies of the Medicommissure.*—It is said to be sometimes double. Among sixty-six brains Wenzel found it absent in ten. It is wanting in at least half a dozen of the (about two hundred) brains prepared or examined by me with reference to it, amongst others in No. 3,334, Professor Oliver.*

§ 153. *Aulix* (sulcus of Monro; part of the interzonal sulcus?).—Most well-preserved brains present a more or less distinct furrow just ventrad of the medicommissure terminating cephalad at the porta ("foramen of Monro") and caudad near the postcommissure, sometimes in the mesocele and sometimes in the epiphyseal recess. It was figured and described by Reichert under the title "sulcus Monroi," for which I proposed (1884, *c*) the mononym *aulix*, a furrow (Figs. 675, 687).†

§ 154. *Epiphysis* (conarium, pineal body or gland; Figs. 675, 687, 707).—Excepting the lancelet (*Branchiostoma*) every vertebrate likewise has this apparently useless or vestigial diverticulum of the diacelian roof. Max Flesch believes that it is associated with the temperature apparatus, but the number of forms in which has been traced a connection between it and a rudimentary mesal eye is so great as apparently to warrant the view that it is the remnant of a primitive mesal organ of vision; see the papers of Béraneck (1892,) Heckscher, Ritter (1891), and Studnička (1899); Ritter also describes the relation of the epiphysis to a blood sinus in *Phrynosoma*.

§ 155. *Acervus* (*acervulus cerebri*).—The adult epiphysis frequently has embedded in follicular cavities calcareous particles known by the above names, and as "brain-sand"; in the brain shown in Fig. 687, it was so abundant as to leave a considerable cavity when removed, but this unusual feature is not represented.

* I venture to suggest that some of the reported cases may have been based upon inadequate evidence. Unless the brain is medisected while fresh, or prepared by the injection of a preservative into the arteries or the cavities, or both, the medicommissure commonly fails to be reached; its peculiar softness causes it to break easily; and the imperfect preservation of the adjacent thalamic surfaces might lead to the non-recognition of the slight elevation indicating its existence. If the specimen is allowed to dry slightly, and is then held so that the light is reflected from the smooth endymal surface of the thalamus, then the presence of the remnant of the commissure will be indicated by the absence of such reflection from an area corresponding with its usual location. There are few other parts of the brain where errors of observation are more likely to occur.

† His and others have applied the name "sulcus Monroi" to an alleged sulcus extending from the mesocele to or toward the optic recess, and have interpreted it as a portion of the interzonal sulcus (*sulcus limitans ventriculorum*); the grounds for dissent from this interpretation are stated in my papers 1896, *d*, and 1897, *a*.

§ 156. *Peculiar Topographic Relations of the Epiphysis.*—One of the striking results of the segmental overlapping and crowding is the embedding, as it were, of the epiphysis amongst four segments. Although directly connected with the thalami, the epiphysis leans caudad so as to rest upon the pregeminum; the cephalic aspect of the cerebellum rests upon the postgeminum and abuts against the epiphysis; finally the callosum, a cerebral commissure, has its splenial curvature upon the epiphysis. Between all these parts, of course, there are membranes and vessels, but if they are disregarded the epiphysis, a part of one segment, the diencephal, may be described as encompassed by three others, the mesencephal, the epencephal, and the prosencephal. With a brain hardened in its natural shape, a disc 2 cm. in diameter (*e.g.*, a "nickel") will cover parts of all four encephalic segments; see particularly specimens 385 and 2,268; in drawings, for the sake of clearness, the parts are sometimes represented as if less crowded; *e.g.*, Figs. 672 and 687.

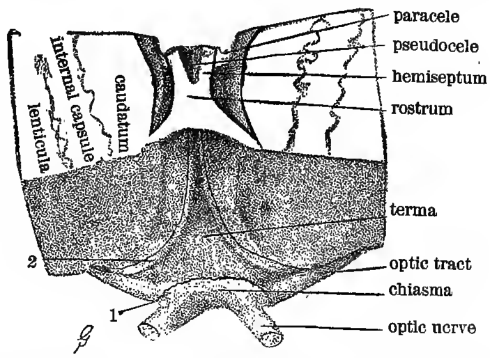


FIG. 711.—Cephalic Aspect of the Terma ("*lamina terminalis*") and Adjacent Parts of a Young Child; 213. × 1.5. 1, Torn margin of the pia on the chiasma; it has been removed from the adjacent surface; 2, gyrus subcallosus, continuous dorsad with the "peduncle of callosum."

Preparation.—The brain was exposed by removing the skull with nippers and scissors so as to avoid tearing the terma; the optic nerves were divided close to their foramina of exit. After hardening in alcohol, the parts adjacent to the terma were carved away; the surface at either side is concave, following the general direction of the terma. The block was strengthened by a long (shawl) pin passed from side to side, and a common pin was pushed into the striatum at either side so as to project beyond the optic nerves and keep the latter from striking the sides of the vial. The removal of the pia from the terma was the most difficult part of the preparation, and the utmost care did not prevent the tearing of a small slit in the left side, which is ignored in the figure.

§ 157. *Fig. 711 illustrates:* A The existence and completeness of the terma (*lamina terminalis* or *l. cinerea*), constituting the cephalic boundary of the mesal encephalic cavities; in the embryo it is actually the most cephalic part of the brain, but is later concealed by the projecting hemicerebrums.

B. The continuity of the terma with the chiasma, leading to the rupture of the former during the removal of the brain unless the optic nerves are early divided.

C. The extreme thinness and delicacy of the terma which cannot be represented adequately in such a view, and is not always indicated in the medisections; Fig. 687.

D. The existence of a somewhat thicker extension of the terma at each side, forming the cephalic boundary of the optic recess.

E. The pair of slightly raised bands, commonly called the "peduncles of the corpus callosum," continuous ventrad with the gyri subcallosi.

F. The convexity of the entocelian surface of the caudatum (see also Fig. 707).

G. The relation of the callosal rostrum to the hemiseptums, the lateral halves of the septum lucidum.

H. The somewhat unusual thickness of the hemiseptums in this specimen.

VII. PROSENCEPHAL. — § 158. Synonyms: Prosencephalon; telencephalon; forebrain; secondary forebrain; cerebrum;* pallium. The prosencephal is here regarded as composed of the cerebrum (cerebral hemispheres) less the olfactory bulbs and tracts, and the parts and cavities connecting them across the meson. See Table II., p. 153.

§ 159. *Peculiarities of the Prosencephal.*—From the other segments the prosencephal is distinguished by (*a*) the extraordinary range of variation among vertebrates, as seen in, *e.g.*, the hag (Fig. 791), the lamprey (Fig. 790), the salamander (Fig. 717), the frog (Fig. 685); the rabbit (Fig. 681); and cat (Fig. 682); (*b*) its preponderance in the human adult as contrasted with its primary insignificance (Fig. 676); (*c*) its (generally conceded) function as the organ of the "mind."

§ 160. *Prosocele.*—The prosencephalic cavity is primarily single and mesal, as indicated in the diagram, Fig. 674; it may remain so in cyclopean monsters (Fig. 712), and a nearly undivided adult cerebrum has been described by Turner (Fig. 713).

§ 161. *Fig. 712 illustrates:* A. The increase of the prosencephalic vesicle in size and in the thickness of its parietes. As shown in Fig. 2 of the original paper, the floor and cephalic wall of the mesal region are 7 to 11 mm. thick, supposing the parts to be of natural size.

B. The subordination of the lateral extensions to the mesal portion of the prosencephal; they do not, as in the normal brain, extend cephalad of the mesal boundary, but merely laterad, caudad, and to a certain extent ventrad, so as partly to overlap the mesal portion.

C. The partial formation of fissures, one of which may represent the Sylvian.

D. As stated in the text, the prosencephalic cavity is single, *i.e.*, not divided by constricted orifices (portas or "foramina of Monro") into a mesal aula and lateral paraceles. In this respect the cyclopean brain may be compared to the normal brain of "fishes" (Ganoids and Teleosts).

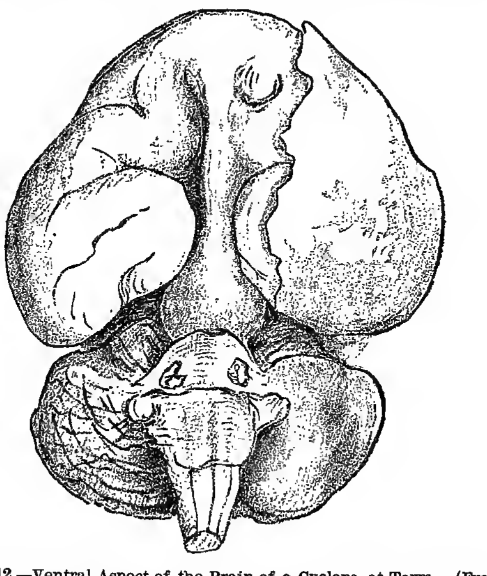


FIG. 712.—Ventral Aspect of the Brain of a Cyclops, at Term. (From Cleland, *Journal of Anatomy and Physiology*, xii., Pl. xvii., Fig. 1.) The size of the specimen is not stated. The arachnoid has been removed from the mesal region, and from the left. The original paper contains a figure of a medisection of the entire mass, a description of some animal cyclopians, and a brief discussion of the nature of the malformation.

E. The morphological instructiveness of many malformations. Goethe well said, "In her mistakes Nature often reveals her secrets"; indeed it is scarcely possible to imagine any encephalic malformation that may not

* Cerebrum is sometimes employed loosely as embracing not only the olfactory region, but the thalami, quadrigeminum, and crura.

suggest, illustrate, or apparently contravene some morphological idea.*

§ 162. *Fig. 713 illustrates:* A. The possibility that an individual should reach maturity with a cerebrum so

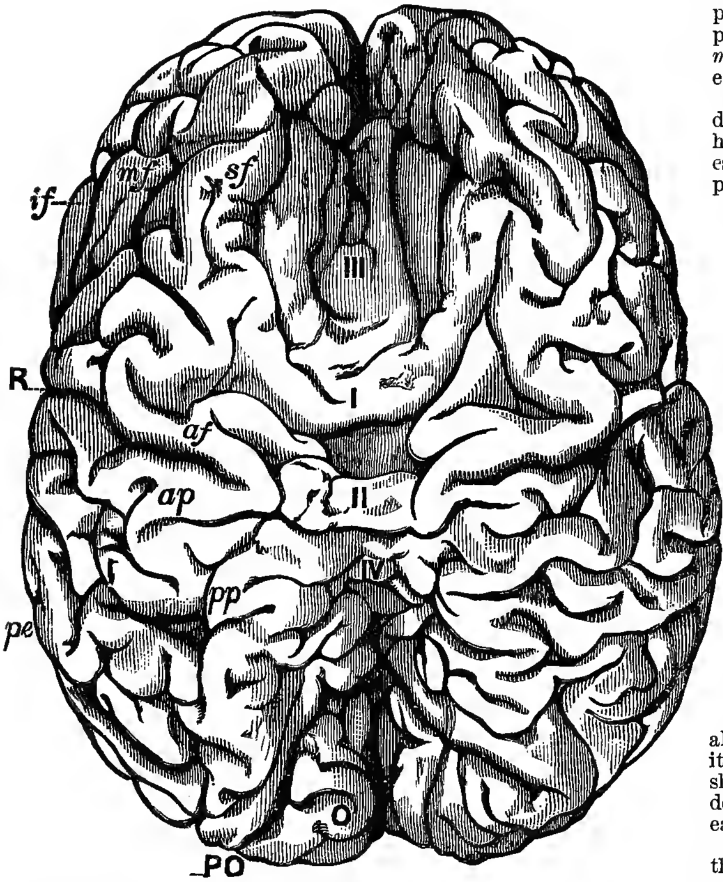


FIG. 713.—Dorsal Aspect of an Imperfectly Divided Cerebrum. × .7. (From Turner, *Journal of Anatomy and Physiology*, xii., January, 1878, pp. 241-253.) *af*, Precentral gyre; *ap*, postcentral gyre; *if*, subfrontal gyre; *mf*, medifrontal gyre; O, occipital lobe; *pe*, "convolution of parietal eminence"; PO, occipital fissure; *pp*, "postero-parietal convolution"; R, central fissure; *sf*, superfrontal gyre; I, II, mesal transverse gyres, nearly at the level of the adjoining hemicerebrum; III, sloping cortical surface; IV, mesal gyres at a lower level than I and II.

Preparation.—The brain was taken from an epileptic imbecile, male, forty-eight years of age, 146.7 cm. (four feet ten inches) high, and weighing 55.7 kgm. (123 pounds). The entire brain weighed 1,111.7 gm. (39.25 ounces), of which the cerebrum constituted 978 gm. (34.5 ounces). Most unfortunately this rare, if not actually unique, specimen was simply placed in alcohol, which was not changed; hence the base was ill-preserved, and the ental features, although described in some detail by Turner, cannot be fully understood. A transection disclosed a single mesal, cerebral cavity, about 5 cm. wide, the floor of which is said to have been "formed of the upper surfaces of the corpora striata and optic thalami, which bodies were related to each other and to the *tænia semicircularis* as in a normal brain"; yet "the third ventricle opened freely into the cerebral cavity along the middle of the floor." It is to be hoped that figures and more detailed descriptions may be published respecting the structure of this remarkable specimen. A good abstract of the original paper is given in *Brain*, i., 133-134, April, 1878.

nearly undivided. Substantially, the prosencephalic vesicle has not only increased in size and in parietal thickness, with but slight differentiation into a mesal and lateral mass, but the entire mass has developed fissures and gyres after the usual pattern, in general, excepting that certain gyres cross the meson; *a priori*, indeed, it is not clear why such a brain should not be efficient for mental as well as bodily manifestations.

* On this account it is to be the more regretted that so few such specimens are adequately preserved, examined, figured, described, and explained; indeed, no case is known to me in which the best possible use has been made of the opportunity; it is particularly desirable that, when malformation is suspected, the brain be thoroughly hardened by alinjection (injection of alcohol) of both the arteries and the cavities.

§ 163. "*Third Ventricle.*"—The cavity commonly so-called really represents the mesal portions of the cavities of three segments; so much as lies between the thalami is the diacele; but the portion cephalad as far as the terma and fornix, although relatively small, pertains to the prosencephal and rhinencephal; in some lower vertebrates (*e.g.*, *Chimaera*, my paper, 1877, *a*) it is much more extensive.

§ 164. *Fig. 715 illustrates:* A. The fundamental morphological relation of each hemicerebrum as a lateral outgrowth, process, diverticulum, or "wing" of the mesal portion of the prosencephal.

B. The non-formation or obliteration of

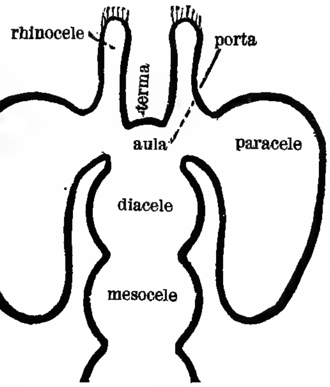


FIG. 714.—Diagram of the Prosocele and Adjoining Cavities.

all the fissural corrugations and inequalities, excepting the Sylvian, which is a mere shallow depression extending obliquely dorso-caudad along the lateral aspect of each hemicerebrum.

C. The enormous size of the porta, yet the maintenance of its complete circumscription.

D. The tenuity of most of the parietes; in the occipital region they are no thicker than a sheet of ordinary paper, and are really exaggerated by the two ink lines and intervening space.

E. The extraordinary distinctness of the mass named *caudatum*, of which another view is given in Fig. 722.

F. The peculiar form and relations of the rounded mass intervening between the caudatum and the lateral wall, and which may represent the lenticula.

G. The non-appearance of the thalamus in the floor of the paracele.

H. Upon the whole, the retention, substantially, of a condition of the cerebrum comparable with the normal state at a much earlier period of development; it is, as it were, an expansion of such a cerebrum as exists at twelve weeks (see Fig. 667).

§ 165. *Paraceles* ("lateral ventricles").—But the lateral extensions speedily become so considerable as to warrant the specification of a mesal portion, *aula*, a pair of *paraceles* ("lateral ventricles"), and constricted communications, the *portas* ("foramina of Monro") (see Figs. 678, 684, 690, 723).*

§ 166. *Cornua.*—Each paracele is primarily subspherical and simple as in Figs. 667 and 678; in hydro-

* If the rhinencephal is regarded as a segment, the aula and portas must be regarded as pertaining in part to it.

cephalus this condition may be maintained approximately till birth (Fig. 715). But normally, by the unequal thickening of the parietes, by their encroachment upon the cavity, and perhaps by the further extension of the latter, there are somewhat vaguely demarcated a central *cella*, continuous through the *porta* with the *aula*, and

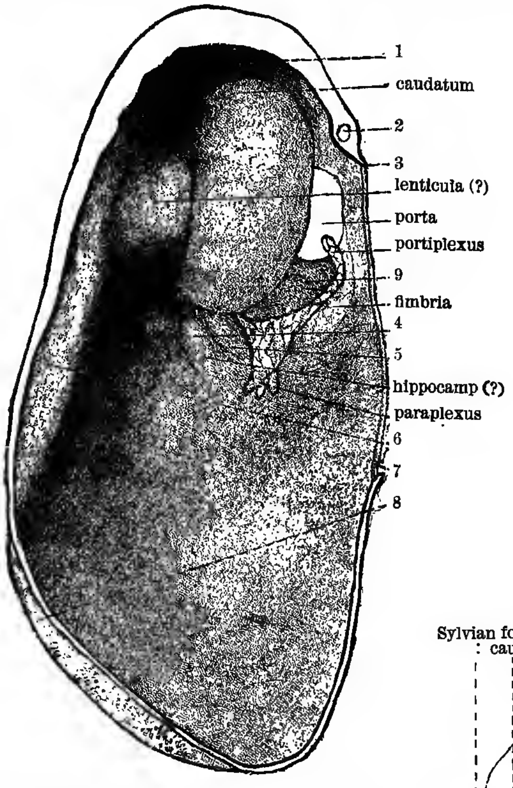


FIG. 715.—The Left Paracele (Lateral Ventricle) of a Female New-Born, (7 Months ?) Hydrocephalus. No. 2,131. × 1. 1, One of several slight undulations of the ental surface in the frontal region; 2, slight pit, probably artificial; 3, cephalic margin of a break, apparently natural, in the mesal parietes; the ventral margin of this break is indicated by 7, and the corresponding caudal margin projects slightly mesad just caudad of the line; it may be supposed that this interruption of the mesal wall represents the location of the callosum that might have been formed; 4, 5, slight elevations as yet undetermined; 6, distinct though rounded ridge corresponding to the shallow Sylvian fissure, the only recognizable fissure; 7 (see 3); 8, occipital end of the hemicerebrum, projecting slightly beyond the cut surface; 9, membranous portion of the parietes (perhaps an attenuated tenia) through which the thalamus shows.

Preparation.—The child was supposed by the physician and parents to be seven months advanced; it breathed a few times; the weight was 1,618 gm. The neck and scalp were swollen, but the head was not unusually large. Normal salt solution was injected into the umbilical vein and escaped, with blood, from the jugular. Then half a litre of ninety-per-cent. alcohol was injected, the jugular being closed. The scalp, calva, and dura were removed, and the head supported in brine while the brain was extracted; in spite of care there was some separation of the hemicerebrums at the meson. The contained liquid was allowed to escape, the brain placed in ninety-per-cent. alcohol, and the hemicerebrums inflated to their natural size; they were then covered with a thin layer of absorbent cotton to keep them submerged. The alcohol was changed twice at intervals of two days, and on the fifth the various sections were made under alcohol. The mass supposed to represent the caudatum was extremely dense. The pia was firm, and in parts more substantial than the attenuated parietes. The condition of the diencephal was not fully determinable: the mesocele seemed to be wholly occluded, which would account for the condition of the cerebrum. The entire specimen needs further study and comparison with similar cases.

three "horns," a ventral *medicornu*, a cephalic *precornu*, and a caudal *postcornu*. The last exists only in Primates (man, apes, monkeys, and lemurs) and a few other mammals, mostly members of the seal family. The cornua appear in Figs. 684, 720, 726, 735, and 736.

§ 167. *Fig. 716 illustrates:* A. The great extent of the paraceles at this period, relatively to the entire cerebrum, and to the mesal part of the prosocele, the aula.

B. The less difference in the thickness of the parietes than in the adult.

C. The distinct collocation of the hippocamp with the hippocampal fissure.

D. The topographical relation of the Sylvian fossa, the first stage of the Sylvian fissure, to the caudatum.

E. The extension of the postcornu farther caudad of the aula than the precornu extends cephalad.

F. The absence of the insula at this period.

G. The outgrowing margin of the operculum.

H. The depth and peculiar shape of the lambdoidal fissure (see Fig. 750).

§ 168. The *porta*, in a little modified condition, may be seen in the large salamander, *Cryptobranchus*. When the lateral wall of the alinjected hemicerebrum is removed (Fig. 717), the paracele is seen to communicate with a mesal space (aula) and thereby with its opposite and with the diacele, through a considerable orifice, the porta. Its caudal end is narrower than the cephalic, but it is seen to be completely circumscribed by ordinary nervous walls.

§ 169. *Fig. 717 illustrates:* A. The simple condition of the prosencephal in this amphibian; each hemicerebrum is an elliptical, thin-walled sac, the cavity of which, the paracele, communicates through a porta with the aula and so with the diacele.

B. The large size of the porta, its length equalling

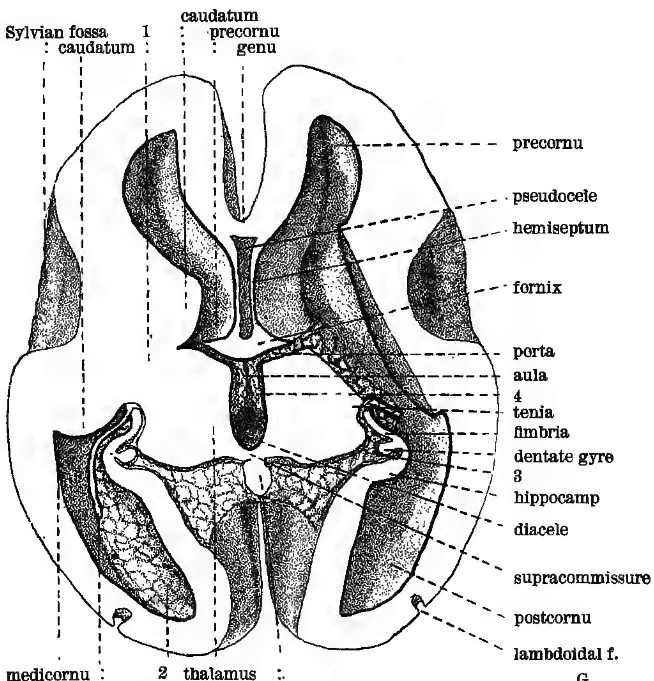


FIG. 716.—Ventral Exposure of the Prosocele of a Fetus about 24 cm. Long, and Estimated to be Twenty Weeks Old; 499. × 1.5. 1, Line of continuity of the thalamus and the caudatum; 2, thin extension of the paraplexus into the postcornu; soon after the preparation was made this became detached and was lost; another specimen must be depended upon to show whether or not such extension exists, and in what way it is disposed of in case it be deciduous; 3, hippocampal fissure; 4, diaplexus.

Preparation.—The brain was hardened in place by arterial alinjection; the scalp and calva were removed piecemeal, and the dorsal part of the cerebrum removed by one sweep of the knife under alcohol. The paraplexus was cut at each side as indicated by the heavy line (endyma) enclosing the lighter area. The left caudatum was removed so as to expose the paracele more completely on that side and make the figure comparable with that of the cat (Fig. 686).

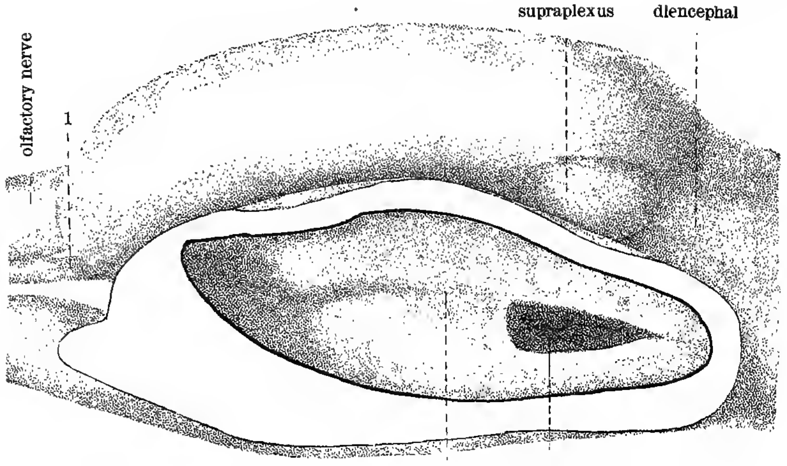


FIG. 717.—Prosencephal of *Cryptobranchus* (a Salamander), the Left Paracele Exposed; 291. × 6. *Preparation.*—The fresh brain, while supported by the skull, was alinjected by lifting the metatela (membranous roof of the "fourth ventricle") and pointing the cannula at the broad epicele; the entire brain at once swelled somewhat, and the thinness of the walls caused it to harden almost immediately; the lateral wall of the left hemicerebrum was then sliced off, and the paraplexus cut off where it projected from the aula through the porta into the paracele.

about one-third that of the entire cerebrum; its cephalocaudal direction as compared with that of mammals, birds, and reptiles, where—especially in mammals—it is dorso-ventral.

C. The absence of a rima; the prosoplexus enters the aula from the supraplexus and sends a prolongation through either porta into the paracele, where it hangs freely.

§ 170. The porta is completely circumscribed, so that a cast has a definite outline, viz., that of an elongated ellipse, its longer diameter, 4–6 mm., its shorter 1–3 (see Figs. 718, 724). The portal boundaries are as follows: caudal, the thalamus (perhaps the te-

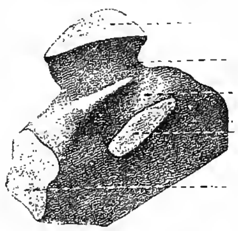


FIG. 718.—Cast of Aula, Portas, and Part of Diacele. × 1.5. The main object of the figure is to demonstrate the complete circumscription of the porta, and its independence of the rima (§ 177). The material used was a mixture of wax and gutta percha. The mesal ridge which represents the aulic recess is just dorsad of the precommissure (Fig. 724). The figure should have been so placed as to make this ridge nearly vertical.

nia); cephalic, the column of the fornix; ventral, the junction of the thalamus and column; dorsal, the endyma reflected from the thalamus and column upon the intruded portiplexus (Fig. 668). So long as this endyma retains its adhesions, so long the circumscription of the porta is complete.

§ 171. The exact conditions and relations of the rima, paraplexus, tenia, fimbria, and thalamus near the porta have not been as yet clearly made out. Preparations should be made with special reference to their elucidation, and figures upon a very large scale. Excepting the metapore ("foramen of Magendie") no part of the brain involves so many and so important morphological questions; see the difficulties and doubts admitted under Fig. 719.

§ 172. *Fig. 719 illustrates:* A. The size, form, and direction of the porta from the mesal aspect.

B. The complete circumscription of the porta, dorsad, by the reflection of the endyma upon the intruded plexus (Fig. 668).

C. The greater length of that part of the prosoplexus which hangs in the porta (portiplexus) than of that which hangs in the aula (auliplexus).

D. The constitution of the velum as a fold of pia, with blood-vessels intervening; one lamina of the fold belongs to the fornix, and the other to the thalamus, or rather to the diatela or primitive diacelian roof (Fig. 710).

E. The relation of the ventral end of the porta to the aulix ("sulcus of Monro").

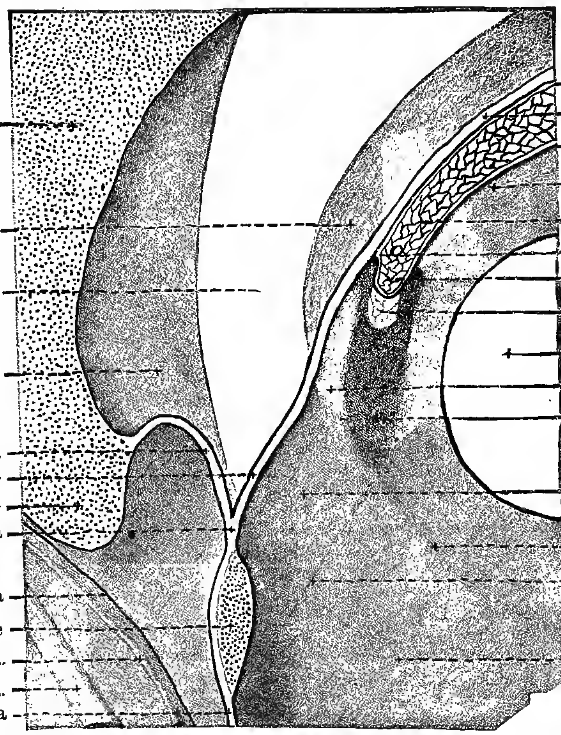


FIG. 719.—The Right Porta and Adjacent Parts, Seen Obliquely from the Caudal Side; 385. × 4. The lateral aspect of the left porta of the same brain is shown in Fig. 720, under which the mode of preparation is described. 1, Dotted line from the ventral end of the porta to the ventral margin of the precommissure, and assumed to demarcate the diacele from the aula; 2, part of the mesal surface of the hemiseptum, unusual and not fully understood (see § 172, H).

Defects.—The area marked 2 is not a cut surface as its plainness would indicate; it was shaded lightly in the drawing, but became blank in the engraving. The extent of the pseudocele and the length of the copula are so unusual as to be anomalous; these peculiarities, however, do not materially affect the porta, which is the important feature of the figure.

F. The thinness of the commissure of the fornix, *a*.

G. The unusual length of the copula connecting the callosal rostrum with the prosoterma.

H. The unusual extension of the pseudocele and of its lateral parietes, the hemiseptums; it is uncertain how far this existed naturally, or was produced by the pressure of alinjection.

§ 173. *Fig. 720 illustrates:* A. The location and general form of the paracele; unfortunately, however, the post-

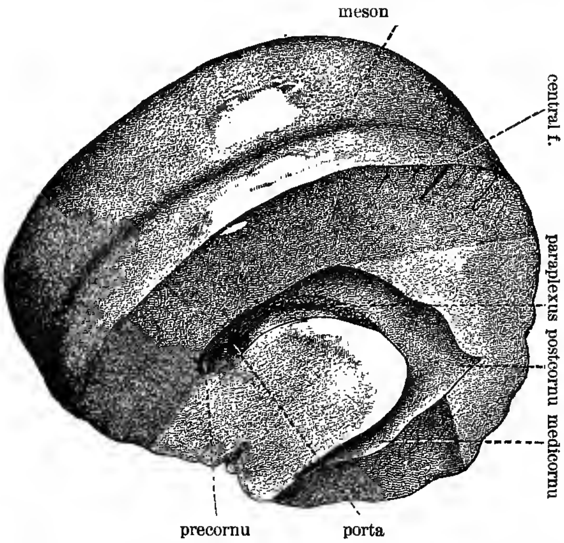


FIG. 720.—The Left Paracele ("Lateral Ventricle"), Viewed Obliquely from the Latero-Cephalic Aspect; 385. × about .5. (This figure was published in the New York *Med. Jour.* for March 21, 1895, and is here reproduced by permission.)

Preparation.—The arteries and cavities were alinjected. When the brain was thoroughly hardened the medicornu was first exposed by removing successive slices of the temporal lobe till it was reached; contiguous parts were then removed till the entire paracele was brought to view; this involved the formation of five cut surfaces, all oblique excepting the most dorsal, which was about 1.5 cm. from the meson. The dura was retained until the preparation was complete and the drawing made; it has since been medisected, so that the left porta may be looked through.

cornu is unusually short, and foreshortened by the way in which the preparation is viewed; but the sharp curve of the medicornu is well seen, and the projection of the precornu cephalad from the porta.

B. The absence of any indication of a rhinocele, which exists in the sheep (Fig. 792), and in mammals generally.

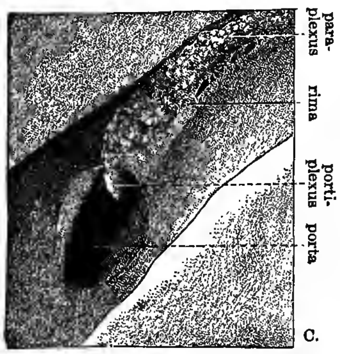


FIG. 721.—The Left Porta and Adjoining Parts of the Alinjected Brain Shown in Fig. 720; 385. × 3. The form of the lateral or paracelian orifice of the porta appears more distinctly, and the endyma is seen clearly to be reflected upon the portiplexus from the adjoining surfaces. Just dorsad of the line from *rima* are a few (presumably) artificial rents in the endyma.

C. The indistinctness of the colliculi, calcar, collateral eminence, and occipital eminence; whether this was due to hydrocephalus or to the pressure of the injected alcohol it is impossible to say.

D. The location and size of the porta, which is shown on a larger scale in Fig. 721.

E. The location of the paraplexus and of the rima through which it enters, covered, however, by the endyma (Fig. 759).

§ 174. *Fig. 722 illustrates:* A. The great size of the porta in this hydrencephal; its ventral half is concealed by the caudatum, but the total length (dorso-ventral dimension) is 19 mm. (three-fourths of an inch) and its width 8–9 mm.

B. The complete circumscription of the porta, not-

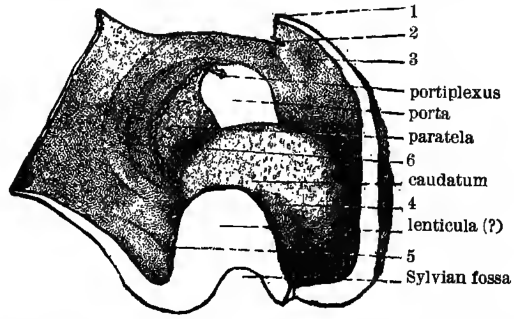


FIG. 722.—Lateral Aspect of the Right Caudatum and Porta (Foramen of Monro) of a New-Born (seven months?) Hydrocephalus. 2131. × 1. 1, Angle between two cut edges of the thin mesal wall; 2, cephalic end of the natural (although presumably abnormal) hiatus in the mesal wall, corresponding with 3 in Fig. 715; 3, ental surface of mesal wall; 4, depression between caudatum and adjoining parietes; 5, triangular depression near tip of medicornu; 6, membranous part of parietes; see § 3, C.

Preparation.—See Fig. 715; the paraplexus on this side was trimmed closely.

withstanding the delicacy of the parts and the pressure that may have caused its enlargement.

C. The great extension of the paraplexus and adjoining portions of the parietes; the parts marked 6 and 7

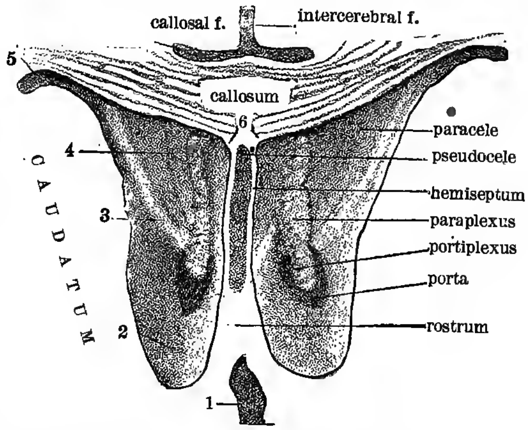


FIG. 723.—The Two Portas, from the Precornua; 2,345. × 1.5. 1, Part of the intercerebral fissure, between the rostrum dorsad and the chiasma ventrad; 2, precornu; 3, tenial vein; 4, undetermined band on the cephalic slope of the thalamus; 5, dorsal part of right paracele; 6, the short diverging lines point to the locations of veins (septal?) at the angle of junction of the hemiseptums with the callosum; dorsad of the junction of the hemiseptums with the rostrum is a small (septal?) vein at either side.

Preparation.—See under Fig. 724. The slice including the portas is 12 mm. thick; the caudal (aulic) aspect is shown in Fig. 724, the cephalic (precornual) in this.

Defects.—The shading does not indicate with sufficient distinctness that the entire surface, and plexus at either side dorsad of the porta, slope dorso-caudad beneath the callosum, and are not continuous with it. As in Figs. 724 and 739, the lines representing the callosal fibres are diagrammatic. Other preparations and figures upon a still larger scale are needed, in order to exhibit the somewhat intricate relations of the parts about the porta. The morphological importance of the entire aulic region can hardly be overestimated.

are membranous; the zone just caudad of 7, and forming part of the upper margin of the figure, may be the fimbria; and the thicker zone just caudad of it may be the hippocamp.

§ 175. *Fig. 723 illustrates:* A. The existence of the two portas, and their obviously natural condition. This point, already shown in several previous figures, is here reiterated because this aspect of these orifices is seldom presented, and because a distinguished anatomist has declared (*Progrès Médical*, Nos. 25 and 26, 1879) that when one finds a communication between the middle and lateral ventricles in an adult human brain it results from an artificial perforation; see my papers, 1884, *a* and 1884, *f*.

B. The transection of the callosum in two places, viz., dorsad near the genu and ventrad through the rostrum; the part of the septum or pseudocele here shown was therefore embraced by the genual curve of the callosum (see Figs. 687 and 756).

C. The continuity of the hemiseptum with the corresponding column of the fornix; so far as the porta is concerned, the former may be compared to a thin partition, and the latter to a door-post; see also Figs. 707 and 709.

§ 176. *Fig. 724 illustrates:* A. The existence, form, size, and complete circumscription of the two portas ("foramina of Monro").

B. The extent of the aula, the mesal division of the prosocele, and the cephalic or prosocelian constituent of the "third ventricle." It includes the interval between the portas, extending ventrad so as to include the precommissure, only part of which appears in the figure.

C. The existence of the aulic recess, a subtriangular depression between the precommissure and the two columns of the fornix; the line from the word *aula* ends in this recess; on the cast shown in Fig. 718, it is a ridge.

D. The peculiar curvature of the columns of the fornix. They converge dorsad, curving at the same time caudad,

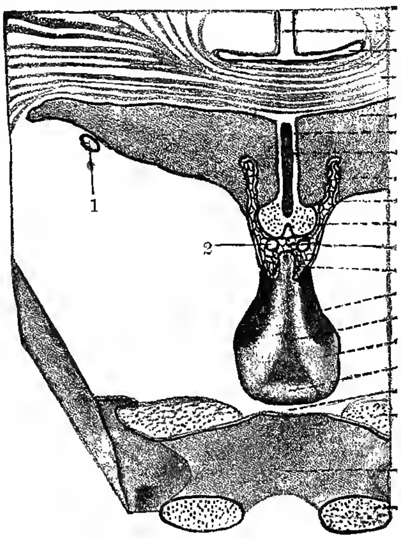


FIG. 724.—The Two Portas, as Seen from the Aula, Looking Obliquely Dorso-Cephalad; 2345. × 1.5. (Compare with Figs. 723 and 739.) 1, Tenial vein; 2, velar vein; the number rests upon the thalamus.
Preparation.—From a brain, the arteries of which had been injected with the red glue mixture, and the cavities with alcohol, a transection was removed, 12 mm. thick, so as to include the chiasma; for security of handling it was trimmed down so as to include little more than the parts represented. The optic nerves were divided obliquely, to show their cut ends more fully.
Defects.—The alba and cinerea are not distinguished, and the figure is not upon a scale large enough to show certain details as to the connections of the velum and plexuses. The divided ventral ends of the columns of the fornix were inadvertently omitted, but may be seen in Fig. 739.

so as to appear as cut ends in this transection; ventrad they diverge, are twisted somewhat, and again curve caudad, so that their cut ends should appear again just dorsad of the optic tracts, as shown in Fig. 739.

E. The relation of the precommissure to the columns, which pass just caudad of it. In a figure including a greater width of this region, the cut ends of the precommissure would appear at the side, as in Fig. 739.

F. The reflection of the endyma upon the plexuses from the fornix and thalami, at two points upon each side; such lines of reflection constitute a ripa.

G. The continuity of the hemiseptums with the callosum dorsad and the fornix ventrad.

§ 177. *Rima.*—The porta is primary, and constant among all vertebrates where the prosocele presents a tripartite condition (§ 60). In reptiles, birds, and mam-

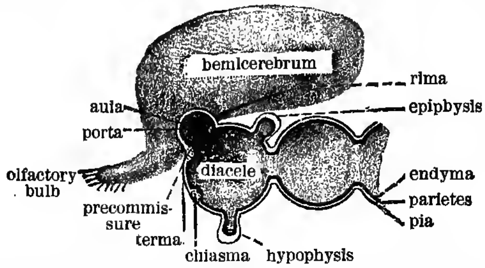


FIG. 725.—Schematic Medisection of the Prosencephal and Two Adjoining Segments; approximately the right half of Fig. 714, seen from the mesal aspect. (See § 178.)

mals (perhaps also among some lower forms) at the dorsal end of the porta there begins a line of greater or less length along which the proper nervous parietes of the paracele are abrogated for the intrusion of a pial extension, the paraplexus; this line of intrusion is the rima (chief part of the so-called "great transverse fissure") shown in Figs. 720, 725 (diagram), 730, and 735. It is to be noted that (1) the paraplexus fills the space, and (2) the endyma is carried before it, so that there is no true solution of continuity. The only way in which the porta and the rima can become continuous is by the artificial rupture of the membranous attachment, but this is by no means infrequent with brains removed and handled in the usual way.

§ 178. *Fig. 725 illustrates:* A. The communication of the paracele (lateral ventricle) with the mesal series of encephalic cavities solely through the porta ("foramen of Monro").

B. The reduction in size of the aula, the mesal division of the prosocele, relatively to the diacele, and to the prosocelian lateral extensions, the paraceles.

C. The location, in man and other mammals, of the aula at the dorso-cephalic side of the diacele, instead of directly cephalad as in Amphibia.

D. The concomitant change in the direction of the diacelian and prosocelian floors; instead of cephalo-caudal, their direction is more or less nearly dorso-ventral.

E. The crowding of the epiphysis caudad by the overlying cerebrum; the epiphysis and hypophysis are retained in the figure, however, mainly as landmarks.

F. The relation of the rima (essential part of the "great transverse fissure") to the porta. The line along the meso-ventral aspect of the hemicerebrum represents a narrow tract where the paracelian parietes are reduced to the lining endyma and the covering pia, and where the latter, or its vessels, intrudes into the paracele, still covered, however, by the endyma. The rima always begins at the margin of the porta, and extends, in man, to near the tip of the medicornu (see § 183 and Figs. 728 and 734).

G. The secondary and morphologically unessential nature of the caudato-thalamic extension, the enormous thickening of the thalamus, the lateral wall of the diacele, and of the caudatum, the wall and floor of the paracele. This feature of the mammalian brain, which is very confusing and not altogether easy to describe, may be ignored in a diagram like the above, where the parietes are represented of nearly uniform thickness, as in the embryo and in adult amphibians.

§ 179. *Fig. 726 illustrates:* A. The close contact and even interdigitation of the mesal aspects of the frontal lobes of the sheep concomitantly with the absence of a falx.

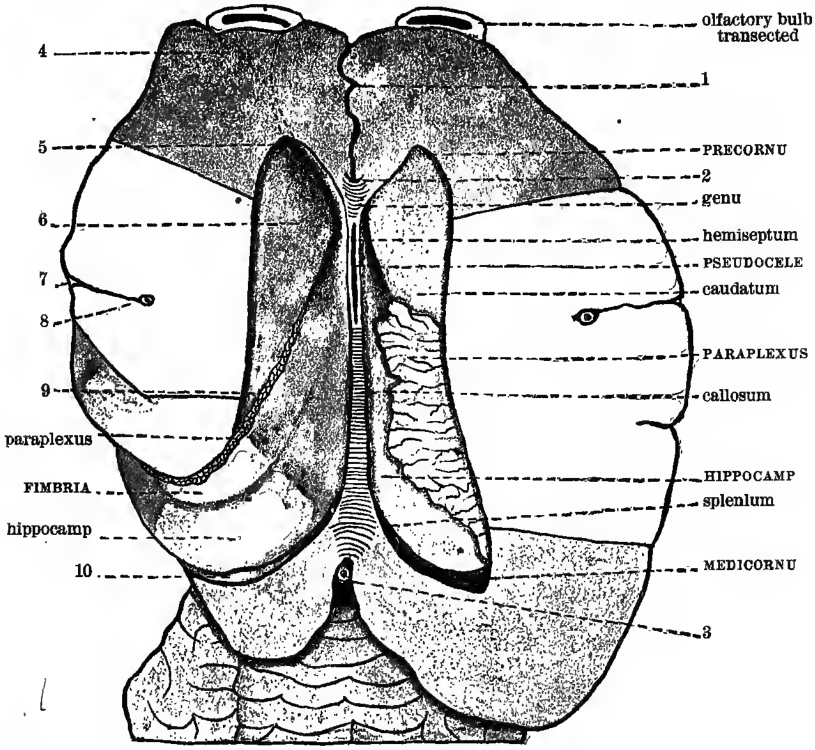


FIG. 726.—Sheep's Brain, the Paraceles ("Lateral Ventricles") Exposed. × 2. (From my "Physiology Practicums.")

Preparation.—By the removal of successive slices the paraceles have been opened; the left has then been more completely exposed by oblique sections, and the paraplexus trimmed off so as to expose the wide fimbria and the furrow between it and the hippocamp. The plane of section did not coincide exactly with the callosum; the caudal three-fifths of this is represented by the transverse lines; also the cephalic end, the genu; but an intermediate portion is wholly removed, exposing the narrow pseudocele ("fifth ventricle") and its thin lateral walls, hemiseptums.

Defects.—The cerebral cortex is not represented. The caudal half of the cerebellum is omitted. 1, Intercerebral fissure; 2, callosal fissure; 3, vessel; 4, interrupted lines indicating the continuation of the paracele into the rhinocele (Fig. 792); 5, precornu; 6, caput of the caudatum; 7, Sylvian fissure crossed by arachnoid; 8, vessel at bottom of fissure; 9, cauda of caudatum; 10, part of caudal wall of paracele.

B. The width of the fimbria and hippocamp, and thence of the entire fornix, as compared with the human.

C. The apparent absence of the tenia.

D. The total exclusion of the thalamus, even in appearance, from the paracelian floor.

§ 180. *Fig. 727 illustrates:* A. That, at this age, the paraceles extend much farther dorsad than in the adult, far beyond the level of the callosum.

B. That the paraplexus is relatively more extensive.

C. That the caudatum is relatively larger.

D. That the margin of the fimbria reaches the groove between the caudatum and the thalamus, which probably represents the tenial sulcus of the adult.

E. That the thalamus is therefore absolutely excluded from the paracelian floor, without even the appearance of representation which exists in the adult.

§ 181. With all mammals other than man, the apes and certain members of the seal family, the margins of the rima are, throughout their whole extent, separated only so far as to permit the intrusion of the paraplexus, *e.g.*, the sheep (Fig. 726); nor does this adhesion yield at all in cases of hydrocephalus, observed by me in dogs and cats. With the human fetus, also, up to the estimated age of four months (Figs. 727 and 734), at least, the tenia and the fimbria are closely apposed—as closely, that is, as they can be and yet allow the plexal intrusion; at this age, therefore, the human thalamus is as perfectly excluded from the paracele as it is in mammals generally.

§ 182. *Paratela.*—But with all human adults (perhaps also with the new-born, and possibly with fetuses during the later months) the tenia and fimbria, for most of their length, are separated by an interval, 2–7 mm. in width, narrowing at the porta and in the medicornu. This interval is filled by (1) the paraplexus, which retains its attachment to the fimbria rather than to the tenia; (2) an extension of the endyma from the margin of the tenia with or without the adhesion of the subjacent pia. This zone of endyma, or endyma and pia, extending from the porta to near the end of the rima is the *paratela* (Figs. 732, 735).

§ 183. *Fig. 728 illustrates:* A. The existence of substantial walls of nervous substance about the medicornu at the distance of at least 1 cm. from the tip of the temporal lobe.

B. The concomitant non-extension of the rima ("great transverse fissure") to the extremity of the medicornu.

C. The existence of digitations at the ventral end of the hippocamp (*pes hippocampi*).

D. The non-extension of the hippocamp to the extremity of the medicornu.

E. The dilatation of the medicornu in hydrocephalus.

F. The efficacy of alinjection in maintaining the size of an encephalic cavity and preserving the contour of its parietes.

G. The nearly typical zygal, or H-shape, of the orbital fissure (see Fig. 778, III.).

§ 184. *The Rima Not Coextensive with the Medicornu.*—The rima extends from the porta to near the extremity of the medicornu, but for about 1 cm. from its extremity

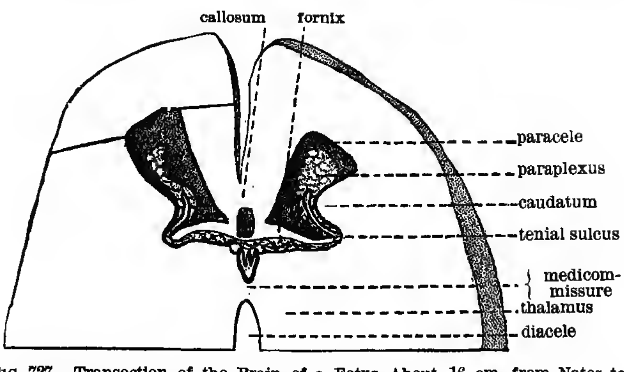


FIG. 727.—Transection of the Brain of a Fetus, About 16 cm. from Nates to Bregma, and Estimated at Four Months; 1816. × 1.3.

Preparation.—The fetus was received in alcohol, not very well preserved. The calva was cut away with scissors, and the dura and pia removed. The entire brain was then transected at the level of the medicommissure, but only the dorsal half of the divided surface is included in the figure; it is the cephalic aspect of the caudal part. The two lines crossing the right hemicerebrum indicate the plane of the section shown in Fig. 761.

the parietes are substantial (Fig. 728). The transition to the rima is constituted by the riparian part, *pala*, which connects the two rimal margins, fimbria and tenia. This

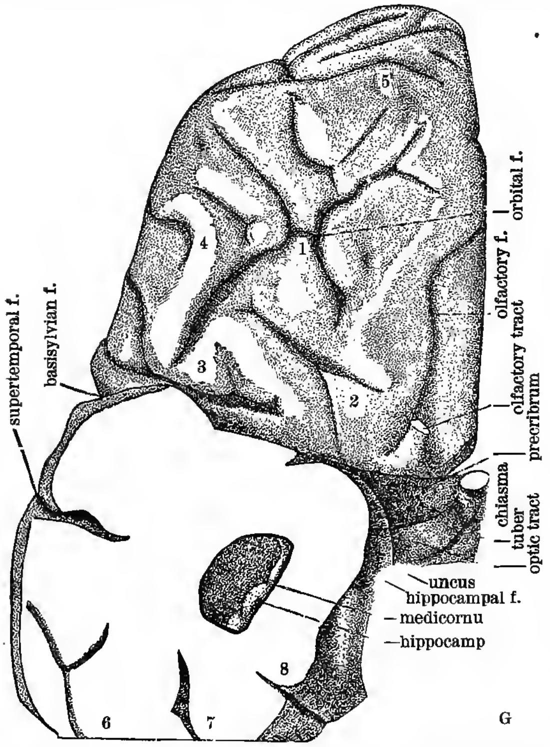


FIG. 728.—Ventral (Orbital) Aspect of the Right Fronto-Temporal Region of the Hydrencephal Shown in Fig. 743, after removal of the tip of the temporal lobe; 747. × 1. 1, Zygon of the orbital fissure (see Fig. 778); 2, 3, 4, undetermined fissures; 5, undetermined fissure, zygal in form, perhaps the orbito-frontal; 6, meditemporal (?) fissure; 7, subtemporal (?) fissure; 8, collateral fissure. *Preparation.*—See Fig. 743.

thin portion has, in man, a shape like the blade of a turf-cutter; it is not distinctly shown in any of the figures in this article, but in Fig. 730 it would constitute the thin

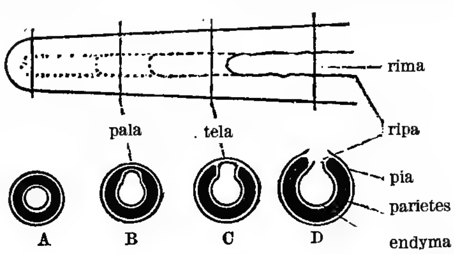


FIG. 729.—Schematic Transections of the Medicornu at Four Different Levels. For simplicity the cornu is represented as tubular and straight, normalized, so to speak (§ 38), and the parietes merely as substantial tissue covered by pia and lined by endyma. For some distance from its extremity (1-2 cm. in man) the medicornual parietes are typical, as at A; this condition of the parts appears in Fig. 728. The proper nervous parietes suddenly become very thin and transparent, so as to resemble the terma and valvula, as at B. At C the proper nervous parietes have entirely disappeared, leaving only the two membranes; this is the normal constitution of a tela, and sometimes exists near the tip of the medicornu, though relatively for a much less distance than on the diagram. Finally, whether or not a plexus is intruded into the cavity, as is the case with the medicornu, the tearing away of the tela leaves a ragged edge which is a ripa at either side of the rima.

lamella at the ventral end of the fimbria. In the diagram, Fig. 729, the pala is seen in transection at B.

§ 185. *Fig. 730 illustrates:* A. The early and distinct formation of the caudatum (see also Fig. 715).

B. The continuity of the two margins of the rima, the fimbria and tenia, near the tip of the temporal lobe, the place of their union, at and after birth, being somewhat distinct, the pala.

§ 186. *Fig. 731 illustrates:* A. The thinness of the fornix at the meson (§ 202).

B. The considerable extent of the pseudocele; since this is not connected with the true encephalic cavities, it cannot be exaggerated by the hydrocephalous condition.

C. The completeness of the paracelian floor after the removal of the thalamus; the interval, rima, between the substantial tenia and the lateral margin of the fornix (fimbria) is completely filled by the paraplexus and the paratela.

D. The greater width of the rima in the cella than near the end of the medicornu.

E. The extension of the calcarine fissure (stem of united occipital and calcarine) across the hippocampal gyre; it does not, however, reach the hippocampal fissure.

§ 187. *Fig. 732 illustrates:* A. The main point is the continuity of the floor of the paracele ("lateral ventricle") irrespective of the dorsal surface of the thalamus, and the concomitant exclusion of this diencephalic mass from

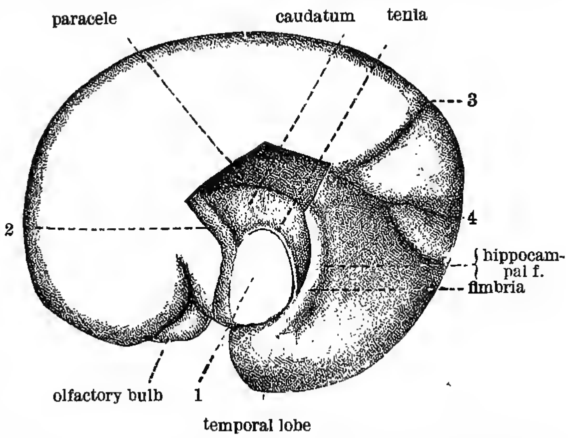


FIG. 730.—Mesal Aspect of a Right Fetal Hemicerebrum, Partly Dissected; 3,000. × 2.5. 1, Transection surface between the caudatum and thalamus; 2, part of cut surface left by removing a section of the mesal wall (including the rudimentary fornix and callosum) in order to expose the caudatum; the paraplexus was also torn from its attachments, leaving the rima open; its margins, the tenia and fimbria, are separated more than is natural; in a fetus of this age they should be closely apposed (see § 181 and Fig. 727); 3, 4, transitory fissures in the places of the future occipital and calcarine.

this portion of the prosencephalic cavity; but so many other points are shown incidentally that the figure will be described in detail.

Beginning at the dorsal side of the figure, the intercerebral fissure is seen to separate the apposed mesal surfaces of the hemicerebrums. The arachnoid dips into this fissure to a certain depth, so as to pass around the ventral margin of the falx (not shown in the figure); since this has (as seen in Fig. 801) a curved margin, and becomes narrower (dorso-ventrally) cephalad, the extent of the arachnoidal fold varies at different levels; in the specimen here figured, for example, which is about 1 cm. thick at the level of the callosum, the arachnoid crosses 5 mm. dorsad of the callosum on the caudal aspect and 8 mm. on the cephalic. The pia, however, follows the apposed hemicerebral surfaces to and into the callosal fissure at either side and is continuous upon the dorsal surface of the callosum. Of the vessels the figure includes only the two parallel precerebral arteries (4). The callosum itself presents a slight mesal elevation, which is more distinct at the cephalic side of the section and of a somewhat different color (§ 217). The callosum extends laterad and likewise dorsad to form the roof of the paracele, and it is to be noted that the lateral portion of this cavity would be opened by a horizontal section at the level of the dorsal surface of the callosum; hence the appearance commonly described and figured under the name of "*centrum ovale majus*" seldom if ever exists. For the condition of things in fetal brains, see Fig. 727, § 180.

Ventrad of the callosum is the fornix, connected therewith by a thin lamina, the hemiseptum, at either side of a mesal cavity, the pseudocele. The lateral margin of the fornix is formed by the fimbria (corpus fimbriatum).

At the extreme left of the figure the lateral wall of the paracele is seen to be formed by a cinereal mass, the caudatum. By reference to Figs. 707 and 735, it will be seen that this narrows rapidly from the cephalic end (caput) as a slender prolongation (cauda); but this cauda is really folded somewhat upon its longitudinal axis so as to constitute, in at least part of its course, not only the side but a part of both the roof and floor of the paracele; in the figures just mentioned the roof portion and part of the lateral is removed, leaving only the floor portion. Along the mesal border of the cauda there passes a vein (3), the tenial vein, which may be regarded as indicating the boundary between the caudatum and the thalamus.

Projecting mesad of the vein is seen a lamina, consisting evidently of the paracelian endyma, and also, at least near the caudatum, of some nervous substance; this is, or includes, the white band named *tenia* in this article, but commonly called *tænia semicircularis* or *stria cornea.*

All the parts so far described are unquestionably constituents of the prosencephal; the remaining portions shown in Fig. 732 belong to the diencephal. The walls of the diacele are the thalami, of which the figure includes only the portions dorsad of the level of the medi- and postcommissures (see Fig. 687).

The mesal surface is covered by endyma, which is continued over the low ridge called habena ("habenula") seen from the mesal aspect in Fig. 687, and from the dorsal in Fig. 707. Just dorsad of the habena is a slight furrow, the habenal sulcus; here the endyma meets the pia covering the dorsal aspect of the thalamus, and is reflected with it dorsad and then mesad toward the opposite side. Instead of passing horizontally across the interval between the thalami, however, the endyma is deflected over the two vascular plexuses (folds of pia or vessels therefrom) which hang in the diacele. The habena and its sulcus, more accurately, perhaps, the latter, constitute the boundary line between the mesal, entocelian, endymal surface of the thalamus, and the dorsal, ectocelian, and pial surface, which extends dorso-lateral.

Between the dorsal surface of the thalamus and the ventral surface of the fornix (including, of course, the fimbria), the pia is freely separable, and appears to consist of but a single layer; but laterad it is traceable to the paraplexus, and it is almost inconceivable that a plexus should be formed of a single layer of pia as a free edge covered by endyma. When, however, this fornico-thalamic pia is traced mesad, it is found to separate into two layers, a dorsal, belonging to the fornix, a ventral, constituting part of the diacelian roof (diatela) with a pair of arteries, a pair of veins, and numerous smaller vessels in the intervening space. The ventral layer is not separable (in man) from the diacelian endyma, but the dorsal not only may be detached from the fornix in an alcoholic specimen, as may the pia from most of the surfaces which it covers, but here, excepting at the margins, the disjunction was almost spontaneous, and there is a distinct space (8) between it and the commissure, bounded at the sides by the thicker (hippocampal) constituents of the fornix. This double curtain of pia is the velum (interpositum), which belongs equally to the diencephal and to the superposed prosencephal. Were it possible in separating the two segments, the dorsal layer should accompany the cerebrum, and the ventral remain attached to the thalami; the continuity of the two is seen at the aula and the two portas, as well as along the entire margin of the paraplexus (see Figs. 710 and 737).

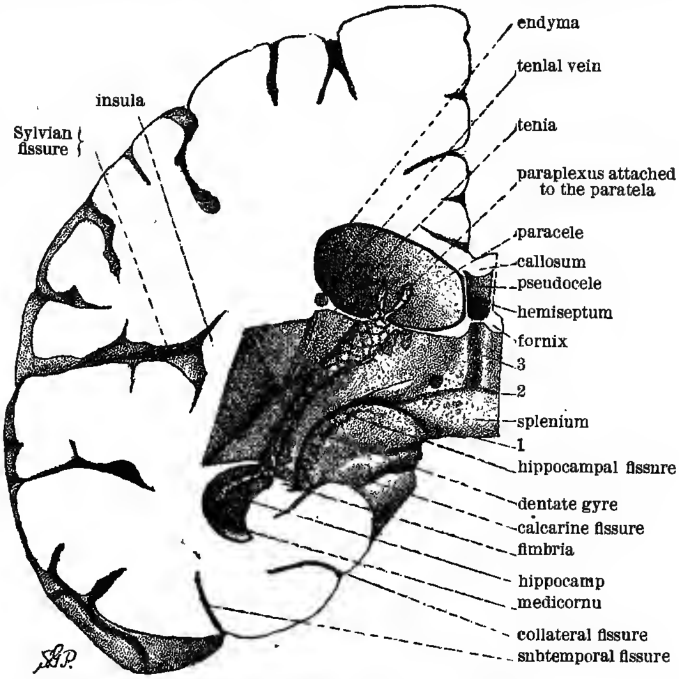


FIG. 731.—Transection of the Right Hemicerebrum of an Adult Hydrocephalus; 747. × 1. 1, Ventral curvature of splenium; 2. groove at cephalic margin of splenium; 3, mesal furrow of fornix (the line does not quite reach it). The furrow between the lines from *hippocampal fissure* and *dentate gyre* is the continuation of the callosal fissure, separated from the hippocampal by a flattened area of cortex. The deep fissure opposite the word *insula* is the central.

Preparation.—This represents the cephalic aspect of the caudal part of the hemicerebrum, the mesal aspect of which is shown in Fig. 743. The transection was along the oblique line *d–v* on that figure. So much of the thalamus as was included was cut away, together with some of the adjoining prosencephalic mass, capsula, lenticula, and perhaps claustrum, leaving little more than the cortex of the insula at that point.

Defects.—The shading does not discriminate sufficiently between the natural and artificial surfaces, but the former are curved while the latter are straight and bounded by sharp lines. The alba and cinerea are not distinguished. The left hemiseptum is added by dotted lines.

Corresponding with the margin of the fimbria, the dorsal surface of the thalamus presents a shallow groove, the fimbrial sulcus ("sulcus choroideus," Fig. 707); laterad from this the surface is nearly regular, and overlaid partly by the paraplexus and a membrane apparently endyma only, and partly by the thin but more substantial lamina (tenia?) already described as an extension of the caudatum.

The entire dorso-mesal surface of the thalamus, instead of being homogeneous, as it has been sometimes figured and described, may be divided, first and most sharply into a mesal, or entocelian, and a dorsal, or ectocelian, portion, the boundary between the two being the habena and its sulcus. The dorsal surface itself presents a twofold division into a subfornical (B) and a parafornical (C and D), separated by the fimbrial or choroid sulcus. Finally, the parafornical area is covered partly by the paratela and plexus and partly by the tenia, and may thus be distinguished as subparatelar (C) and subtenial (D), there being occasionally a furrow, the tenial sulcus, between them. The desirability of discriminating between these areas will appear in connection with Fig. 733, where certain different, and perhaps anomalous, conditions are described.

So far as this preparation is concerned, there is absolutely no adhesion of endyma to any part of the thalamus dorso-laterad of the habenal sulcus; on the contrary, the endyma is traceable in uninterrupted continuity about each paracele, over, in turn, the ventral surface of the callosum, the caudatum, the tenia, the paraplexus, the fimbria, the thicker portion of the fornix, and the hemiseptum, back again to the callosum.

§ 188. With some specimens the interval between the paraplexus and the caudatum seems to be occupied by a somewhat substantial lamina, separable from the thalamus, continuous with the caudatum, and perhaps merely a special development of the tenia, but requiring further investigation (Fig. 733).

§ 189. The point illustrated upon Fig. 733 is the continuity of the paracelian floor from hippocamp to caudatum without the intrusion of the thalamus. This figure is to be studied in connection with the transection (Fig. 732), and the dorsal view of the floor in Fig. 735.

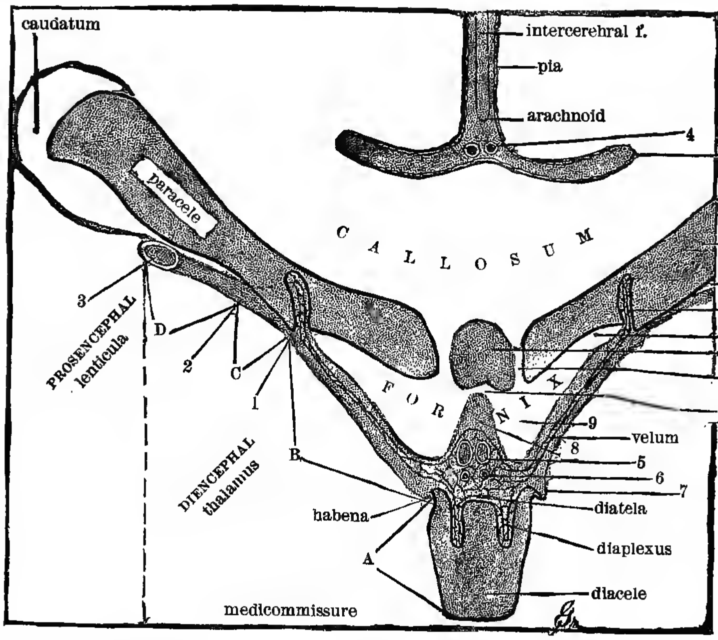


FIG. 732.—Transection, Partly Schematic, of the Fornix and Adjacent Parts at a Level Corresponding with the Interval between the Medicommissure and the Postcommissure; 1,824. × 2.5. 1, Fimbrial sulcus ("sulcus choroideus"); 2, tenial sulcus (in some specimens); 3, tenial vein; 4, precerebral arteries; 5, velar veins; 6, velar arteries; 7, habenal sulcus; 8, interval (natural ?) between the velum and the commissure of the fornix; 9, lateral part of the fornix (hemifornix); A, mesal, endymal surface of thalamus; B, C, D, zones of its dorsal surface; B, subfornical; C, subendymal; D, subtenial. Between the left paraplexus and the tenia the membranous floor of the paracele is the paratela.

The figure represents the caudal surface of the transection; the observer is looking cephalad, and his right coincides with the right of the specimen and the figure; the two sides are substantially identical, but less is shown upon the right; the meson of the figure, the anatomical middle of the various parts and cavities represented, is dextrad of the middle of the area covered by the figure. Throughout the figure the cavities are shaded and the blank areas represent transected surfaces. The arachnoid is represented by a narrow, straight line, the pia by a corrugated line, and the endyma by a heavy line; the endyma is made to adhere closely to the entocelian surfaces, but the pia and arachnoid are separated slightly from the parts which they cover.

Preparation.—See Fig. 744, representing another transection of the same brain. The celian parietes were thoroughly hardened before the brain was removed from the skull, and the membranes and plexuses have retained their connections notwithstanding much handling and considerable transportation. There is some distortion and dislocation of the loosely connected parts about the fornix, but it has been possible to clear up most of the doubtful points by comparison of the two sides and with adjoining sections. So far as respects the exclusion of the dorsal surface of the thalamus from the paracele, the preparation affords unequivocal evidence.

Defects.—As in several other figures representing transections of plexuses, it has been assumed that a plexus consists of a fold of pia covered by endyma; for present purposes it matters not whether there is a complete fold of the pia, or merely an extension of vascular loops. The ventral lamina of the velum is made too low. The medicommissure, the dorsal margin of which is included at the ventral side of the figure, did not actually appear in this section, which was just caudad of it, but is introduced as a readily recognized landmark. The indusium is not shown (§ 217).

There are, however, differences between these and other preparations which are not easy to explain, excepting upon the general supposition that a region in which the conditions are nearly peculiar to the human brain might naturally be expected to present individual peculiarities and even anomalies.

§ 190. There seems to be considerable variation in the details of the parts involved in the apparent representation of the thalamus within the paracele; this is perhaps to be expected, since the conditions that have made the usual statements possible constitute a great and perhaps peculiar modification of the primitive and typical relations—indeed, almost a malformation.

It is hoped that the foregoing descriptions and figures may at least serve to induce anatomists to investigate the subject in all its bearings.

§ 191. *In What Sense does the Thalamus Form Part of the Floor of the Paracele (Lateral Ventricle)?*—So widespread and so deeply rooted seems to be the notion that the thalamus constitutes a part of the paracelian floor in the same sense as do the caudatum and the hippocamp, that, much as I would prefer to avoid the critical attitude, I am induced to comment upon the current representations of this region.

Admitting, for the sake of occupying common ground, that a certain area of the dorsal surface of the human thalamus is covered by endyma; that it is continuous with the caudatum, and that therefore, like that body, it enters into the composition of the paracelian floor; none will deny that an adjoining area of this same dorsal surface is as distinctly covered by pia; that it is continuous with the optic lobes (gemina), and like them wholly excluded from the encephalic cavity.

To represent the entire dorsal aspect of the thalamus as a smooth, unbroken surface is practically to affirm one of two things: either the whole is pial or ectocelian, which would be in contravention of the obvious facts; or else the whole is endymal or entocelian, which would involve not only the gemina but the cerebellum and oblongata, a manifest *reductio ad absurdum.**

§ 192. *The Colliculi.*—This collective term is applied to the rounded eminences and ridges which project into the paraceles ("lateral ventricles") from their parietes. They are the caudatum (caput and cauda), hippocamp ("*hippocampus major*"), calcar ("*hippocampus minor*"), collateral eminence, and occipital eminence. Excepting perhaps the first, each of these

* For a fuller discussion of the relations of the thalamus to the paracele, and for commentaries on the misrepresentations in standard works, see the first edition of the REFERENCE HANDBOOK, viii., 144–147, and ix., 107, and my papers, 1888, *a*, and 1889, *d*. The delicacy of the membranes, the readiness with which they are detached along a ripa, the rough handling to which brains are commonly subjected during the ordinary processes of removal and examination, the slight degree in which preservatives can reach the parts in question when the entire organ is merely immersed as usual, and, finally, the fact that some agents, excellent for microscopic purposes, do not well preserve the endymal attachments—all these conditions conspire to bring it about that the endyma across the wide rima should be torn, and the dorsal surface of the thalamus protrude through the rent.

represents a corrugation of the entire thickness of the parietes, the ental elevation (colliculus) being collocated with an ectal depression (fissure); this collocation is indicated in the list of total fissures, § 258.

§ 193. *The Callosal Eminence.*—Besides the colliculi named in § 192, all of which are more or less distinct in at least some adult brains, there is one which is perfectly obvious in some fetuses (Fig. 734, 1), and which, from its apparent collocation with the callosal fissure (Fig. 742), may be called, provisionally, the callosal eminence. It, the hippocamp, and the occipital eminence form an irregular triradiation. Its commencement and disappearance require further observation, but its unbroken continuity with the hippocamp confirms the idea that the callosal and hippocampal fissures are essentially parts of one, merely deflected by the splenium of the adult.

§ 194. *The relative size* of the colliculi is not the same in the adult as in the fetus. This is clear from the comparison of Fig. 734 with Figs. 744 and 761. The callosal eminence may disappear wholly; the occipital is seldom recognized (Fig. 744); the collateral is certainly less prominent in the adult than in the fetus (Fig. 734).

§ 195. *Fig. 734 illustrates:* A. The contiguity of the margins of the fimbria and the tenia (the edge of the caudatum) with just room for the entrance of the paraplexus, and the concomitant complete exclusion of the thalamus from the paracelian floor (compare Figs. 732 and 733).

B. The existence of an ental ridge (1) at this period, continuous and corresponding with the hippocampal and callosal fissures; whether it extends still farther cephalad, as in Fig. 742, cannot be ascertained from this specimen.

C. The branching off of a ridge corresponding apparently to the occipital fissure, and representing the adult occipital eminence.

D. The existence of two intermediate ridges, perhaps prefiguring the calcar and collateral eminence.

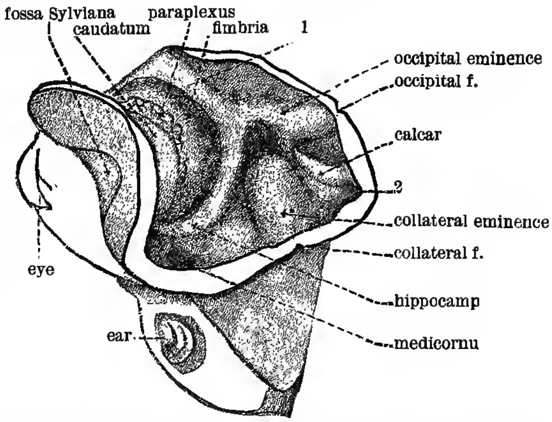


FIG. 734.—Left Hemicerebrum, Laid Open, of a Fetus Weighing 88 gm. (3 ounces), Measuring 15 cm. from Heel to Bregma, and Estimated at Fourteen Weeks; 2,083. × 1.5.

Preparation.—The fetus was received fresh; the head was cut off and pinned by the neck to a cork loaded with sheet lead; a shawl pin was inserted as a handle at one side of the head. A slit was made through the scalp at the lateral angle of the prefontanel, and the guarded cannula adjusted so that ninety-five-per-cent. alcohol should enter the paracele gently, with opportunity for egress at the side of the cannula. After six hours the alinjection was discontinued, but the specimen remained in alcohol for two days, when the scalp was removed and the specimen placed in ten-per-cent. nitric acid. After five hours the calva was so far decalcified that it could be cut away with the scalpel and scissors without jarring the very delicate brain. The left hemicerebrum was then exposed as indicated, and the nape of the neck removed to expose the collateral fissure. Upon a larger scale some of the points would have appeared more clearly.

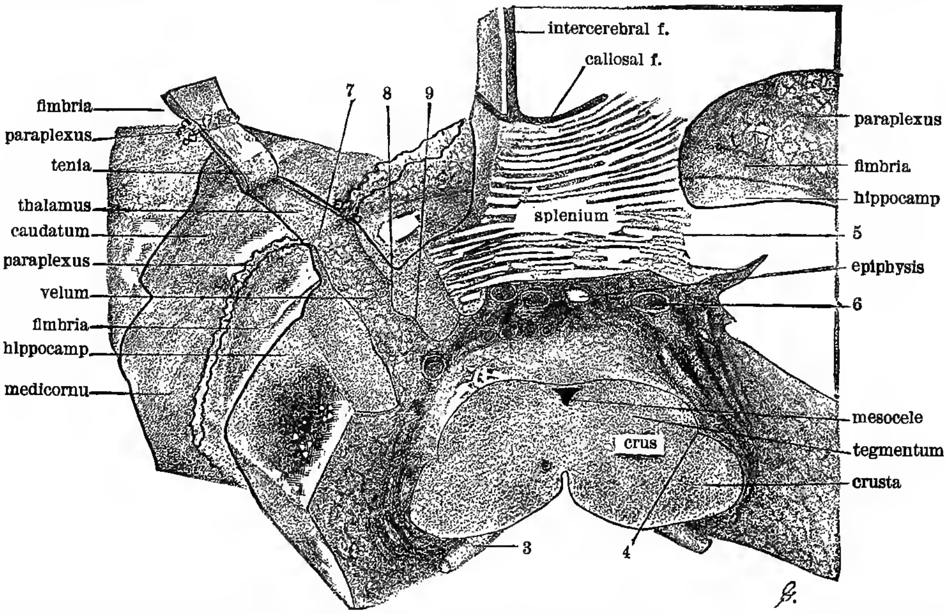


FIG. 733.—Dissection, Partly Schematic, of the Floor of the Left Paracele ("Lateral Ventricle"), Caudal Aspect; 2,345 and 2,347. × 1.5. Compare in part with Fig. 706. 4, Lateral sulcus of the mesencephal; 3, oculomotor nerve; 5, line of somewhat sudden deflection of the splenial fibres caudad into the occipital lobe; 6, large vein; 7, fimbrial sulcus; 8, angle between the fimbria and the hippocamp; 9, hippocampal fissure.

Preparation.—The arteries were injected with the red glue mixture, and the cavities with alcohol. When hardened, a thick slice was taken by one transection at about the middle of the length of the callosum and another at the splenium, just shaving off the tip of the epiphysis. The original transection of the brain stem between the mesencephal and epencephal was modified by carrying two sections cephalo-mesad, meeting at the level of the valvula. On the right of the cerebrum the parts were left undisturbed, excepting that the paraplexus was raised so as to expose the floor of the cavity. On the left, a thin slice of the hemicerebrum is left attached to its opposite by the pia. In order to expose the paracelian floor as completely as possible from this point of view, the sections had to be made in many directions. The paraplexus was trimmed down for a certain distance; then a wedge-shaped piece was cut from the thick caudal wall, hippocamp, etc., including part of the thinner floor, fimbria: this exposed the velum, the double fold of pia between the dorsal surface of the mes- and diencephal and the ventral surface of the fornix. Very cautiously then the two parallel incisions were carried across the floor to and into the caudatum constituting the lateral wall; the strip so enclosed was then lifted; it included (1) a piece of the fimbria; (2) the disconnected part of the paraplexus; (3) a strip of the thin lamina intervening between the plexus and the caudatum; in 2,347 all these were found separable from the dorsal surface of the thalamus, substantially as in the transection, Fig. 732; in 2,345 there were complications which should form the subject of monographic consideration. See § 189.

Defects.—The defects of the figure are due mainly to the attempt to combine the appearances presented by two different preparations.

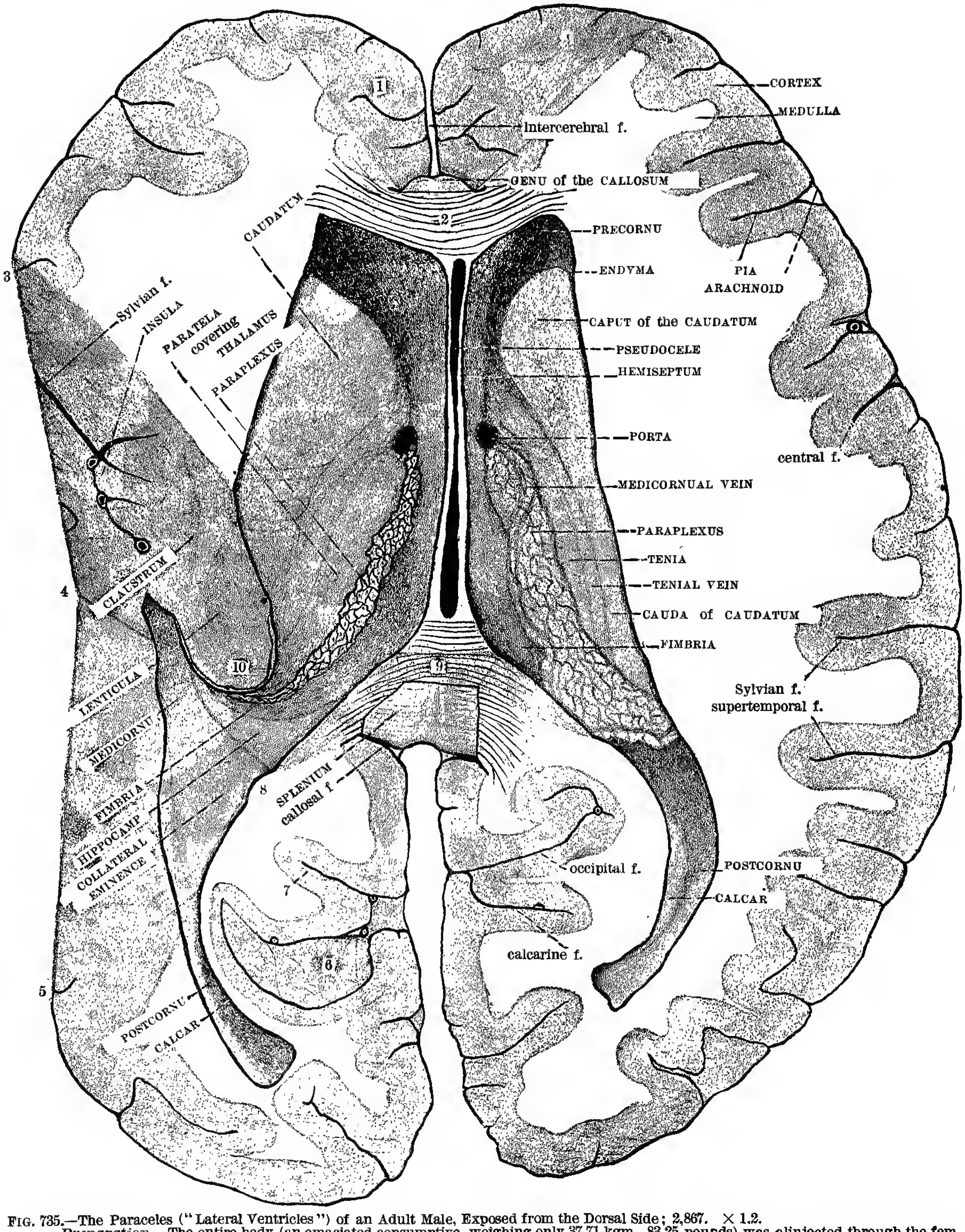


FIG. 735.—The Paraceles ("Lateral Ventricles") of an Adult Male, Exposed from the Dorsal Side; 2,867. × 1.2.

Preparation.—The entire body (an emaciated consumptive, weighing only 37.71 kgm., 83.25 pounds) was alinjected through the femoral artery. Eight and one-half litres were introduced on the first day, and some escaped from the mouth. On the second day, and again on the fourth, another litre was injected. On the fifth day there was injected a litre of Pansch-Gage starch mixture (see article *Brain: Methods*, etc.). When the brain was removed, on the eighth day, the only odor was of the alcohol. The substance had already hardened somewhat and the arteries were well filled, notwithstanding some of the mass had extravasated into the thorax. The brain was transected through the mesencephal (see *Brain: Methods*), and the paraceles exposed by removing the dorsal portion of the cerebrum in thick slices down to the level of the callosum; then in thinner slices and wedge-shaped pieces till the desired condition was reached. On the left the medicornu was exposed into the part extending cephalad; the terminal portion extending also mesad could not be shown without cutting away an undesirably large mass. On the left also the occipital lobe was cut to a slightly lower level than on the right; hence, on the right appears the dorsal slope of the calcar, while on the left the plane of section coincides with the line of its greatest elevation, and the width of the postcornu is correspondingly reduced. To lessen the width of the figure a part of the lateral convexity was removed by dorso-ventral incisions between 3 and 4, and 4 and 5, so the line representing the pia ceases at 3 and 5. Finally, the left paraplexus was trimmed off quite closely. (For the rest of this explanation, see at bottom of page 179.)

§ 196. *Fig. 735 illustrates:* A. The general relation of the paraceles (lateral ventricles) to the cerebrum; although relatively much smaller than in the fetus, they are absolutely extensive; here their natural extent has been maintained by the injection of alcohol; when examined in a fresh brain or in one hardened in the usual way their walls are often found nearly in contact.*

B. The terminal dilatation and squareness of the postcornu, as contrasted with the pointed form which usually exists in brains not prepared by filling the cavities; sometimes, indeed, there has been doubt as to the extent of the postcornu, as admitted by Huxley, Zoöl. Soc. Proceedings, 1861, p. 250; in Krause's "Handbuch" (1880), Fig. 479, the postcornua are merely linear.

C. The great thickness of most of the parietes as compared with their thinness in the fetus, Fig. 667.

D. The retention of the fetal tenuity of a portion of the mesal wall, viz., the hemiseptum (halves of the septum lucidum).

E. The considerable length and width of the human pseudocele (fifth ventricle); so far as I have observed it is wider than in any other animal; in Fig. 726 (of the sheep) it is unnaturally wide.

F. The relation of the cortex (cerebral ectocinerea) to the medulla (alba), as an ectal layer following the fissural indentations.

G. The relation of the insula to the Sylvian fissure; the former is a typical subgyre, the latter is a typical superfissure.

H. The relation of the claustrum to the insular cortex ectad and the lenticula entad (see also Fig. 782).

I. The constitution of the caudatum by two regions, a larger cephalic, the caput, and the cauda, narrow, and following the curve of the medicornu.

J. The junction of the occipital and calcarine fissures so as to constitute as it were a single bifurcate fissure.

K. The size and distinctness of the collateral eminence, an ental elevation or colliculus, corresponding to the collateral fissure upon the ventro-mesal aspect of the cerebrum.

L. The existence, on the left, of an elevation, the occipital eminence, corresponding with the occipital fissure. This colliculus is distinct in the fetus (Figs. 734 and 761), and in some adults (Fig. 744) is better marked than in this specimen.

M. The location of the portas (foramina of Monro), and their visibility in a direct dorsal view of the paraceles; by reference to Figs. 720 and 724, it will be seen that each porta opens into the corresponding paracele obliquely, looking laterad, cephalad, and also dorsad; hence it is visible from three different directions at right angles with one another.

N. The distance between the two portas. Deducting the slight length of the passages themselves, this distance represents the width of the aula, the mesal division of the prosocele, which is commonly reckoned as merely the cephalic part of the "third ventricle."

O. The continuity of the hemiseptum, a part of the mesal wall of the paracele, with the fimbria, a part of its floor; indeed, their topographical relations may be illustrated by bending a sheet of paper or metal, and holding it so that one portion is vertical and the other nearly horizontal; the former will represent the hemiseptum, the latter the fimbria.

P. The narrowness of the human fornix as measured by the distance between the lateral margins of the two fimbrias in their horizontal portions: compare the sheep, Fig. 726. It is true the word *fornix* does not occur on the figure; but, as discussed in § 197, the fornix is constituted by the two hippocamps, with their fimbrias, united at the meson by the commissure (Fig. 732); in this dissection the commissure is invisible, being upon a lower plane, so the fornix, as a whole, cannot be indicated.

Q. The smallness of the paraplexus as compared with its fetal condition, Figs. 667 and 747.

R. The formation of the free margin of the paraplexus by the medicornual vein, considerable in size and more or less contorted, by which the blood of the plexus is returned to the velar vein.

S. The considerable width of the attached portion of the paraplexus. This appears on the left side where the plexus has been trimmed quite closely. The rima is the line of apparent interruption of the parietes for the intrusion of the paraplexus, and is unusually wide in this specimen.

T. The completeness of endymal continuity and celian circumscription. These terms have been discussed in §§ 63–66, as exemplified upon the mesal aspect of the brain, Fig. 687. There only the mesal cavities are visible. In the present figure (aside from the pseudocele, which is not a true member of the series) there appear only the great lateral cavities of the prosencephal. The continuity of the endyma is represented by the uninterrupted heavy line surrounding either paracele. Likewise is the endyma a continuous sheet upon the sides and floor of this cavity. At the margins of the rima it may be traced as a smooth surface upon the intruded paraplexus, and its cut edges are represented on the left in this figure. I am aware that several authors claim or admit the existence of orifices along the medicornu whereby the neurolymph may escape therefrom into the adjacent subarachnoid space; but I am compelled, at present, to regard these as artifacts, like the half-dozen ruptures of the endyma near the porta in the preparation shown in Fig. 721.

U. The *apparent* entrance of the thalamus into the composition of the floor of the paracele. This condition is presented on the left side; on the right it is hidden by the overlapping paraplexus.

§ 197. *Fornix* is a collective noun, a comprehensive name applied to a congeries of parts, each of which has its own name, and all of which, with a single exception, may exist in lower vertebrates and in man or other mammals, in certain anomalies, without the formation of the fornix as a whole.

§ 198. *Columns of the Fornix.*—In each hemicerebrum there is a bundle of fibres ascending from the albicans and thalamus, passing just caudad of the precommissure, forming the cephalic boundary of the porta, diverging presently from its opposite, pursuing a curved direction along the floor of the medicornu and ending in the temporal lobe; in the aulic region, where it is most compact and exposed, this is commonly called an "anterior pillar of the fornix"; see Fig. 739.

§ 199. *Hippocamp* ("*hippocampus major*").—In each

* The paper of E. A. Spitzka (1900) will contain an account of the topographic relations of the paraceles to the cerebral surfaces.

(Fig. 735.)—1, Cut surface, extending meso-ventro-cephalad; 2, cut surface of the genu, the cephalic curvature of the callosum; part of its natural, pial surface lies just cephalad; the transverse lines on the areas 2 and 9 are introduced merely to indicate the direction of the callosal fibres, not as representations of microscopic structure; 3, point of disappearance of the pia as a result of cutting away part of the lateral convexity of the cerebrum; 4, meeting-place of the two oblique cut surfaces caused by the exposure of the medicornu; 5, point of reappearance of the pia, which was interrupted at 3: 6, is an area just caudad of the left calcarine fissure; 7, the occipital fissure; 8, the occipital eminence (see under *Defects*); 9, oblique cut surface of the splenium, of which a part of the natural surface is shown just caudad; 10, the cut edge of the paratela covering the thalamus; from 10 a line should pass mesad to the narrow area between the two lines.

Defects.—The alcohol had so bleached the cinerea as to render the recognition of its outlines somewhat difficult, so the width of the cortical zone is only approximately accurate.

The absence of shading upon the larger part of the surface would imply that it is all upon one level; really, however, the highest part corresponds nearly with the length of the exposed portion of the right caudatum, and from that level there are gentle slopes cephalad, caudad, and laterad. The cut edges of the hemiseptums are also at a lower level than the adjacent lateral parietes. Not all of the arteries are represented. The occipital eminence (8) is indistinct upon the right and made too small upon the left. The cut edge of the paratela (10) is made too thick and the relations of parts are indistinct (see § 191).

On the left, near the word *fimbria*, is a defective patch of shading du- to a blemish in the paper.

The arachnoid is represented distinct from the pia at only two places, viz., on the right, near the cephalic end, where the former crosses the wide mouth of a fissure, while the latter dips into it as a fold, and at the collosal fissures, just caudad of the splenium.

hemicerebrum there is a corrugation of the entire thickness of the parietes, resulting in the formation of a total fissure, the hippocampal (§ 259, C), and an ental elevation, or colliculus, the hippocamp, along the medicornu; the hippocamp is thickened also, and intimately associated with the fibres of the column already mentioned.

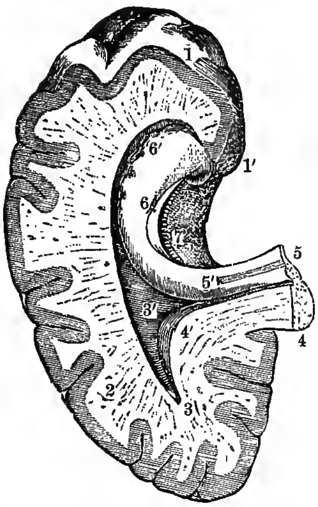


FIG. 736.—The Left Hippocamp and Adjoining Parts. × 5. (From Quain, altered from Hirschfeld and Leveillé.) 1, Apex of the temporal lobe; 1′, uncus; 2, cut surface of the cerebral medulla surrounded by the cortex; 3, at the apex of the postcornu; 3′, collateral eminence; 4, part of the splenium, nearly medisected; 4′, points to the calcar; 5, cut end of the lateral portion of the fornix which is continued at the hippocamp (5′) and the fimbria (6); 6, the fimbria; 6′, the terminal expansion of the hippocamp, called *pes hippocampi*; 7, dentate gyre ("*fascia dentata*").
Preparation.—The left occipitotemporal region of the cerebrum was separated from the rest, together with a part of the splenium and fornix, and the dorsal and lateral parietes of the postcornu and medicornu sliced away so as to expose nearly the entire extent of the cavities.
Defects.—The specimen had not been alinjected, and the figure looks somewhat diagrammatic, especially as to the dentate gyre (7); the actual extremity of the medicornu does not appear (see Fig. 728). There is no indication, along the free margin of the fimbria, that one surface of this lamina was covered by pia and the other by endyma, and that they were continued in and upon the removed paraplexus.

§ 200. *Fimbria.*—In each hemicerebrum between the hippocamp, with its corresponding cortex, and the rima, or line of intrusion of the paraplexus, there is a zone consisting of alba alone, and forming, as it were, a margin for the hippocamp (Figs. 733, 735, and 759). This is the fimbria (*corpus fimbriatum, tænia hippocampi*).

§ 201. The column and its caudal, curved extension, the hippocamp and the fimbria, are simply portions of the prosocelian parietes, mainly of the paracelian floor; they are continuous with the mesal wall, hemiseptum (Fig. 732), and thus indirectly with the roof (callosum); excepting at the ventral end, in the tip of the temporal lobe, however, their substantial continuity with the caudatum and tenia and other portions of the paracelian parietes is interrupted by the rima. It would be perfectly legitimate, therefore, to designate the irregular, elongated portion of either paracelian floor, composed of hippocamp, fimbria, and fornicolumn, by a special name, *e.g.*, *hemifornix.*

§ 202. *Commissure of the Fornix.*—The parts composing either hemifornix pertain each to its own hemicerebrum, and in brains in which the callosum is undeveloped, these have no connection across the meson dorsad of the aula and portas, representing the primitive mesal cavity of the prosencephal. So far as I know, the fornicommissure is thinner in man than in any other mammal; Fig. 731.

§ 203. The fornix is monographed by Honegger in the *Recueil Suisse* (zoölogie), 1890, v., 311–434. The hippocamp has been treated by Alex. Hill, in a paper of which an abstract is published in the Royal Society Proceedings, vol. iii., p. 5. Variations in the form of the hippocamp and the collateral eminence are described by Howden in *Journ. Anat. and Physiol.*, xxiii., p. 283, January, 1888. J. G. MacCarthy has described an interesting feature of the hippocampal structure in *Journ. Anat. and Physiol.*, xxxiii., p. 76, 1898. In the same journal are several recent papers by G. Elliott Smith discussing instructively the fornix and the commissures generally.

§ 204. *Lyra.*—When the fornix is transected through the columns (Fig. 737) and turned caudad the exposed ventral surface, including the splenium, is seen to present lines which have been rather fancifully compared to the strings of a harp; the lyra is not a part, but merely a surface.

§ 205. *Fig. 737 illustrates:* A. The general form of the velum, a double fold of pia between the thalami and the superposed cerebrum, one of the layers belonging to each of the two segments (Fig. 710); the great veins are between the two, and others enter them from adjoining organs. The free lateral margins of the velum project into the paraceles as the paraplexuses (Fig. 720), and its rounded apex hangs in the aula and the two portas as the auliplexuses and portiplexuses (Figs. 721 and 724).

B. The triangular form of the fornix; the cephalic, or "ascending" part, consisting of the two parallel columns, constituting the so-called "anterior pillar"; it expands caudad, the sides being incurved instead of nearly straight, as with the cat, and at the splenium is quite wide. Each lateral half here is practically composed of

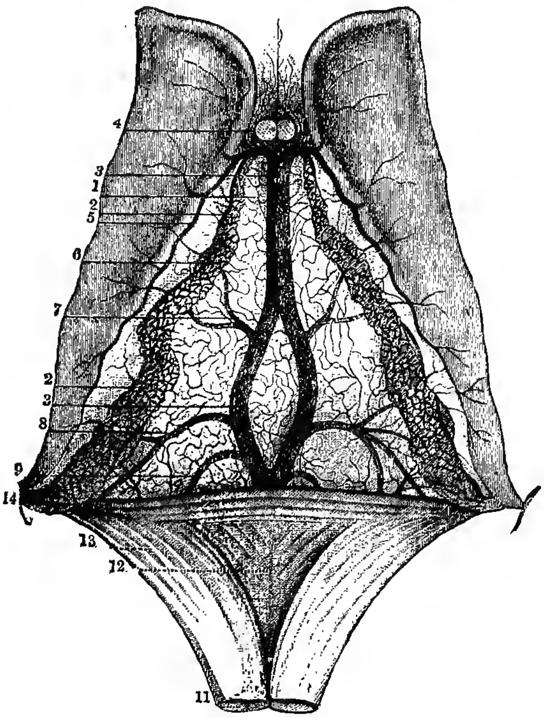


FIG. 737.—The Velum and Lyra. × 1.5. (From Quain, after Sappey and Vicq d'Azyr.) 1, The narrower cephalic part of the velum; 2, left paraplexus, the margin of the velum which enters the paracele as the paraplexus; 3, left velar vein, partly covered by the right; 4, columns, with small veins said to come from the callosum and septum, the precornual veins; 5, tenial vein; 6, medicornual vein; 7, thalamic vein; 8, vein from left medicornu; 9, postcornual vein; 11, body of fornix, transected and reflected; 12, lyra; 13, on the lateral part of the fornix; 14, splenium. (The names here employed for the veins are those adopted in the article *Brain, Circulation of*, in this volume.)
Preparation.—With a preparation such as is represented in Fig. 735, if the fornix were transected at its middle (*f*), the caudal half turned caudad, and the cephalic half, with the attached hemiseptums, removed down to the middle of the height of the portas, the appearances would be nearly as in the present figure.
Defects.—The relation of the parts shown to the rest of the brain would be clearer if there were included at least an outline of one side or of the adjoining region. The tenias are omitted, between which and the fornical margins, fimbrias, the paraplexuses enter; at the mesal side of each paraplexus should be a line, a ripa, indicating where the endyma covering the plexus was torn or cut in the separation of the fimbria. The whole, especially the lyra, is somewhat idealized.

the corresponding hippocamp and fimbria, which, as they continue along the medicornu, are sometimes called the "posterior pillar."

C. The nature of the lyra (§ 204). The line from 12 ends at the meson, the location of the fornicommissure or thin part connecting the thicker lateral portions.

D. The double relation of the splenium to the callosum and the fornix. The larger part, body, of the callosum consists of fibres which pass laterad, dorsad of the paraceles, constituting their roof; at the splenium some fibres pass dorsad, some caudad, some ventrad, and others in intermediate directions; now all the constituents of the fornix form parts of the floors rather than the roofs of the paraceles, and at the splenium fornix and callosum become continuous.

§ 206. *Modifications of the Prosocelian Parietes.*—Primarily the cerebrum is a pair of lateral extensions of a small mesal rudiment, the first (cephalic or "anterior") encephalic vesicle; this forms their only bond of union with one another and with the other segments; their walls are thin and vary little in thickness or composition. Secondarily, the two hemicerebrums are closely conjoined by the callosum and other commissures; between the cerebrum and the crura (and thus the oblongata, the myel, and indirectly the entire body) are developed extensive fibrous communications, the capsulas or "internal capsules"; the parietes are, for the most part, extraordinarily thickened, the most notable, and physiologically the most important of these increments constituting what are commonly called the "corpora striata," from the appearance presented on sections of alternating strips of alba and cinerea. Each striatum, however, is now recognized as composed of an entocelian ("intraventricular.") portion, the caudatum, and an ectocelian ("extraventricular") portion, the lenticula ("lenticular" or "lentiform nucleus"), separated by the capsula already mentioned (Figs. 739 and 782).

§ 207. *The Caudatum and Lenticula.*—With all Reptiles, Birds, and Mammals, and at a very early period, the lateral wall and floor of the paracele present a more or less distinct elevation; in man, and some other mammals, the form is such as to suggest the application of *caput* to the cephalic (precornual) portion, and *cauda* to the tapering continuation along the medicornu, thus of *caudatum* to the entire mass (Fig. 735).

Between the caudatum and the cortex the greatly thickened hemicerebral wall presents (*a*) the medullary lamina called *capsula* (§ 208); (*b*) next the cortex, a subcircular disc of cinerea, the *claustrum* (Figs. 739 and 782); and (*c*) the *lenticula*, consisting of three zones, all more or less striated, the ental the smallest, and the ectal, also called *putamen*, the largest. The lenticula, like the claustrum, may be a dismemberment of the cortex. This entire region, from caudatum to operculums, is of great morphological as well as physiological interest and should be studied in the other mammals.

§ 208. *Capsula and Corona.*—As already stated (§ 206) the capsula or "internal capsule" is the thick layer of fibres between the caudatum and thalamus mesad and the lenticula laterad; it is continuous with the crura caudad, and expands in the substance of the cerebral alba in such a way as to be called there *corona* (*radiata*). The histological and physiological aspects of the capsula and corona are considered in other articles; here an attempt will be made to indicate only their topographical relations by explanations of the accompanying figures (738 and 739).

§ 209. *Fig. 738 illustrates:* A. The general relations of the alba (medulla) to the ectocinerea (cortex).

B. The locations of the two great masses of entocinerea (central tubular gray), the caudatum and the thalamus.

C. The intermediate position of the lenticula, as a blunt wedge-shaped mass between the caudatum and thalamus.

D. The position of the capsula ("internal capsule") as a stratum of alba between the lateral lenticula and the other two masses, and constituting a fibrous path for motor and sensory conduction between the cortex and the crura.

E. The existence of two zones in the lenticula, the more lateral being distinguished as *putamen;* a third would have appeared at a level farther ventrad (Fig. 739).

F. The existence of a thin, cinereal lamina ectad of the lenticula, between it and the cortex; this is the claustrum; it and the cortical corrugations of this region are shown upon a larger scale in Fig. 782.

§ 210. *Fig. 739 illustrates:* A. The existence and relative positions of four important masses of connecting fibres, the *callosum, columns of the fornix, precommissure,*

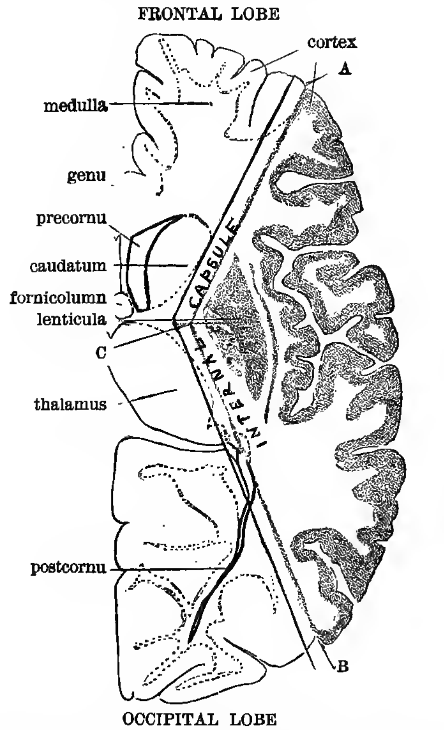


FIG. 738.—Longisection of the Right Hemicerebrum at the Level of the Aula. × .05. (From nature [2,397] and from Gray.)
Preparation.—The mesal outlines of the removed frontal and occipital regions were adapted from Gray. The plane of section corresponds nearly with the direction of the dotted line from *aula* on Fig. 739. The line *A, B, C* should have been dotted. This line and the one parallel with it mesad by the "internal capsule" were introduced with reference to another figure which is not given here.

and *chiasma*, differing from one another in either their direction or their appearance upon this section. The most ventral, the chiasma, is mainly a decussation, as described in the article *Cranial Nerves*. The next, precommissure, is a true commissure, connecting corresponding regions of the temporal (and frontal?) lobes; at the meson it is seen as a raised transverse band, but laterad, on account of its deflection caudad, it is divided obliquely, and appears as an elliptical dotted area. The two columns have at this level a nearly dorso-ventral direction, appearing as raised bands just dorsad of the precommissure (the line from the word *aula* ends upon the right), but they are curved in such a way as to be divided obliquely in two places—one at the level of the precommissure, and the other about 1 cm. (on this scale) dorsad. Finally the callosum, a true commissure, uniting corresponding regions of the cerebrum, is divided in the direction of its fibres.

B. The general relation of parts and cavities at this important level. Two segments are represented—the diencephal (thalami, chiasma, and diaterma) and prosencephal (the remaining and much the larger part). Of the cavities, the mesal space between the chiasma and precommissure is the cephalic part of the diacele, the darkest portion being the optic recess. The prosocele is represented by the *aula*, the mesal space dorsad of and including the precommissure; by the considerable lateral cavities, *paraceles;* and by the intervening *portas.* All these are true encephalic cavities, but the dark triangular area still farther dorsad is the pseudocele.

Three kinds of surfaces are included, viz.: entocelian, lined by endyma; ectocelian, covered by pia; and pseudocelian, with no distinct membrane. There is ectocinerea (cortex), entocinerea (caudatum and thalami), and what may, for the sake of a general term, be called *medicinerea*, the lenticula, and the claustrum, probably dismemberments of the ectocinerea.

C. The extension of the hemicerebrum nearly equally in three directions from the place of its morphological centre, the porta; were this brain not somewhat depressed by its own weight, the width and height would be nearly the same.

D. The thickness of most of the parietes as compared with the earlier fetal conditions shown in Figs. 667 and 716; the hemiseptums and the terma, however, have retained their tenuity in great degree.

E. The absence of the crista which was seen in a young brain (Fig.. 793), and is constant in the cat (Fig. 686); whether it is absorbed or merely obscured in the human adult is not known (§ 366).

F. The overlapping of the prosencephal at the sides of the diencephal, of the cerebrum upon the thalami.

G. The relations of the several layers of alba and cinerea between the thalamus and the lateral surface of the cerebrum. The capsula (5) has an oblique direction, dorso-laterad, between the thalamus and caudatum and the lenticula (see Fig. 738). The lenticula itself comprises three more or less distinct segments, each extending farther dorsad than the one mesad of it; all present the alternating lines of white and gray which led to the application of *striatum* to the united lenticula and caudatum. The thin lamina of cinerea between the putamen, the most lateral division of the lenticula, and the insular cortex is the claustrum, and the alba between it and the lenticula is commonly, but inappropriately, called the "external capsule."

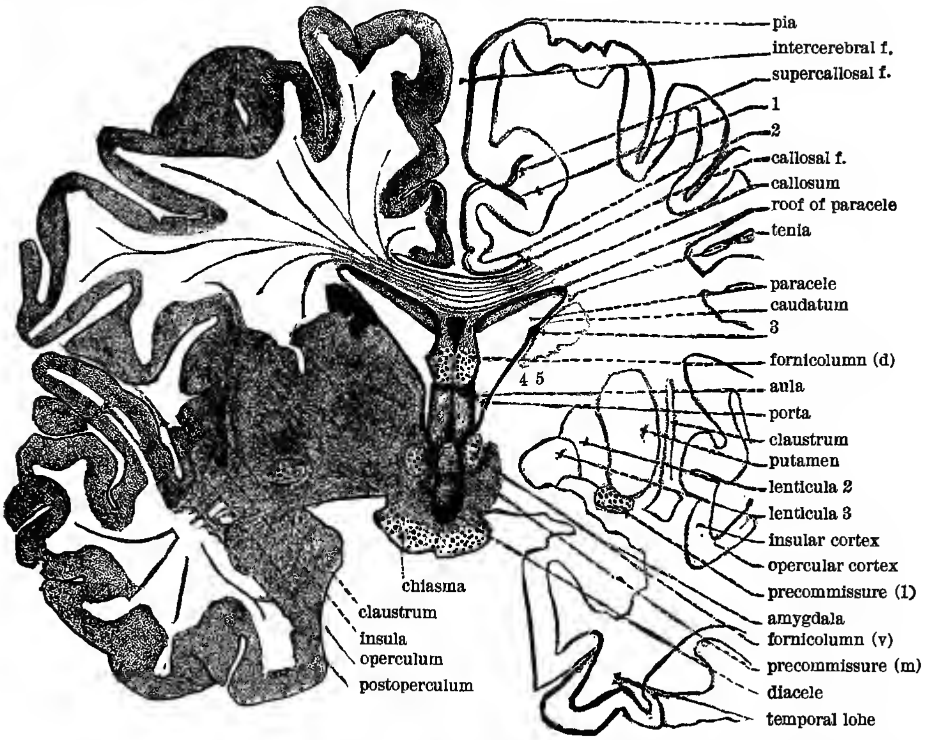


FIG. 739.—Transection at the Chiasma and Precommissure, Caudal Aspect. (From Dalton, by permission.) Reduced one-sixth and modified (compare Figs. 724, 738, and 782). 1, A subgyre (covered gyre) at the bottom of the supercallosal fissure; 2, margin of the cortex dorsad of the callosal fissure; 3, tenial vein; 4, the cephalic part of the thalamus, faintly outlined on the other side; 5, capsula.

Defects.—The dots representing cut fibrous areas are too heavy. The lines representing the callosal fibres are diagrammatic; one of them is interrupted. The pseudocele is not specified. The area of the thalamus is too vaguely indicated. See § 210.

H. The relations of the insula to the parts just named, and to the overlapping gyres which constitute the operculums (see Fig. 782).

I. The relation of the cinereal mass called *amygdala* to a fissure opposite the *m* of *postoperculum*, which has thence been called the amygdaline fissure; but it is doubtless homologous with the postrhinal of quadrupeds. (§ 372, Fig. 765.)

§ 211. Besides the precommissure, a medisection displays two extensive lines of cut surface (Figs. 670, 682, 687, and 765), indicating that there was a continuity of the apposed, mesal surfaces of the two hemicerebrums. Of these the dorsal, more extensive and more substantial, is the *callosum* (Figs. 724, 737, 739, and 740); the ventral is the *commissure of the fornix* (Figs. 732 and 743).

§ 212. *Callosum.*—When the fresh hemicerebrums are divaricated, as in Fig. 740, the bottom of the intercerebral fissure is seen to be formed by a white mass which unites them for more than the middle third of their length; upon hardened brains this, the callosum (*corpus callosum*, *trabs cerebri*, etc.), is easily determined to be fibrous, and somewhat firm in consistency, and to extend into the hemicerebral masses. At about the middle of its cephalo-caudal extent, the trend of the callosal fibres is almost directly laterad, but at the cephalic and caudal ends, especially the latter, the direction is oblique, giving rise to the conditions known as *preforceps* and *postforceps* (Figs. 735 and 740). The rounded cephalic region of the callosum is the *genu*, and the caudal, the *splenium*. As seen in medisections (Figs. 670, 687, and 743) the genu appears like a folding of the callosum upon itself; the ventral continuation being the *rostrum*, which, in man and other primates, is connected with the terma by the thin *copula*. The gentle curve of the genu gives to the cephalic part of the pseudocele a rounded outline.

§ 213. *Fig. 742 illustrates:* A. The primary continuity of the hippocampal and callosal fissures, and of the frontal extension marked 1.

B. The existence of several early fissures, some of which are probably transitory.

C. The continuity of the callosum, fornix, and terma.

D. The degree of separation of the callosum and the fornix at this period, and the concomitant form and extent of the pseudocele.

§ 214. *Splenium.*—This region of the callosum is much less easy to understand than the genu from the study of normal adult brains, but most of the difficulties are removed or diminished by the study of fetal and hydrocephalous specimens (Figs 742 and 743). From these it is clear that, like the genu, the splenium represents a flexion of the callosal sheet upon itself so that there is a dorsal lamina, a ventral lamina, and a caudal connecting portion; commonly the dorsal and ventral portions are

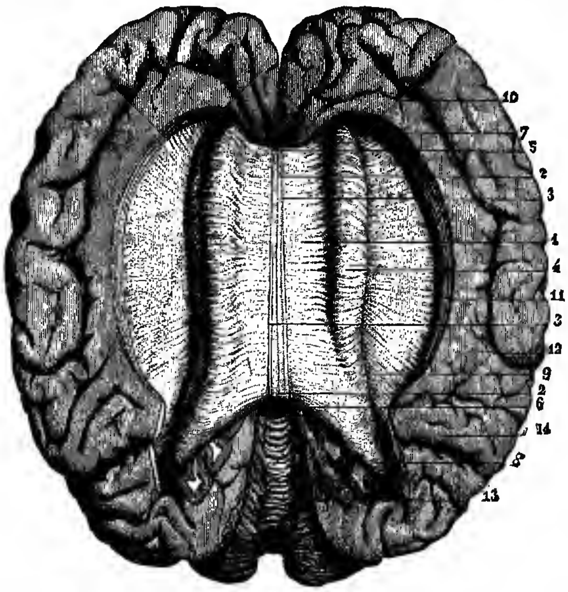


FIG. 740.—The Dorsal Aspect of the Callosum, Exposed by Divaricating the Hemicerebrums. (From Quain, after Sappey and Foville.) × 0.5. 1, Dorsal surface of the body of the callosum; 2, mesal ridge or raphé; 3, lateral ridges, bounding furrows in which, sometimes at least, are lodged the precerebral arteries; 4, lateral ridge, said to be formed by the arching of the callosum over the paracele; 5, cephalic curved margin, genu; 6, caudal curved margin, splenium; 7, preforceps, callosal fibres passing cephalad into the frontal lobes; 8, postforceps, fibres entering the occipital lobes; 10, cephalic portion of the callosal gyre, the line crossing the cephalic end of the supercallosal fissure; 11, callosal fissure; 12, caudal part of the callosal gyre, the line crossing the paracentral gyre; 13, cephalic surface of the cerebellum, the number being just caudad of the occipital fissure.

Preparation.—While fresh the dorsal portions of the hemicerebrums were separated widely; the curved margin of the callosal gyre ("*gyrus fornicatus*") has been detached and pushed laterad so as to expose more completely the extension of the callosal fibres into the hemicerebrum; caudad this gyre has been divided. See § 212.

in close contact, but in hydrencephals (Fig. 743), as in the fetus at a certain stage, they are separated by a considerable interval; in these cases the pseudocele has a greater extent and a somewhat rounded caudal end. For the most part the callosum extends dorsad of the paraceles, thus constituting their actual (though not primary) roof; but the fibres extending obliquely cephalad and caudad from the genu and spleni-um are parts of the mesal wall of the precornu and postcornua respectively, while those which compose the ventral lamina and the splenium are parts of the para-

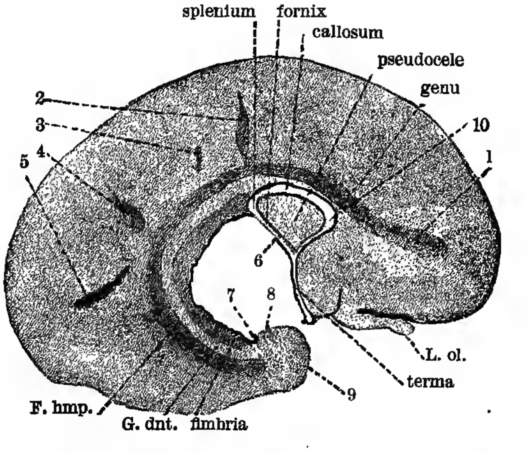
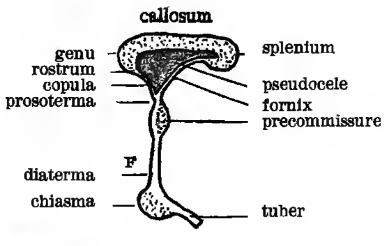


FIG. 742.—Mesal Aspect of the Left Hemicerebrum of a Fetus, Measuring 16.8 cm. from Heel to Bregma, and Estimated at Eighteen Weeks; 2,084. × 1.5. 1, Cephalic extension of the primitive callosal fissure; 2, 3, 4, 5, short but distinct radial fissures, some of them probably transitory; 6, point of reflection of the endyma from the fornix at the dorsal end of the porta; 7, point of reflection of the endyma at the tip of the rima upon its other margin, the tenia, which has been removed; 8, region which would have become the uncus; 9, tip of the temporal lobe; *F. hmp.*, the hippocampal fissure; *G. dnt.*, the dentate gyre (*fasciola* or *fascia dentata*); *L. ol.*, olfactory bulb.

Preparation.—The fetus was ill preserved and the head distorted; the entire head was medisected with a scalpel; the brain was so tender that the caudatum and plexus broke loose.

Defects.—The terma is shown too thick; the tenderness of the specimen did not permit determining the location and form of the chiasma and precommissure.



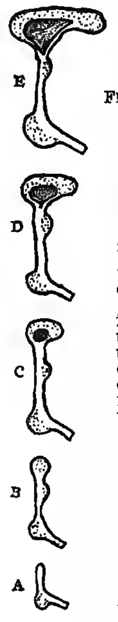


FIG. 741.—Six Diagrams of the Development of the Human Callosum; to be viewed from below upward. The chiasma and tuber are introduced merely to facilitate orientation by comparison with Figs. 670 and 687. In A the primitive end wall of the mesal series of cavities is undifferentiated but reinforced by the chiasma which demarcates the tuber below and the terma above. In B the terma is reinforced by the precommissure, and its dorsal end (margin really, but seen as an end in medisection) is enlarged, constituting the proton * or rudiment of the callosum and fornix. In C the elongation of the whole terma renders more obvious its demarcation into the diencephalic portion (diaterma) and the prosencephalic (prosoterma); the calloso-fornical proton presents a slight cavity or vacuole, the proton of the pseudocele. In D the callosum, fornix, and pseudocele are enlarged especially caudad. In E and F the process continues and all the adult structures are seen. The lateral wall of the pseudocele is the hemiseptum, and it (the pseudocele) is never in communication with either the ental or the ectal surfaces.

celian floors, continuous with the fornix (Figs. 733 and 744).

§ 215. *Fig. 743 illustrates:* A. The complete separation of the fornix and callosum as far as the splenium, which is thus a common bond between them, although usually, and perhaps properly, reckoned as a constituent of the callosum only.

B. The concomitant extension of the pseudocele and of the hemiseptum.

C. The large size of the porta.

D. The wasted appearance of the visible gyres, in contrast with those of Chauncey Wright (Fig. 788).

§ 216. *Fig. 744 illustrates:* A. The continuity of the splenium with both the floor, roof, and caudo-mesal wall of the paracele; some of the fibres pass dorsad, some ventrad into the hippocamp, while others, constituting the postforceps, extend caudad into the calcar, dorso-caudad into the occipital eminence, and ventro-caudad into the collateral eminence.

B. The unusual distinctness of the occipital eminence, this being, in fact, the preparation in which it first attracted my attention (comp. Fig. 761).

C. The prominence of the calcar, here seen, of course, greatly foreshortened; of the left hippocamp only a segment of the caudal convexity appears in this prepara-

* This neuter noun is employed to designate the primitive, undifferentiated mass or rudiment of a part, thus in the sense of *Anlage* of the German embryologists (as adopted by Minot and others), and of *fundament*, as proposed by Mark ("Comparative Embryology"). It avoids certain obvious objections to those terms as English words, is shorter than *primordium* (proposed by Willey), and is in harmony with the following phrases from Aristotle, kindly quoted by President B. I. Wheeler: τὸ πρῶτον; ἡ πρώτη ὕλη; ἡ πρώτη αἰτία.

tion, with the collateral eminence just beyond (compare Fig. 735).

§ 217. *Indusium.*—This term (coupled with the adjective *griseum*) was given by Obersteiner (1892, p. 82) to

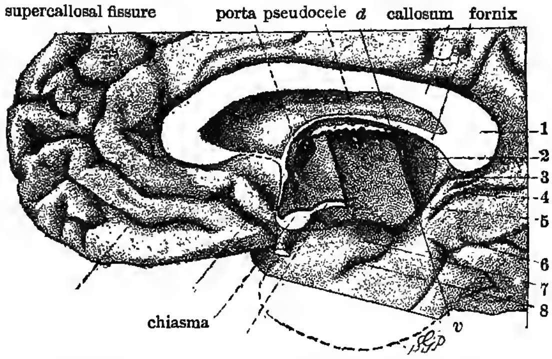


FIG. 743.—Mesal Aspect of Part of the Right Hemicerebrum of an Adult Hydrocephalus; 747. × .7. The dorso-ventral line, *d v*, indicates the transection plane represented in Fig. 731. 1, Splenium; 2, ventral surface of fornix; 3, subsplenial gyres; 4, 5, ?; 6, collateral fissure; 7, uncus; 8, hippocampal fissure. The tip of the temporal lobe, included by the interrupted line just cephalad of *v*, indicates what was removed to expose the parts shown in Fig. 728.

the thin layer of cinerea upon the dorsal surface of the callosum. It has been discussed by Giacomini, Blumenau, and more recently by Fish, 1893, *a*.*

§ 218. In several (perhaps half a dozen) brains in the Cornell museum the callosum presents a decided thinning at about the junction of the middle with the splenial third; most if not all of the individuals were mentally defective in some degree.

§ 219. *Incallosal Brains.*—In addition to about fifteen cases of shortness or thinness of the callosum, there have now been reported at least a dozen instances of its complete absence, together with the mesal part of the fornix. Commonly this deficiency was accompanied with mental and physical weakness, amounting often to idiocy; but Malinverni reported (*Giornale del R. Acad. Torino*, 1874; *Gazette médicale de Paris*, January 16th, 1875; *Gazetta delle Cliniche*, 1874, No. 15; *London Medical Record*, 1874, No. 73) the case of a soldier, forty years of age, who had been noted merely for melancholy, taciturnity, and lack of neatness. A case of total absence of the callosum and fornix is described and figured with unusual fulness by Alex. Bruce, in *Brain*, xiii., 171–190. There are included abstracts of previous cases and reduced copies of the illustrations of some.

§ 220. *Fig. 745 illustrates:* A. The absence of the callosum and of the commissure (mesal part of fornix).

B. The development of the columns as far dorsad as a point corresponding apparently to the dorsal limit of the aula and porta (which is not distinctly indicated).

C. The roofing in of the aula and diacele by a thin (membranous?) tela, the remnant of the primitive roof of the cavities.

D. The absence of the medicommissure and small size of the precommissure, in contrast with the same parts in the incallosal cat (§ 221).

E. The independence of the occipital fissure, and the *apparent* junction of the calcarine with the hippocampal.

F. The radial disposition of the mesal fissures; some of them probably represent the transitory fissures mentioned in § 227.

§ 221. Among other mammals than man the total absence of the callosum has been observed, so far as known to me, only in three cats examined in the anatomical laboratory of Cornell University; one of these (No. 381) has been described in my paper (1883, *c*), and was represented in the first edition of the REFERENCE HANDBOOK, Fig. 4,835. At the Boston meeting of the Association of American Anatomists, December 29th, 1890, I showed the brain of a sheep (No. 2,844) in which the callosum is represented, if at all, by a short thin lamina; but this specimen, fortunately unmutilated and thoroughly hardened, has not yet been figured or described.

§ 222. *Pseudocele* ("*fifth ventricle,*" "*ventriculus septi pellucidi*").—This compressed, subtriangular mesal cavity has no connection with the true encephalic cavities either in the adult or at any stage of development. Its anatomical relations are shown in Figs. 687, 732, 735, and others; but they are more clearly understood from the series of diagrams in Fig. 741 based upon my own specimens and the account of Marchand ("Ueber die Entwickelung des Balkens im menschlichen Gehirn," *Archiv für mikr. Anat.*, xxxvii., pp. 298–334).

§ 223. In the cat (Fig. 682) and mammals generally, both the anatomical and developmental conditions are different. The fornix commissure and the callosum constitute portions of two lines of secondary junction of the two hemicerebrums and are continuous at the splenium

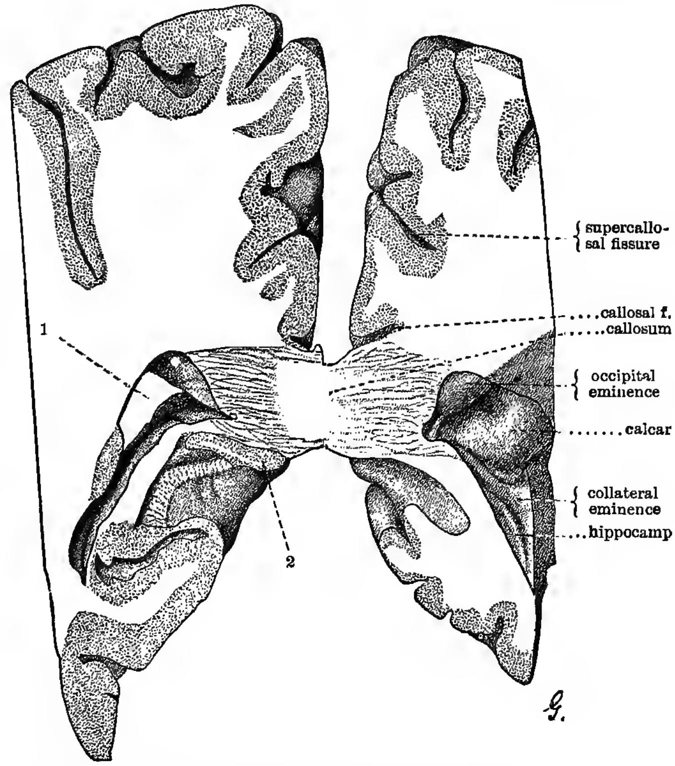


FIG. 744.—Transection of an Adult Brain through the Splenium; 1,824. × 1. 1, Postcornu; 2, section of a subsplenial gyre.

Preparation.—The brain was that of a Pole, male, and was received in the head through the kindness of Dr. F. Cary, a former student. With the special object of furnishing reliable preparations for the elucidation of the cellan parietes (see Fig. 732), the sides of the head were sawn off so as to expose the medicornu, and into this was injected a mixture of alcohol (95°) and water, each 2 litres, ammonium dichromate, 10 gm.; the same was injected into the arteries. When the brain was completely hardened it was removed and transected at intervals of about 1 cm.

Defect.—The lines representing the callosal fibres should be continued across the meson.

* I have to record with some chagrin that, upon a series of transections of an adult brain (1,824), sections of which are shown in Figs. 732 and 744, hardened in a mixture of ammonium dichromate and alcohol, the continuity of the cinerea upon the callosum was recognized in October, 1880; notwithstanding its significance, further examination and publication were deferred.

as in man; but cephalad the callosum ends as a point so that the triangular area is not completely circumscribed; commonly, also, the interval corresponding to the pseudocele is narrower than in man.

§ 224. In three apes (orang, gorilla, and chimpanzee*) and in all the monkeys examined by me the conditions are as in man; the mode of development is not known to me.

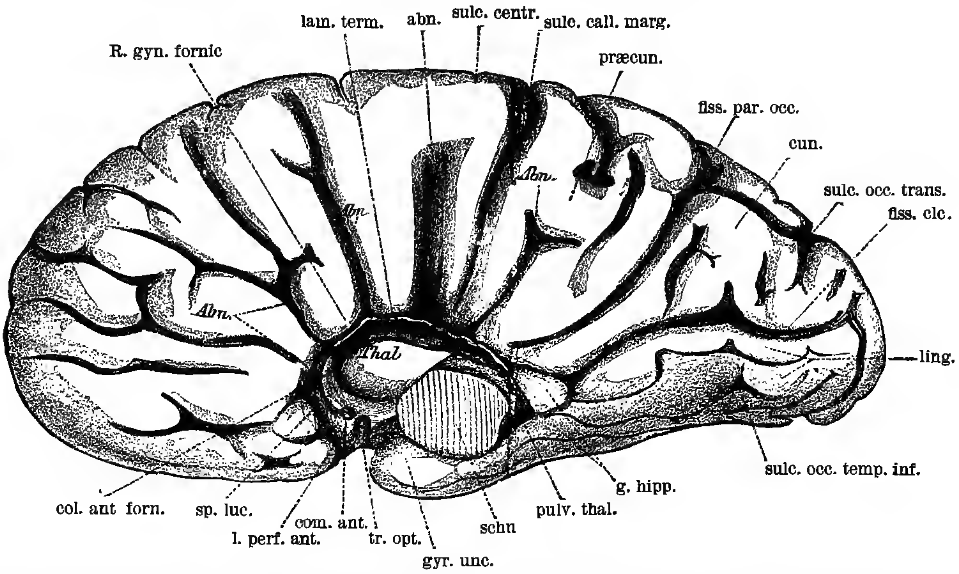


FIG. 745.—Mesal Aspect of the Right Hemicerebrum of an Incallosal, Microcephalic, Adult Brain. × .93. (From Onufrowicz.) *Abn.*, abnormal radiating fissures; *Col. ant. forn.*, fornicolumn; *Com. ant.*, precommissure; *Cun.*, cuneus; *Fiss. clc.*, calcarine fissure; *Fiss. par. occ.*, occipital fissure; *G. hipp.*, hippocampal gyre; *G. unc.*, uncus; *L. perf. ant.*, precribrum; *Lam. term.*, terma [aulatela and diatela]; *ling.*, subcollateral gyre; *præcun.*, precuneus; *Pulv. Thal.*, pulvinar (of the thalamus); *R. gyr. fornic.*, margin of the callosal gyre (*gyrus fornicatus*); *Schn.*, cut surface between the diencephal (thalami, etc.) and mesencephal (gemina); *Sp. luc.*, hemiseptum [?]; *Sulc. call. marg.*, supercallosal fissure [?]; *Sulc. centr.*, central fissure; *Sulc.* occ. *temp. inf.*, collateral fissure; *Sulc.* occ. *tr.*, "transverse occipital fissure" [?]; *Tr. op*, optic tract.

Preparation.—This was the brain of a male idiot, thirty-seven years of age, who had never learned even to feed himself; it seems to have been obtained fresh early and well preserved; the paper ("Das balkenlose Mikrocephalengehirn Hofman," *Archiv für Psychiatrie*, 1887, xviii., pp. 1–24) from which the figure is taken is by Onufrowicz, but this and most of the other figures are by Forel. There are several transections, but the lack of distinct indication of endymal continuity renders them less instructive than they might have been. The weight of the entire brain is not stated. See § 220.

§ 225. To English-speaking anatomists interested in the morphology of the cerebral fissures and commissures are particularly commended the recent writings of D. J. Cunningham, and G. Elliot Smith in the *Journal of Anatomy and Physiology*.

FIG. 746.—Right Side of the Brain of a Fetus Measuring 49 mm. from Nates to Bregma, and Estimated at Twelve Weeks; 1,828. × 1.4. (The left side of the same is shown in Fig. 673, where the mode of preparation is described.)

§ 226. *Fig. 746 illustrates:* A. The condition and relative size of the encephalic segments at this period.

B. The presence of transitory fissures which are absent from the other hemicerebrum (Fig. 673).

C. The indication, so far as these transitory fissures are concerned, that in this individual the right hemicerebrum was more advanced than the left.

§ 227. *Transitory Fissures.*—During the third and fourth months both the lateral and mesal surfaces of the cerebrum present linear depressions corresponding with ental ridges and thus representing corrugations of the wall (Fig. 747). They do not branch. Their general direction is radial. By the end of the fourth month they disappear from the lateral surface (Fig. 748) and partly at least from the mesal, although there is reason to believe that two of them may be practically perpetuated by the formation of the permanent calcarine and occipital fissures along the same lines (Fig. 730).

§ 228. *Fig. 747 illustrates:* A. The great size of the paraceles and paraplexuses at this stage; compare Fig. 667.

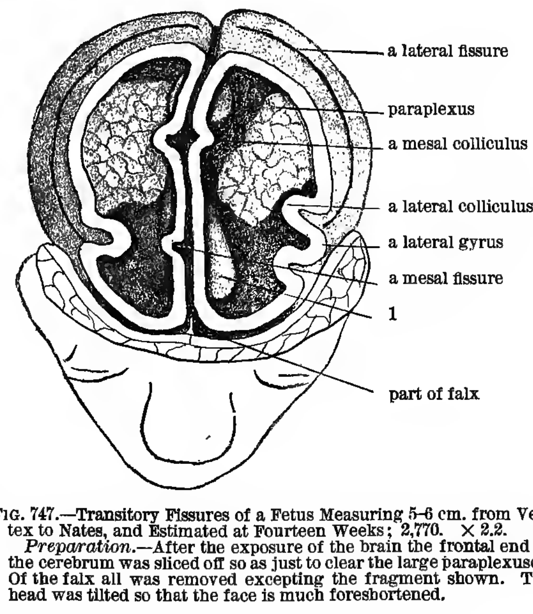


FIG. 747.—Transitory Fissures of a Fetus Measuring 5–6 cm. from Vertex to Nates, and Estimated at Fourteen Weeks; 2,770. × 2.2.

Preparation.—After the exposure of the brain the frontal end of the cerebrum was sliced off so as just to clear the large paraplexuses. Of the falx all was removed excepting the fragment shown. The head was tilted so that the face is much foreshortened.

* A gibbon brain has not yet been available.

B. The slight and nearly uniform thickness of the parietes.

C. Suggestion of a wrinkling or corrugation of the parietes as if from growth within a confined space.

FIG. 748.—Fetus Measuring 7 cm. from Nates to Vertex, and Estimated at Fourteen Weeks; 2,761. × .9. Neg. 1,090. Received in weak alcohol and injected through the umbilical vein with alcohol and zinc chloride.

D. The approximately symmetrical distribution of these corrugations.

E. The length of the fissure on either side, reaching from the Sylvian fossa nearly to the meson.

F. The absence of any indication of branching.

§ 229. *Fig. 748 illustrates:* A. The large number of transitory fissures at this stage.

B. Their general arrangement as radiating from the Sylvian fossa; compare, however, Fig. 747.

C. The considerable difference in their length; one of the longest is indicated by the line from "transitory fissure"; one of the shortest is just below it.

§ 230. *Transitory Fissures Probably Mechanical in their Origin.*—The simplest explanation seems to be that their formation is due to the growth of the cerebral walls at a rate more rapid than that of the cranium; and that their disappearance results from the yielding or more rapid growth of the cranium.

§ 231. *Fig. 749 illustrates:* A. The disappearance of the transitory fissures, at least upon the lateral aspect.

B. The concomitant increase in the length of the cerebrum, apparently from the development of the occipital region; compare Figs. 667 and 673.

C. The non-appearance of the lambdoidal fissure (Fig. 750).

D. The commencement of the postoperculum as a fold of the temporal lobe projecting over the Sylvian fossa.

E. The non-appearance at this stage of the other operculums or of any elevation indicating the future insula.

§ 232. *Abnormal Persistence of Transitory Fissures.*—In several brains lacking the callosum (*e.g.*, the one shown in Fig. 745), the mesal permanent fissures present the radial arrangement characterizing the transitory fissures. This condition likewise exists upon the lateral aspect in the case described by Hans Virchow and shown by Cunningham (1892, Fig. 7).

§ 233. *Are Transitory Fissures Peculiar to the Human Brain?*—Hitherto, as remarked by Cunningham, they

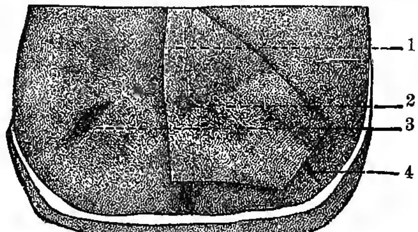


FIG. 750.—Dorso-Caudal Region of the Cerebrum of a Fetus Measuring about 30 cm. from Heel to Bregma, and Estimated at Six Months; 1,817. × 1. 1, Sagittal suture; 2, lambdoidal suture; 3, right lambdoidal fissure; 4, left lambdoidal fissure.
Preparation.—The entire fetus had been preserved in alcohol. From the left side the calva and dura were removed, excepting a narrow strip along the meson; on the right there was left a trapezoidal area, 12 to 25 mm. wide, including most of the sagittal and lambdoidal sutures.

have been observed only in man. Before, however, concluding that they constitute a real human peculiarity they should be looked for in the other primates, where I believe they will be found at corresponding periods of development; the examination of the fetal gorilla described by Duckworth will be interesting in this respect. Cunningham has considered the transitory fissures quite fully, but the subject requires further investigation.

§ 234. *Lambdoidal Fissure.*—In several fetuses estimated at from three to seven months I have observed a fissure directly underlying the lambdoidal suture (see Figs. 750 and 761, and my paper 1886, *a*). It is apparently identical with what are called by Cunningham "external calcarine", and "external perpendicular" (1892, *a*, Plates I. and II.); but I am unable to concur in his disposition of the matter or to decide whether the fissure disappears or persists (see Fig. 777).

§ 235. *Fig. 750 illustrates:* A. The distinct collocation of a fissure and suture at this period.

B. The early appearance (or late disappearance?) of this, the lambdoidal fissure; excepting, perhaps, the dorsal end of the occipital, the rest of this region is smooth.

FIG. 749.—Fetus Measuring 8.8 cm. from Vertex to Nates, and Estimated at Four Months; 2,644. × .9. It is not very well preserved and the cerebrum is evidently shrunken.

C. The peculiar sharpness of outline, reminding one of the transitory fissures (Figs. 746 and 747; § 227).

§ 236. *Intercerebral Fissure.*—The interval between the apposed, mesal surfaces of the two hemicerebrums is the *intercerebral fissure* ("interhemispheral," "sagittal," or "great longitudinal") (Figs. 682, 707, and 739). It differs from ordinary fissures in the following respects: 1, It is mesal or azygous, while all others are lateral or in pairs; 2, although its sides are formed by cinerea, its bottom, the callosum, is apparently alba, with a comparatively thin layer of cinerea, the indusium, § 217; 3, although the pia has the usual relation, the arachnoid, instead of passing directly across, dips into it to a greater or less depth on account of the falx (Figs. 687 and 732); 4, it is, in one sense, a superfissure (§ 328) since in its depths are concealed the callosal fissures.

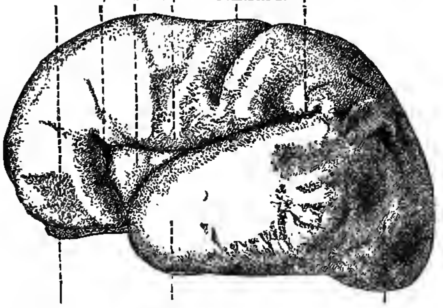


FIG. 751.—Left Fetal Hemicerebrum; 1,820. × 1. 1, Orbital region, unfissured; 2, temporal lobe, unfissured; 3, slight furrow, the preoccipital fovea; 4, circular depression, unidentified (see § 241).

Preparation.—The fresh hemicerebrum was placed in a mixture of alcohol and glycerin, equal parts; after two days half the mixture was replaced by alcohol; after two days more alcohol alone was used, and renewed on the following day. The original mixture seemed to prevent the usual distortion of fetal brains, and to facilitate the removal of the pia. Unfortunately the age and size of the fetus were not recorded.

§ 237. *Poles and Lobes of the Cerebrum.*—The two ends of either hemicerebrum are distinguished as the frontal and occipital poles respectively, and the tip of the temporal lobe as the temporal pole. For topographical convenience, and not because they represent perfectly natural divisions, either anatomical, histological, or physiological, each hemicerebrum may be regarded as forming five lobes, the insula and the frontal, parietal, occipital and temporal lobes (Figs. 757 and 758). In a general way, but by no means accurately, the last four lobes coincide with the cranial bones for which they are named.

§ 238. The *insula* (*lobus opertus*, "central lobe") is nearly or quite covered in the adult brain by folds (operculums) from the adjoining lobes (Figs. 762 and 767); excepting at part of the ventral side the insula is surrounded by an irregular furrow, the circuminsular fissure (Figs. 781 and 782).

§ 239. The other four lobes have more or less complete natural boundaries on either the lateral or mesal surface, but not on both. The primary division is by the line of the central fissure (Fig. 751) into a frontal region and an occipito-temporo-parietal region. The former, although commonly accepted as a single lobe, is so extensive as to be conveniently subdivided by a line continued dorso-cephalad from the presylvian fissure into a *postfrontal* and *prefrontal* lobe, the latter including the orbital surfaces.

§ 240. The region caudo-ventrad of the central fissure line is divided first by the occipital fissure into a *parietal* and an occipito-temporal portion, and the latter again into a *temporal* and an *occipital* lobe by artificial lines drawn from the preoccipital fovea, the indentation of the ventral margin corresponding with the petrous portion of the temporal bone (represented by the emargination opposite the word *collateral* in Fig. 757) to the splenium on the mesal aspect and on the lateral to the extremity of the Sylvian fissure.

§ 241. *Fig. 751 illustrates:* A. The early appearance of the Sylvian, presylvian, and central fisures, and of a depression which perhaps represents the beginning of the paroccipital. See the ventral surface of this specimen (Fig. 789).

B. The nearly uncovered and slightly fissured condition of the insula at this period; the faint dorso-ventral line just caudad of the end of the line from *insula* represents the just commencing transinsular fissure.

§ 242. *Permanent Fissures.*—The surface of the adult cerebrum presents alternating depressions, *fissures*, and elevations, *gyres* (or "convolutions"). The fissures vary in depth from 1 mm. to 30, and in length from 1 cm. to 10. The intervals between the fissures (and thus the width of the gyres) vary greatly, but an adult brain seldom presents an unfissured surface more than 20 mm. in width. Notwithstanding considerable variations in different brains, and in different parts of the same brain, one can hardly fail to be impressed with the approximate uniformity of the interfissural spaces (when viewed squarely, as suggested under Fig. 763), as if the fissures were produced mechanically by the extension of the surface within a confined space.

§ 243. *Fig. 752 illustrates:* A. The condition of the insula and operculums at this stage. The former is distinctly elevated, but as yet perfectly smooth, while in the otherwise less advanced brain shown in Fig. 751 it has a slight transinsular furrow. The subsylvian fissure is just forming as the ventral boundary of the preoperculum.

B. The demarcation of the subfrontal gyre by the subfrontal fissure.

C. The non-continuity of the parietal and paroccipital fissures.

D. The non-appearance of the precentral and postcentral fissures.

E. The peculiar triangular depression which seems to represent the commencement of the supertemporal fissure.

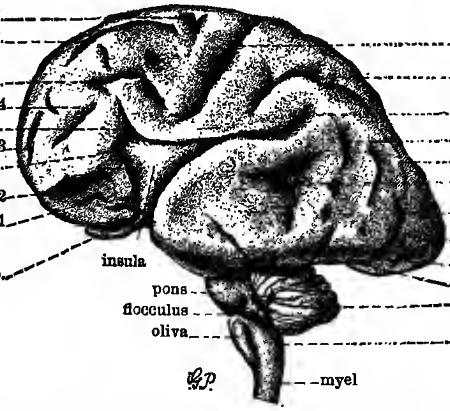


FIG. 752.—Lateral Aspect of the Left Half of the Brain of a Fetus, Size and Age Unknown; 2,278. × 1. 1-8, Fissures not identified with certainty. On the temporal lobe, just dorsad of the pons, the apparent fissure is an artificial crack.

Preparation.—The brain was medisected while fresh and this half placed in alcohol upon its mesal aspect; it has become thinner and wider than natural, but exhibits the fissures more perfectly on this account.

F. The presence of three fissures or series of fissures caudad of the supertemporal, the middle of which may represent the exoccipital (§ 344).

G. The interruption of the central fissure near its dorsal end; so much as appears in the figure is continuous, but near the mesal margin of the hemicerebrum is a slight depression separated from the longer lateral portion by an isthmus (comp. Fig. 772).

H. The small size of the cerebellum, the distinctness of the flocculus, and the prominence of the oliva.

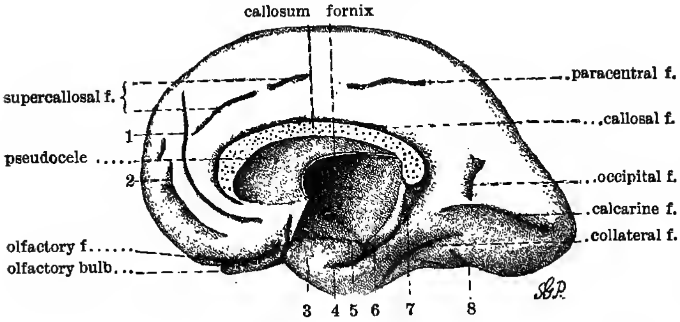


FIG. 753.—Mesal Aspect of the Left (Reversed) Hemicerebrum of a Fetus, Size and Age Unknown; 2,278. × 1. The lateral aspect of the left half of the same brain is shown in Fig. 752. 1, 2, Rostral fissures; 3, tip of temporal lobe; 4, ventral end of hippocampal fissure; 5, uncus; 6 (should have been extended a little farther so as to reach the light band), fimbria; 7, dentate gyre (*fascia dentata*); 8, undetermined fissure.

§ 244. A cerebral fissure is a narrow space vacant of brain tissue and containing only a fold of pia with blood-vessels; yet it has many and sometimes important relations, a complete account of which would embrace about fifty distinct topics. There are also about one hundred problems of a more or less general nature applying to several or all of the fissures.

§ 245. *Fig. 753 illustrates:* A. The existence of three independent furrows between the callosum and the margin of the hemicerebrum along the line of what is commonly called the calloso-marginal fissure.

B. The distinctness at this period of the four total or collicular fissures, occipital, calcarine, collateral, and hippocampal.

C. The independence of the occipital and calcarine.

D. The extension of the calcarine alone nearly or quite as far as the point reached in some other brains by the occipital alone or by the stem of the two. Sometimes the occipital is the longer in the fetus and occasionally, as in Fig. 754, union fails to occur.

§ 246. *Fig. 754 illustrates:* A. The complete separation of the calcarine fissure from the occipital by a calcarine isthmus. On the other side the two are connected as usual.

B. The bifurcation of the calcarine at each end, constituting a long zygal fissure (§ 307).

C. The extension of the occipital fissure so as to represent what is usually the common stem of it and the calcarine.

D. The presence of a "spur" extending caudad from the occipital toward the calcarine upon the isthmus.

E. The appearance of trifurcation of the dorsal end of the occipital. The middle extension, however, is continuous with the fissure only superficially; the cephalic branch is apparently my adoccipital; the caudal, although doubtless the dorsal part of the occipital, presents an unusual curve and is invisible from the lateral aspect.

F. The extent of the precuneal fissure.

G. The considerable extension of the central upon the mesal aspect.

H. The presence of a subcalcarine fissure.

§ 247. Each of the forty or more fissures demands monographic treatment; but the limits of this article will permit the detailed consideration of only two, the central (§§ 269–303) and the paroccipital (§§ 309–325), as exemplifying different phases of fissural study.

§ 248. *Fig. 755 illustrates:* A. An early stage in the formation of the Sylvian fissure, the presylvian fissure being represented by a mere notch.

B. The incomplete separation of the calcar and the occipital eminence.

C. The size of the postcornu relatively to that of the entire hemicerebrum.

D. The corrugation constituting the collocated calcar and calcarine fissure.

E. The equally distinct collocation of the occipital fissure at this period with the adjoining colliculus, occipital eminence, sometimes called "bulb of the posterior cornu."

§ 249. *Collocation of Permanent Fissures with Cranial Sutures.*—In the adult the dorsal end of the occipital fissure has a notably constant position at the mesal angle of the lambdoidal suture, as seen in Fig. 670. With fetuses of between three and seven months this suture is decidedly caudad of the occipital fissure, but is distinctly collocated with the lambdoidal fissure (Fig. 750); this collocation does not persist after the seventh month, and it is not yet known whether the fissure disappears or changes its position. The approximate collocations of the central and other fissures with sutures are considered in the article *Brain, Surgery of the.*

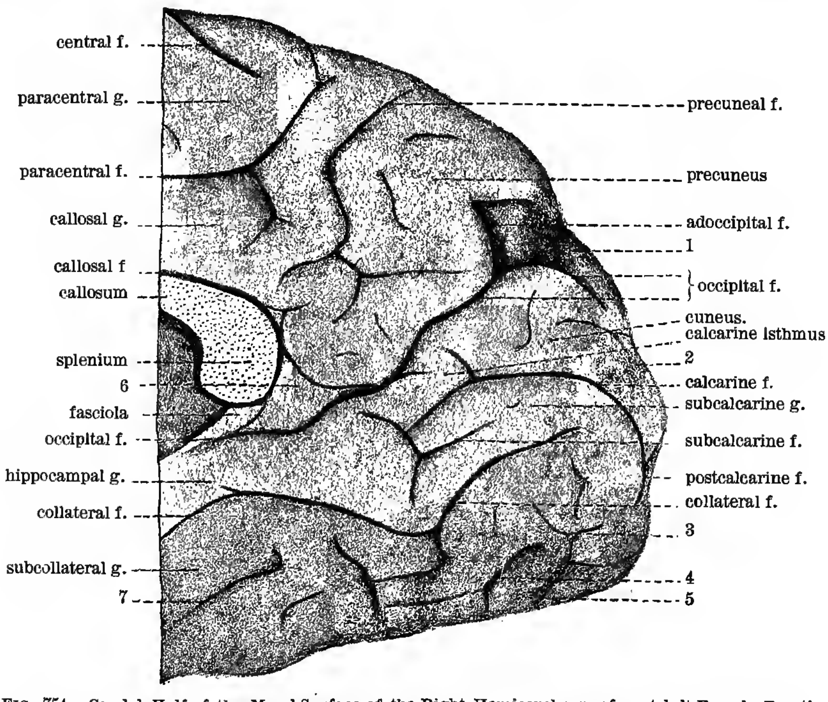


FIG. 754.—Caudal Half of the Mesal Surface of the Right Hemicerebrum of an Adult Female Paretic. No. 2,358 in the Museum of Cornell University. × 1.

§ 250. Fissures should be studied before gyres, because: 1, They are simpler, being represented by lines instead of planes; 2, they are more commonly entirely independent of other fissures; 3, they are comparable with the rivers of a region which are employed as boundaries of

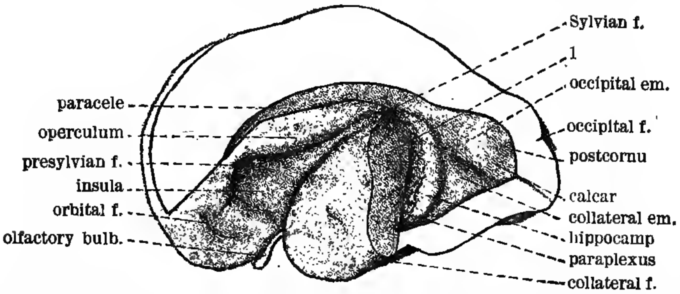


FIG. 755.—Left Hemicerebrum of a Fetus, Size and Age Unknown. Opened from the lateral aspect; 1,819. × 1. 1, Obliquely cut surface; the unshaded area represents a surface cut parallel with the meson. The line from *paraplexus* ends somewhat vaguely; it should reach the narrow zone between the hippocamp and the cut surface marked 1. See § 248.

the subdivisions; 4, themselves structureless, they really represent the locations of a greater amount of cinerea than lines of equal width and extent on the gyres, and have thus a greater, presumptive, physiological significance, although there seems to be a difference of opinion as to the functions of the intrafissural cinerea.

§ 251. With children born at term the main fissures are always well defined, and in some cases there seems to be little difference between infant and adult cerebrums in respect to fissural complexity, although the insula is always less developed and less completely covered by the operculums (see Fig. 663). Such brains are often more readily obtained and removed than those of adults, and if well preserved and carefully handled may materially aid both teaching and research.

§ 252. For the elucidation of the intricacies of adult fissures, *fetal brains are much more serviceable than those of monkeys.* This, in contravention of the view and practice of Meynert, has been insisted upon by me (1886, *g*). Some of the peculiarities and complexities of the monkey brain are represented in Fig. 787.

§ 253. Adult cerebrums commonly present individual peculiarities which prevent their serving as types or standards. I have found such in every brain examined; not merely, for example, in that of the philosopher, Chauncey Wright (Figs. 768, 770, 788) but also in that of a mulatto; simple in several respects, it has peculiarities and complexities not as yet fully understood (see Figs. 762–766).

§ 254. *Fig. 756 illustrates:* A. In connection with Figs. 663 and 702, the perfection and beauty of form of the human brain at birth.

B. The relatively small size of the cerebellum at birth.

C. The distinctness and prominence of the pons.

D. The lateral extent of the pseudocele; at the genu (cephalic curvature) of the callosum it is 1 mm. deep, representing about one-half of its entire lateral extent.

E. The distinctness and depth of the principal fissures and the large number of minor ones.

F. The peculiar ventral curve of the caudal half of the calcarine fissure, and the concomitant expansion of the cuneus.

G. The length of the fissure in the subcalcarine gyre.

H. The appearance of the cephalic stipe of the paroccipital fissure (18) upon the meson (see Figs. 774 and 775).

§ 255. The study of fissures upon actual brains is facilitated by reference to diagrams such as have been published by C. L. Dana, Eberstaller, Ecker, Jensen, Pansch, Schäfer (in "Quain"), and others. My present views are embodied in Figs. 757 and 758.

§ 256. *Comments upon the Fissural Diagrams* (Figs. 757 and 758).—A. They represent my views at this time, but are not identical with those previously published (1886, *g*, and first edition of the REFERENCE HANDBOOK), and are subject to further modifications with increasing knowledge of the facts. For example, the small fissures caudad of the occipital are but little understood, and the orbito-frontal of Giacomini may prove to be more nearly constant than now supposed.

B. An attempt has been made to indicate the relative depth and constancy of the fissures by lines of three degrees of width; this grouping, however, is provisional.

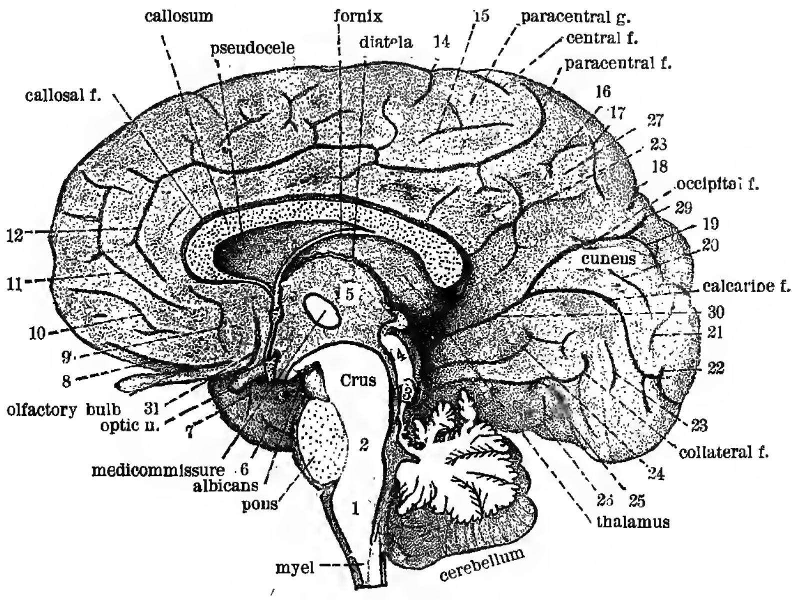


FIG. 756.—Mesal Aspect of the Right Hemicerebrum of a Male Child, at Term; 478. × .84. Other aspects of the same specimen are shown in Figs. 633, 774, and 775. 1, Postoblongata; 2, preoblongata; 3, postgeminum; 4, pregeminum; 5, thalamus, its mesal surface, forming the lateral wall of the diacele: the dorsal, pial surface is designated by the line from the word *thalamus;* these are parts of one and the same organ, separated by the membranous diatela; but the triangular area dorso-cephalad of them marked *pseudocele* and apparently separated only by the narrow white area marked *fornix*, is the *hemiseptum*, part of the mesal surface of the cerebrum; 6, 9, 16, 17, 21, 23, 24, 25, 26, 31, unidentified fissures; 7, postrhinal; 8, olfactory; 10, 11, rostral fissures; 12, supercallosal fissure, continuous with the paracentral; 15, intraparacentral fissure; 14, inflected fissure; 18, cephalic stipe of paroccipital fissure; 19, a ventral branch of the occipital fissure; 20, 21, intracuneal fissures; 22, dorsal branch of the calcarine fissure; with the more caudal of the two ventral branches perhaps it represents the forked fissure sometimes called *postcalcarine;* 27, precuneus; 28, precuneal fissure; 29, dorsal end of the occipital fissure; 30, the common stem of the diverging occipital and calcarine.

Defects.—The specimen spread while hardening under its own weight, and is therefore wider and thinner than natural; this is, however, an advantage for the study of the fissures. The naturally considerable cranial flexure became still more marked as the brain rested upon the lateral aspect while photographing, and this, for convenience, is preserved in the drawing. The thalamus is unnaturally, though very instructively, uncovered by the callosum so that its caudal prominence, the pulvinar, is visible. The habena is not distinctly seen. The cerebellum is not represented accurately as to details, but is enlarged in Fig. 702. The hypophysis is lacking, and the aulic region is not shown in detail.

C. Each separate line represents what I now regard as a fissural integer so far as the human brain is concerned. The following are also regarded as integers, although continuous with others: occipital, calcarine, postcalcarine, postrhinal. The presylvian, subsylvian, and basisylvian are really branches or continuations of the Sylvian, but are separately named for convenience.

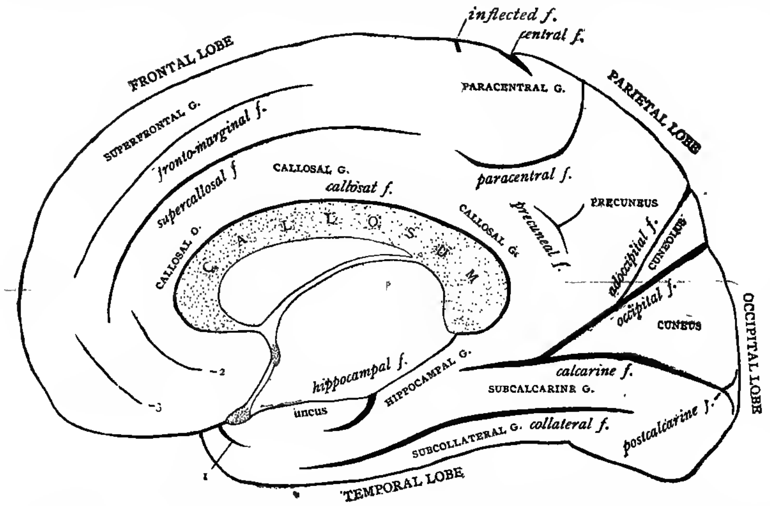


FIG. 757.—Diagram of the Fissures upon the Mesal Aspect. The outline and certain fissures are from the mulatto brain (322), which was hardened within the cranium. 1, Postrhinal (amygdaline) fissure; 2 and 3, rostral fissures.

D. The fissure lines are nearly straight and simple, excepting where branching is a practically constant feature, as, *e.g.*, with the paroccipital, paracentral, precuneal, and postcalcarine.

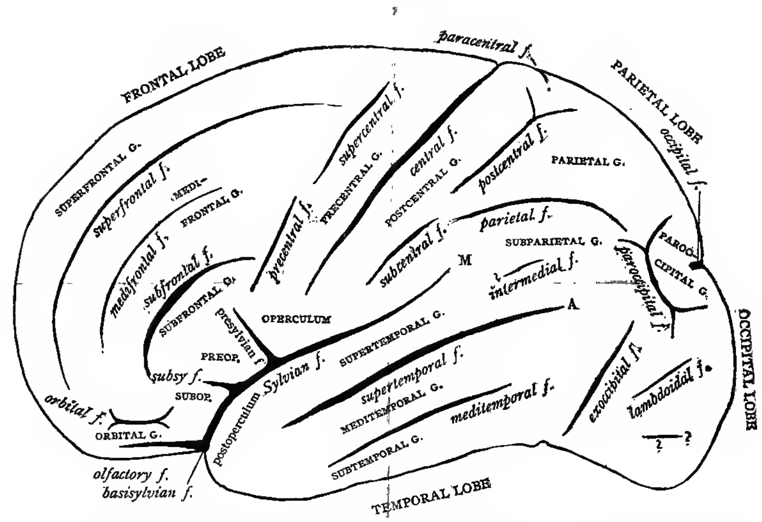


FIG. 758.—Diagram of the Fissures upon the Lateral Aspect. The outline and certain fissures are from the mulatto brain (322), which was hardened within the cranium. M, the "marginal" gyre; A, the "angular" gyre; Preop., the preoperculum; Subop., the suboperculum; Subsy. f., the subsylvian fissure. The interrogation points on the lateral aspect of the occipital lobe indicate my doubts as to the existence of certain fissures, or as to the names that should be applied to them if they do exist. The subtemporal fissure is not shown (see Fig. 765).

E. The connections are of two distinct kinds: primary, invariable, and inevitable from the mode of formation of the parts; secondary, and more or less common, but not necessary.

F. *Invariable* and apparently inevitable fissural connections are (1) of the Sylvian with the basisylvian, presylvian, and subsylvian, all which might be regarded as its continuations or branches; (2) of the callosal with the hippocampal.

G. *Usual* connections are of the occipital with the calcarine, and of the supercallosal with the paracentral, but there are occasional exceptions.

H. *Common* connections are of the superfrontal and supercentral; the precentral and subfrontal; the precentral and supercentral; the postcentral and subcentral and parietal; the parietal and paroccipital.

I. *Occasional* connections are of the precentral with the Sylvian, and of the central with the Sylvian over the margin of the operculum; in these cases, so far as known to me, the junction is seldom very deep.

§ 257. From the deservedly popular fissural diagrams of Ecker, the publication of which has so materially advanced the general knowledge of the subject, these differ mainly in the following respects:

A. The omission of branches and contortions.

B. The inclusion of the callosal, inflected, adoccipital, postrhinal, postcalcarine, medifrontal, precuneal, and postcentral fissures.

C. The disjunction of the supercallosal from the paracentral; of the precentral from the subfrontal and supercentral; of the postcentral from the subcentral; and of the subcentral from the parietal.

D. The recognition of the adoccipital fissure and the cuneolus.

E. The introduction of the exoccipital as probably representing the true "ape-fissure" of Wernicke.

F. The combination of the "transverse occipital" of Ecker with the caudal portion of his "interparietal" as a distinct fissural integer, the paroccipital.

G. The adoption from various writers of what seem to be the best fissural names of a single word each—*e.g.*, from Huxley, *collateral;* from Owen, *callosal, hippocampal, medifrontal, subfron-*

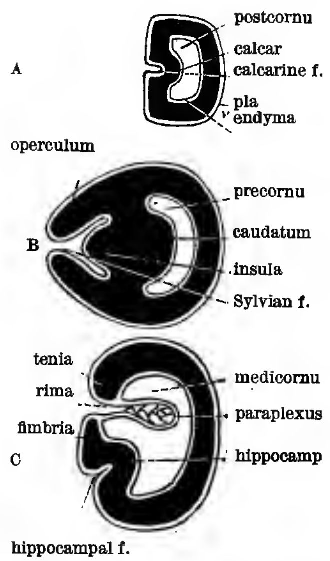


FIG. 759.—Schematic Transections of the Three Paracelian Cornua in the Order of their Complexity. See § 259.

Brain.

tal, supercallosal; from Wernicke, *fronto-marginal;* from Jensen, *intermedial;* from Pansch, *occipital* and *parietal;* from Schwalbe, *precentral* and *postcentral;* from Meynert, *preoccipital;* from Lussana and Lemoigne, *inflected* (Ital., *inflesso*).

H. The substitution of several mononyms for polyonyms, viz.: of *presylvian* for *ascending branch of the Sylvian; subsylvian* for *anterior branch; basisylvian* for the part ventrad of the presylvian; and the restriction of *Sylvian* to the "posterior branch."

I. The replacement of *lingual lobule* and *fusiform lobule*

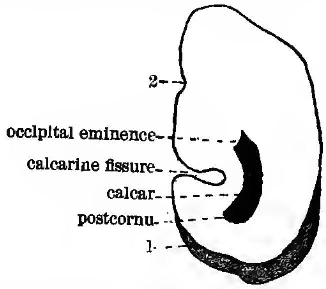


FIG. 760.—Transection of the Left Occipital Lobe of a Fetus, Size and Age Unknown; 2,278. × 1.5. This figure is almost diagrammatic in its simplicity; it shows very clearly the relation of the calcarine fissure to the calcar as represented in Fig. 759, A.

(not at all easy to apply correctly), by *subcalcarine gyre* and *subcollateral gyre*, names at once associated with the fissures which respectively constitute the dorsal boundaries.

J. The use of one and the same word, *fissure*, for all the cerebral depressions excepting the two foveas.

K. The use of one and the same word, *gyre*, for all subdivisions of the lobes, excepting the cuneus and pre-

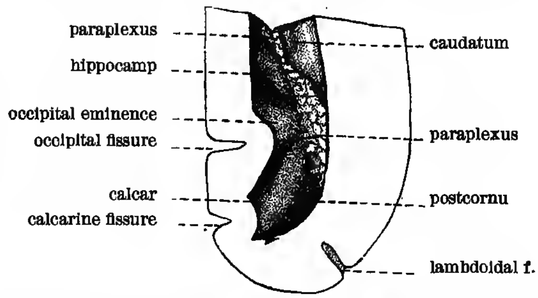


FIG. 761.—The Caudal Part of the Right Hemicerebrum of a Fetus, Measuring 14 cm. from Nates to Bregma, and Estimated at Four Months; 1,816. × 1.5. (See § 261.)
Preparation.—This is part of the specimen shown in Fig. 727, where the mode of preparation is described; the postcornu was exposed by removing the paracelian roof along the lines in that figure. The plexus was partly cut away, although not so represented in this figure.

cuneus, already well distinguished by mononyms, and the cuneolus.

§ 258. *Total and Partial Fissures.*—Of the permanent fissures most affect merely the cortex and the adjacent alba and are therefore sometimes called *partial* fissures; the central, for example, though constant and deep, is only a partial fissure. But others represent corrugations of the entire parietes, so that the ectal depression, fissure, is opposite and obviously correlated with, an ental elevation or colliculus; the fissures commonly enumer-

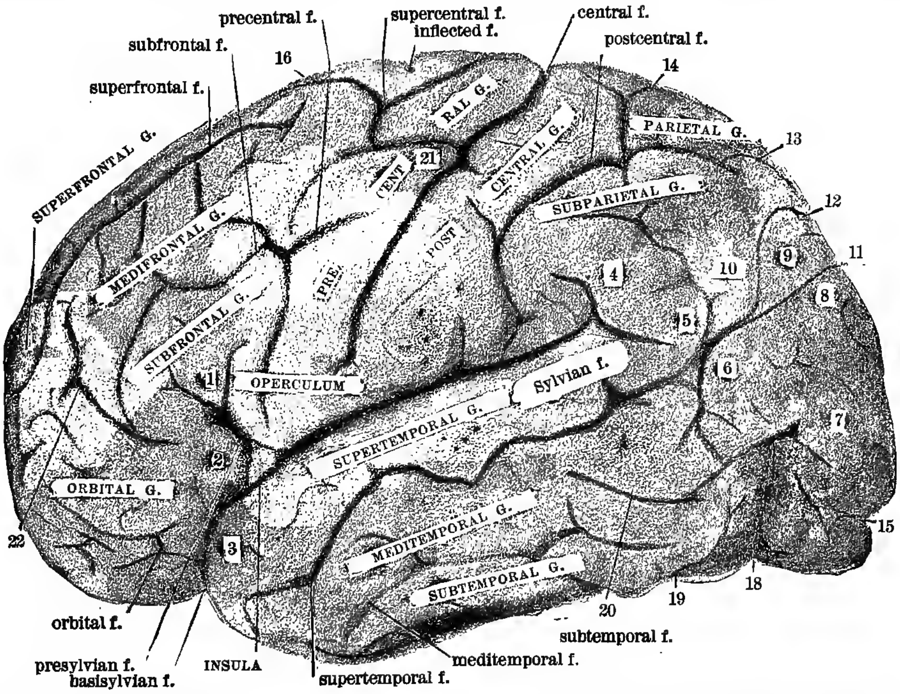


FIG. 762.—Lateral Aspect of the Left Hemicerebrum of a Mulatto; 322. × .8. 1, Cephalic part of the operculum demarcated from the rest by a fissure that does not extend through its entire thickness; 2, preoperculum; 3, postoperculum; the subsylvian fissure is probably represented by a short indentation, visible only when the postoperculum (3) is removed; 4, what is commonly called the "supramarginal gyre"; 5, may represent part of what is called the "angular gyre"; 6, a supergyre overlapping the concealed, caudal part of the angular; 7, unidentified occipital gyre; 8, 9, portions of the unidentified supergyre that overlaps the lateral part of the paroccipital gyre; 10, gyre at the caudal (apparently dorsal) side of the dorsal, deflected end of the supertemporal fissure; 11, opposite the dorsal end of the occipital fissure (this is, however, invisible, and the straight fissure that extends laterad from 11 between 8 and 9, and curves ventrad at 6, may possibly be the exoccipital or Wernicke's fissure, one of the so-called "ape-fissures"; it has apparent, though not real, connections with the occipital and supertemporal fissures); 12, curved fissure in the same supergyre, superficially connected with the supertemporal; 13, cephalic stipe of the paroccipital fissure; 14, dorsal fork of the postcentral fissure; the subcentral is not indicated by a separate number and is continuous with the postcentral; 15, caudal extremity of the calcarine fissure, really simple and independent; 16, cephalic radius of the triradiate supercentral fissure (see Fig. 765); 18, 19, 20, unidentified occipito-temporal fissures; 21, just ventrad of the strait between the central and supercentral fissures (see Fig. 764); 22, the most cephalic of three distinct fissures crossing the medifrontal gyre.

ated as total are the hippocampal (Fig. 755), calcarine (Fig. 760), and collateral (Fig. 755); the Sylvian may

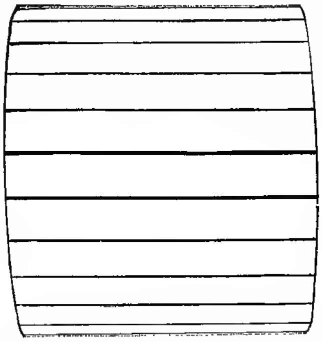


FIG. 763.—Diagram Illustrating the Effect of the Convexity of the Cerebral Surfaces upon the Apparent Width of the Gyres. Upon a cylinder were drawn parallel lines at the uniform distance of 1 cm.; one side of the cylinder was then photographed, and the figure is a reproduction of the photograph, reduced one-half. The reduction of the intervals according to the distance of the lines from the part nearest the eye illustrates the fact, not always distinctly recognized, that the fissures near the periphery of a cerebral convexity always appear to be nearer together than they really are; the intervening gyres consequently appear of less than their actual width; see, for example, the superfrontal gyre in Figs. 762 and 764.

possibly be correlated with the caudatum (Fig. 716); the callosal and occipital are total fissures in the fetus (Figs.

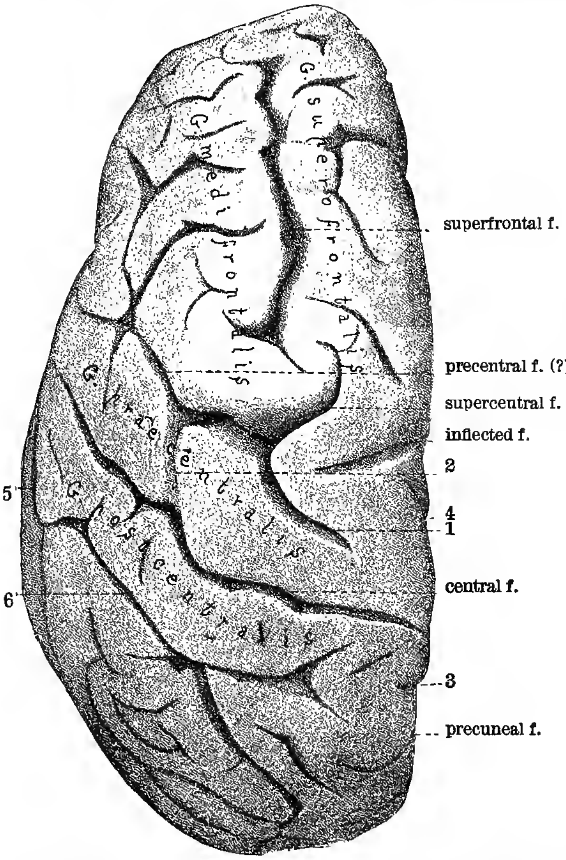


FIG. 764.—Dorso-Cephalic Aspect of the Left Hemicerebrum of a Mulatto; 322. × .8. 1. Caudal radius of the triradiate supercentral fissure; 2, strait between the central and supercentral fissures; 3, caudal end of paracentral fissure (see Fig. 766); 4, cephalic end of the same (?); 5, Sylvian fissure; 6, postcentral fissure. See § 264.

734 and 761), and the ental correlative of the latter is sometimes recognizable in the adult (Fig. 744).

§ 259. *Fig. 759 illustrates:* A. The mesal wall of the postcornu presents a ridge, the calcar, and the mesal surface of the occipital lobe a furrow, the calcarine fissure; as seen in Figs. 760 and 761, the ectal depression and the ental elevation are obviously correlated.

B. The precornu presents an ental elevation, the caudatum, and a depression nearly opposite, the Sylvian fissure. But the correlation of the two is not quite clear and the conditions are complicated by the formation of the intrafissural (or intergyral) elevation called *insula.*

C. Here, as in the postcornu, there is no doubt respecting the correlation of the ental elevation or colliculus, the

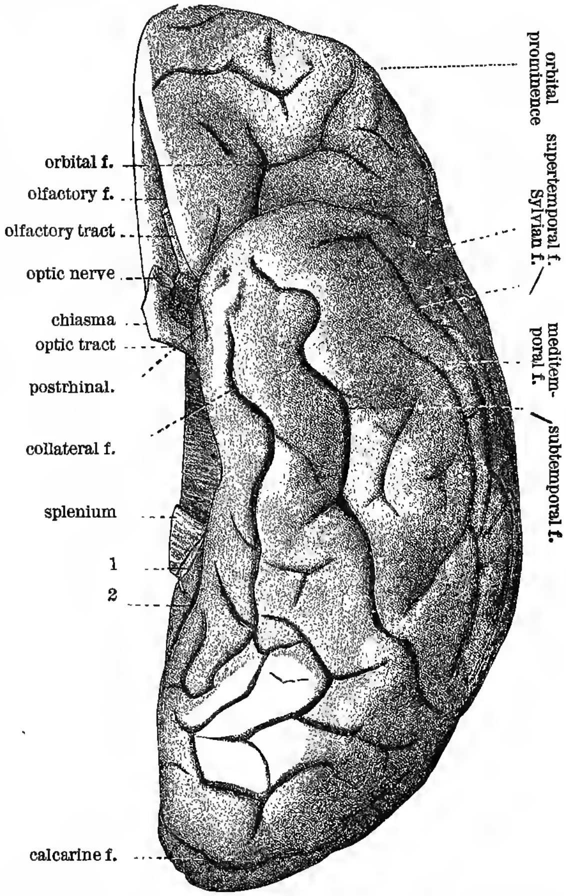


FIG. 765.—Ventral Aspect of the Left Hemicerebrum of an Adult Male Mulatto; 322. × .8. 1, Ridge ventrad of the splenium, representing, perhaps, one of the gyres described by A. Retzius, British Association Proceedings, 1885; 2, stem of the occipital and calcarine fissures. See § 265.

Preparation.—See Fig. 757. The olfactory bulb has been removed.

hippocamp, and the ectal furrow, the hippocampal fissure; in addition, the proper nervous parietes are abrogated along a line, the rima, and the paraplexus is formed by the intrusion of the pial process covered by the endyma; the margins of the rima are specialized and become the fimbria and tenia; on the figure the tenia is not indicated as separate from the caudatum (Fig. 730).

§ 260. *Classification of the Permanent Fissures.*—The following grouping of the fissures is approximately natural and has been found convenient by me; at the best, however, any such arrangements are provisional: *

* Whatever may be desirable in theory, or eventually practicable, at present nothing seems to be gained by attempting to classify cerebral depressions as fissures and sulci, and in this article all are designated as *fissures.*

A. Total fissures, representing a corrugation of the entire paracelian parietes; *e.g.*. calcarine.
B. Partial fissures with some structural correlative; *e.g.*, olfactory.
C. Partial fissures, nearly or quite constant, and demarcating recognized gyres; *e.g.*, subfrontal.
D. Inconstant, intragyral fissures; *e.g.*, medifrontal.

§ 261. *Fig. 761*, in addition to A and B, specified under Fig. 727, *illustrates:* A. The contiguity of the two margins of the rima, excepting for the intruded paraplexus.
B. The concomitant, absolute exclusion of the thalamus from the paracelian floor.
C. The depth and peculiar form of the lambdoidal fissure (Fig. 750).

§ 262. *Fig. 762 illustrates:* A. The form of this adult, mulatto, left hemicerebrum, unaltered save from alcoholic shrinkage.
B. The general aspect of the gyres, comparable with the appearance in the cerebrum of the philosopher, Chauncey Wright (Fig. 788).
C. A simple, almost typical condition of certain fissures, *e.g.*. central and Sylvian, in a large part of their course, combined with great and unusual peculiarities of the same or other fissures.
D. The visibility of the insula (see Figs. 767 and 788).
E. The presence of a vertical branch of the presylvian fissure, which, however, does not extend through the thickness of the operculum.
F. The union of the subfrontal with the precentral and with two of the fissures crossing the medifrontal gyre.
G. The apparent narrowness of the superfrontal gyre, which nevertheless, as seen from the dorsal aspect, is of considerable width; in fact the narrowest portion of the superfrontal is just as wide as is the subfrontal measured in line with the stem of the presylvian fissure; this is a forcible exemplification of what is explained under Figs. 763 and 764.
H. The great length of the supertemporal fissure, and its apparent dorsal branching in four directions; its true and deep continuation is cephalad between 5 and 10.
I. The continuation of the calcarine fissure around the margin of the hemicerebrum so as to appear upon the caudo-lateral aspect as an undivided end (15); the calcarine is believed to be continuous commonly with a bifurcated postcalcarine, and the condition in this brain seems to be unusual; see also Fig. 785.
J. The superficial connection of the central and precentral fissures.
K. The partial appearance of the subtemporal fissure on the lateral aspect; see, however, Fig. 765.
L. The forking of the Sylvian into an episylvian fissure, near 4, and a hyposylvian near 5.

§ 263. The apparent width of gyres upon convex surfaces of the cerebrum is affected by the point of view. Compare, *e.g.*, the superfrontal gyre of the mulatto as shown in Figs. 762 and 764. The conditions are schematically illustrated in Fig. 763.

§ 264. *Fig. 764 illustrates:* A. The length and independence of the superfrontal fissure, and its close parallelism with the hemicerebral margin.
B. The width of the supercentral gyre when viewed directly as compared with the oblique view shown in Fig. 762 (see § 262, G).
C. The triradiate form of the supercentral and its relation to the inflected.
D. The continuity of the supercentral with the precentral and central; in each case, however, there is a vadum or shallow.

§ 265. *Fig. 765 illustrates:* A. The presence of a distinct though rounded orbital prominence between the frontal and the lateral portions of the outlines, but the absence of any such boundary between the lateral outline and the occipital.
B. The narrowness of the olfactory gyre, between the olfactory fissure and the mesal margin of the frontal lobe.
C. The distinctly zygal form of the orbital fissure.
D. The length and distinctness of the subtemporal fissure.
E. The extension of the calcarine fissure upon the occipital end of the hemicerebrum.
F. The presence of a fissure (orbito-frontal?) on the orbital surface cephalad of the orbital fissure.

§ 266. LIST OF PARTIAL FISSURES, CONSTANT OR NEARLY SO, AND DEMARCATING GYRES.

Fissures.	Aspect.	Gyres separated by them.
1. Basisylvian	Ventral	Orbital. Temporal.
2. Central	Lateral	Precentral. Postcentral.
3. Circuminsular	Lateral	Insular. Adjoining.
4. Inflected	Lateral	Superfrontal. Precentral.
5. Insular	Lateral	Insular.
6. Olfactory	Ventral	Orbital. G. rectus.
7. Orbital	Ventral	Subfrontal. Orbital.
8. Orbito-frontal	Lateral	Superfrontal. Orbital.
9. Paracentral	Mesal	Paracentral. Precuneus, etc.
10. Parietal	Lateral	Parietal. Subparietal.
11. Paroccipital	Lateral	Paroccipital. Subparietal.
12. Postcentral	Lateral	Postcentral. Parietal.
13. Postrhinal	Mesal	Uncus Temporal
14. Precentral	Lateral	Precentral. Medifrontal.
15. Presylvian	Lateral	Operculum. Preoperculum.
16. Subcentral	Lateral	Postcentral. Parietal.
17. Subfrontal	Lateral	Subfrontal. Medifrontal.
18. Subsylvian	Lateral	Preoperculum. Suboperculum.
19. Supercallosal	Mesal	Callosal. Fronto-marginal.
20. Supercentral	Lateral	Precentral. Super- and medifrontal.
21. Superfrontal	Lateral	Medifrontal. Superfrontal.
22. Supertemporal	Lateral	Supertemporal. Meditemporal.
23. Transinsular	Lateral	Preinsula. Postinsula.

§ 267.—LIST OF INCONSTANT FISSURES, WITH THE GYRES IN WHICH THEY OCCUR.

Fissures.	Gyres.
1. Adoccipital	Precuneus.
2. Episylvian	Subparietal.
3. Exoccipital	Occipital (?).
4. Fronto-marginal	Fronto-marginal.
5. Hyposylvian	Supertemporal.
6. Intermedial	Subparietal.
7. Intraparacentral	Paracentral.
8. Medifrontal	Medifrontal.
9. Postcalcarine	Occipital (?).
10. Postcuneal	Occipital (?).
11. Postoccipital fovea	Occipital (?).
12. Postparoccipital	Paroccipital.
13. Precuneal	Precuneus.

14. Preoccipital fovea........ Subtemporal.
15. Preparoccipital .... Paroccipital.
16. Rostral.................. Callosal.
17. Suboccipital............. Occipital (?).
18. Subtemporal............. Medi- and subtemporal.
19. Transtemporal........... Meditemporal.

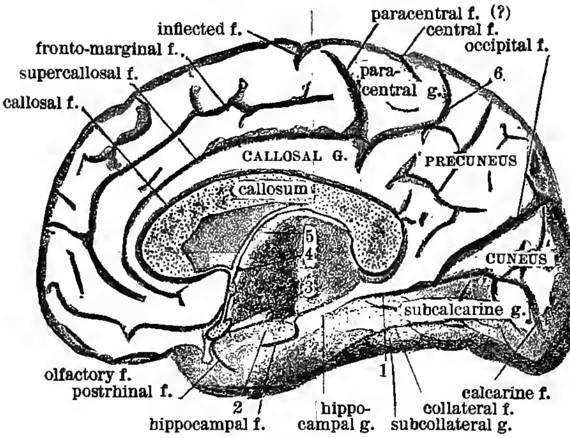


FIG. 766.—Mesal Aspect of the Left (Reversed So as to Appear the Right) Hemicerebrum of an Adult Male Mulatto; 322. × .5. 1, The common stem of the occipital and calcarine; 2, uncus; 3, optic tract, divided obliquely; 4, fornix; 5, retreating ventral surface of the fornix; 6, paracentral fissure. There can be no doubt that 6 is the caudal or main portion of the paracentral, but the cephalic portion so named is thought by E. A. Spitzka to represent the intraparacentral, the true cephalic limb being absent. Mr. Spitzka concludes (1900) that the inflected, like the central, typically indents the margin of the paracentral gyre. Unfortunately, at this time, I cannot determine the point by re-examination of the specimen; but the need of doing so exemplifies the remark in § 253.
Preparation.—See Fig. 757.
Defects.—Most of the fissure lines are too faint; the emargination of the ventral outline just cephalad of the optic nerve is too decided.

§ 268. *Fig. 766 illustrates:* A. The existence and unusual extent of the fronto-marginal fissure.
B. The complexity of the precuneal fissure.
C. The length of the collateral fissure.

Taking all things into account, the central fissure demands first and fullest consideration; there is, indeed, no fact concerning it that is not worth recording or that may not prove significant morphologically or practically valuable. The order in which the following topics are presented is far from perfect, but it may serve to indicate the many-sidedness of these cerebral features. To save space the pronoun *it* will commonly designate the central fissure.*

§ 270. *The Name.*—It has been called, to use the Latin forms, *fissura, scissura,* and *sulcus,* with the qualifying adjectives *centralis, Rolandica,* and *postero-parietalis,* all these having, of course, appropriate equivalents in the various modern languages. My doubts as to the utility of discriminating, at present, between fissures and sulci have been expressed in § 260, *note.* My reasons for preferring *central* to *Rolandic* have been stated upon several occasions since 1882; but as the former name has now been adopted by the Association of American Anatomists and the Anatomische Gesellschaft it will probably supersede the latter with anatomists of other nations.

§ 271. *General Location and Direction.*—On the dorsolateral aspect of the cerebrum, at about the middle of its length; from a point at or near the dorsi-mesal margin, it extends latero-cephalad at an angle of about 70 degrees with the meson, or about 140 degrees with its opposite.

§ 272. *Dimensions.*—Among adult hemicerebrums in the museum of Cornell University the length of the fissure, measured in a straight line between the two ends, varies from 8 to 10.5 cm., the usual length being about 9.5 cm., or about one-fourth of the entire circumference of a cerebrum as measured in a dorso-ventral plane intersecting the fissure at about the middle of its length. If measured along the sinuosities, as if the fissure were straightened out, the length may be one-seventh greater than if measured across the curves. The greatest depth varies from 10 to 15 mm.

§ 273. *Relation to Ental Elevations.*—There is no evidence of any special collocation between it and any ental elevation, in man or any other mammal; hence, though so deep, it is not a total but a partial fissure (§ 258, A).

§ 274. *Constancy.*—The only case of absence of the central fissure known to me is that described by Sir William Turner (*Jour. Anat. and Physiol.*, xxv., 327–348).

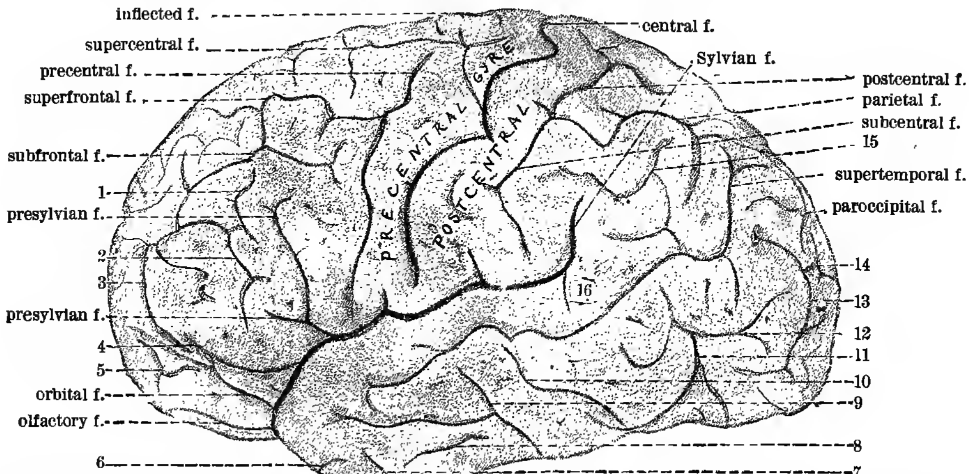


FIG. 767.—Lateral Aspect of the Left Hemicerebrum of an Adult Swedish Carpenter, Presenting an Unusual Degree of Fissuration; 318. × .6—. *Preparation.*—The hemicerebrum was hardened resting upon the mesal surface, and apparently with little change in form. The right was likewise numerously fissured. Of the unidentified fissures the only ones that seem to call for comment here are 9 and 10, which are transtemporal fissures, and 16, a well-marked hyposylvian. See § 275.

D. The distinctness of the postrhinal fissure.
E. An apparent peculiarity of the paracentral fissure as stated briefly in the description; the subject is discussed by E. A. Spitzka, 1900.

§ 269. *Pre-Eminent Importance of the Central Fissure.*—

The subject was an epileptic, twenty-six years old, and the entire (alcoholic) brain weighed 1,107 gm. (39¾ ounces);

* The central fissure is quite fully discussed by Cunningham (1892, chap. iii.).

the left hemicerebrum 530 gm., the right 437. The left fissures are stated to have had a normal development and arrangement, but on the right the Sylvian fissure was

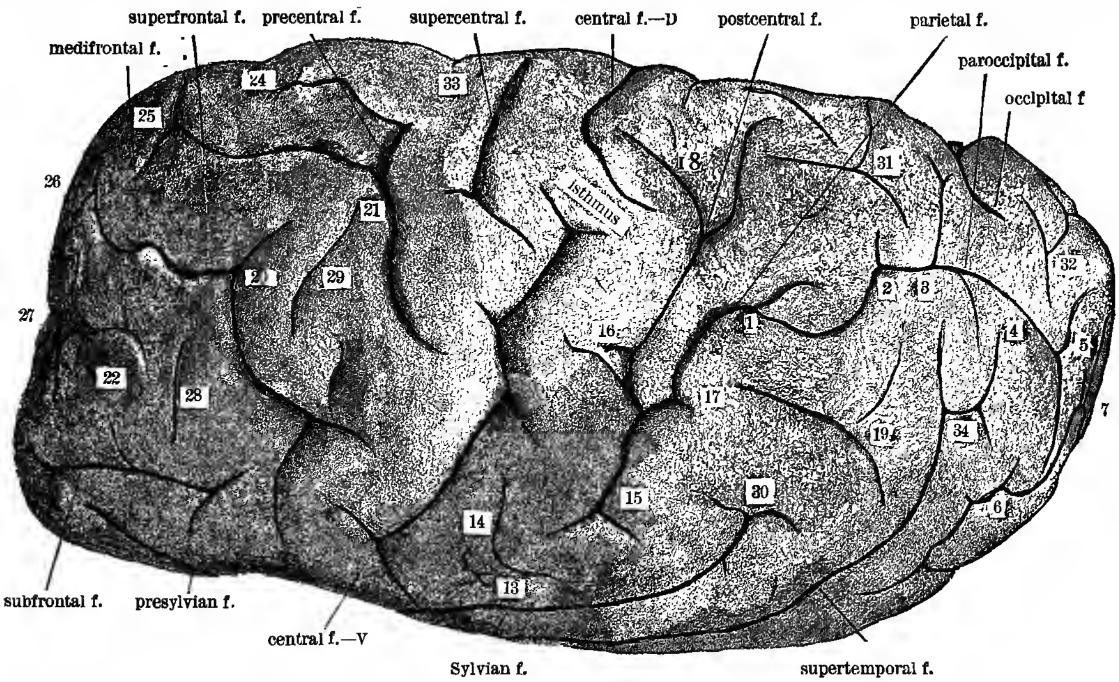


FIG. 768.—The Left Hemicerebrum of a Philosopher (Chauncey Wright), from the Dorso-Lateral Aspect. × .9.

Preparation.—See Fig. 788. The figure is based upon a photograph taken as nearly as possible at an angle of 45° with the meson, so as to present the dorso-lateral aspect. The line connecting the superfrontal and medifrontal fissures was made inadvertently.

The numerals 1 to 22 are at the same points as in Fig. 788; on that figure 23 designated the central isthmus, which here has the word printed upon it: 33 is just at the end of the short inflected fissure.

wide open so as to expose the insula largely; *the central fissure was wholly absent*, together with the precentral and postcentral; the lateral surface presented three arched fissures, demarcating four arched gyres about the Sylvian fissure, a condition analogous to that in the dog and many other carnivora. The interest and importance attaching to this case would have warranted a larger number of better figures, and a representation of the left hemicerebrum.

§ 275. *Fig. 767 illustrates:* A. The unusual number of minor fissures, especially of the slight depressions which I have called *fossulæ*.

B. The three cephalic curves of the central fissure, and their decided character.

C. The extent of the supertemporal fissure.

D. The continuity of the postcentral, parietal, and paroccipital fissures.

E. The length of the dorsal branch of the presylvian.

F. The two dorsal branches of the Sylvian, and the distinct hyposylvian branch (16).

G. The crossing of the temporal lobe ventrad of the supertemporal fissure by two transtemporal fissures.

H. The non-union of the subfrontal with the precentral; this last is not named but is the ventral continuation of the supercentral, beginning about opposite the subfrontal.

I. The continuity of the postcentral, subcentral, parietal, and paroccipital, constituting what has been called the "intraparietal complex"; § 306.

§ 276. *Topographical Importance.*—This is well indicated in the following vigorous declarations of Wagner and Ecker: "*Man muss sie immer zuerst aufsuchen, um sich von da in dem scheinbaren Chaos der Hirnwindungen. . . .*" "*Bildet sie die den sichersten Ausgangspunkt für die Aufsuchung der Windungen. . . .*"

§ 277. *Form, or Course in Detail.*—According to Broca it normally presents two cephalic convexities with an intermediate caudal convexity. In most adults it is certainly more or less serpentine or tortuous, and the regular curves are sometimes distinct; but three cephalic convexities have been observed in sufficient number to show the need of careful observation and tabulation.

§ 278. *Branches.*—Offshoots from the central are usually rather short and straight, starting at the summits of the curves; but in the brain presenting the most decided curvatures (Fig. 767) there is scarcely any branching.

§ 279. *Fig. 768 illustrates:* A. The unfamiliar appearance of a hemicerebrum when viewed from this oblique aspect.

B. The distinctness of the angles between the cephalic and the dorsal and ventral outlines; this was commented upon by the first describer of this brain, Prof. Thomas Dwight, and appears in Fig. 788, though less markedly.

C. The completeness and width of the isthmus between the dorsal and ventral portions of the central fissure; in Fig. 788 this is marked 23, but is so much foreshortened as to be hardly visible.

D. The simple, curved form of the dorsal part of the central fissure, with no bifurcation such as exists at both ends of the ventral portion.

E. The independence of the supercentral fissure.

F. The presence of a medifrontal fissure subdividing the large area between the subfrontal and superfrontal fissures.

G. The junction of the subcentral fissure with the parietal, and the continuity of the parietal with the paroccipital; whether this junction occurs at 1 or at 2 cannot be determined at present.

H. The great length of the supertemporal fissure and the complexity of its dorsal end.

I. The presence of a long and curved fissure, 6–7, on the lateral aspect of the occipital lobe.

J. The presence of an unusual crescentic fissure (14) ventrad of the subcentral (15).

§ 280. *Junctions.*—So far as I am aware, connections between the central and other fissures (excepting the intercerebral, § 236) are rare, and incomplete or shallow when they occur; *e.g.*, in Fig. 762, where the concealed vadum between the central branch and the supercentral nearly reaches the surface, and in Fig. 767, where there is also a nearly invisible vadum just at the apparent union of the supercentral with the central. The occasional confluence of the central with the Sylvian over the margin of the operculum is commonly shallow, but sometimes quite deep, as in the right hemicerebrum of James Burk, figured by Mills (*Journal of Nervous and Mental Disease*, vol. xiii., September, 1886). The depth of such straits should always be stated.

§ 281. *Bifurcation.*—Terminal division of the central fissure at either end is rare; among the few cases known to me the ventral end is bifurcated on the right in a supposed insane person (385) and the ventral on the left of Chauncey Wright (Fig. 768); the dorsal end is bifurcated on both sides in Professor Oliver (Fig. 664).

§ 282. *Relation to the Mesal Aspect.*—Cunningham found (1892, 162) that the fissure indented the dorsal margin so as to appear on the mesal aspect (as in Fig. 757) in sixty per cent. of the hemispheres examined. My own observations would make the proportion somewhat larger. For the final determination of the ratio there should be employed only adult specimens retaining their natural form.

§ 283. *Special Location.*—About midway between a line coinciding with the precentral and supercentral fissures cephalad, and a line coinciding with the postcentral and subcentral caudad.

§ 284. *How to Distinguish from Adjoining Fissures.**—When the precentral is separate from the supercentral, and the postcentral from the subcentral, the central is notably longer than either. When these two pairs of fissures unite, however, it is the middle of the group of three fissures at about the middle of the hemicerebrum having a general dorso-ventral direction. The following characters should be noted in case of doubt: its greater depth and length; its location relatively to the entire length of the cerebrum, and the angle it forms with the margin; its more complete independence; the usual absence of terminal forks; particularly its extension to or across the dorsal margin just cephalad of the paracentral, thus indenting the paracentral gyre (Fig. 769).

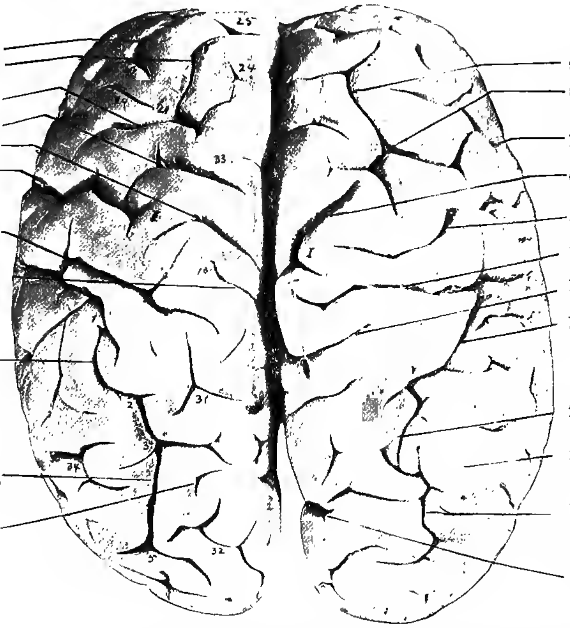


FIG. 770.—Dorsum of the Cerebrum of Chauncey Wright, a Philosophic Writer, Critic, and Mathematician (see description of Fig. 788). × .8. When photographed the cerebrum was inadvertently tilted a little to the left. I, Central isthmus on either side; the numbers correspond to those on Figs. 768, 779, and 788.

FIG. 769.—Right and Left Paracentral Regions of an Adult; 3,132. × .5. Each piece was cut from the dorso-mesal region of the hemicerebrum by an incision at about 45° with the meson; the pieces rest upon the oblique cut surfaces and the dorso-mesal margins correspond approximately to lines between the two Ds and the two Ms. 1, Dorsal outcrop of the cephalic end of the paracentral, which is also continuous with the supercallosal; 2, a crescentic fissure which, in the foreshortened position of the parts, appears to join the paracentral, but is really separated from it by a vadum barely below the surface; 3, a similar fissure on the right, separated by a complete isthmus from the paracentral, which latter has no dorsal outcrop, but is continuous with the supercallosal; in the light of E. A. Spitzka's observations 2 and 3 may be the inflected fissures.

§ 285. *Alleged Duplication.*—Calori and Giacomini have each described (1884) a brain which they interpreted as having two central fissures nearly parallel and separated by an "intercentral" gyre. The conditions in an educated suicide (3129) were similarly interpreted by me (1894, *a*); but a later comparison with a larger number of brains leads me to conclude rather (1900, *a*) that the supposed second or caudal central is really an unusually long resultant of the union of the postcentral and subcentral, caudad of which is the parietal. The bifurcated dorsal end of the postcentral has the usual relation with the paracentral as it crosses the meson (see Fig. 769).*

§ 286. *Fig. 769 illustrates:* A. The more usual relation of the central fissure to the dorsal margin, crossing it so as to appear on the mesal aspect.

B. The constant relation of the central

* The macroscopic methods here enumerated might require confirmation from the histology of the region in question, as indicated in the discussion of my paper, 1900, *a*, by Donaldson, Spiller, and Mayer (Jour. Nerv. and Mental Disease, October, 1900, 540).

* After the above paragraph was in type the kindness of Dr. D. S. Lamb enabled me to obtain a transcript of the "Nota preventiva" of C. Leggiardi-Laura (Archiv di Psich. Sci. Penol. ed Antrop. Crimin., Torino, 1899, p. 421), "Duplicita della scissura di Rolando nei criminali." It is there claimed that among thirty-seven female brains central reduplication occurred once, on the left, and among thirty males, twice on the left, once on the right, and once on both sides. In the absence of figures, especially photographs, and detailed descriptions, I must refer these to the same category as my own; see also the remark of Dr. C. K. Mills upon my paper (1900, *a*) in Jour. Nerv. and Mental Disease, October, 1900, pp. 537-541, and my later note on the subject, 1900, *x*.

fissure to the paracentral, the former directed at the concavity of the latter.

C. The usual relations of the paracentral and postcentral fissures, the former directed at the reentrant angle formed by the bifurcation of the latter.

D. The not unusual bifurcation of the supercentral (upper precentral) fissures.

E. The asymmetry of the paracentral in respect to a dorsal outcrop of the cephalic end.

F. The danger of depending upon appearances in respect to the independent fissures 2 and 3.

§ 287. *Interruption.*—As shown in Figs. 770 and 771, the central fissure is completely interrupted on both sides of the brain of Chauncey Wright, the isthmus* being fully on a level with the adjacent gyres. The brain of Dr. Fuchs, figured by Wagner, exhibited a like peculiarity, and the complete interruption has now been recorded for perhaps fifteen hemicerebrums, a very small proportion of the enormous number examined. The left central is completely interrupted in the educated suicide (3,129) referred to in § 285; but the right is continuous.

§ 288. *Fig. 770 illustrates:* A. The unusual squareness of the frontal outline.

B. The unusual length of the region caudad of the central fissures, and concomitantly that of the parietal fissure.

C. The width and simplicity of most of the gyres, especially as compared with those of Professor Oliver (Fig. 664).

D. The complete interruption of both central fissures by an isthmus, (Fig. 771).

E. The lack of symmetry of the central fissures in respect to (*a*) distance of the isthmus from the meson, (*b*) difference in form of the dorsal portions; (*c*) unlike dorsal terminations of the ventral portions.

F. The unusual depth of both paracentral fissures and their non-oppositeness.

G. The unusually caudal location of the right paracentral so as to embrace the dorsal end of the postcentral as if the latter were the central.

H. The asymmetric condition of many other fissures.

I. The unequal depths of the occipitals; the right extends barely beyond the rounded cerebral margin; the left is at least three times as deep; this fact has been ascertained since the publication of the diagram of the paroccipital region in the Proceedings of the Ass'n Amer. Anatomists, 1895.

J. The details of the paroccipital region are considered under Fig. 779. In certain respects this brain is unique and merits extended monographic treatment; but this also will be easier and more instructive when a normal standard has been more nearly obtained.†

§ 289. *Partial Interruption.* — Several writers have called attention to the not infrequent presence of a vadum

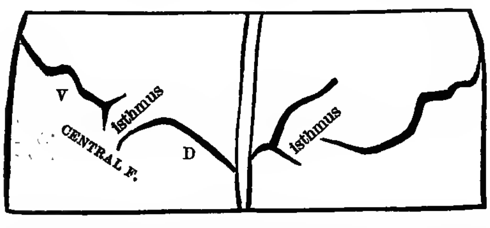


FIG. 771.—Central Region of the Dorsum of the Cerebrum of Chauncey Wright (Fig. 770), showing only the interrupted central fissures and the isthmuses; on the left the two portions of the fissure are designated by V and D respectively. × 5.

or shallow in the depths of the central fissure, commonly nearer the dorsal end; among 1,087 hemicerebrums examined, Heschl found in 152 (about fourteen per cent.) an elevation (vadum) rising from one-sixth to five-sixths of the entire depth of the fissure, and suggests that the rare

FIG. 772.—Dorsum of the Cerebrum of a Fetus Supposed to be Six Months Advanced; 2,972. × 1. One of twins, both males, stillborn.

cases of complete interruption result from the greater development of this feature. In view of these observations the vadum should always be looked for.*

§ 290. *Mode of Formation.*—In at least three specimens in the Cornell Museum, viz., 827 (Fig. 773), 2,278 (Fig.

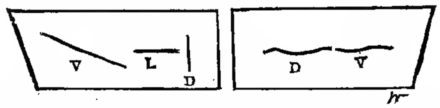


FIG. 773.—Diagrams of the Right and Left Central Fissure Regions of a Fetus, 56 cm. Long and Estimated at Twenty Weeks; 827. × 2.

752) and 2,972 (Fig. 772) there are evidences that the central begins in at least two portions, a dorsal and a ventral. Cunningham's views are summarized thus in 1897, *a*, 593: "1. The typical mode of development is in two more or less distinct pieces. 2. Judging from the specimens in my possession this would likewise appear to be the more usual mode." † The cases of partial (by vadums) or total (by isthmuses) interruption in the adult may be regarded as retentions of the (usual or not infrequent) fetal condition.

§ 291. *Fig. 772 illustrates:* A. The unsymmetrical development of the central, postcentral, and parietal fissures.

B. The representation of the right central fissure by a longer ventral portion; a dorsal portion which is merely a dimple, but perfectly distinct; and an intervening vadum.

§ 292. *Fig. 773 illustrates:* A. The interrupted condition of both central fissures at their first formation.

B. The lack of symmetry; on the right are two parts, the right ventral (V) being 2 mm. deep at its middle and the dorsal (D) 2.5 mm.; on the left are three distinct divisions—the dorsal parallel with the meson, the lateral at right angles with it, and the ventral oblique.

§ 293. *Time of First Appearance.*—Nearly all writers

* This term is equivalent to *pli de passage*, *annectent convolution*, and *bridging convolution*; the latter is misleading, for the interruption of a fissure has no analogy with a bridge, but rather with a dam, dike, or isthmus, absolute size being of no moment.

† The need of an improved standard for the study of fissures is clearly recognized by Mickle, 1895, opening paragraph.

* The morphological and zoological significance of vaduma is forcibly stated by Cunningham (1897, *a*, 593): "A close study of the memoir of Retzius (1897) has left on my mind the impression that he somewhat understates their morphological value. With Eberstaller I hold that they constitute one of the great and distinctive characters of the human brain."

† The distinction between "*typical*" and "*usual*" in a case like this is not apparent.

state that the central fissure is formed about the end of the fifth month, the twentieth week. The following observations show that there is probably some variation in this respect, or—as is perhaps equally probable—that the length of the fetus varies considerably at the same stage of fissural development. In fetuses 827 and 1,817, respectively 56 and 65 cm. long, the fissure is vague or absent; in 1,820, 61 cm. long, it is distinct and deep; in 2,278, 67 cm. long, it is well developed, and several other lateral fissures are visible.

§ 294. *Relative Order of Appearance.*—Excluding the transitory fissures (Fig. 748) and the lambdoidal (which may be transitory, Fig. 750), the central is apparently the first of the lateral fissures to be developed after the Sylvian (Fig. 751). But some of my preparations indicate that this order may not be invariable; in 2,081 the parietal and supertemporal are more advanced than the central; in 1,817 there is no trace of a central, although both superfrontals are distinct. Numerous and careful observations are needed on this point.

§ 295. *Form in the Fetus.* — When first distinctly formed, the fissure line is nearly straight, with a slight cephalic convexity (Fig. 751).

§ 296. *Proximate Cause.*—There is no evidence that it depends upon the pressure of a blood-vessel. The causation of fissures and of encephalic corrugations in general has been discussed by Jelgersma, Cunningham (1892), and A. J. Parker (1896), and briefly by Schäfer (1893, 162).

§ 297. *Relation to Primitive Fissures.*—There is no good reason for regarding either of the three radiating, presumably transitory, fissures shown in Fig. 746, as the direct precursor of the central.

§ 298. *Integrality.*—For the definition of *fissural integer* see § 305. The occasional complete interruption (§ 287), the not infrequent existence of a vadum (§ 289), and the mode of appearance in several cases (§ 290), suggest the possibility that the central consists really of two fissural integers, commonly connected, and comparable, perhaps, with the parietal and paroccipital (§ 306). For the present, however, it seems justifiable and certainly more convenient to regard the conditions above named as anomalous, and to treat the central as a single fissure.

§ 299. *Lateral Variation.*—Clevenger states that it is usually located farther caudad on the left side than on the right; its relations to motor areas would lead one to expect considerable lateral variation in position, direction, and shape.

§ 300. *Physiological and Surgical Relations.*—It is completely surrounded by important motor areas, and its exact relations to the cranium and surface of the scalp are of great pathological and surgical importance; these matters are considered in the articles *Brain, Surgery of the*, and *Brain: Functions of Cerebral Cortex.*

§ 301. *Psychological Relations.*—Clevenger has a suggestive paper (*Journal of Nervous and Mental Disease*, April, 1880) on the ratio between the location of this fissure and the intelligence of the individual or species; although unable to admit his identification with the cruciate fissure of Carnivora, or to accept all his conclusions, I regard the determination of the relative bulk of the precentral (frontal) region of the cerebrum and the postcentral (occipito-parieto-temporal) region as of great importance in connection with the comparison between individuals and species in respect to intellectual power and voluntary inhibition or self-control.

§ 302. *Condition in Other Primates.*—In the apes and in all the ordinary monkeys the fissure is readily recognized; *e.g.*, in the *Macacus*, Fig. 787.

§ 303. *Carnivoral Representative.*—By various authors it has been homologized with the following fissures of the cat and dog: superorbital, ansata, coronal, and cruciate. Notwithstanding the similar relations of the central and cruciate fissures to motor areas, the question of their homology (morphological identity) must be held as yet undetermined. A clue may be furnished by the observations of P. A. Fish (1899, 37) as to the collocation, in the seal (*Phoca*), of what seems to be the calcar with the ventral portion of the splenial fissure.

§ 304. *Fig. 774 illustrates:* A. The form of a perfect and typical paroccipital fissure, very symmetrical, and completely independent of the parietal, although its cephalic ramus and what seems to be an extension of the parietal overlap and approach very closely.

B. The peculiar appearance of the entire hemicerebrum and of the central fissure from this point of view. Other points are commented upon under Fig. 775.

§ 305. *Fissural Integer.*—This term was proposed by me (1886, *e*) to designate a fissure which is independent in

FIG. 774.—Dorso-Caudal Aspect of the Right Hemicerebrum of a Child at Birth; 478. × 1. This figure was published in the *Journal of Nervous and Mental Disease*, June, 1886. Other aspects of the same brain are shown in Figs. 663, 756, and 775.

some species or individuals, and deepest at or about the middle of its length, corresponding nearly with the place of its first appearance. Any marked and frequent shallowing of a supposed fissural integer is reason for questioning its integrality, and for seeking, in other individuals and in allied species, evidence that it really consists of two.

§ 306. *The "intraparietal * fissure"* of Turner probably represents two fissural integers, the parietal and the paroccipital, because (1) in nearly half the cases examined by me there are two fissures separated by an isthmus of greater or less width; (2) when the two are continuous there is often a vadum at the point corresponding to the isthmus; (3) each of the two portions, whether separate or continuous, is usually deepest at or near its middle; (4) at their first appearance in the fetus they are always completely independent.

§ 307. *The typical paroccipital fissure* consists of (*a*) the zygon or bar, the first part to be formed; (*b*) cephalic and caudal stipes continuing the curve of the zygon about the dorsal outcrop of the occipital; (*c*) cephalic and caudal rami, imparting to each end the characteristic form seen in Fig. 774. The paroccipital is a typical zygal fissure.

§ 308. *Fig. 775 illustrates,* in addition to points seen equally well in Figs. 756, 663, and 775), the greater depth of the paroccipital zygon at the middle of its length, a fact hardly compatible with the supposition that it is only a caudal extension of the parietal, or that the caudal stipe and ramus constitute an independent fissure, the "transverse occipital" of Ecker.

§ 309. *What Is the So-Called "Transverse Occipital Fissure"?*—Most writers seem disposed to adopt the view

* Often, but incorrectly, written interparietal.

of Ecker that the caudal stipe and ramus of the paroccipital represent a "sulcus occipitalis transversus" which unites with the longitudinal bar or zygon. None of the

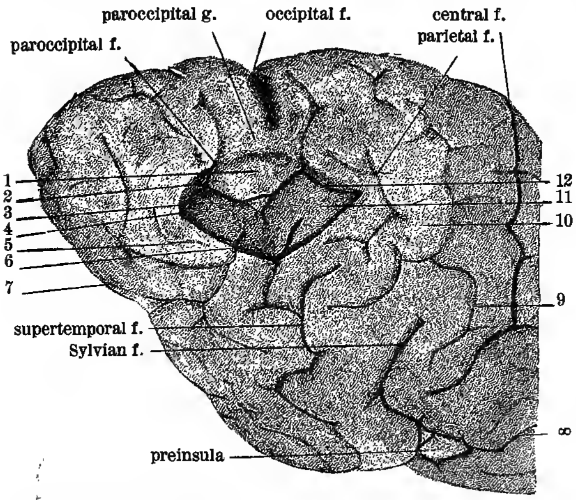


FIG. 775.—Dorso-Caudo-Lateral Aspect of the Right Hemicerebrum of a Child at Birth, Partly Dissected; 478. × 1. See the lateral and dorsal aspects (Figs. 663 and 774). 1, Lateral surface of the zygal part of the paroccipital gyre; this is, of course, pial, but the point of the V-shaped incision reaches a slightly lower level than the bottom of the fissure, occasioning the triangular cut area at the bottom; 2, line representing the junction of the zygon with its caudal stipe; 3, ectal line of the caudal ramus; 4, ental line of the same; 5, should have crossed the cut surface to the outcrop of the fissure marked 7 in Fig. 663; 6, the exoccipital fissure (?); 7, unidentified fissure; 8, presylvian fissure; 9, postcentral fissure; 10, gyre between the postcentral and the parietal fissures; 11, cephalic slope of the cut surface; 12, cephalic ramus.

Preparation.—By reference to the lateral aspect, Fig. 663, the paroccipital fissure will be seen to be indicated by the name itself, connected with the middle of the zygon. For the present figure a wedge-shaped piece was removed by two incisions, starting respectively at the tip of the rami and meeting at an obtuse angle at the exoccipital. The removal of this piece exposed the lateral aspect of the paroccipital gyre and of the gyres adjoining it cephalad and caudad; also the depth of the zygon and the two rami.

specimens examined by me seems to confirm this interpretation, and I am compelled to regard the very interesting condition shown by Cunningham (1892, Fig. 51) as simply anomalous. Much, however, remains to be done in this region.

§ 310. *Fig. 776 illustrates:* A. The degree of fissuration at this period.

B. The early condition of the paroccipital fissure as a upsiloid (U-shaped), depressed line with lateral branches, rami.

C. The independence of the paroccipital fissures at this period.

D. The absence of any fissure closely resembling the "transverse occipital."

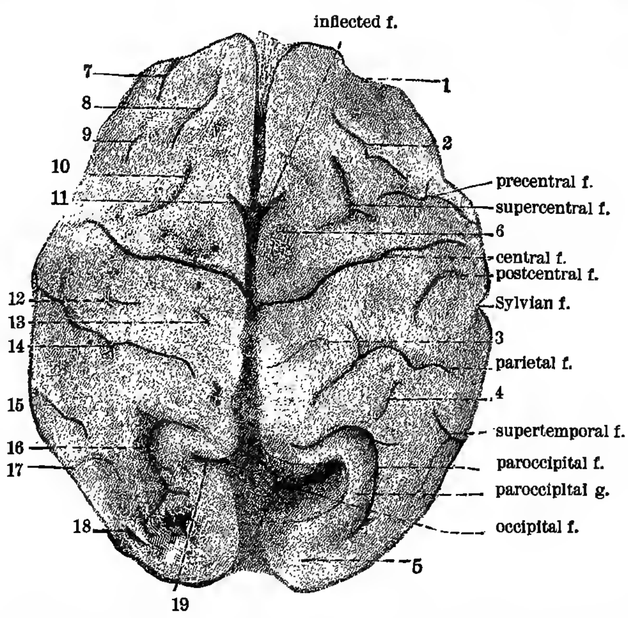


FIG. 776.—Dorso-Caudal Aspect of the Brain of a Fetus Measuring 41 cm. from Heel to Bregma, and Estimated at Eight Months; 734. × 1. 11, Left inflected fissure; 12, 13, separate portions of the left postcentral; 14, left parietal (?); 16, left paroccipital; 17, left supertemporal; 19, left occipital fissure. The remaining numbers indicate fissures of doubtful identity.

Preparation.—The arteries were injected with starch mixture; extravasation took place at several points, especially the two following: (1) into the dorsal part of the right occipital fissure, converting it into a kind of fossa, at the bottom of which is seen the unaffected part of the fissure; (2) into the left paroccipital fissure, separating its walls to some extent. The essential relations of parts are not affected.

E. The distinctness of the inflected fissures at this period.

F. The difficulties of identifying fetal fissures in the condition of those upon the frontal and parietal regions of this specimen.

§ 311. *Fig. 777 illustrates:* A. An almost schematic condition of the paroccipital fissure, simple in form and

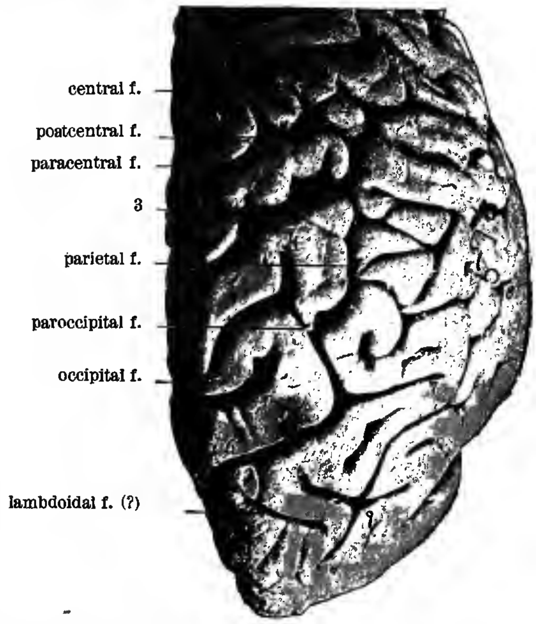


FIG. 777.—Dorso-Caudal Aspect of the Occipital Region of the Right Hemicerebrum of an Irishwoman, Thirty-Five Years Old, Exhibiting an Unusually Simple Condition of the Paroccipital Fissure; 385. × .8. Other aspects of this brain are shown in Figs 720 and 721. 1, Subcentral fissure, continuous with the parietal, but separated from the postcentral by a considerable isthmus; 2, the branch of the postcentral just below (caudad of) the isthmus does not really enter the parietal, although the shadow upon the slightly depressed narrow portion of the isthmus gives that appearance; 3, an independent fissure parallel with the postcentral; 4, cephalic ramus of the paroccipital; 5, cephalic stipe of the same; 6, 7, caudal stipe and ramus; 8, supertemporal; 9, the triradiate termination of a fissure superficially continuous with the supertemporal. The name *lambdoidal* is applied with considerable hesitation.

wholly independent of the parietal, although the isthmus (opposite the end of the line from paroccipital) is slightly depressed.

B. An unusual divergence of the caudal stipe (6) and ramus (7) of the paroccipital; the former again bifurcates just over the margin on the mesal aspect.

C. The presence of an oblique independent fissure caudad of the paroccipital suggesting the persistence of the lambdoidal of the fetus (§ 234 and Fig. 750).

D. The separation of the postcentral from the subcentral by an isthmus, 2.

E. The depth, simplicity, and cephalic trend of the occipital.

§ 312. *Continuity of the Paroccipital with the Parietal Occurs More Frequently on the Left.*—This has been noted by Ecker, Cunningham, and myself. In a recent paper (1900, *a*) I reported the results of the tabulation of 200 mated hemicerebrums, *i.e.*, from 100 individuals; all but 5 were adults, the 5 infants ranging from term to three years.

(*a*) Of the 100 left, 77 present continuity of the paroccipital with the parietal; in 23 the two fissures are separated. Of the 100 right there is continuity in only 39 and separation in 61.

(*b*) Of the 116 cases of continuity, 77 (66 per cent.) occur on left hemicerebrums, and only 39 (34 per cent.) on the right. Of the 84 cases of separation, 23 (28 per cent.) occur on the left and 61 (72 per cent.) on the right.*

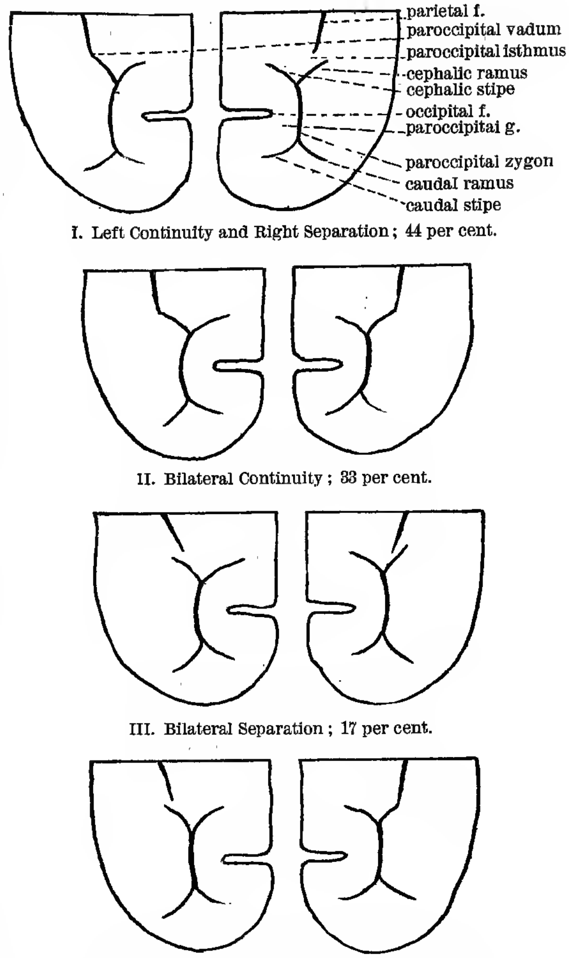
§ 313. *Have the Combinations Any Significance with Respect to Age, Sex, Race, Character, or Mental Condition?*—For the purpose of testing this, the 100 individuals were grouped as in the appended Table; but the grouping is obviously unsatisfactory.

§ 314. Table V.—Provisional and Unsatisfactory Grouping of One Hundred Individuals Whose Paroccipital Fissures are Known on Both Sides.

Group.	Characterization.	Number.
A	Educated and orderly...............	10
B	Ignorant or unknown...............	50
C	Insane—various degrees.............	25
D	Murderers..........................	5
E	Africans, various grades...........	5
F	Infants under three years..........	5

§ 315. In Table V. the ten members of Group A are as follows: Chauncey Wright; Prof. James Edward Oliver (3,334); a lawyer (2,870) and his wife (3,065); a teacher of mathematics (3,091); an educated farmer (3,350); a physician (3,531); a woman physician and advocate of social reforms (3,430); a woman college student (3,416); and a dentist (3,129).†

§ 318. *Commentaries on Fig. 778 and Table VI.*—Although I believe the number of mated hemicerebrums is larger than in any previous tabulation it is still too



I. Left Continuity and Right Separation; 44 per cent.

II. Bilateral Continuity; 33 per cent.

III. Bilateral Separation; 17 per cent.

IV. Left Separation and Right Continuity; 6 per cent.

Fig. 778.—Diagrams of the Paroccipital Fissure.

§ 316. Table VI.—Percentages of Occurrence of the Four Parieto-Paroccipital Combinations in the Six Groups of Individuals.

Group.	Character.	Number.	I. L. Continuity. R. Separation.	II. R. and L. Continuity.	III. R. and L. Separation.	IV. L. Separation. R. Continuity.
A	Educated and orderly ...	10.......	60%....................	20%....................	20%....................	0%
B	Ignorant or unknown ...	50.......	48	34	12	6
C	Insane..................	25.......	40	28	24	8
D	Murderers	5.......	20	60	20	0
E	Africans	5.......	20	60	0	20
F	Infants.................	5.......	40	20	40	0

§ 317. *Fig. 779 illustrates:* A. The complexity of this paroccipital region (compare Figs. 774 and 777).

B. The narrowness of the isthmus between the paroccipital and the parietal.

C. The extension of the fissure marked 36′, over the margin of the hemicerebrum, a feature not distinctly apparent in Fig. 770.

* A somewhat different ratio existed among twenty unmated hemicerebrums.

† This was the educated suicide mentioned in § 285; he was, however, highly esteemed by others besides myself.

small for final results; especially is this the case with groups, A, D, E and F. Hence the following remarks must be regarded as suggestive rather than conclusive.

§ 319. *Paroccipital Integrality.*—Superficially there are more cases of continuity (116) than of separation (84). But when the known or presumptive vadums are taken into account the balance of evidence seems to be the other way. It is certainly more convenient to speak of the paroccipital fissure than of the "occipital" or "posterior portion of the intraparietal complex."

§ 320. *Symmetry and Asymmetry.*—In 33 brains there is double continuity; in 17, double separation. In 44 there is right separation and left continuity; in 6, left separation and right continuity. In 50, therefore, the conditions are symmetrical and in the other 50 unsymmetrical.

§ 321. *Postpartum Changes.*—Condition III., bilateral separation, occurs in only 17 per cent. of the total, but

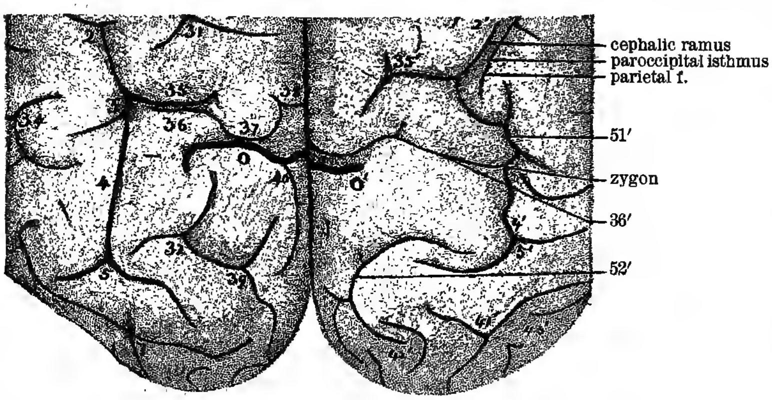


FIG. 779.—The Paroccipital Region of Chauncey Wright. On the left, the numbers correspond to those on Figs. 770 and 788. On the right, homologous parts have the same numbers with the addition of prime. O and O′, the occipital fissures. The left parietal fissure joins the cephalic ramus of the paroccipital at 2, where there is a vadum; on the right the isthmus is narrow and slightly depressed. The fissure marked 36, 37, and 38 is somewhat deep and separated from the occipital by a visible vadum; on the right (36′) it enters the paroccipital fissure.

in 40 per cent. of the five infants. So far as this small number goes there is borne out the conclusion of Cunningham that in many cases the union is delayed until after birth.

§ 322. *Fig. 780 illustrates:* A. The least common of the four possible combinations of the paroccipital and parietal fissures of the two sides, viz., right continuity and left separation.

B. The continuity of the parietal and postcentral fissures on both sides, but with differences that are unusual and somewhat perplexing.

C. The existence, on the right, of a clearly defined triangular fissure, 3.

D. The unusual extension of the caudal ramus of the paroccipital, 4.

E. The appearance of the trench (6) due to the pressure of an artery.

§ 323. *Parieto-Paroccipital Combinations in Individuals.*—Four different combinations are possible (Fig. 778), viz.: I. Left continuity and right separation; II. Continuity on both sides; III. Separation on both sides; IV. Left separation and right continuity. Amongst the 100 individuals tabulated (all that were accessible to me at the time), combination I. existed in 44; II. in 33; III. in 17; and IV. in only 6.*

§ 324. *May Combination I. (Right Separation and Left Continuity) be Regarded as Normal?*—Among the ten educated and moral whites (Group A) combination IV. does not occur (but neither does it among the five murderers). Combination I. occurs in 60 per cent. of Group A, in 48 per cent. of Group B (ignorant or unknown); in 40 per cent. of C (insane), and in 20 per cent. each of D (murderers) and E (Africans).

§ 325. There are many questions, general and special, that arise in connection with the paroccipital, but

* Mr. E. A. Spitzka informs me that this combination exists in the brain of Dr. Edouard Seguin. (See his papers, 1900, *a*, *b*.)

space permits mention of only two which were briefly discussed in my paper (1900, *a*): (1) In tabulating should not the cases in which the vadum equals in height more than one-half the greatest depth of the "parieto-paroccipital combination" be included under "separation"? (2) What weight is to be assigned to the condition in apes and monkeys where continuity is the rule, perhaps without exception? The developmental conditions in other primates than man are not known.

§ 326. *Fig. 781 illustrates:* A. The location and common form of the insula.

B. The existence of fissures and intervening gyres, radiating in general from its summit.

C. The division of the whole by a somewhat deep fissure, the transinsular (2), into a cephalic region, *preinsula* and a caudal, *postinsula*.

§ 327. *Supergyres and Subgyres.*—The ectal surfaces of two adjoining gyres are commonly at about the same level, excepting for a marked change in the general contour of the cerebrum, as, *e.g.*, at its several margins. But sometimes one gyre may be developed much more than its neighbor, and encroach upon it so as to conceal it more or less completely. The covering gyre is here called a *supergyre*, and the covered a *subgyre*.

§ 328. *Superfissures and Subfissures.*—These terms are employed herein to designate the fissures which result from the formation of supergyres and subgyres. The line of overlapping of a supergyre is a *superfissure*, as also is the line of junction of two supergyres meeting from opposite directions. A *subfissure* is one which is concealed by a

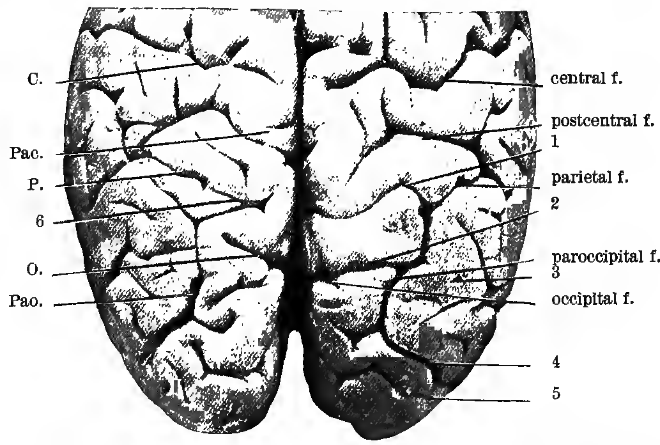


FIG. 780.—Dorsum of the Occipital Half of the Cerebrum of an Insane Swiss Woman, Fifty-Three Years Old; 2,964. × 0.6. Her mother was also insane. 1, A fissure apparently, but not really, connected with the paroccipital; 2, the cephalic stipe of the paroccipital; 3, a triangular depression; 4, an unusual and deep extension of the paroccipital; 5, undetermined fissure. On the left, 6, a vascular trench between the parietal and occipital; C., central fissure; Pac., paracentral; P., parietal; O., occipital; Pao., paroccipital.

supergyre, and invisible until the lips of the superfissure are divaricated.

§ 329. *Normal, human subfissures* are the circuminsular, which encircles the insula (Fig. 782), the transinsular and others crossing the surface of the insula (Fig. 781), and those which indent the ental or insular surfaces of the operculums (Fig. 783). Unusual subfissures appear in Fig. 786, after the removal of the unusual supergyre; superfissures are shown also in Fig. 787.

§ 330. The *insula* ("island of Reil") and the operculum and postoperculum (parietal and temporal operculums). Owing to the non-development of the other two operculums the cephalic portion of the insula is exposed like the rest of the cortex, and the "*sulcus limitans*" of Reil (part of my circuminsular fissure) is represented by a "fronto-orbital sulcus."

I regret that this interpretation is not borne out by the study I have been able to make of the material at Cornell University. There are more than fifty brains of monkeys and lemurs, and during the past sixteen years I have prepared with special care ten fresh ape brains (one gorilla, three chimpanzee, and six orang); all have been photographed; some have been sectioned or partly dissected, and one (chimpanzee) has been drawn. Still I hesitate, and am not sure that it will be possible for me to decide until there is available a fetal ape brain displaying the region in question in process of formation.

§ 334. The *operculum* is not strictly a single gyre but includes portions of at least two, the precentral and the subfrontal. It is as if the eastern half of the southern extremity of Africa were owned by the Dutch and the western by the English, each half having its own territorial designation; we might still speak of the Cape of Good Hope composed by the two countries. In general the same may be said of the postoperculum, suboperculum, and preoperculum.

§ 335. *Fig. 783 illustrates:* A. The extent to which the several operculums lap over the insula, constituting so many supergyres.

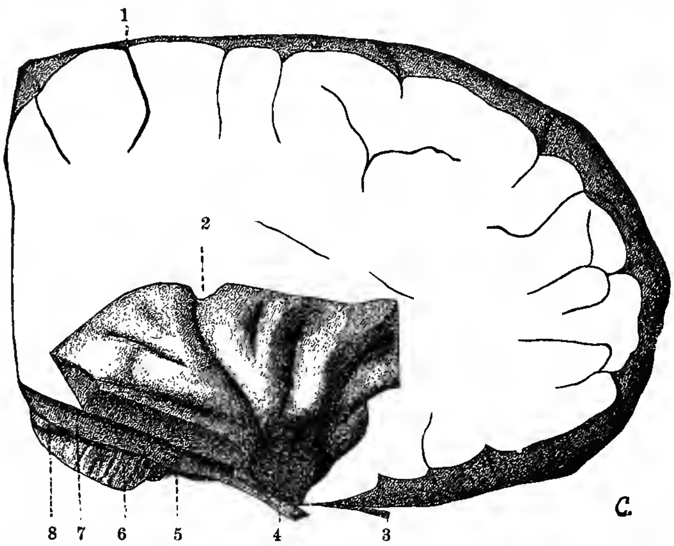


FIG. 781.—Right Adult Insula, Exposed from the Lateral Aspect; 480. × 1. 1, Central fissure; 2, transinsular fissure; 3, olfactory tract; 4, optic nerve; 5, optic tract; 6, crus; 7, pregeniculum; 8, postgeniculum.

constitute normal and typical examples of subgyres and supergyres. As may be seen in Figs. 663, 667, 752, and 782, and in the diagram, Fig. 759 (B), the insula is a part of the cortex, which, at one period wholly superficial, is gradually covered, more or less completely, by converging folds of the adjacent regions. The insula thus becomes a subgyre, while the operculum, preoperculum, suboperculum, and postoperculum are supergyres. For other supergyres see §§ 336 and 342.

§ 331. *Fig. 782 illustrates:* A. The existence of two zones of the lenticula, an ectal, the putamen, and a second, entad of the first, as seen in Fig. 739. There is still a third, but it does not extend sufficiently far dorsad to appear in this or Fig. 738.

B. The constitution of the insula as an elevation of the lateral region of the hemicerebrum, its cortex and medulla being continuous with the rest and with the overlapping operculums.

C. The peculiar form and location of the claustrum, a thin, subcircular disc of cinerea, between the putamen and the insular cortex, of which it is probably a dismemberment.

§ 332. The insula has notable topographical relations with (*a*) the several operculums, (*b*) the claustrum and lenticula. Although perhaps, upon the whole, most developed in man, relatively to the size of the entire brain, it is perfectly distinct in apes and monkeys, in dogs, the porpoise, and many other mammals; its comparative anatomy and its human variations are fruitful and important subjects for further observation; see especially the papers of E. C. Spitzka (1879, *a*) and (Clark, 1896).

§ 333. *The Insula in Apes.*—According to Cunningham (1897, *b*, II., 22), he and Marchand have reached independently the conclusion that in apes (orang, chimpanzee, gorilla, and gibbon) only the caudal portion of the insula is covered by the operculum

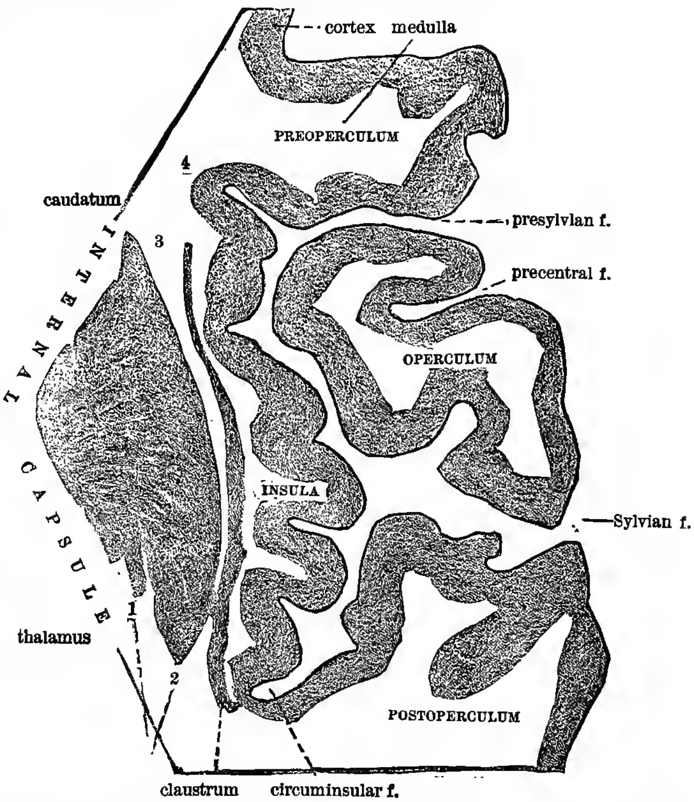


FIG. 782.—Longisection of the Right Insula and Adjacent Parts; 2,397. Enlargement of the corresponding region of Fig. 738. 1, 2, Zones of the lenticula, the lateral and larger the putamen; 3, the stratum of alba between the putamen and claustrum, sometimes (most undesirably) called "external capsule"; 4, opposite the circuminsular fissure. *Internal capsule* should be simply *capsula*.

B. The fissuration of the ental surface of the operculums.

C. The distinctness of the supercallosal fissure, and the absence of a fronto-marginal between it and the dorsal margin of the hemicerebrum.

D. The length of the postrhinal fissure, partly concealed by the optic nerve.

§ 336. *Subfrontal Fissure and Gyre* ("*Broca's convolution*").—From every point of view, anatomical, histological, physiological, psychological, anthropological, and zoological, a most interesting and important cortical region is that which Broca first showed to be related to the faculty of articulate speech. Although the conditions are often, perhaps usually, complex and perplexing, there seem to me to be a sufficiently large number of cases like those represented in Figs. 663 and 784 to warrant describing the gyre as curving about the presylvian fissure, and the fissure as zygal and U-shaped; the topography is much like that of the paroccipital fissure and gyre.

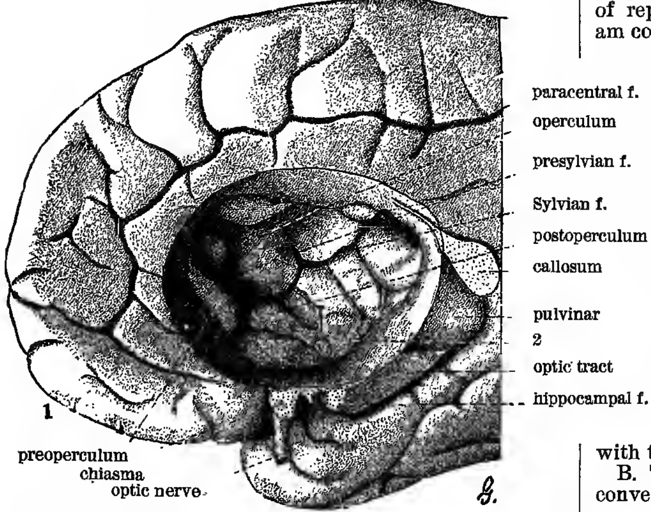


FIG. 783.—The Mesal Aspect of the Right Operculums of a Child at Term; 1,823. × 1.

Preparation.—The hemicerebrum had been hardened in alcohol while resting on the meson, and hence is a little thinner and wider than natural, but thereby better suited to the desired object. A probe was pushed through from the lateral aspect at the triangular place of divergence of the Sylvian, basisylvian, and presylvian fissures; from the hole so made upon the mesal aspect, cuts were carried in various directions, cautiously, until most of the thalamus, caudatum, lenticula, and insula were removed, thus exposing the ental or mesal surfaces of the operculum, postoperculum, and preoperculum, with the intervening Sylvian and presylvian fissures.

Defects.—The inclusion of the occipital region would have rendered the figure somewhat more intelligible. The suboperculum and subsylvian fissure are not exposed; the cut surface at the ventral side should be traversed by a line starting from just cephalad of the chiasma to represent that part of the basisylvian fissure.

§ 337. *Fig. 784 illustrates:* A. An unusually simple condition of the subfrontal gyre as a U-shaped region about the presylvian fissure.

B. An unusually simple zygal form of the subfrontal fissure, comparable with that in the infant brain shown in Fig. 663.

C. The complete separation of the subfrontal fissure from the precentral and the bifurcation of the latter at the point reached by the line from the name.

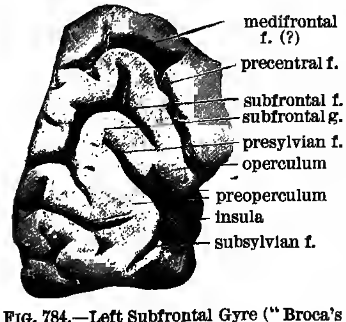


FIG. 784.—Left Subfrontal Gyre ("Broca's Convolution") and Adjacent Parts of a Man about Thirty-Three Years Old. × .5. He was the son of a clergyman, but was found dead after a drunken debauch.

D. The relatively large size of the preoperculum as compared with the suboperculum; these proportions also are as in Fig. 663, and the reverse of those in Fig. 752.

E. The (probable) partial exposure of the insula in the adult brain.

§ 338. *The Subfrontal Gyre in Apes.*—A paper on this subject has been published by Hervé (1888). I am not prepared to discuss Hervé's conclusions as to the degree of representation of the subfrontal gyre in apes; but I am compelled to dissent from the statement (p. 22) that of the two branches of the Sylvian fissure "ascending" and "horizontal" (corresponding respectively to my presylvian and subsylvian) the latter is the more constant.

§ 339. Recalling my own earlier erroneous interpretation of the parts, I am compelled to insist upon the necessity of exposing them fully by removing the postoperculum, and of determining whether or not a given fissure cuts through the entire thickness of the operculum.

§ 340. Supergyres and subgyres occur by exception in other parts of the cerebrum, especially the occipital (see Figs. 785 and 786), and normally in many monkeys, the *poma*, § 351, Fig. 787.

§ 341. *Figs. 785 and 786 illustrate:* A. The presence of a postcuneal fissure along the caudal margin of the cuneus; its dorsal end is free, but ventrad it has a very shallow connection with the calcarine.

B. The concealment, in the undissected brain, of the convexities of the paroccipital fissure and gyre and part of the occipital fissure by an extensive supergyre, analagous to, though probably not homologous with, the poma (occipital operculum) of monkey brains (Fig. 787).

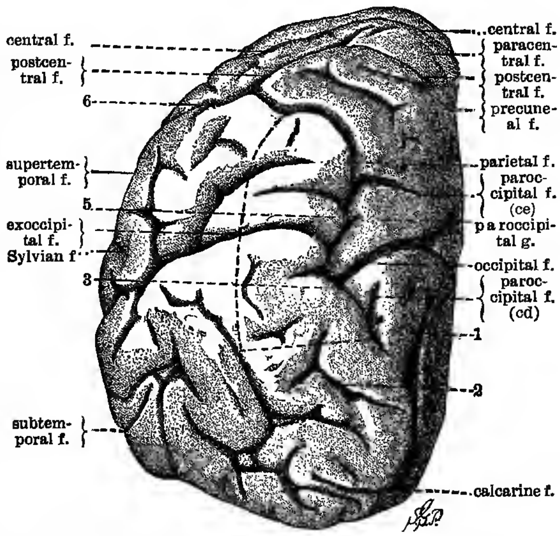


FIG. 785.—Dorso-Caudal Aspect of the Left Hemicerebrum of an Adult Male Mulatto; 322. × .8. 1, Nearly straight fissure along the caudal margin of the cuneus, the postcuneal f. (?); 2, unidentified occipital f.; 3, margin of a supergyre overlapping the paroccipital fissure, part of the paroccipital gyre, and the lateral end of the occipital fissure; 5, near the margin of the same supergyre; 6, ventral part of the postcentral f. The interrupted L-shaped line from opposite 1 to the middle of the length of the parietal fissure indicates the lines of incision by which the supergyre was removed, as seen in Fig. 786, where the two fissures are commented upon (see § 341).

For the *preparation*, see Fig. 757.

C. The conversion of the paroccipital fissure and gyre into a subfissure and subgyre.

D. The apparent continuity of the exoccipital with the occipital in the undissected brain.

E. In general, the desirability of checking all conclusions based upon the obvious features of the cerebrum, by an examination of the concealed conditions.

§ 342. The so-called "external occipital," or "external perpendicular," fissure of monkeys is a superfissure,

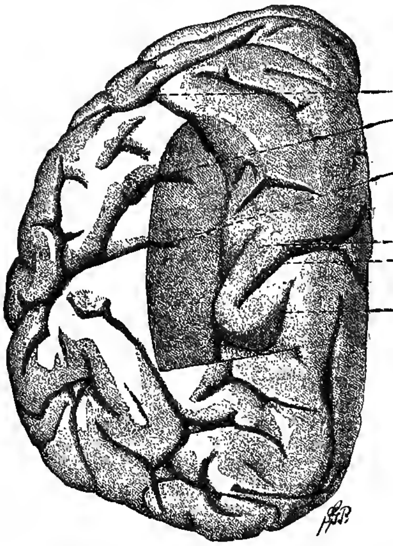


FIG. 786.—Dorso-Caudal Aspect of the Left Hemicerebrum of an Adult Male Mulatto, Partly Dissected; 322. × .8. 1, Junction of the parietal and postcentral fissures; 2, a fissure connected with the exoccipital.

Preparation.—By two incisions along the L-shaped line shown in Fig. 785 the supergyre there indicated by 3 and 5 has been removed.

factitious, variable, and heterogeneous, resulting from the lapping of a supergyre, the *poma* ("occipital operculum"), upon the parts cephalad of it; it may therefore be called the *pomatic* fissure.

§ 343. *Fig. 787 illustrates:* A. The relation of the poma ("occipital operculum") of monkeys, as a typical supergyre, to the paroccipital and part of the supertemporal, which are here subgyres.

B. The relation of the pomatic ("external occipital") fissure of monkeys, a typical superfissure, to the paroccipital and occipital fissures, which are here wholly or partly subfissures.

C. The, so to speak, factitious nature of the pomatic fissure, since it results, not from the opposition of two adjoining and approximately equal gyres, but from the lapping of one over the crests of those adjoining. As may be seen by comparing the two sides, it really comprises three distinct parts, viz., a lateral, between the pomatic margin and the ectal surface of the temporal gyre; an intermediate, coinciding with the cephalic stipe of the paroccipital fissure; a mesal, formed by the pomatic margin and the paroccipital gyre; finally, since the dorsal termination of the occipital fissure is covered by the poma, there results an apparent continuity of the pomatic and occipital fissures.

D. The continuity (depth not determined) of the paroccipital fissure with the parietal; see § 325.

E. The junction of the Sylvian and supertemporal fissures.

F. The distinctness of the "angular gyres."

G. The existence of peculiarities and complexities which, in my judgment, render monkey brains less serviceable than those of human fetuses for the elucidation of fissural problems.

§ 344. Under the various titles "external perpendicular," "external occipital," "temporo-occipital," "ape-fissure," "vordere occipital," etc., have been included several different human fissures or combinations of fissures, viz.: (A) The dorsal outcrop of an unusually deep occipital fissure; Marshall, "The Brain of a Bushwoman," *Philosophical Transactions*, cliv., p. 511, Figs. 1, 9, *h;* (B) a fissure on the lateral aspect caudad of the supertemporal, and having a general dorso-ventral direction; the *vordere occipital* of Wernicke ("Das Urwindungssystem des menschlichen Gehirns," *Arch. für Psychiatrie*, 1875, pl. v., Figs. 19 and 22, *k*); called *exoccipital* in the present article in order to avoid using the more natural mononym, *preoccipital*, already applied elsewhere by Meynert; (C) the combination of A and B,* on account of a supergyre which covers the dorsal end of the true occipital fissure (A) and permits the adjacent end of B apparently to become continuous with it, as in Figs. 785 and 786.

§ 345. No one of the fissures or fissural combinations mentioned in § 344 is identical with the pomatic fissure of most monkeys; but the exoccipital may exist in the true apes and in *Ateles* (Huxley, *Zool. Proc.*, 1861, pl. xxix.). It is doubtful whether the term "ape-fissure" is a desirable one to retain.†

§ 346. *What Significance Has the Arrangement of the Fissures?*—The query is warranted by two classes of facts, viz.: (1) with the mammals whose cerebrums are fissured a more or less definite fissural pattern has been recognized in most of the species studied in that respect;

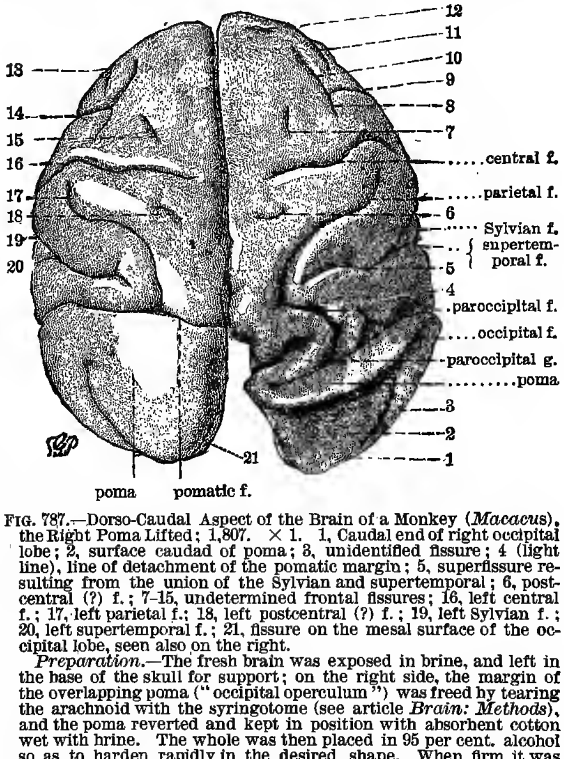


FIG. 787.—Dorso-Caudal Aspect of the Brain of a Monkey (*Macacus*), the Right Poma Lifted; 1,807. × 1. 1, Caudal end of right occipital lobe; 2, surface caudad of poma; 3, unidentified fissure; 4 (light line), line of detachment of the pomatic margin; 5, superfissure resulting from the union of the Sylvian and supertemporal; 6, postcentral (?) f.; 7-15, undetermined frontal fissures; 16, left central f.; 17, left parietal f.; 18, left postcentral (?) f.; 19, left Sylvian f.; 20, left supertemporal f.; 21, fissure on the mesal surface of the occipital lobe, seen also on the right.

Preparation.—The fresh brain was exposed in brine, and left in the base of the skull for support; on the right side, the margin of the overlapping poma ("occipital operculum") was freed by tearing the arachnoid with the syringotome (see article *Brain: Methods*), and the poma reverted and kept in position with absorbent cotton wet with brine. The whole was then placed in 95 per cent. alcohol so as to harden rapidly in the desired shape. When firm it was photographed from the dorso-caudal aspect, the lifted poma being greatly foreshortened. The parts on the left were undisturbed.

(2) the fissures of idiots are commonly peculiar in some way. There is, therefore, no reason, *a priori*, why one should not seek fissural correlation with sex, family, race, capacity, attainment, and character.

§ 347. Some idea of the problems involved and the difficulties of their solution may be gained from the com-

* "The so-called ape-fissure has been so termed because it imitates in disposition the opercular [my pomatic] fissure of the apes. It is, however, not a perfect homologue of that fissure, though its presence, when it is due to the fusion of the external occipital with the internal perpendicular sulcus, is a significant sign of disturbed cerebral growth" (E. C. Spitzka, "Insanity," 1887, 286).

† For some years I have been gathering materials for the elucidation of one of the most perplexing subjects in cerebral topography, the so-called "ape-fissure," but this is not the occasion for a full presentation of either facts or opinions.

parison of the cerebrums of the two philosophers, Wright and Oliver, the Swedish carpenter, and the unknown mulatto (Figs. 664, 762, 767, 770, and 788). The first two differ markedly not merely in detail but in general aspect; architecturally speaking, the gyres of Oliver are Corinthian in style, those of Wright, Egyptian. An approximation to this is seen in the mulatto. The mechanic's cerebrum is fissured to an unusual degree and the insula completely hidden; the philosopher had a larger brain, but its lateral aspect presents an equally unusual absence of fissural complexity and the insula is exposed.

§ 348. *Comments upon Fig. 788.*—Pending the detailed study and description of this very interesting brain by the writer, to whom it has been generously loaned from the Museum of Harvard Medical School, with the consent of its preparator and first describer, Dr. Thomas Dwight, the professor of anatomy, the following points may be noted: A. The great length of this hemicerebrum as compared with that of the mulatto (Fig. 762).

B. The special length of the caudal part, whether the central or the Sylvian fissure be taken as the dividing line.

C. The height of the frontal region.

D. The apparently slight extent of the prefrontal lobe; *apparently*, because, as is shown upon the dorsal aspect (Fig. 770), a large part of this region is invisible from the side, and is of unusual width.

E. The simplicity of the visible gyres, due to the few contortions of the main fissures, and the comparative infrequency of minor ones; *visible*, because the unseen cephalic surface of the prefrontal lobe presents a much greater complexity.

F. The condition of the minor fissures as sharp incisions rather than as slight depressions, like those in the Swedish brain (Fig. 767).

G. The visibility of the insula, at least equal to that in the mulatto (Fig. 762). Whether any of this condition is due to the pressure during hardening which may have occasioned also a peculiar roundness of the temporal lobe, it is impossible to determine, and Dr. Dwight does not recall the condition of the parts when the brain was removed.

H. The great length of the supertemporal fissure, and its dorsal subdivision.

I. The bifurcation of the Sylvian fissure, constituting perhaps an episylvian and hyposylvian as in the mulatto.

J. The complete independence of the precentral and subfrontal fissures.

K. The union of the proximal parts of the presylvian and subsylvian fissures, so as to separate the pre- and postoperculum.

L. The presence of an unusual, curved fissure (14) ventrad of the subcentral.

M. The crossing of the temporal region ventrad of the supertemporal fissure by several irregular fissures (transtemporal).

N. The complication of the zygal form of the orbital fissure by a branch extending cephalad from the middle of the zygon.

O. The complete interruption of the central fissure by an isthmus which is more clearly indicated in Figs 770 and 771.

P. The fulness or "plumpness" of the gyres, remarked by Dr. Dwight.

§ 349. *Is There a Criminal Type of Fissures?*—Benedikt and others have held that, in murderers for example, there is a tendency to fissural confluence or to a condition resembling that in certain carnivora. The materials at my disposal lead me to share the doubts expressed by Donaldson (*Amer. Neurol. Transactions*, 1892, p. 54), Schwekendiek (*Amer. Jour. Neurol. and Psychiatry*, i., 569–573), and Schäfer ("Quain"), 1893, 161. Upon the whole, notwithstanding the able contributions of Dercum (1889, 1892), Mickle (1896), Mills (1886), Weinberg (1896),

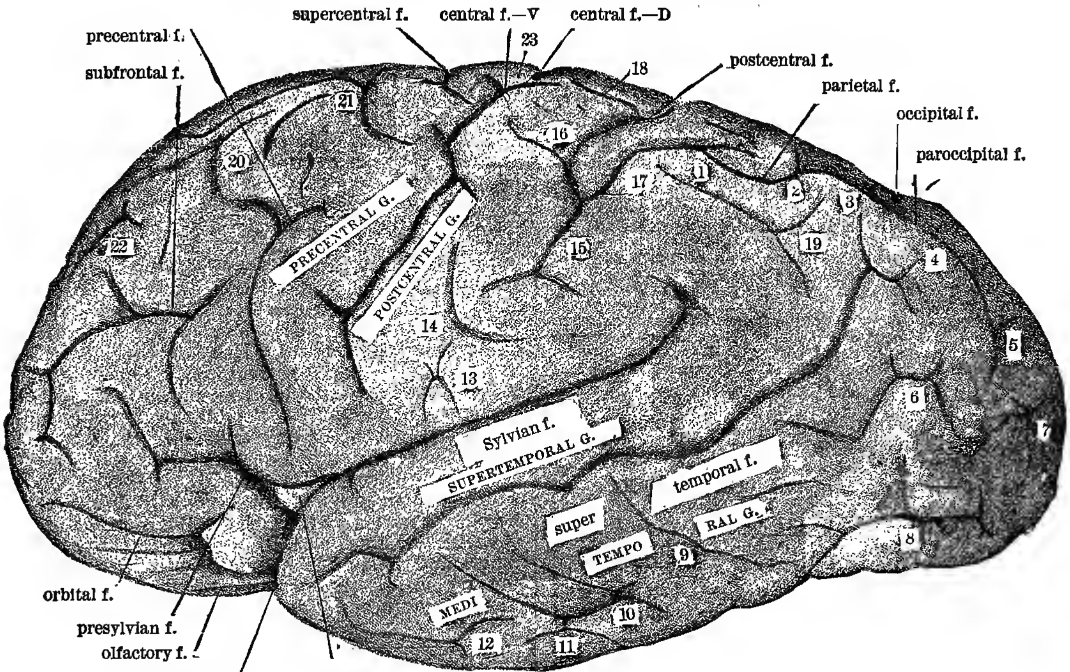


FIG. 788.—Lateral Aspect of the Left Hemicerebrum of Chauncey Wright, a Distinguished Philosophical Writer, who died in 1875 at the age of forty-five. × .85.

Preparation.—The brain was removed with care (in the usual way) and hardened in zinc chloride; there seems to have been considerable dorso-ventral sinking and lateral spreading. In the absence of a cast or measurements of the cranial cavity, it is of course impossible to say how extensive this distortion has been; enough, probably, to account for the flatness of the dorsal surface, and the consequent foreshortening of the fissures of that region as seen from the side, but not sufficient to have produced the great width of the prefrontal lobes, noted under Fig. 768. The figure accompanying Dwight's suggestive remarks upon this brain (*American Academy Proceedings*, 1877, xiii., pp. 210–215) is stated to be somewhat diagrammatic, largely, apparently, for the sake of exhibiting the entire lateral aspect to better advantage.

Wilmarth and others, I am disposed to regard as premature any conclusions as to fissural correlation, and to urge renewed and systematic efforts in three directions, viz.: (1) The determination of the standard fissural pattern for the *average well-born, orderly, and educated white male;* (2) the collation of the conditions in large numbers of individuals of the other sex, of other races (especially the African), and mental and moral conditions; (3) the detailed description and portrayal of the fissures of individuals of marked characteristics.

§ 350. *The Value of Organization.*—In France there has existed for many years a "Societé mutuelle d'Autopsie." In 1890 was formed the American Anthropometric Society, which has already received the brains of Harrison Allen, Edward D. Cope, Joseph Leidy (its first president), of his brother, Dr. Philip Leidy, and Dr. James W. White. I had already prepared a "Form of Bequest of Brain" which was first executed in 1889, and which, as since amended, is here reproduced:

FORM OF BEQUEST OF BRAIN.

I, ..., now of ...., student of .... from .... to ...., and graduated from .... in ...., recognizing the need of studying the brains of educated and orderly persons rather than those of the ignorant, criminal, or insane, in order to determine their weight, form, and fissural pattern, the correlations with bodily and mental powers of various kinds and degrees, and the influences of sex, age, and inheritance, hereby declare my wish that, at my death, my brain should be entrusted to the Cornell Brain Association (when that is organized) or (pending its organization) to the curator of the collection of human brains in the museum of Cornell University, for scientific uses, and for preservation, as a whole or in part as may be thought best. If my near relatives, by blood or by marriage, object seriously to the fulfilment of this bequest, it shall be void; but I earnestly hope that they may interpose neither objection nor obstacle. I ask them to notify the proper person promptly of my death; if possible, even, of its near approach.

Signature ....

Date..............................

Witness..........................

NOTES.—1. A duplicate copy of this form should be filled out and retained by the testator.

2. The bequest should be accompanied by a photograph and a sketch of life or character, or a reference to published biography.

3. The testator should give notice of any change of address, not merely on account of the bequest, but also in order that copies of circulars or other publications may be sent.

4. A brain is safely transmitted in a tin pail of some liquid of nearly its own specific gravity (about 1.04) in which it will just float without either pressing on the bottom or rising above the surface. The most readily prepared is nearly saturated brine, made by dissolving in water as much common salt as it will dissolve, then pouring it off, and adding a little water till the brain is just suspended. Preservation as well as safe transportation may be assured by adding sufficient salt to water containing three, four, or five parts of commercial (forty per cent.) formalin.*

5. The lid of the pail should be secured with surgeon's adhesive plaster; the pail should be addressed as follows: *Anatomical Department, Cornell University, Ithaca, N. Y. Specimen of Natural History. Perishable.*

6. Copies of provisional diagrams of the fissures will be mailed upon application. For a statement of reasons for the study of the brains of educated persons, see Buck's REFERENCE HANDBOOK OF THE MEDICAL SCIENCES (Wm. Wood & Co., New York), VIII., 163, and IX., 110.

Besides the nine named in § 315 whose brains have already come into our possession, the "Form" has been filled out by more than fifty, including undergraduates, alumni, and teachers in this and other institutions of learning.

§ 351. *The Public should be Educated in This Respect.*—From the physiological and psychological standpoint it is clearly desirable to study the cerebrums of persons whose mental or physical powers were marked and well known.† The present condition of things is illogical and unprofitable. We scrutinize and record the characters and attainments of public men, clergymen, and friends, whose brains are unobtainable. We study the brains of paupers, insane, and criminals, whose characters are unknown or perhaps not worth knowing.

It is at once a reproach and an irreparable loss to science that the community has not yet been convinced that the preservation and study of one's brain is an honor to be coveted. Who can set a limit to the results that might have been attained from the examination of the brains of soldiers like Grant, Sherman, and Sheridan; of preachers like Beecher, Brooks, and Howard Crosby; of naturalists like Agassiz, Gray, and Jeffries Wyman; of lawyers like Tilden, Conkling, and Benjamin Butler? How long must science wait for a general sentiment such as is embodied in the declaration of an eminent historian, that science is as welcome to his brain as to his old hat, and that he wishes he had ten of them?*

§ 352. *Brain Weight.*—This interesting topic is discussed from the human side in the article *Brain, Growth of the,* but a few words may be added here as to comparative weight.†

§ 353. In *absolute* weight the human brain is exceeded by those of whales and porpoises (2,265–3,171 gm., 5–7 pounds) and of elephants (4,530 and upward, 10 pounds or more). The lowest of these figures approximates the greatest weight claimed for a *non-hydrocephalic* ‡ human brain. A negro brain described by Dr. C. Tompkins, *Virginia Med. Monthly,* January, 1882, pp. 291–293, weighed 1,983.80 (70 ounces or 4 pounds 6 ounces). Van Walsem has described (*Neurologisches Centralblatt,* xviii., No. 13, 1899) the brain of an epileptic idiot which weighed, when fresh, 2,850 gm. (90 ounces, or 5 pounds 10 ounces)!

§ 354. But in no animal other than those mentioned above is the brain as heavy as the smallest human, viz., that of a Bushwoman, 871 gm. (30.75 ounces). In a bull it was 337 gm., in a lion, 198, and in an adult gorilla only 425 (15 ounces) (Owen, iii., 144). The largest ape brain is then only half as large as the smallest normal human.

§ 355. The *relative weights* of the body and brain vary greatly according to the condition of the former at death. Most of the cases tabulated were of persons dying after more or less prolonged disease, and the figures are as follows: for 81 males, 1 to 36.50; for 82 females, 1 to 36.46; according to Bischoff, 1 to 35.20. Quain concludes that in healthy individuals dying suddenly from disease or accident, the ratio is probably about as 1 to 45. In comparing man with animals in this respect this last ratio should commonly be adopted.

§ 356. Owen estimates the adult male gorilla at 200 pounds, or 90,720 gm., and the brain would be as 1 to 213; in a bull it was as 1 to 2,000, and in a lion as 1 to 555. On the other hand, in a sparrow the ratio was as 1 to 25; and in a marmoset (*Midas*) 1 to 20 (Owen, iii., 142); and in *Jacchus vulgaris* (No. 664, Cornell University Museum), as 1 to 19. But it is to be noted that in these small monkeys, as in birds, the cerebrum is *not fissured.* Perhaps the least misleading mode of stating the case is to say that the human brain is relatively heavier than that of any animal larger than a cat in which the cerebrum is fissured.

VIII. RHINENCEPHAL.—§ 357. *Olfactory Bulb and Tract.*—These parts of the human brain have already been shown from various aspects in Figs. 663, 670, 672, 689, 751, 752, and 765. In Fig. 789 they present almost diagrammatic simplicity as a tongue-like extension from the region of the postcribrum ("anterior perforated space") more or less completely covering the olfactory fissure.

* For other liquids adapted to the transportation and preservation of the brain, see the article, *Brain: Methods.*

† Among the individuals best adapted to subserve this object are college professors, who have usually somewhat sharply defined capacities and attainments, and are the subjects of prolonged and discriminating observation and discussion among their trustees, colleagues, and students; no professor's brain should be lost to neurological science.

* It is encouraging to know that the brain of the late George Grote, historian of Greece, has been described by John Marshall in the Jour. of Anat. and Physiol., vol. xxvii., pp. 21–68.

† The two papers of Waldeyer (1896) contain the titles of six hundred and thirty-seven books and papers relating to fissures, gyres, commissures, and brain weight, and published, for the most part, between 1879 and 1898.

‡ The brain of a Chippewa Indian squaw, eighty-five years old, rachitic, in the Army Medical Museum, Anatomical Section, No. 1,031, weighed when fresh 73.5 ounces (2,083.72 gm.), but it was *hydrocephalic,* and the curator informs me that the "ventricular liquid was probably included in the weight."

§ 358. *Fig. 789 illustrates:* A. The length of the olfactory bulb at this period, as compared with its tract, which latter is the longer in the adult.

B. The concealment of the entire olfactory fissure by the olfactory bulb; in the adult, usually, the fissure projects considerably beyond the bulb (Fig. 672).

C. The apparent continuity of the insula with the lateral root of the olfactory tract.

D. The partial covering of the insula at this period.

E. The thickness and roundness of the margin of the operculum.

F. The formation, at this period, of the presylvian fissure, constituting the cephalic limit of the operculum, but the non-existence of a subsylvian fissure.

§ 359. The corresponding parts in several other vertebrates are shown in Figs. 680 (turtle), 685 (frog), 717 (salamander), 682 and 686 (cat), and 688, 726, and 794 (sheep). Any remnant of the former anthropotomical idea that the olfactory tracts and bulbs constitute merely the first pair of cranial nerves * will probably be dispelled

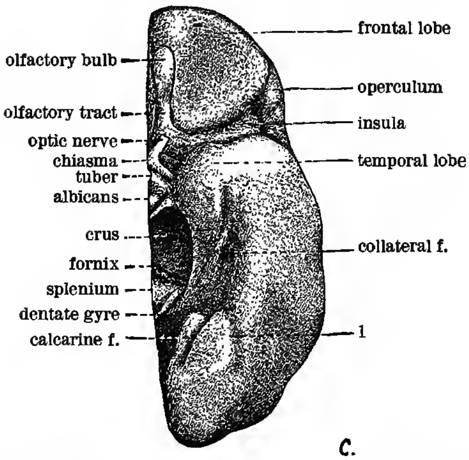


FIG. 789.—Ventral Aspect of the Left Hemicerebrum of a Fetus, Size and Age Unknown; 1,820. × 1. The lateral aspect of the same preparation is shown in Fig. 751.

by noting the relative extent of the corresponding parts in still lower forms, the lamprey (Fig. 790) and the hag (Fig. 791).

§ 360. *Fig. 790 illustrates:* A. The representation of all the six definitive segments in this lowly vertebrate; the mesencephalic lobes (geminum) are prominent; the cerebellum is small and was removed with the rest of the roof.

B. The preponderance of the olfactory bulbs over the lateral masses presumably representing the cerebral hemispheres.

C. The concomitantly large size of the lateral portion of the rhinocele.

§ 361. *Fig. 791 illustrates:* A. The most distinctive character of the myxinoid brain, *i.e.*, the insignificance of the intermediate region represented in most vertebrates by the more or less prominent cerebellum and quadrigeminum; hence the entire organ naturally divides itself into a caudal portion, the oblongata, obviously an enlargement of the myel, and the brain proper, comprising four pairs of lobes narrowing caudad.

B. The large size of the olfactory bulbs, especially as seen from the ventral side.

C. The continuity of the olfactory bulbs across the meson, as seen from the ventral aspect.

D. The unusual location or trend of the mesal body provisionally named "epiphysis or dorsal sac," viz., nearer the cephalic than the caudal limit of the segment interpreted as the thalami or diencephal.

E. The vagueness of certain features due to the imperfect condition of the specimen. It was prepared by me in 1875 and the membranes, including the metatela, prematurely removed. There has not been time to prepare another, and the published accounts and figures do not clear up all the doubtful points.

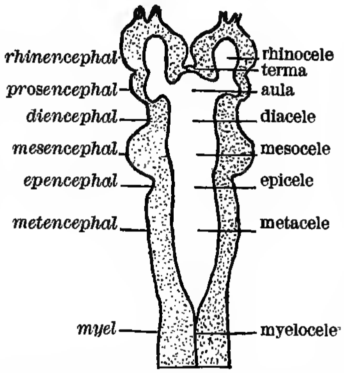


FIG. 790.—Diagram of the Brain of the Sea-Lamprey, *Petromyzon marinus*, as if the roof of the cavities was removed: enlarged. It is based upon several preparations made by me in 1874, and would be changed in some respects if made from microscopic sections; but the main features are believed to be accurate.

§ 362. *Rhinocele.*—In vertebrates generally (*e.g.*, the lamprey, Fig. 790) and in most mammals (*e.g.*, the sheep, Fig. 792), the olfactory bulb and crus contain a cavity, the *rhinocele*, continuous with the paracele and united with its opposite across the meson by the aula. Strictly and by analogy *rhinocele* should apply to the entire cavity of the rhinencephal, but for the present it is at least convenient to employ it also for either lateral portion.

§ 363. The development of the olfactory portion of the brain varies so greatly among mammals that Broca, Turner, and others have proposed groupings based thereon, viz., into *macrosmatic, e.g.*, the armadillo; *microsmatic, e.g.*, man and apes; and *anosmatic*, the porpoise, where the olfactory tract and bulb seem to be wholly absent, although the early fetal conditions are not known. The conditions in dogs are peculiar, as appears in the following abstract of P. A. Fish's paper, 1891:

1. The facts do not warrant Broca's statement as to the existence of a true ventricular axis (core of solid material in place of the primitive cavity) in the olfactory bulb, even in rat-terriers.

2. The bulb is not completely but partially occluded, or perhaps in process of becoming entirely so.

3. The cavity of the tract, in some wild forms as well as domestic, is completely closed, thereby cutting off all communication between the paracele and the cavity of the bulb.

4. The acuteness of the sense of smell is

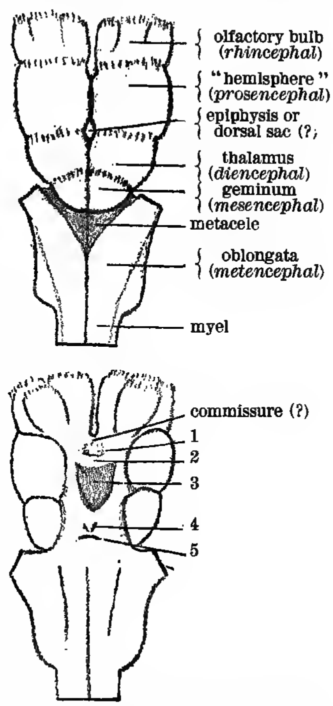


FIG. 791.—Dorsal (Upper) and Ventral (Lower) Aspects of the Brain of the Hag, *Bdellostoma*; 212. × 2.5.

* For the present it will probably prove convenient at least to avoid modification of the accepted numerical designations of the heterogeneous cranial nerves by regarding as the "first pair" the nervous filaments which connect the olfactory bulbs with the nasal mucosa.

not essentially dependent upon the relative size of the rhinocele.

5. Atrophy is not a necessary concomitant of occlusion.

6. Domestication, and the consequent disuse of olfaction as a means for procuring sustenance, may be a factor in promoting occlusion.

7. In the classifications of Broca and Turner the dog seems to hold an anomalous position, in that he gives every external evidence of macrosmatic power; but by the almost total occlusion of his rhinocele he approaches structurally the conditions found in the microsmatics. Physiologically he is macrosmatic; morphologically he is microsmatic.

§ 364. *Precommissure.*—As stated in §§ 45 and 210, this fibrous bundle, single at the meson, soon divides into a cerebral portion (*pars temporalis*) and an olfactory (*pars olfactoria*). The gross relations of the two are well shown in Fig. 792. For the microscopic arrangement of this and other fibrous constituents of the olfactory apparatus see the article *Brain, Histology of the.*

§ 365. *Fig. 792 illustrates:* A. The divergence of the olfactory and cerebral divisions of the precommissure just laterad of the meson.

B. The relatively large size of the olfactory division in the sheep.

C. The large size of the rhinocele, but the narrowness of the strait connecting it with the precornu.

§ 366. *Crista.*—In the cat, adult as well as fetal, the caudal or celian aspect of the terma, between the columns of the fornix, presents (Fig. 686) a mesal hemispherical

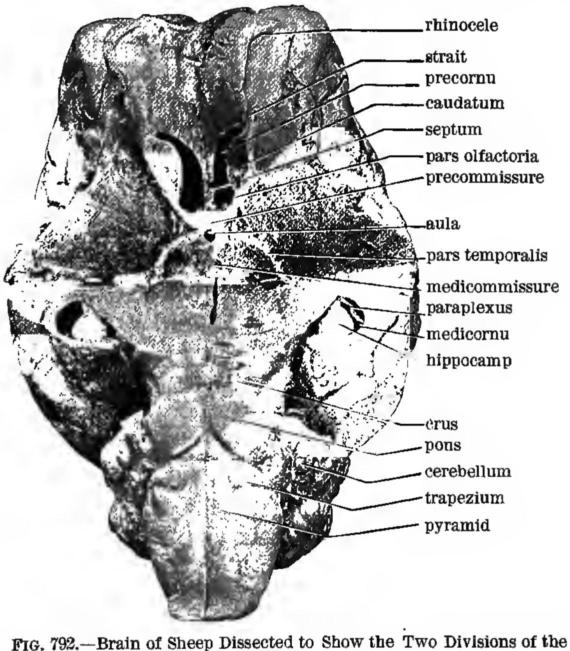


FIG. 792.—Brain of Sheep Dissected to Show the Two Divisions of the Precommissure; 2,653. × .9. Prepared by P. A. Fish. The cerebrum was cut from the ventral side in two planes meeting at about a right angle along the line indicated by the shadow just caudad of the line from the word *medicommissure.* The cephalic slope was then very carefully sliced to a deeper level, so as to leave the precommissure in relief. Unfortunately the *pars olfactoria* on the left (right of the picture) has since been broken, accounting for the interruption in the figure. Just within the aula may be dimly seen the crista. Compare with the medisected brain (article, *Brain: Methods*), and that of the cat (Fig. 686).

body which is translucent when fresh. In some lower vertebrates it seems to be represented by a membranous mass. It has been observed in comparatively few forms, and its structure, connections, and significance are undetermined. I have never seen it in adult human brains, but it is perfectly distinct in the preparation represented in Fig. 793. If there is a rhinencephalic segment the crista is to be regarded as one of its constituents.

§ 367. *Fig. 793 illustrates:* A. The presence of the crista in a child at term.

B. The dorsal limitation of the aula and the two portas by the line of reflection of the endyma constituting a ripa.

C. The narrowness of the body of the fornix as compared with that of the cat and most other mammals.

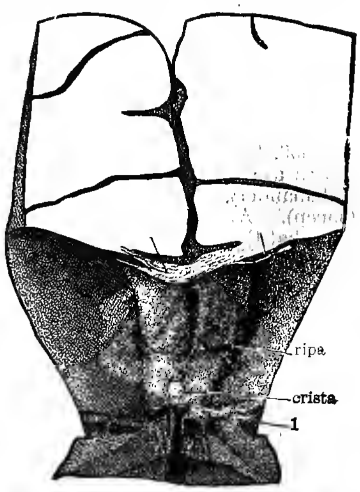


FIG. 793.—The Crista and Adjacent Parts of a Child at Term; 4. × 1.5.

Preparation.—After transection at about the middle of the diacele, the thalami were torn from their continuity with the fornix, leaving the irregular surface at and ventrad of 1. The lateral parts were then removed, as indicated in the drawing. The paraplexus was torn from the margin of the fimbria, constituting the lateral part of the fornix; the short line at the right ascends from the fimbria, crossing the intervening space; paracele. On the left the similar line begins more nearly at the middle of the fornix, and crosses first the callosum itself, and then the callosal fissure. Before photographing, the crista was touched with white paint.

Defects.—The brain was ill preserved, and broke apart during dissection; the shading is too heavy.

D. The division of the caudo-ventral surface of the fornix, by the ripa mentioned under B, into an entocelian area, covered by endyma and forming the cephalic wall of the aula and the two portas, and an ectocelian area, covered by pia, the dorsal or fornical layer of the velum.

§ 368. *The Word Rhinencephalon Used in Several Senses.*—Some confusion may be avoided if it is clearly recognized that one and the same word has at least five different significations.

1. Owen applied *rhinencephalon* to the two olfactory bulbs and their tracts (or crura) without apparent reference to any mesal or connecting constituents.*

2. Turner proposed (1890) to regard the prosencephal as divided horizontally by the rhinal fissure (olfactory and postrhinal) into a ventral portion, the rhinencephalon, and a dorsal, the pallium.

3. Shäfer proposed (Quain, 1893, 160) to include under rhinencephalon the remainder of the so-called "limbic lobe" (the hippocampal gyre), and the callosal or "*gyrus fornicatus.*" †

4. His considers (1893) that the bulbs and tracts, the precribrums ("anterior perforated spaces") and some other parts, under the name rhinencephalon, constitute one of three components of the dorsal zone of the most "anterior" segment, which he names *telencephalon.* This view has been adopted by the Anatomische Gesellschaft and is indicated in the Table in the article, *Brain, Development of;* see also my Table I.

5. In the report of the Committee on Anatomical Nomenclature which was adopted by the Association of the American Anatomists in 1897 (*Proceedings,* p. 47) the rhinencephalon was regarded as a definitive segment consisting of the olfactory bulbs and tracts and some other parts united across the meson by the pars olfactoria of the precommissure, the lateral cavities being connected

* The mesal contact or coalescence of the bulbs in frogs and toads, and (as observed by Mrs. Gage, 1895) in certain turtles and birds, is a secondary condition that has no bearing on the segmental constitution of the parts.

* Since the name and notion of a "*lobus limbicus*" seem to he sometimes adopted without adequate inquiry, I cannot refrain from pointing out that, as is clear in Shäfer's diagram (Fig. 109), its alleged boundaries are not continuous in man, and I am not aware that they are in any animal.

by the mesal aula. The other constituents of the rhinencephal are named in Table I. (See above § 713.)

§ 369. *Commentaries on Fig.* 794.—Besides facilitating the recognition of certain important parts and their rela-

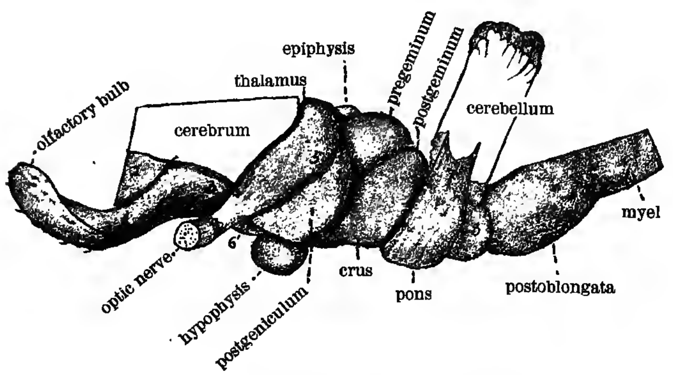


FIG. 794.—Left Side of the Sheep's Brain After the Removal of Portions of the Cerebrum and Cerebellum, So as to Display the Segmental Constitution of the Organ. (From "Physiology Practicums"; compare Fig. 688.)

1, 3, Olfactory tract; 2, a part of the pallium which has not been cut; 4 (indistinct), chiasma; 5, pregeniculum (external or anterior geniculate body), distinct in man but here little more than a lateral portion of the thalamus; 6, tuber (*cinereum*), the slight convexity to which the hypophysis is attached; 7, medipeduncle; 8, trapezium.

The short lines on the surface of the olfactory bulb represent the olfactory nerves. The cut end of the left optic nerve is dotted to indicate its fibrous structure.

Excepting the unshaded areas, representing cut surfaces, all the parts seen in this figure were covered by pia.

Preparation.—The cerebellum is left of its natural height, but the cephalic and caudal convexities are sliced away so as to expose the parts which are overhung by them. The cerebrum has been cut down to the level of the thalami; the caudal portion cut away along the oblique line of its projection over the part marked 5; the lateral portion so as to expose the part marked 3; also the cephalic projection which overhangs the olfactory bulbs.

tive positions, this figure well illustrates the *segmental constitution* of the brain, which is obscured in the entire organ by the preponderance of the cerebrum and cerebellum. There is a series of more or less distinct masses demarcated by constrictions of greater or less depth. Admitting that there is still some doubt as to number and limits of the segments, the following assignments may be accepted provisionally:

Olfactory bulbs and tracts	RHINENCEPHAL.
Cerebrum	PROSENCEPHAL (fore-brain).
Thalami, epiphysis, hypophysis, chiasma, and geniculums	DIENCEPHAL (inter-brain).
Geminums and crura	MESENCEPHAL (mid-brain).
Cerebellum, pons, and preoblongata	EPENCEPHAL (hind-brain).
Postoblongata	METENCEPHAL (after-brain).

See the fuller Table on page 153.

§ 370. *Is there a Rhinencephalic Segment?*—That I am at present disposed to answer this question in the affirmative is indicated in diagrams (Figs. 674 and 675), Tables (I. and II.), and remarks (§ 45) in the earlier part of this article; see also Figs. 790, 791, and 794. The whole subject is still under discussion and likely to be for some time to come, and this is not the occasion for detailed argument. There may be stated here, however, three facts that may not be familiar to all students of normal human anatomy:

1. In the lamprey and hag, although the olfactory bulbs are paired, the olfactory sac and nostril are single and mesal.

2. In the lancelet (*Amphioxus* or *Branchiostoma*) the olfactory bulb is single and approximately mesal, although, like several other organs of this peculiar vertebrate, not quite mesal.

3. In the malformation called monophthalmia or cyclopia (see Fig. 712 and the article *Teratology*), not only the cerebrum but also the olfactory portion of the brain may be single and mesal. A very instructive case is described and figured by Cunningham and Bennett, Royal *Irish Acad. Trans.*, xxix., 101–122.

§ 371. *Limits of the Rhinencephal.*—These were not defined in the report adopted by the A. A. A., and cannot yet, perhaps, be determined with accuracy. But as an individual I may here express the opinion that in mammals the caudal boundary coincides practically with the origin of the medicerebral ("middle cerebral") artery, or with the place of junction of the Sylvian fissure with the "rhinal," including by this the olfactory and the postrhinal (amygdaline) together. This leaves the tip of the temporal lobe, the lobus hippocampi, and the whole hippocampal gyre as parts of the prosencephalic pallium, although they may contain the cortical centres of the olfactory sense. In the lower mammals, the elevation sometimes called *protuberantia natiformis* similarly lies caudad of the rhinencephalic boundary.

§ 372. *Postrhinal Fissure*—Although regarded as lying within the pallium and thus in the prosencephal rather than the rhinencephal its associations are such that a few words may be added here as to its apparently different locations in man and in the lower mammals. In the latter both it and the olfactory fissure are visible from the lateral aspect. But in the lower monkeys the greater development of the pallium crowds them to the ventral side, and in man and apes the postrhinal fissure becomes actually mesal (Figs. 765, 766).

IX. MENINGES (THE ENVELOPES OR MEMBRANES OF THE BRAIN AND SPINAL CORD).—§ 373. *Definitions.*—*Meninges* is the plural of *meninx*, from the Greek μῆνιγξ, signifying any membrane or coating, as of the eyeball, and even the scum upon milk or wine: but, as stated by Hyrtl ("Onomatologia," p. 324), the word was restricted by Aristotle ("Hist. Anim.," lib. i., cap. 16) to the coverings of the brain (and myel?), and the limitation has been since maintained. The synonyms of *meninx* are: Fr., *méninge;* It. and Sp., *meninge;* Ger., *Hirnhaut.*

§ 374. *The Three Meninges.*—Nearly all anatomists recognize three chief membranous envelopes between the substance of the neuron (brain and spinal cord) and the craniospinal canal, viz.: an ental, the *pia;* an ectal, the *dura;* an intermediate, the *arachnoid.* Their relative positions when the cranium is opened are indicated in Figs. 795 and 796. Properly speaking the pia pertains to the neuron, and the dura to the craniospinal canal, while the arachnoid has more or less varied relations to both the other meninges. All three present differences according to their location within the cranium or the spine, and there are transition conditions in the cephalic portion of the latter which are not yet fully made out.*

§ 375. The term *pachymeninx* (tough envelope) is sometimes used for the dura, irrespective of the recognition of a parietal layer of arachnoid. In like manner *leptomeninx* (tender envelope) is sometimes used for the pia and the commonly admitted visceral layer of arachnoid. The pathological terms, *pachymeningitis* and *leptomeningitis* are derived from these words.

§ 376. *Fig. 795 illustrates:* A. The successive coverings of the brain, hairy scalp, periosteum, calva

* The conditions of investigation of the meninges are peculiar. The pia and arachnoid are relatively delicate; they are easily torn and their attachments ruptured; they are surrounded by an unusually tough membrane, the dura, and the whole is enclosed within a case of bone, which must be sawn or otherwise forcibly opened by measures which are almost sure to rupture the pia and arachnoid. It is much to be desired that the subject be reviewed by some anatomist having the use of a mechanical bone-cutting apparatus, *e.g.*, the electro-osteotome of the late Dr. M. J. Roberts.

(calvarium) dura (ental periosteum), arachnoid, and pia.

B. The shadowy appearance of a fissure covered by the piarachnoid and the sharper outline when it is removed (Fig. 802).

C. The difficulty of separating the arachnoid from the pia; in a transection of a fissure, however, the former

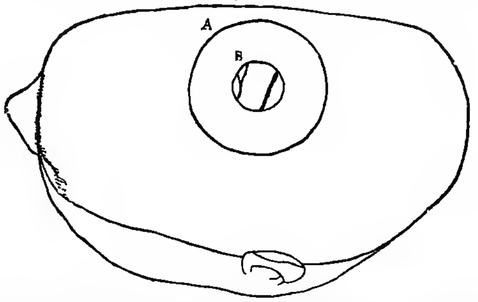


FIG. 795.—Outline of the Dorso-Lateral Aspect of the Left Half of the Head of an Adult Man, with the Brain Exposed in the Region of the Central Fissure; 811. × .3.

Preparation.—The entire head was alinjected by continuous pressure for a week, and medisected as shown in Fig. 670. From the general region of the central fissure was removed a disc of the scalp about 6 cm. in diameter (A); in the centre of the area so exposed, a disc of the calva (calvaria, cranial vault) was removed with a trephine 2.5 cm. in diameter, and the corresponding disc of dura cut out (B). The further preparation of the specimen is described under Fig. 796; the present outline is mainly given in order that the region may be located approximately upon the head.

will be seen to pass across the fissure from gyre to gyre, while the latter, with blood-vessels, dips into the fissure as a fold (Fig. 735).

D. The presence on the ental surface of the piarachnoid of a pial fold, the *ruga*, lying in the fissure.

E. The minutely punctate aspect of the depiated cortex by reason of the extraction of minute vessels entering from the pia. The ental surface of the pia, here represented smooth, should have a flocculent appearance, called *tomentum*, from the attachment of these vessels.

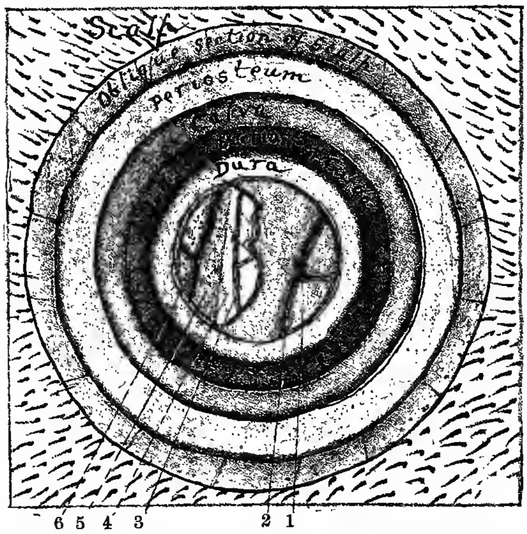


FIG. 796.—The Several Coverings of the Brain Exposed as a Series of Terraces; 811. × .9. 1, The arachnoid, the ectal layer of the piarachnoid; 2, a fissure, still covered by the piarachnoid; 3, ruga, the fold of pia that has been pulled out of the fissure 6; 4, ental (pial) surface of the flap of piarachnoid everted from the surface of 5, a gyre, between fissures 2 and 6; 6, a fissure from which the ruga and adjacent piarachnoid have been removed.

Preparation.—The region here included is a square of the region shown in Fig. 795. The outer line corresponds with the circle A, and the inner with circle B. The scalp was divided obliquely so as to expose a converging surface. A disc of periosteum was cut out a little smaller than the ental line of the scalp. The original trephined orifice in the calva was then enlarged with nippers, so as to leave a converging surface, the ectal circle a little smaller than the hole in the periosteum, and the ental about as much larger than the hole in the dura. Two fissures could be seen; over the caudal the piarachnoid was left undisturbed; at the cephalic side of the dural orifice a semilunar flap was lifted and reflected so as to expose the ental surface and the fissure and adjoining gyres which it had covered.

§ 377. *Fig. 797 illustrates:* A. The subcylindrical form of the myel, and the relations of the areas of alba and cinerea at this level; see the article, *Spinal Cord.*

B. The existence of a dural sheath (theca) of the myel, independent of the periosteum, the two being united in the cranium.

C. The somewhat loose adhesion of the arachnoid to the dura, leaving slight and scattered subdural spaces.

D. The presence of the *septum posticum* at this level; it is said (Shäfer, iii., 188) to be most perfect in the cervical region, and more or less incomplete farther caudad.*

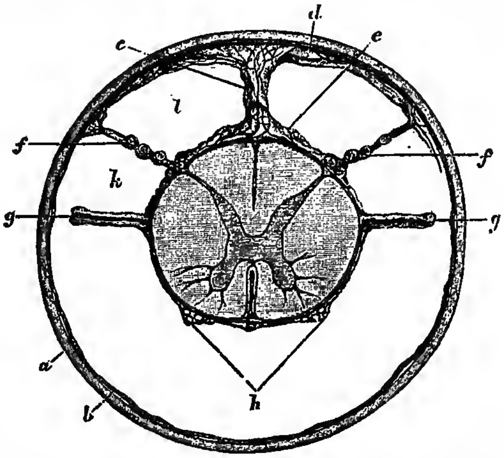


FIG. 797.—Transection of the Myel and Its Meninges in the "Upper" Thoracic Region. (Enlarged somewhat from Key and Retzius, Taf. i., Fig. 7, after Shäfer: Quain, iii., Fig. 132.) *a*, Dura (not the spinal periosteum, but representing the ental layer of cranial dura); *b*, arachnoid: c, septum posticum; *d*, *e*, *f*, trabeculæ in the subarachnoid space, those at *f* supporting the dorsal (posterior) nerve roots; *g*, ligamentum denticulatum; *h*. ventral (anterior) nerve roots, cut off; *k*, *l*, subarachnoid spaces. The pia is not designated, but may be recognized as the double outline of the myel dipping into the dorsal fissure as a narrow septum and into the ventral as a fold.

Note.—The foregoing is substantially the description in Shäfer. But some of my observations lead me to suggest that the spinal, like the cranial, arachnoid comprises two layers, a dural and a pial, connected by the reflected layers of the septum posticum. This view, however, would homologize the space *k*, *l*, with the intrarachnoid space of the cranium, and hence their free communication with the postcisterna would be difficult to explain.

E. The size of the subarachnoid space traversed by the spinal nerve roots, the trabeculæ, and the *ligamentum denticulatum.*

F. The location of the *ligamentum denticulatum* at either side of the myel. This is a fibrous band connected with the pia, and reaching the dura by a triangular extension in the intervals between the nerve roots; but opposite the roots (as in this figure) it is narrower, and does not reach the dura.

§ 378. *Dura.*—This mononym is rapidly replacing *dura mater* and the German *harte Hirnhaut.*† As shown in Figs. 796, 799, and 804, the cranial dura is apparently a single sheet, dense, strong, fibrous, and unyielding, lining the bones and constituting their ental periosteum (endocranium). But a closer examination detects two layers, an ectal and an ental, which gradually separate in the cephalic part of the cervical region, and in the

* *Septicum posticum* is an undesirable term, but *septum dorsale* might be confounded with the prolongation of the pia into the dorsal fissure of the myel.

† The reduction of the polyonyms, *pia mater* and *dura mater*, to the mononyms pia and dura was urged by me twenty years ago (1880, *f*). The use of pia and dura, and of the natural adjectives, pial and dural, has now become quite general. The simplification has been recommended by the Association of American Anatomists (December 27th, 1889), by the American Association for the Advancement of Science, 1890 and 1892, and by the American Neurological Association, June 5th, 1896.

spine maintain diverse relations, the one with the canal, the other with the myel.

§ 379. *Theca.*—The ental or myelic portion of the spinal dura constitutes a fibrous tube, the theca. It is

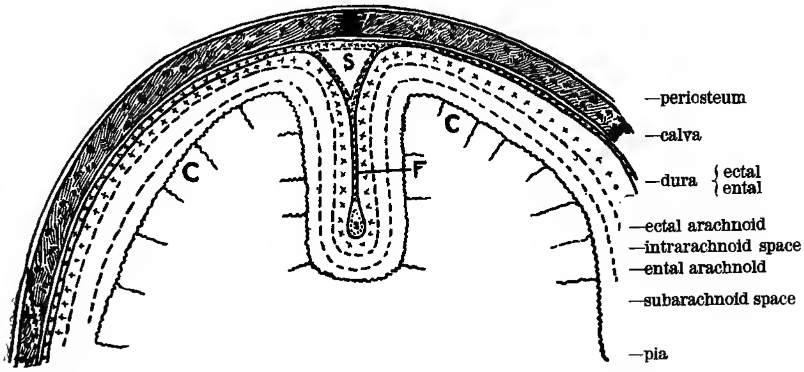


FIG. 798.—Schematic Transection of the Parietal Region of the New Born, to show the Relations of the Meninges to the Cerebrum and Cranium. (From Langdon, 1891.) C, C, Cerebrum; F, falx; S, longitudinal sinus; xxx, subserous connective tissue between the dura and the ectal arachnoid.

*Defects.**—The mesal dark area dorsad of S (the longitudinal sinus) represents the ligamentous connection of the two parietal bones; it should be continuous with the periosteum and ectal dura. The "subserous dura," between the dura and the arachnoid, represented by the series of crosses, is made too wide in proportion.

considerably longer and larger than the myel itself, and separated from the periosteum constituting the wall of the canal by venous plexuses and much areolar tissue. The cavity between the pia and the dura is occupied by cerebro-spinal fluid (neurolymph), and is divided by the curtain-like arachnoid into the spaces subdural and subarachnoid. Within the latter the myel, closely covered by pia, is suspended, being kept in position by a ligament on each side, *ligamentum denticulatum* (Fig. 797), which fixes it at frequent intervals to its sheath, and by the roots of the spinal nerves (Fig. 797, *f*), which cross the space from the surface of the myel to the intervertebral foramina.

§ 380. *Fig. 798 illustrates:* A. The existence of two layers of dura in the cranium, the one corresponding with the periosteum of the spinal canal, the other with the dural sheath of the myel, Fig. 797, *a*.

B. The existence of two layers of arachnoid—an ental or pial, and an ectal or dural.

C. The propriety of regarding the so-called subdural space as an intrarachnoid space, analogous with the serous sacs in other parts of the body (see § 399).

§ 381. *Fig. 799 illustrates:* A. The formation of a nerve root from the union of several funiculi or rootlets.

B. The extension of the myelic dura upon the root at its exit from the spinal canal, to be lost in the sheath of the nerve.

§ 382. *Epidural Space.*—In the spine, since there are two layers of dura, an ectal (periosteal) and an ental (myelic), the interval between them constitutes an epidural space. In the figures this is nowhere clearly shown, but it may be represented in Fig. 797 by drawing around the present ectal outline, the myelic dura, a second at a little distance therefrom; the interval would be the epidural space.

§ 383. Two questions naturally arise in connection with the epidural space.

1. Does it communicate with the subdural space? If so, where?

2. If not, what is the source of the liquid occupying the space, and what is its nature?

§ 384. *Fig. 800 illustrates:* A. The relation of the dura to the cranium as a complete lining of considerable thickness.

* Dr. Langdon informs me that the cut does not represent the original drawing quite fairly in some respects.

B. The relation of the falx (1) and falcula (13), as mesal extensions of the dura, to the tentorium (8) as a transverse extension.

C. The tent-like form of the tentorium, the lateral margins coinciding approximately with the long axis of the cranium, the intermediate portion rising toward the meson at an angle rapidly increasing from the occiput cephalad.

D. The inversion of the falcula as compared with the falx.

E. The general arrangement of the more prominent fibres of the falx; there is a marked divergence or radiation from about the place of intersection of the free margins of the falx and the tentorium.

F. The locations of the principal sinuses along the lines of attachment of the dural folds to one another or to the cranium.

G. The direction of the current in the principal sinuses: in the longitudinal (2) and tentorial (6) (with the falcial) (4) toward the torcular; in the lateral (9), toward the exit in the base of the skull at the jugular vein (4), in the superpetrosal and subpetrosal (10, 11) to the lateral.

The entrance of the supercerebral veins into the longitudinal sinus at the points indicated by the black spots in the course of the latter and at others not indicated.

§ 385. *Tentorium.*—The cerebral region of the cranium is partitioned off from the region containing the cerebellum by a fold of the ectal layer of the dura, which, from

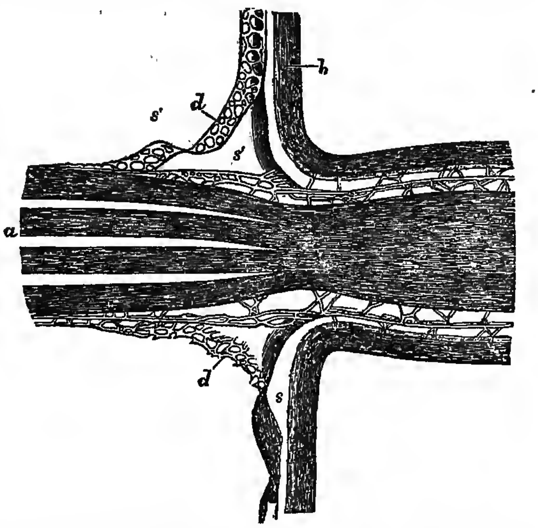


FIG. 799.—Section, Lengthwise, of a Ventral Nerve Root at Its Place of Exit from the Spinal Canal. Enlarged. (From Key and Retzius, Taf. i., Fig. 10; after Shäfer: Quain, iii., Fig. 128.) *a*, Four funiculi uniting to constitute the root; *b*, dura reflected upon the root at its emergence through the intervertebral foramen (the periosteum is not shown); *c*, arachnoid; *d*, reticular lamella of the arachnoid reflected upon the root (compare Fig. 797, *f*); *s*, subdural space; *s'*, subarachnoid space.

its arched shape, is called the *tentorium* (*cerebelli*), Fig. 800. See also the article *Brain, Circulation of.*

The tentorium exists in most, if not all, mammals, but not, so far as I am aware, in other vertebrates; in the carnivora it is ossified.

§ 386. *Falx.*—From the cerebral side of the tentorium extends cephalad a mesal duplicature of the dura, the falx, well named from its sickle shape (Figs. 800 and 801). The narrower cephalic end is attached to the *crista galli.* The distance between the free margin of the falx and the callosum increases cephalad. The relations of the falx to the longitudinal and falcial sinuses are shown in Figs. 800, 1; 801.

§ 387. *Falcula.*—This name (wrongly printed *falcicula*) was proposed by me as a mononym for *falx cerebelli,* designating the mesal fold of dura which extends ventrad from the tentorium to the *foramen magnum,* where it bifurcates. It is vaguely shown in Figs. 800 and 801.

§ 388. *Fontanels* (Fr. *fontanelles*).—These are the intervals between the corners of the infantile parietal bones before these corners have formed sutural union with the adjacent bones. There are six fontanels, two mesal and two pairs of lateral. The lateral, at the cephalic and caudal angles of the ventral border of the parietal bone, are small, irregular, and of comparatively little interest. The two mesal fontanels are at the ends of the sagittal suture; their more common designations, *anterior* and *posterior*, may appropriately give place to *prefontanel* and *postfontanel.*

§ 389. *Analogy of the Fontanels with the Telas.*—The structure of a tela was described in § 22. But since, in mammals at least, the telas are always more or less closely adherent to adjacent parts, and their margins are easily detached, their relations are sometimes not clearly appreciated. But if an infant or fetal cranium be divided across the prefontanel diagonally so as to include either parietal bone and the opposite frontal, the cut edge will present three layers, viz., an ental, the dura, representing the endyma; an ectal, the pericranium, representing the pia; an intermediate, the bone, representing the nervous parietes. At the fontanel this third element is absent, and the conjoined dura and pericranium contribute a membranous area quite comparable with a tela and available for illustration thereof.

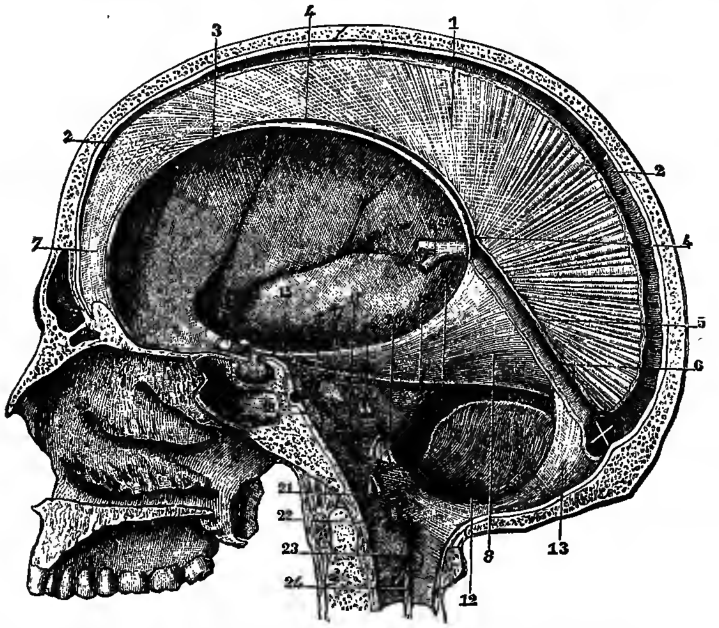


FIG. 800.—Mesal Aspect of Right Half of Medisected Skull Retaining the Dura. × .5. (From Sappey, iii., Fig. 462; after Shäfer: Quain, iii., Fig. 129.)

Defects.—As usual, there is no indication of the change that occurs at or near the foramen magnum, by which the apparently single dura of the cranium divides into a true dura related to the myel (Fig. 797) and a spinal periosteum; see, however, Shäfer (Quain), iii., Fig. 182. The region of the postoccipital sinus (12) is so heavily shaded as to give the impression of its considerable width; as shown in the original of Sappey, this sinus is no longer than the subpetrosal; according to Browning this is merely a constituent of the irregular basilar plexus of venous channels. The vein of Galen (25) here joins the tentorial sinus at an angle of about 45°; really, as shown in Fig. 801, it curves about the rounded splenium and joins at nearly a right angle.

1, Falx; 2, longitudinal sinus; 3, concave ventral margin of falx; 4, falcial (inferior longitudinal) sinus; 5, base of the falx where it joins the tentorium; 6, tentorial (straight) sinus or *s. rectus*; 7, cephalic, narrow end of falx, a little dorsad of the *crista galli* to which it is attached; ventrad of the line is a frontal (air) sinus, seen also in Fig. 670; 8, right side of tentorium, sloping latero-ventrad from the attachment to the falx to the side of the cranium along the lateral sinus (9); X, the torcular, the place of confluence of the two lateral sinuses, the longitudinal and the falcial; 10, the superpetrous (superior petrosal) sinus: 11, the subpetrous (inferior petrosal) sinus; 12, postoccipital (posterior occipital) sinus; the arrows indicate the direction of the blood in the larger sinuses; the lateral sinus is continuous with the entojugular vein; 13, falcula (falx cerebelli); 14, optic nerve; 15, oculomotor nerve; 16, trochlearis nerve; 17, trigeminus (trifacial) nerve; 18, abducens nerve; 19, facial and auditory nerves; 20, glosso-pharyngeal, vagus, and accessory nerves; 21, hypoglossal nerve; 22, 23, first and second cervical nerves; 24, cephalic end of the *ligamentum denticulatum* (see Fig. 797); 25, union of the velar veins to constitute the vein of Galen opening into the tentorial sinus (see Fig. 801).

A defect in the analogy is this: The cranial bone is of nearly uniform thickness, and thins out at the margin of the fontanel. But in the brain, although the immediate margins of the telas may be thin, the general parietes are commonly very massive, and there is usually a parallel zone specially differentiated, *e.g.*, the habena.*

§ 390. *Fig. 801 illustrates* (in addition to the points mentioned under Fig. 687 and in § 66): A. The degree of retention of the dura in this specimen is greater than with any brain ever seen or heard of by me. The brain was most skilfully removed, according to my directions, by Prof. W. C. Krauss, a former student (see the article *Brain: Methods*).

B. The existence, in the caudal three-fifths of the cerebrum, of a distinct and considerable mesal depression, containing the longitudinal sinus, so that here the retreating surface of the dura is seen beyond its dorsal cut margin; presumably this corresponded with a mesal thickening of the cranium.

C. The distinctly sickle-shape of the mesal extension of the dura between the two hemicerebrums, whence its name *falx.*

D. The non-correspondence of the width of the falx with the area dorsad and cephalad of the larger part of the callosum.

E. The location, form, and extent of the medicisterna (*cisterna ambiens*), the irregular space between the cerebellum, the splenium, and the geminums, roofed by the arachnoid and tentorium.

F. The location, form, and extent of the ventricisterna (*cisterna intercruralis*), between the crura, the pons, and the tuber (*tuber cinereum*), infundibulum and hypophysis. It forms a very deep indentation of the ventral outline of the brain, corresponding with the cranial or mesencephalic flexure (Fig. 671). It is bridged by the arachnoid, following substantially the line of the dura, and thus includes the arteries of this region.

G. The location, extent, and form of the postcisterna (*cisterna magna cerebello-medullaris*), the interval between the dorsum of the oblongata, the cerebellum, and the adjacent portion of the cranium, or strictly the ectal layer of arachnoid in that region, represented by the black line marked 10 (see Figs. 806 and 807, § 408).

H. The location of the metapore (foramen of Magendie), the orifice in the metatela (*tela choroidea inferior*), constituting the roof of the metacele or metencephalic portion of the "fourth ventricle" (see §§ 78–83). In this

* It is proper to add that, although this analogy between the telas and the fontanels had already occurred to me, I was reimpressed with it on listening to an admirable lecture upon the anatomy of the brain by Prof. D. K. Shute, at the Columbian Medical College, Washington, D. C., December 16, 1889.

specimen its relations are complicated by the postcerebellar artery, a loop of which lies just dorsad of it (see under Defects).

I. The location of the postcerebellar artery. This is not named on the figure and is imperfectly shown. The central portion, from its origin at the vertebral, is invisible here, but shows in Figs. 691 and 806. Just at the side of the metapore it turns sharply upon itself, forming a loop, somewhat as in Fig. 806; but in the present figure the peripheral portion of the artery alone is seen, and looks as if it began in the metapore. The two principal divisions are as here represented. There is apparently considerable variation in the course and subdivision of this vessel.

J. The length of the longitudinal sinus, equalling nearly the greater curvature of the cerebrum; its cephalic end was probably not quite reached.

K. The presence of the falcial sinus (2) along the ventral, free margin of the falx. This is said to be often wanting. I suggest that the alleged absence of this sinus in the fetus sometimes may be due to its non-detection.

L. The straight course of the tentorial sinus in line with the falcial, along the ventral margin of the caudal fifth of the falx, where the latter is continuous with the tentorium (Fig. 800, 8). The tentorial sinus is not named or otherwise designated on this figure, but in Fig. 800 it it is numbered 6; it is also called straight sinus or *sinus rectus.*

M. The junction of the mesal longitudinal and tentorial sinuses at the torcular (Herophili). The course of the lateral sinuses thence is indicated in Fig. 800.

N. The location of the right velar vein (3) between the splenium of the callosum and the conarium, and its junction with its opposite at the point indicated by .the circular spot at the edge of the splenium, just in line with the dotted line from that word. The two velar veins form the short vein of Galen.

O. The brief course of the vein of Galen about the splenium, and its entrance at 4 into the tentorial sinus, at the place of continuity of the latter with the falcial when this is present.

P. The location of the right precerebral artery (anterior cerebral). Branches of this are seen dorsad and cephalad of the callosum. The main trunk extends dorso-cephalad from the chiasma. The dark spot between the dotted lines leading from the words *terma* and *precommissure* represents the junction of the two precerebral arteries at the meson; in some cases they are separated by a considerable interval and communicate by a slender precommunicant artery. Here, however, they unite by their full width and again diverge.

Q. The origin of the termatic artery from the place of junction of the two precerebrals; its course, parallel with the terma and copula, then around the genu at least to the dorsum; its short branches to the terma and adjoining parts of the hemicerebral meson.

R. The location of the postcerebral artery. The beginning of this, severed from the basilar, is represented by the circular spot between the hypophysis and the convexity of the pons. From it are seen small arteries entering the crura. For the two large vessels represented in the ventricisterna, see under *Defects.*

§ 391. *Pia.*—This was formerly more often called *pia mater,* sometimes also *meninx vasculosa* (Ger., *dünne*

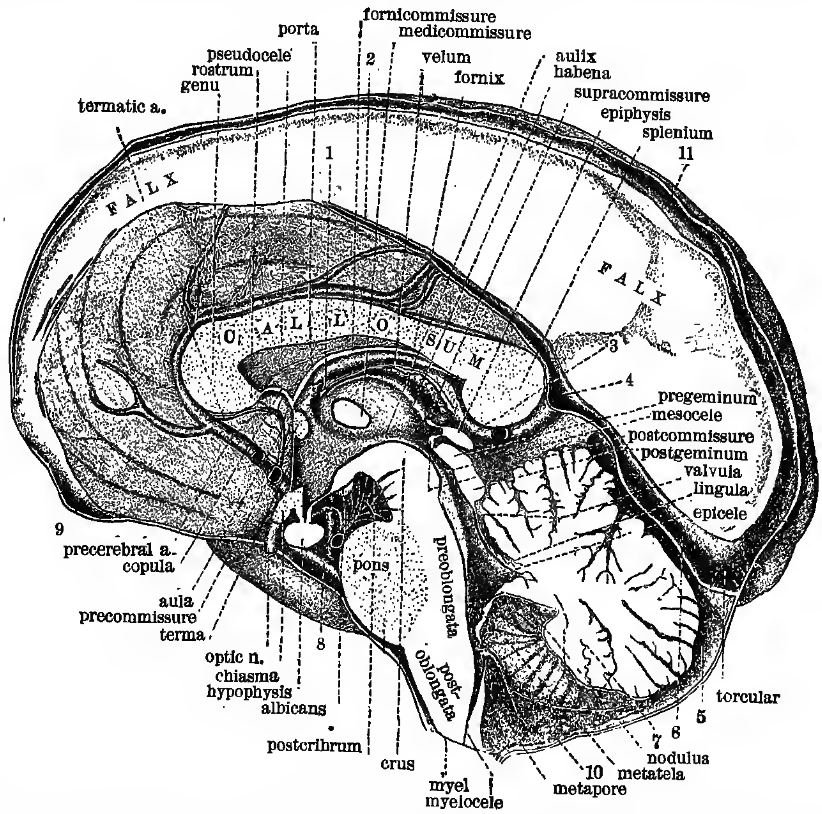


FIG. 801.—Mesal Aspect of the Right Half of the Brain of an Adult White Man; 376. × .65. 1, Auliplexus; 2, falcial sinus; 3, right velar vein; 4, orifice of Galen's vein into the tentorial sinus; 5, falcula or "cerebellar falx"; 6, tentorial sinus; 7, uvula, a mesal division of the cerebellum; 8, tuber ("tuber cinereum"); the line seems to stop at the artery, but should reach the thin floor of the diacele just caudad of the hypophysis; 9, ventral end of the falx; 10, cut edge of the ectal layer of the arachnoid, § 408; the line is too heavy and should be white instead of black; at a point between the lines from 8 and 7 it becomes attached to the cerebellar piarachnoid; 11, longitudinal sinus.

Preparation.—The brain was removed in the dura. It was duly supported and injected through the basilar artery with the starch mixture containing alcohol described in the article *Methods,* etc. The injection caused the brain to fill the dura completely, and presumably assume its natural form. It was then hardened in alcohol and medisected. The same specimen was the basis for two figures in my paper, 1885, *b,* and this figure is reproduced in the work of C. K. Mills, 1897; the mesal cavities are shown on a larger scale in Fig. 687.

Defects.—Although one of the purposes of the preparation of this figure was to indicate the relations of the dura to the brain, the word dura is omitted altogether. *Falx* designates its mesal extension between the halves of the cerebrum, as shown in Figs. 800 and 804. Along the longitudinal sinus (11) should be indicated the points of entrance of the supercerebral veins (see Fig. 800). The sinus, dorso-caudad of the cerebellum, between the torcular and the point marked 4, should be named *tentorial sinus.* On the precerebral artery, dorso-cephalad of the chiasma, are two orifices. The more caudal, at the root of the termatic artery, is caused by the removal of the left precerebral (see § 390, P). The more cephalic, between the lines from *copula* and *aula,* should be omitted, together with the intervening depressed area; they represent an accidental excavation of the artery. The arteries in the ventricisterna, the interval between the pons, the crura, and the tuber, are vaguely and inaccurately shown (see § 390, F). The postcerebellar artery (undesignated but lying between the lines from *metapore* and *metatela*) looks as if it begins in the metapore (see, however, § 390, H). The pia is nowhere distinctly represented. The black line marked 10 is the ectal layer of the arachnoid (see Fig. 806); the ental layer, in contact with the cerebellum, may be recognized; they unite just dorsad of the line from 7. The curved white line about midway between the callosum and the fornicommissure is due to an error; the surface of the hemiseptum forming the lateral wall of the pseudocele should be uniformly shaded. For other defects see Fig. 687.

Hirnhaut, weiche Hirnhaut ; Fr., *pie-mère*). It is delicate, fibrous, highly vascular, and intimately connected with the neuron (central nervous system), into the substance of which it sends numerous nutrient small vessels. When stripped off, these vessels commonly break at a short distance from the pia, and their number and minuteness impart to the ental surface of the membrane a flocculent or woolly aspect, the *tomentum* (§ 376, E).

§ 392. *Myelic Pia.*—This is thicker and firmer than the encephalic, less vascular, and more closely adherent to the nervous substance. It has sometimes been called the "neurilemma of the cord." Two layers are recognized: the ental, sometimes called *intima pia,* sends a fold into the ventral ("anterior") fissure, and into the dorsal a lamina not recognizable as a fold. Along the ventri-meson the pia presents a conspicuous fibrous band, the *linea splendens,* not represented in Fig. 797.

§ 393. *Encephalic Pia.* — According to Shäfer (Quain, iii., 186), only the ental of the two myelic layers of the pia is represented on the brain, but where and how the other layer disappears is not stated. The pia follows all the undulations of the encephalic surfaces, dipping into the fissures and rimulas as folds or rugas of corresponding depth (see Fig. 796). At the bottom of the intercerebral fissure, the mesal cleft between the dorsal portions of the two hemicerebrums, the pia enters the callosal fissure at either side, is then reflected, and crosses the callosum *

§ 394. *Telas and Plexuses.*—For these structures of the pia see §§ 22–24.

§ 395. *Fig. 802 illustrates :* A. The different aspect of the cerebral surface (*a*) before the removal of the piarachnoid or leptomeninges, as in the cephalic (upper) third of the figure; (*b*) after it has been removed completely, as in most of the caudal two-thirds; and (*c*) when there remains the intrafissural fold, as in the left central and the part of the right central crossed by the line.

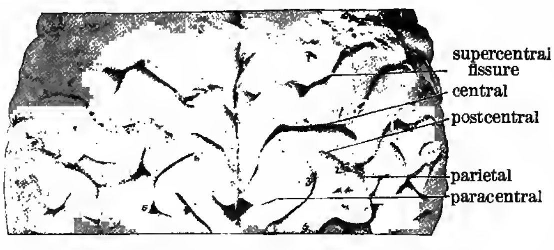


FIG. 802.—Central Region of an Adult Brain, Partly Denuded of Piarachnoid and Exhibiting on the Right a Departure from the More Common Relation of the Postcentral and Paracentral Fissures; 4,222. × .5. 1, The caudal end of a fissure which is mostly covered by the pia; 2, a small spur of the postcentral representing the usual caudal branch, which is marked 5 on the left; 3, an undetermined fissure; 4, a triangular depression comparable, perhaps, with the expansion of 5 on the left; 6, the cephalic branch of the left postcentral.

B. The usual relation of the central fissures to the paracentrals on both sides.

C. The usual relation of the left paracentral fissure to the dorsal fork of the postcentral (compare Fig. 769).

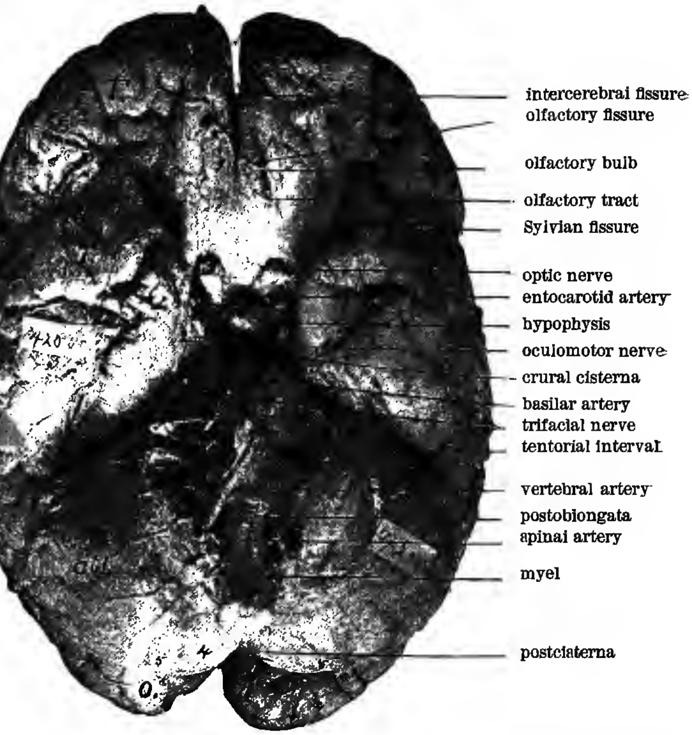


FIG. 803.—Base of the Brain of a Man Estimated at Sixty-Five Years, Before the Removal of the Piarachnoid and Blood-Vessels; 4,206. × .5. 1, Between the meson and the right olfactory bulb and opposite the point where the arachnoid ceases to pass directly from one hemicerebrum to the other and is carried into the intercerebral fissure by the falx (compare Figs. 801 and 804); 2, cut or torn margin of the arachnoid at the crural cisterna; 3, an artery on the right lateral lobe (pileum) of the cerebellum, *cbl.*; 5, 5, indicate approximately the lateral boundaries of the postcisterna (Fig. 807); *O.*, occipital lobe of the cerebrum; *T.*, temporal lobe; *F.*, frontal lobe.

D. The less common condition of the dorsal end of the right postcentral, the caudal branch being short and the cephalic so long as to intrude between the central and the paracentral and render that portion of the postcentral gyre quite narrow (§ 11, D; compare Fig. 664).

§ 396. *The Arachnoid.*—The word *arachnoid* is derived from the Greek ἀράχνη (signifying either a spider or a spider's web), and εἶδος (form or likeness).* In general the arachnoid may be described as a non-vascular membrane, enveloping the brain and closely attached to the pia, excepting where the latter dips into the intervals between the masses or into the fissures and sulci of the cerebrum and cerebellum. These depressions are bridged, so to speak, by the arachnoid, excepting where the dural folds, falx and falcula, carry it for a certain distance into the intercerebral fissure and the interval between the cerebrum and cerebellum. Wherever the arachnoid remains the outlines of parts are more or less vague, as in Figs. 796, 802, and 803.

§ 397. *Fig. 803 illustrates :* A. The general aspect of the base of the brain when first removed from the cranium; the outlines are less distinct than after the removal of the piarachnoid (compare Figs. 672 and 689), and certain

* Since the pia is practically the ectal surface of the brain, its cut edge is not commonly represented excepting when the figure is on a very large scale; but on blackboard diagrams its vascular character may be instructively indicated by a red line. On such diagrams the endyma ("ependyma" or lining of the cavities) may be represented by yellow or green.

* The open-meshed discs of the common garden spiders, *Epeira, Argiope,* etc., are not comparable; rather the compact glazed sheet constructed by one of the house spiders (*Tegenaria*) which will hold water, or the still more substantial nest of the water spider (*Argyronetra*), which is like a stationary diving-bell and retains the air placed under it against considerable pressure.

features are wholly invisible, *e.g.*, the chiasma, precribrum, and crura.

B. The varying relations of the arachnoid to the intervals between the masses. For nearly half of the distance between the optic nerves and the cephalic end of the cerebrum the arachnoid crosses directly from one frontal lobe to the other so that the intercerebral fissure is barely recognizable as a slight mesal depression. But at the point indicated by 1 the fold of dura constituting the falx (Figs. 801 and 804) begins and forces the arachnoid into the depths of the fissure. The arachnoid dips slightly into the Sylvian fissure, and deeply into the interval between the cerebrum and the cerebellum on account of the dural fold, tentorium (Fig. 800, 8).

C. The existence of a considerable interval, the crural ("peduncular") cisterna just caudad of the hypophysis, between the crura and adjacent brain surfaces and the arachnoid; the latter was torn and cut in removing the brain, and the sharp artificial margin is indicated by 2.

D. The existence of the postcisterna ("cisterna magna" or "cerebello-medullaris") between the oblongata and the cerebellum; by blowing dorsad at either side of the oblongata, where the arachnoid is torn, air entered the postcisterna and it expanded so as to have a convex outline as in Fig 807; but when the photograph was taken most of the air had escaped and the extent of the cisterna is indicated only by the greater vagueness of the cerebellar outline as far as 5 at either side.

§ 398. As to details, however, our knowledge of the arachnoid is even less complete and satisfactory than that of the dura and pia, and there are direct contradictions in the accounts by different anatomists which I have as yet been unable to reconcile. As stated by Langdon (1891), Bichat described (1802, 1813) the arachnoid as a serous, shut sack, conforming in all essential particulars with the serosa of the other cavities. But most recent writers follow Kölliker (1860) in denying the existence of a parietal layer in contact with the dura, and Tuke regards (1882) even the visceral layer as merely an element of the pia.

§ 399. On February 17th, 1888, I made and recorded the following observation upon a child, still-born, at term, No. 2,258: In removing the parietal dura, a delicate membrane separated from it more or less easily in different localities on the two sides; it was observed also by my colleague, Prof. S. H. Gage.*

§ 400. On December 29th, 1890, Dr. Langdon's paper (1891) was presented before the Association of American Anatomists. He records observations made upon two children, at term, and one adult. His summary is as follows:

"The arachnoid is a true shut sac, similar in structure and function to the serosa of the other great cavities. Its parietal layer is easily separable from the dura at the vertex in the fetus and young infant, but practically inseparable in this region in the adult. At the base of the skull it is demonstrable as a separate membrane, even in the adult. To assert that the parietal layer of arachnoid is absent because its subepithelial connective tissue has fused at the vertex with the dura (connective tissue), is as incorrect as to describe the great omentum as one layer of peritoneum, because its original four layers have become matted and adherent."

§ 401. During the preparation of the article *Meninges* in the first edition of the REFERENCE HANDBOOK I verified the correctness of the previous observation as to the presence of an ectal or dural layer of arachnoid, and noted its reflection upon the carotid and vertebral arteries to become continuous, presumably, with the ental, pial, or visceral layer. But no such reflection occurs at the nerve roots unless at some depth within the foramens of exit, and this point I have as yet not had time to determine.

§ 402. *Fig. 804 illustrates:* A. The relative positions of the meninges (compare Figs. 796 and 798).

B. The formation of the longitudinal sinus within the substance of the dura.

C. The projection of the arachnoid villi into the sinus and the parasinual spaces; see the article *Pacchionian Bodies*.

D. The accumulation of the villi at one point, on the right, to such an extent as to cause the protrusion of the dura, and presumably a depression of the ental surface of the cranium.

E. The separability of the arachnoid from the pia, leaving a distinct subarachnoid space increased along the fissure lines.

F. The conterminousness of the arachnoid and the falx, and their separation by a distinct interval.

§ 403. *Fig. 805 illustrates:* A. The complete circumscription of the true encephalic cavities, excepting at the metapore.

B. The non-communication of these cavities with the pseudocele (fifth ventricle).

C. The presence of considerable, irregular intervals, subarachnoid spaces, or cisternas, between the pia and the arachnoid.

D. The continuity of the largest of these, *postcisterna*,

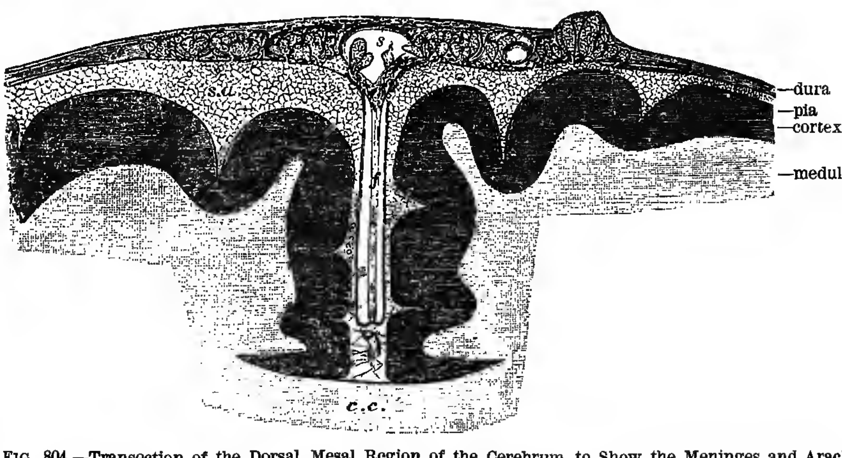


FIG. 804.—Transection of the Dorsal, Mesal Region of the Cerebrum, to Show the Meninges and Arachnoidal Villi. Slightly enlarged. (From Key and Retzius, Taf. xxix., Fig. 4; after Shafer: Quain, iii., Fig. 134.)

Preparation.—The spinal subarachnoid space (Fig. 797, *k*, *l*) was injected with a fine blue mass, which filled (and distended ?) the corresponding space upon the cerebrum and entered the arachnoid villi. The original figure is appropriately colored and on a larger scale. Judging from the relation between the width of the falx and the interval between it and the callosum, the plane of section was not far cephalad of the splenium (see Fig. 801). c.c., Callosum; *f*, falx; *s*, longitudinal sinus; *s.a.* (at the left), subarachnoid space.

Defects.—The pia is not so distinct as I would make it. The relation of the arachnoid to the ventral margin of the falx is not quite clear. There is no extension of the cortical cinerea upon the dorsum of the callosum as an indusium (see § 217). There is no indication of the existence of the two layers of the dura, *e.g.*, periosteal and encephalic, described by Langdon (Fig. 798). The falcial (inferior longitudinal) sinus may have been absent in this case, as it is said to be in many. The *lacunæ laterales* are somewhat indistinct, probably in consequence of the reduction from the original figure, where they are much more clearly shown.

* Although this distinctly indicated the existence of a parietal (ectal) layer of arachnoid, at that time I supposed the subject, *Meninges*, would be treated by another, and was, moreover, then fully occupied with the articles already undertaken; hence the observation was not made public and the point has not been followed up.

between the cerebellum, postoblongata, and occipital part of the cranium, with the spinal subarachnoid space.

E. The relation of the falcula (falx cerebelli) to the

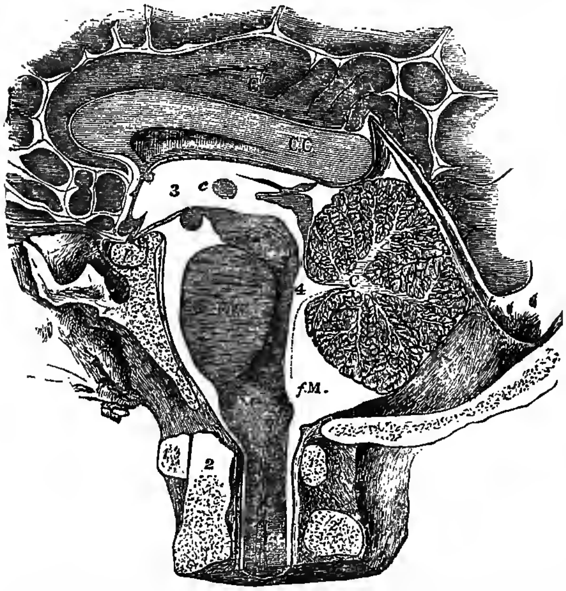


FIG. 805.—Medisection of the Cerebellum and Adjacent Parts. (From Key and Retzius, 1875, Taf. viii., vii., Fig. 1; after Shäfer: Quain, iii., Fig. 131, reduced and somewhat modified.) Compare Figs. 670, 800, and 801. 1, 1′, Atlas vertebra; 2, 2′, axis vertebra; 3, diacele (third ventricle); 4, epicele, the cephalic or cerebellar portion of the "fourth ventricle"; C, cerebellum; C.C., callosum; C′, callosal gyrus; M, postoblongata; P.V., pons; X, falcula (falx cerebelli); c, medicommissure; c.c., just dorsad of (behind) the myelocele (central canal of the cord); *f.*M., metapore ("foramen of Magendie"); *p*, hypophysis; t, torcular.

Preparation.—A blue mass was injected into the spinal subarachnoid space; the head was then frozen and medisected. The original includes the mesal aspect of the entire head, less the integument and mandible. The true encephalic cavities and the subarachnoid spaces are colored, so only the actual mesal parts appear.

Defects.—In the original there is no indication of the arachnoid, although the circumscription of the subarachnoid space was the very feature supposed to be illustrated. Should it be claimed that the arachnoid is sufficiently indicated by the ental boundary line of the dura, the answer would be that, although in places the two meninges may be in contact, they are not in all; furthermore, as distinctly shown upon Taf. vi. of the same work, in Figs. 801, 806, and 807, there is a point near the crest of the cerebellum (nearly opposite *t*) where the arachnoid (or its ectal layer) leaves the cerebellum and passes directly to the dura at the *foramen magnum*. There is no boundary between the metepicele (fourth ventricle) and the subarachnoid space; even if, as in other cases, the membranous roof of the metacele (metatela) adheres to the caudo-ventral surface of the cerebellum, the plexuses and the endyma constituting its ental surface must end somewhere.

Since the cavities are not colored, they appear as white areas without perspective, as if the preparation were a thin mesal slice. Most unfortunately, probably through some defect in execution, there is left a clear line between the epiphysis and the splenium, as if there were a passage from the diacele (third ventricle) to the irregular subarachnoid space between the splenium, epiphysis, pregeminum, and cerebellum. This is altogether misleading, for, as shown in Figs. 670, 687, 759, and 801, and stated in § 66, H, the diacele is completely circumscribed at that point by the endyma reflected from the velum upon the epiphysis. In the present copy this defect has been remedied so far as it could be by uniting the epiphysis and splenium so as at least to block the passage; but it should be remembered that it is closed not by nervous tissue but membranes. The editors of Quain have represented the missing metatela by the dotted line from near the number 4 to near the abbreviation *f.*M. A continuous line would have been more appropriate, and separated farther from the metacelian floor; that could not be changed in the present copy, but the interval representing the metapore (foramen of Magendie) has been enlarged; this, however, is conventional, and as if to correspond with the perhaps unusual condition shown in Fig. 690. Finally, the falcula (falx cerebelli), which was unmarked in Quain, is here designated by a cross (x).

mesal portion, vermis, of the cerebellum. In Fig. 707 this is obscured by the fact that part of the left lateral lobe remains.

§ 404. *The Cisternas.*—At several regions the ental layer of arachnoid is separated from the pia by considerable spaces, called cisternas by Key and Retzius, 1875, p. 93.* They are enumerated and described by Browning.

§ 405. *Fig. 806 illustrates:* A. The general appearance of this aspect of the cerebellum together with the oblongata and pons; in Fig. 697 these two parts were omitted.

B. The extent of the postcisterna (*cisterna magna* or *c. cerebello-medullaris*) upon about one-half the entire caudal aspect; there is, however, considerable variation in this respect.

C. The definite dorsal and lateral limitation of the postcisterna, although the boundary line is undulating and asymmetrical.

D. The lack of ventral boundary of the cisterna; the ectal layer of the arachnoid is attached to the dura so that this cisterna is continuous with the spinal subarachnoid space.

E. The union of the two vertebral arteries to form the basilar.

F. The origin of the postcerebellar arteries from the vertebrals near their junction.

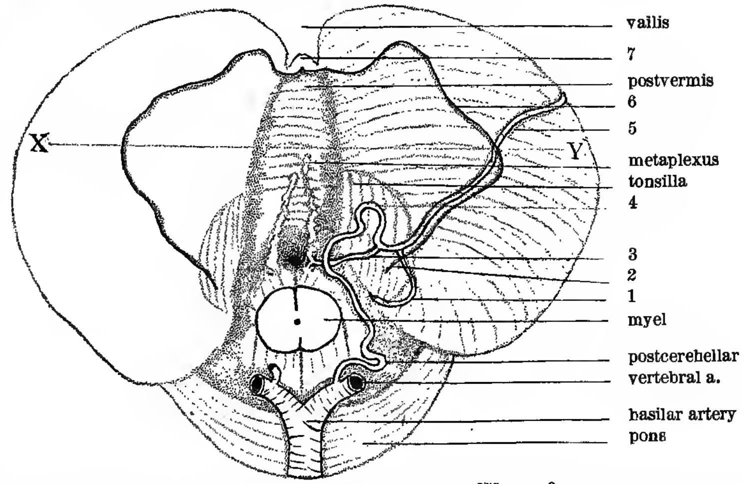


FIG. 806.—Caudal (Lower) Aspect of the Cerebellum, etc.; 376. × .9.

Preparation.—Through the kindness and skill of Dr. W. C. Krauss (a former student, now professor in the Medical Department of Niagara University, the brain was received fresh and in the dura. The cavities were injected with alcohol; the arteries first with alcohol and then with the starch mixture (see article *Brain: Methods*). The alcohol passed through the metapore into the postcisterna and thoroughly preserved all the parietes; it had access also about the myel, where the arachnoid was cut in removing the brain. The ectal layer of the arachnoid was cut away along the line of its attachment.

Defects.—The perspective of the postoblongata is defective. The metapore is vaguely indicated and few of the vessels are shown. Of the lobes only the tonsillas are outlined. The flocculi and nerve roots are omitted, also the rimulas (interfoliar crevices) on the left side. The most serious defect is the non-indication of the dorsal limit of the endyma which presumably accompanies the metaplexuses; see § 417.

1, 3, Branches of the postcerebellar artery, the former passing between the cerebellum and the oblongata, the latter apparently supplying the corresponding metaplexus; 2, 6, edge of the ectal layer of arachnoid bounding the area whence it had been cut away; 4, loop of postcerebellar artery, an example of its tortuous course; 5, main trunk of the artery near where it reaches the crest of the cerebellum; its branches are omitted; 7, mesal ridge formed by the vein which divides into a right and left branch upon the caudal surface; the arachnoid here forms a somewhat sharp angle.

G. The length and course of the postcerebellar artery, and the tortuous course of its central portion.

* Admitting that most of the cisternas do lie between the arachnoid and the pia, as commonly described, my later observations lead me to regard the postcisterna as between two layers of the ental arachnoid itself (see Figs. 805 and 807).

H. The passage of a branch of the postcerebellar artery mesad toward the metapore, apparently supplying the metaplexus.

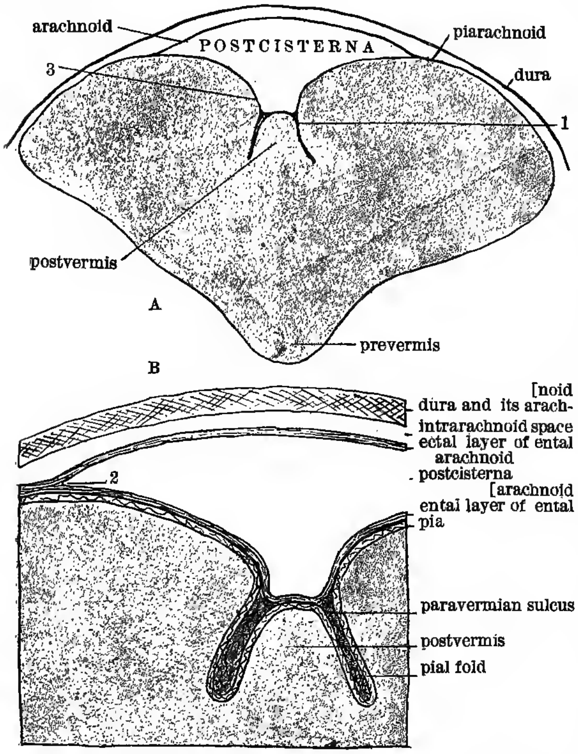


FIG. 807.—Sections of the Cerebellum and Postcisterna; semidiagrammatic.

A. Dorsal (cut) surface of the ventral portion of the cerebellum, together with the adjacent dura and the large "subarachnoid space," postcisterna, commonly called *cisterna magna* or c. *cerebello-medullaris*. At the meson appears the postvermis, separated by the paravermian sulci (1) from the large lateral lobes; 3 is the ental layer of the arachnoid. The meninges are here represented by lines only.

B. Enlargement of the meso-caudal region of A. The meninges are here represented by zones conventionally shaded; 2, the place of junction of the two layers of the ental arachnoid at the margin of the postcisterna.

Preparation.—An adult cerebellum (2,891) was divided at a plane corresponding with the line X—Y in Fig. 806, so as to separate the dorsal two-fifths; on Fig. 801 the plane of section would be indicated approximately by a line across the unshaded (cut) surface connecting the points where the dotted lines from the words *nodulus* and *epicele* intersect the margin of that surface; as seen in Fig. 806 it passes dorsad of the plexuses. The ectal layer of arachnoid is represented as the continuous caudal boundary of the postcisterna, while in Fig. 806 it is supposed to have been trimmed closely along the line of its depression from the ental layer 3.

Defects.—For readier comparison with Fig. 806 the figures should have been inverted so as to have the postcisterna nearer the reader. In B the postcisterna is enlarged two diameters, but the several zones representing the meninges are disproportionately widened, and their shading is conventional for discrimination only, and not for the indication of histological structure. The ectal or dural layer of arachnoid was inadvertently omitted, and there is no indication of the two layers of the dura itself. The numerous rimulas and intervening foliums that were divided in the section are not indicated, and the usual relations of the pia and arachnoid to each other and to narrow encephalic depressions generally are illustrated only at the paravermian sulci. According to the present view * that the metapore is the orifice of an evagination, the postcisterna may be lined, in part at least, by endyma; but it was not recognized in this preparation, and even in the embryo represented by Blake (1898, Fig. 26) it seems to have disappeared at a lower level.

I. The extension of the metaplexuses dorsad from the metapore upon the cerebellum.

§ 406. *Postcisterna.*—Notwithstanding the presumption that all the cisternas form a continuous series, my observations, up to the present time, induce me to regard the space in the angle between the cerebellum and the oblongata as presenting an important peculiarity, viz., as lying, not between the pia and the visceral arachnoid, but between two layers of the latter. The facts upon which this view is based cannot be detailed here. The view is indicated upon Fig. 807.

I am aware of the difficulties involved in its acceptance; without question, the postcisterna communicates on the one hand with the true encephalic cavities through the metapore, and on the other with the spinal subarachnoid space; its free communication with the other cisternas, although commonly accepted, seems to me not yet clearly demonstrated.

§ 407. *Is there Direct Communication of the Subarachnoid Spaces with the Intrarachnoid (or Subdural) Space?*—Whatever view they adopt regarding the constitution of the arachnoid as a whole, most writers agree that the arachnoid covering the brain and myel is continuous, excepting for the capillary spaces about the nerve roots referred to in § 401. Hence, while the neurolymph may pass to and fro between the true encephalic cavities and the postcisterna through the metapore, and may thus enter the other cisternas (§ 406) and the spinal subarachnoid space, it is nevertheless confined thereto.

But Dr. Langdon (1891) holds that "at the base of the cranium there are two points where the visceral [ental] arachnoid is deficient, one on either side, in the 'bridge' of arachnoid which stretches across from the cerebellar lobes to the under [ventral] surface on the oblongata. These foramina measure about half an inch (12 mm.) in longitudinal diameter by one-fourth inch (6 mm.) transversely, and are crossed by three or four fibrous bands, the attachment of which to the edges of the openings produces a multiple crescentic appearance of their margins, which suggests the name '*lunulate foramina.*'"

It will be noted that the location of these alleged lunulate foramina in the arachnoid corresponds with that of the ventral ends of the lateral recesses. Hence, on the one hand, if both are natural, the transfer of the neurolymph from the true encephalic cavities to the arachnoid space is provided for; on the other, the relation of the nerve roots to both the pia and the arachnoid renders both liable to rupture during extraction or manipulation of the brain. Hess implies (1885, Fig. 10, *ar.*) that the arachnoid was cut and reflected at this point. On the whole subject, and on the metapore see the later observations of Blake, 1900.

§ 408. *Fig. 807 illustrates:* A. The usual relation of the meninges in these respects, viz., the independence of the dura; the adhesion of the pia to the brain substance; the dipping of the pia into the narrow depression at either side of the vermis as a vascular fold; the adhesion of the arachnoid to the pia over most of the cerebellum, so as to constitute a piarachnoid (Fig. 796).

B. On the caudal aspect of the cerebellum, the formation of a considerable space, the postcisterna, by the separation of an ectal layer of the ental or visceral layer of the arachnoid.

§ 409. The inadequacy of the foregoing account of the postcisterna and its relations with the metapore is fully conceded. It is no disparagement to the labors of Blake and others to add that no account known to me is altogether clear, consistent, correct, and complete. The difficulties involved can be fully appreciated only by those who have already attempted to elucidate the subject. The material must be specially prepared for the purpose and examined by improved methods, both anatomical and histological.

BURT G. WILDER.

§ 410. The following list includes treatises upon the gross anatomy of the brain, mostly recent, likewise a few special papers; other papers are named in the text. Other things being equal, preference is given to such as contain full bibliographies. The history of Neurology up to 1822 is given in Burdach. For current literature consult the *Journal of Comparative Neurology; Anatomischer Anzeiger; Index Medicus; Neurologisches Centralblatt; Brain; L'Encéphale; Nevráxe; Jahresberichte*

* At the time § 83 was made up into the page I was unaware that the German edition (1894) of Minot's "Embryology" has this passage, p. 698: "The foramen of Magendie (Wilder's metapore) and the openings of the lateral recesses, according to this view, would be not true perforations of the ependyma, but the outlets of evaginations."

für Anatomie, etc. See § 12. *A. A. A. Proc.* stands for *Proceedings of the Association of American Anatomists.*

BIBLIOGRAPHY.

Blake, J. A., 1900: The Roof and Lateral Recesses of the Fourth Ventricle Considered Morphologically and Embryologically. Read before the Assn. Amer. Anat., December 28th, 1898. Jour. Comp. Neurol., x., 79–108, 7 plates.
Broca, P., 1888: Mémoires sur le cerveau de l'homme et des primates, O.
Burckhardt, R., 1895: Der Bauplan des Wirbelthiergehirns. Morphologische Arbeiten, iv., 131–150, taf. viii., 1895.
Burdach, K. F., 1822: Vom Baue und Leben des Gehirns, Q., 3 vols.
Clark, T. E., 1896: Comparative Anatomy of the Insula. Journ. of Comp. Neurol., vi., 59–100, 5 plates.
Dalton, J. C., 1885: Topographical Anatomy of the Brain, Q., 3 vols.
Dana, C. L., 1893: Text-Book of Nervous Diseases; Being a Compendium for the Use of Students and Practitioners of Medicine, O., illustrated, New York.
Dejerine, J., 1895: Anatomie des centres nerveux, R. O., 2 vols., Vol. I., pp. xiii. and 816, 401 figures. [The macroscopic anatomy occupies pp. 233–517 of vol. i.]
Eberstaller, O., 1890: Das Stirnhirn; ein Beitrag zur Anatomie der Oberfläche des Grosshirns, O., pp. 140, with 9 figures and 1 plate; Wien.
Edinger, L., 1896: Vorlesungen über den Bau der nervösen Centralorgane des Menschen und der Thiere. Fifth edition, R. O., pp. 386, 258 figures, Leipsic. (See also Hall, translator, 1899.)
Edinger, L. u. Wallenberg, A., 1899: Bericht über die Leistungen auf dem Gebiete der Anatomie des central Nervensystems. (566 titles, 1897, 1898, with commentaries.) Schmidt's Jahrbücher der Gesammte Medicin, cclxii., pp. 72.
Findlay, J. W., 1899: The Choroid Plexuses of the Lateral Ventricles of the Brain, their Histology, Normal and Pathological (in relation especially to Insanity). Brain, vol. xxii., 1899, pp. 161–202; 3 plates.
Fish, P. A., 1890: The Epithelium of the Brain Cavities. Amer. Soc. Micros. Proc., 140–144, 1 plate, 1890.
———, 1893: The Indusium of the Callosum. Journ. Comp. Neurology, iii., 61–68, 1 plate.
———, 1899: The Brain of the Fur Seal, Callorhinus ursinus, with a comparative description of those of Zalophus Californianus, Phoca vitulina, Ursus Americanus, and Monachus tropicalis, O., pp. 20, 4 plates. From the report on the Fur Seals and Fur-Seal Islands of the North Pacific Ocean, part iii.
Flatau u. Jacobsohn, 1899: Handbuch der Anatomie u. Vergleichenden Anatomie des Centralnervensystems der Säugetiere, I., Makroskopischer Teil, R. O., pp. 578, 6 plates, 120 figures in text, Berlin. [Contains a good bibliography.]
Gage, Mrs. S. P., 1895: Comparative Morphology of the Brain of the Soft-Shelled Turtle (Amyda mutica) and the English Sparrow (Passer domestica). Proc. Amer. Micros. Soc., xvii., 185–228, 5 plates.
———, 1896: Modifications of the Brain During Growth. Abstract of paper read before the Amer. Assn. Adv. Sci., August 24, 1896. Amer. Naturalist, xxx., 836–837, October, 1896.
Gerrish, F. H. (editor and collaborator with Bevan, A. D., Keiller, W., McMurrich, J. P., Stewart, G. D., and Woolsey, G.), 1899: A Text-Book of Anatomy by American Authors, R. O., pp. 917, 950 figures, Philadelphia and New York.
Giacomini, C., 1884: Guida allo Studio delle Circonvoluzioni Cerebrali, O., Turin.
Gordinier, H. C., 1899: The Gross and Minute Anatomy of the Central Nervous System, R. O., pp. 589, 48 plates and 213 figures, Philadelphia.
Gould, G. M., 1900: Suggestions to Medical Writers, O., pp. 180, Philadelphia.
Hall, W. S., 1899 (translator of Edinger, "Vorlesungen," 1896): The Anatomy of the Nervous System of Man and of Vertebrates in General, R. O., pp. xi. and 446; 258 figures, Philadelphia.
Hervé, G., 1888: La Circonvolution de Broca, O., pp. 275, Paris.
Hill, Alex., 1890 (translator and annotator of Obersteiner's "Anleitung" (1887): The Anatomy of the Central Nervous Organs in Health and in Disease, O., pp. 432, with 198 illustrations. Philadelphia, 1890.
Hill, Charles, 1900: Developmental History of Primary Segments of the Vertebrate Head. Contribution from the Zool. Laboratory of the Northwestern Univ. Zoölogischer Jahrbücher, Abt. f. Anat. u. Ontogenie der Thiere, xiii., pp. 393–446, 3 plates and 4 figures in text. [Preliminary paper in *Anat. Anzeiger*, 1899, 353–369].
His, W., 1895: Die anatomische Nomenclatur. Nomina anatomica, Verzeichniss der von der Anatomischen Gesellschaft auf ihrer IX. Versammlung in Basel angenommenen Namen. Eingeleitet und im Einverständniss mit dem Redactionsausschuss erläutert von Wilhelm His. Archiv für Anatomie und Physiologie, Anat. Abth., Supplement Band, 1895, O., pp. 180, 27 figures, 2 plates.
Ibáñez, G., 1899: Die Nomenclatur der Hirnwindungen. Inaug. Dissertation, Berlin, pp. 37.
Key u. Retzius, 1875: Studien in der Anatomie des Nervensystems, F., 2 vols., Stockholm.
Krause, W. [editor], 1880: Handbuch der Menschlichen Anatomie, 3 vols., O. Hanover. [A later edition, 1899, is in course of publication.]
Langdon, F. W., 1891: The Arachnoid of the Brain (read before the Association of American Anatomists, December 29th, 1890). New York Medical Record, August 15th, 1891, 177–178, 2 figures.
Mickle, W. J., 1895: Atypical and Unusual Brain Forms, especially in relation to Mental Status. Presidential address (British) Medico-Psychological Association, 1895. Brit. Med. Jour., September 28th, 1895; Journ. Ment. Sci., July, 1896 *et seq.*
Mills, C. K., 1886: Arrested and Aberrant Development of Fissures and Gyres in the Brains of Paranoiacs, Criminals, Idiots and Negroes. Preliminary study of a Chinese brain. Presidential address, Amer. Neurol. Assoc., 1886. Journ. Nerv. and Ment. Disease, xiii., September and October, 1886, pp. 37, 2 plates. 1897: The Nervous System and its Diseases, R. O., pp. 1056, 459 figs., Philadelphia.
Minot, C. S., 1892: Human Embryology, R. O., pp. 815, 463 figures, New York. German edition, 1894.
Obersteiner, H., 1896: Anleitung beim Studium des Baues der Nervösen Centralorgane im gesunden und kranken Zustande, third edition, O., pp. 572, 205 figures, Leipzig und Wien. (See also Hill, translator of second edition.)
Parker, Andrew J., 1896: Morphology of the Cerebral Convolutions with Special Reference to the Order of Primates. Journ. Acad. Nat. Sci., Philadelphia, N. S., x., Q., pp. 247, 15 plates, 31 figures in text.
Parker, T. J., and Haswell, 1898: A Text-Book of Zoology, 2 vols., O., London and New York. 1900: Manual of Zoology, O., New York.
Pfister, H., 1899: Ueber die occipitale Region und das Studium der Grosshirnoberfläche, O., pp. 86, 4 plates, bibliography of 108 titles. Stuttgart. [Discusses particularly the human homologue of the "ape-fissure."]
Quain, 1890–1898: See Shäfer.
Reichert, C. B., 1861: Der Bau des menschlichen Gehirns, O.
Retzius, G., 1896: Das Menschenhirn: Studien in der Makroskopischen Morphologie, F. and Text, pp. viii. and 167, xiii. (really 141) figures. Atlas, xcvi. plates, Stockholm.
Shäfer, E. A., 1893: Neurology, Part i. of vol. iii. of the tenth edition of Quain's Anatomy, edited by Shäfer and Thane, London and New York, 1890–1898.
Spalteholtz, W., 1900: Handatlas der Anatomie des Menschen, Mit Unterstützung von W. His bearbeitet., Bd. iii., Abt. 2, Gehirn. (Announced.)
Spitzka, E. C., 1884: Contributions to the Anatomy of the Lemniscus. N. Y. Medical Record, xxvi., 393–397, 421–427, 449–451, 477–481, 16 figures, October and November, 1884.
Spitzka, E. A., 1900, *a*: The Brains of Two Distinguished Physicians, Father and Son. A Comparative Study of their Fissures and Gyres. Illustrated with 20 plates, and several figures in the text. To be read before the Association of American Anatomists, December, 1900. 1900, *b*: A Contribution to the Question of Fissural Integrality of the Paroccipital; observations on one hundred brains. Idem. 1900, *c*: The Mesial Relations of the Inflected Fissure; observations on one hundred brains. Idem. 1900, *d*: Preliminary report, with projection drawings illustrating the Topography of the Paraceles in their Relations to the Surface of the Cerebrum and the Cranium. Idem.
Stilling, B., 1878: Neue Untersuchungen über den Bau des kleinen Gehirns des Menschen, etc., Q., pp. 357 and lxxviii., folio atlas of 21 plates, Cassel.
Stroud, B. B., 1895: The Mammalian Cerebellum. Part I., The Development of the Cerebellum in Man and the Cat. Journ. Comp. Neurol., v. 71–118, 8 plates, 1895. 1897, *a*: A Preliminary Account of the Comparative Anatomy of the Cerebellum. A. A. A. Proc., May, 1897, pp. 20–27, 1 plate. 1897, *b*: The Morphology of the Ape Cerebellum. A. A. A. Proc., December, 1897, 107–126, 1 plate. 1899: If an "Isthmus Rhombencephali," why not an Isthmus Prosencephali? A. A. A. Proc., December, 1899, 27–29, 2 figures; Abstract in Science, March 16, 1900.
Studnička, F. K., 1895: Zur Anatomie der sog. Paraphyse des Wirbelthiergehirns. Sitzungsber. der K. Böhm, Ges. Wiss. Math.-Nat. Cl., 1895, pp. 13, 1 plate.
———, 1899: Ueber den feineren Bau der Parietalorgane von Petromyzon marinus. Idem., 1899, pp. 17, 1 plate.
Turner, Prof. Sir W., 1890: The Convolutions of the Brain. Journ. Anat. and Physiol., xxv. 1–53, 42 figures.
Van Gehuchten, A., 1900: Anatomie du système nerveux de l'homme, 3me edition, R. O., 2 vols., pp. xxiv. and 527–579, 702 figures, Louvain. (The macroscopical anatomy occupies 186 pp. of vol. i.)
Weinberg, R., 1896: Die Gehirnwindungen bei den Esten, eine anatomisch-anthropologische Studie, Q., pp. 96, 5 double plates, Cassel.
Waldeyer, W., 1896: Hirnfurchen und Hirnwindungen. [447 titles, with commentaries.] Ergebnisse der Anat. u. Entwickelungsgeschichte, 1896, 146–199.
———, 1899: Hirnfurchen u. Hirnwindungen. Hirnkommisauren. Hirngewicht. [190 titles, with commentaries.] Idem., 1899, 362–401, 8 figures.
Wilder, B. G., and Gage, S. H., 1892: Anatomical Technology as Applied to the Domestic Cat, third edition, from the second revised, O., pp. 600, 130 figures, and 4 lith. plates (chap. x., pp. 400–503, is devoted to the brain), New York and Chicago.
Wilder, B. G., 1896, *h*: Neural Terms, International and National, Journ. of Comp. Neurol., vi., December, 1896, pp. 216–352, including 7 tables; Parts vii.–ix. have also been reprinted under the title "Table of Neural Terms, with Comments and Bibliography." 1897, *e*: What is the Morphologic Status of the Olfactory Region of the Brain? A. A. A. Proc., December, 1897, 94–99; Science, February 4, 1898, vii., 150–152. 1899, *a*: Historic, Ethical, and Practical Considerations Respecting the Names and Numbers of the Definitive Encephalic Segments. Abstract A. A. A. Proc., December, 1899, 3–4. Science, March 16th, 1900. 1899, *b*: Comments upon the Figure of the Mesal Aspect of an Adult Brain as published by His and reproduced in the B. N. A. Abstract A. A. A. Proc., 1899, Science, March 16, 1900. 1899, *c*: The Basis and Nature of a Segmental Schema of the Brain. Abstract A. A. A. Proc., 1899, Science, March 16, 1900. 1899, *d*: Is Neuron Available as a Designation of the Central Nervous System? Abstract A. A. A. Proc., 1899, Science, March 16, 1900. 1900, *a*: Further Tabulations and Interpretations of the Paroccipital Fissures. Abstract A. A. A. Proc., 1900. 1900, *b*: Revised Schema of the Cerebral Fissures. Abstract A. A. A. Proc., 1900. 1900, *c*: Revised Interpretation of the Central Fissures of the Educated Suicide's Brain which was exhibited to the (Amer. Neurol.) Association in 1894. Journ. Nerv. and Ment. Dis., October, 1900, 536–539, vol. xx. For note as to earlier titles, see § 12.

BRAIN, ABSCESS OF.—Cerebral abscess is always the result of the introduction of pus-producing germs into the tissues of the brain. The organisms which are found most frequently are streptococcus pyogenes and 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. $\frac{20}{20}$, L. $\frac{20}{70}$; later, R. $\frac{20}{70}$, L. $\frac{20}{200}$ (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 unvenly. 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 *dimunition 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 nonlocalizing, symptoms of cerebral tumor cannot be discussed here, but must be considered as of much importance in forming the diagnosis. *William N. Bullard.*

BIBLIOGRAPHY.

Bastian: Lancet, July 25th, 1874.
Bernhardt: Beiträge zur Symptome u. Diagnostik der Hirngeschwülste, Berlin, 1881.
Ferrier: The Functions of the Brain, London, 1876.
Ferrier: Glioma of the Right Optic Thalamus and the Corpora Quadrigemina. Brain, 1882, v., p. 123.
Nothnagel: Topische Diagnostik der Gehirnkrankheiten, Berlin, 1879.
Putzel: In Supplement to Ziemssen's Cyclopædia, New York, 1881.
Ross: Diseases of the Nervous System, New York, 1883.
von Monakow: In Nothnagel's Specielle Pathologie u. Therapie, vol. ix., Bd. i., 1897.

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.

* 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 of the mind until he has carefully dissected the muscle 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.

§ 6. *Order of Treatment.*—Introduction and Acknowledgments, §§ 1–6.

§ 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

* The article "Anatomy" in the last edition of the Encyclopædia 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 [diacele] is consequently enlarged."

† That these methods are fairly successful may be concluded from the facility with which those who practise them receive the more advanced or specialized instruction imparted at the great medical schools, and from the nature of the preparations in the museum. Yet there is hardly one of these methods that 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.

* 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 there 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 completely 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

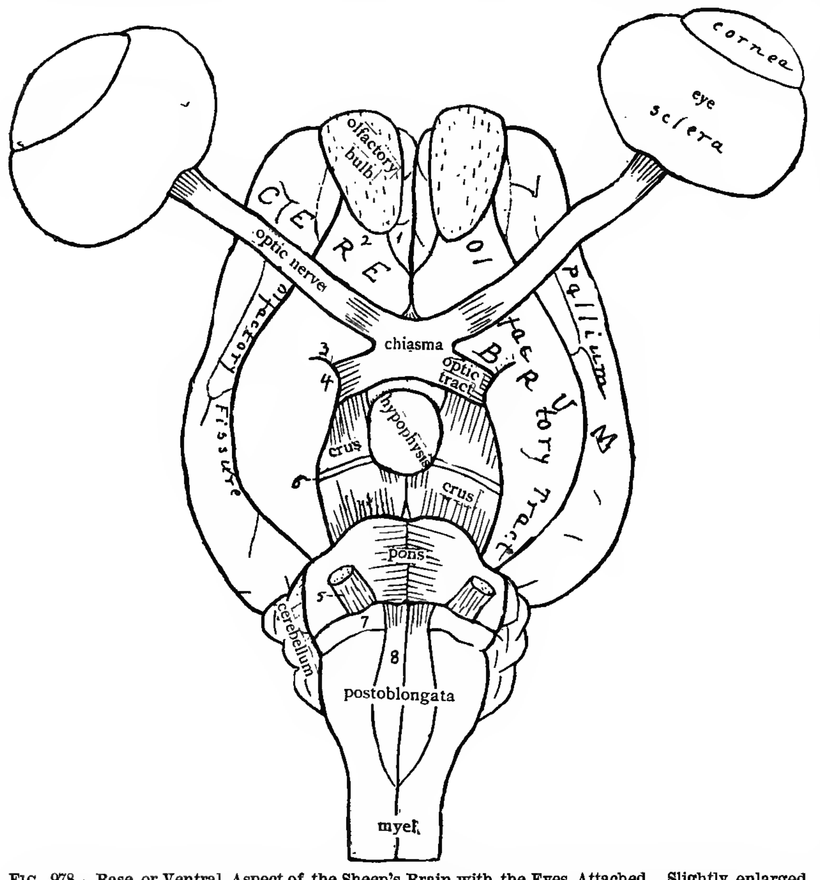


FIG. 978.—Base or Ventral Aspect of the Sheep's Brain with the Eyes Attached. Slightly enlarged. (From "Physiology Practicums.") 1, Frontal portion of pallium mesad of olfactory bulb; 2, narrow portion of olfactory tract (compare Fig. 688, p. 153); 3, precribrum ("anterior perforated space") just cephalad 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 fossæ (§ 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. 423–432. 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.

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

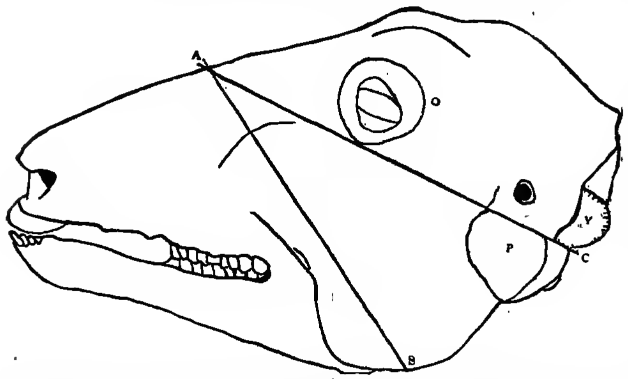


FIG. 979.—Left Side of Head of Sheep, Skinned. (From my paper, 1896, *g*.) Along the line A-B the butcher may cut with saw or cleaver so as to remove most of the face; it extends from the angle of the jaw to a point about midway between the nose and the prominence of the head between the eyes. The rest 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;

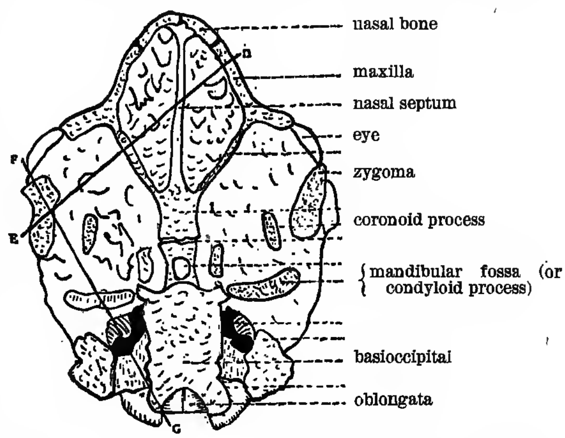


FIG. 980.—Ventral or Cut Surface of the Cranium as Separated from the Face Along the Line A–C (Fig. 979). If the parts outside the lines D–E and F–G are sawn off, the brain may be exposed by removing with the nippers the base and one or both sides of the cranium.

B–B the postoblongata, metencephal, overhung by the cerebellum; C–C, the epencephal (cerebellum, preoblongata, and pons); D–D, the mesencephal (crura and quadrigeminum); E–E, the diencephal (tuber, medicommissure, thalami, etc.), overhung by the cerebrum; F–F, the prosencephal (cerebrum) just cephalad of the chiasma 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

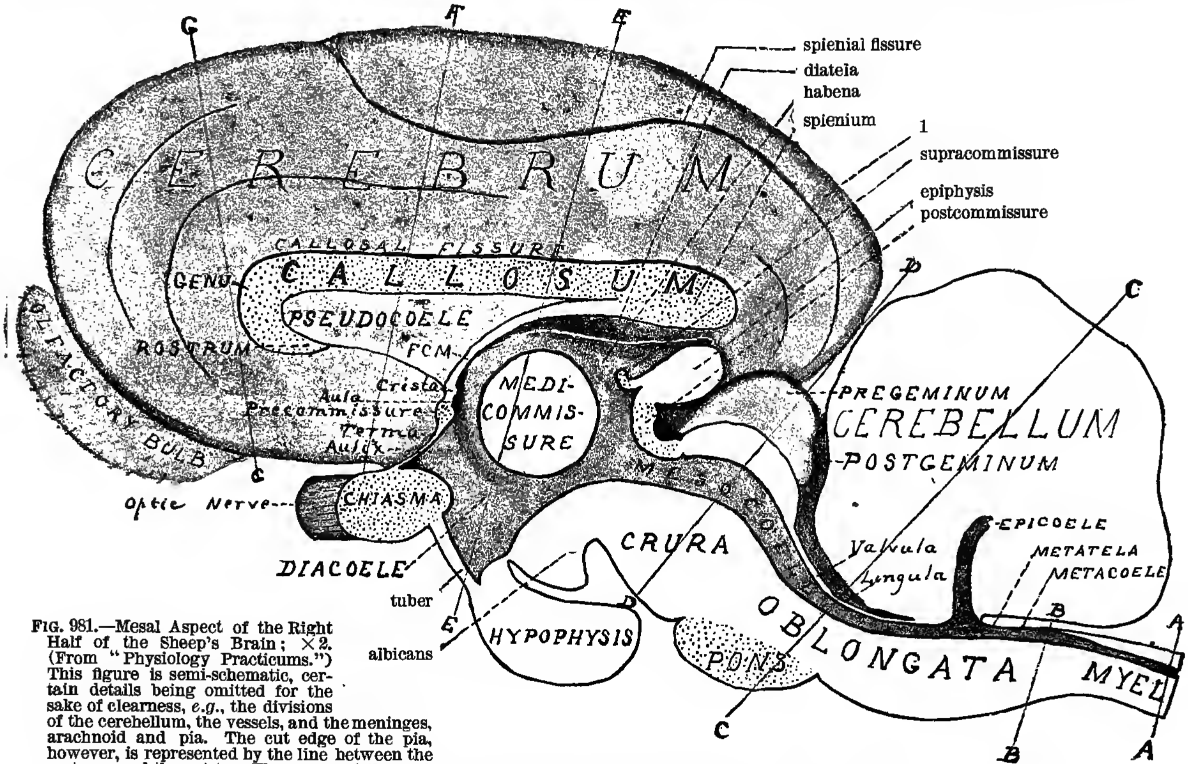


FIG. 981.—Mesal Aspect of the Right Half of the Sheep's Brain; × 2. (From "Physiology Practicums.") This figure is semi-schematic, certain details being omitted for the sake of clearness, *e.g.*, the divisions of the cerebellum, the vessels, and the meninges, arachnoid and pia. The cut edge of the pia, however, is represented by the line between the rostrum and the crista. The names of the cavities, *Diacœle*, etc., should be spelled *Diacele*, etc. The endyma lining the diatela is really continuous at each end with that of the adjacent parts. 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

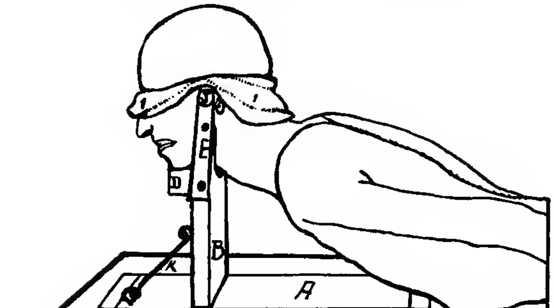


FIG. 982.—Head-Rest Devised by Stroud, in Use. (From his paper, 1900, *b.*) A, Baseboard; B, upright board; D, chin-rest; E, lateral iron bar. For details see Figs. 988–989, and §§ 142–143. 1–1, Reflected portions of the scalp.

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

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

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 medisection 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

* 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 brain are to 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 occiput, 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 smaller part of the calva along 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 especial 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 curved 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 elucidations.

‡ 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.

attached periphery and removed entire, thus exposing the cephalic ("upper") aspect of the cerebellum (Fig. 700, p. 159). If the head is tilted a little to one side and the other, the fingers may be safely passed under the comparatively firm pons so as to lift the whole mass and expose the remaining cranial nerves (Fig. 681, p. 154). When these and the vertebral arteries are divided (Fig. 803, p. 214) the myel itself may be cut well down in the spinal canal. Lastly, after replacing the parts and tilting the head cephalad, may be divided the attachment of the arachnoid about the foramen magnum, and the mass may now be removed. It is advantageously kept entire till hardened, but the cerebrum is more easily dealt with and commonly more instructive if medisected at once.

§ 61. *Medisecting the Fresh Cerebrum.*—This is to be done with a large knife, thin and very sharp. The mass should rest in a wide dish of brine and be steadied but not actually supported by cotton at the sides. The frontal lobes are held closely together by the arachnoid along a line corresponding with the ventral (concave) margin of the falx (Figs. 800 and 801, pp. 212, 213). This arachnoid must be torn or carefully divided so as to permit the slight divarication of the hemicerebrums and the exposure of the mesal zone of the callosum, recognizable from its white color at the bottom of the intercerebral fissure.

If there are special reasons for obtaining an accurate medisection of the callosum itself or of the pseudocele (Fig. 756, p. 189) the section may begin with the callosum, preferably the genu or cephalic curvature.

Commonly, however, I have found the delicate terma and medicommissure more perfectly preserved when the cerebrum rests upon its dorsum and the chiasma is divided first. In either case the knife should be constantly irrigated.

§ 62. *Weighing the Fresh Brain.*—This may be done in any of three ways.

A. With an animal of moderate size, or a child, or a separated head, the weight of the brain represents the loss of weight of the animal, child, or head after its removal.

B. A vessel partly full of water, salt solution, or brine, is balanced upon the scales;* the brain is lifted from the liquid in which it has been, in the hollowed hands; they and the brain are rinsed with water, and the brain is transferred to the vessel on the scales. If the dura remains the weighing cannot be accurate, even by deducting its weight when removed.

C. After recording the weight required to balance the added brain, then—having first wet the hands with a liquid identical in composition with that in which the brain is immersed—remove the brain and record the loss of weight. Theoretically it should be the same as had to be added before; practically there is usually some difference, and the average of the two may be taken as representing the true weight.

§ 63. *Determining the Volume of a Brain.*—This is done, as with any other mass, in either of two ways.

A. Into a vessel of accurately known capacity pour a given volume of liquid; dip the hands in the same, and transfer to it the brain; then from a graduated vessel add enough more of the liquid to fill the first vessel. The difference between the total capacity of the vessel and the sum of the two volumes of liquid introduced represents the volume of the brain.

B. Set a vessel in a deep pan, dish, or pail. With any liquid (salt solution, water, or alcohol and water) that is lighter than the brain, fill the vessel just to the brim. Let the brain into it gradually; the overflow will represent its volume.

Obviously a combination of the two methods is most satisfactory.

§ 64. *Dividing Nerves and Vessels.*—As a rule this should be done with the scissors, not so much to avoid blunting the scalpels by contact with bone as to avoid the almost inevitable traction and breakage of delicate or important attachments.

§ 65. *Closing Divided Vessels.*—This may be desirable either to prevent the disfigurement of the body or clothing by blood, or to permit the injection of the general vascular system. In the latter case, unless the divided vertebrals and carotids can be tied or caught with *serres-fines*, the regions in which they open may be filled with plaster of Paris. In the former case, plugs of absorbent cotton may be pushed into the spinal canal and the vascular orifices at the base of the skull, and the cranium then filled firmly with the cotton so as to be compressed and crowded down by the calva.

§ 66. *Reuniting the Divided Calva.*—If necessary, at once, or at any time, the two parts of the calva may be united by wires, or even cords, passed through holes at the middle and at each end; such holes may be made with a drill, awl, or wire nail.

§ 67. *Reattaching the Calva.*—Whether reunited or not the two pieces of the calva may be secured by wires through holes at each of the four "corners" (§ 60, *D*). Further stability is gained by stitching the divided edges of the temporal fascia.

§ 68. *Sewing up the Scalp.*—A knot should be tied at the end of the silk and the needle introduced at the root of the ear, at first ecto-entad (from the surface inward), afterward ento-ectad (from within outward); the stitches not too long, and not entangling the hair. Even if the concealment of disfigurement is not essential the operation should be neatly done unless there are special reasons for unusual haste.

§ 69. *Other Methods of Removing the Adult Brain.**

§ 70. *By Removal of the Occipital Region of the Cranium.*—At the meeting of the American Neurological Association, June 22d, 1883, as reported in its Transactions, p. 84, as reprinted from the *Journal of Nervous and Mental Disease*, July, 1883, Dr. Spitzka described as follows a method which, he informs the writer, he has known to be employed by some German anatomists. The writer has not tested this method personally, but is disposed to regard it as better adapted to pathological than to anatomical purposes, and as such entitled to be considered in connection with the usual method, and with that described on pp. 789–791 of Vol. V. of the first edition of the REFERENCE HANDBOOK:

"The scalp is divided in the median line, beginning a little in front of the coronal suture, and extending down the neck. If it is desired to remove the spinal cord the incision is extended to the lumbo-sacral region. Two lateral flaps are formed in the head region, the soft parts being peeled from the dorsal aspect of the cervical vertebra and the posterior half of the skull. A circular incision is made [with the saw] in the skull, behind the ears, and completely encircling it down to the foramen magnum, care being taken not to injure the connection between the articular processes of the atlas and the occipital condyles; the posterior half of the skull is removed exactly as the calvarium ordinarily is, by taps of a chisel; sometimes a rongeur forceps suffices to complete the division near the foramen magnum. The adhesion about the lateral [and longitudinal] sinus and torcular Herophili can be readily overcome by a home-made apparatus like the knife [spatula, or round-pointed knife, curved flatwise] shown by Professor Wilder. The advantages of this method are: 1, The spinal cord and brain can be demonstrated *in continuo*; 2, the critical operation of lifting the hemispheres and gouging out or injuring the cerebellum in dividing the tentorium is obviated; 3, the nerves and arachnoidal laminæ at the base may be divided without allowing the brain to drag by its own weight. These nerves are divided from behind forward. As soon as the chiasm is divided, the skull is inclined a little, and the brain allowed to fall into the hands of the operator by its own weight, it being completely separated, except where the olfactory filaments pass through the ethmoid;

* Some trouble will be avoided if, after the pan of liquid has been counterpoised upon the scales by an approximately equal weight, say 500 or 1,000 or 1,500 gm., the exact balancing is accomplished by removing or adding liquid with a syringe.

* See the article *Autopsies.*

but these yield readily, and I have gotten the olfactory bulb intact as often by this as the other method. The removal accomplished, the occipital segment is riveted back, and a stick of wood inserted in the spinal canal and extending to the cranial interior restores the strength to the head support, impaired by the breaking up of part of the vertebral attachments."

§ 71. The method of Féré (as briefly described in a paper "Procedé de coupe du crâne," *Soc. Anat. de Paris Bulletin*, ii., 206–207, March, 1877) is by a circular incision very low down from the eyebrows ventrad of the auditory meatus to a point between the foramen magnum and the dorsal arch of the atlas. This, if successful, would uncover the brain very fully and permit its replacement in the calva after extraction; but it seems inevitable that the petrous bones should give trouble as well as be themselves destroyed.

§ 72. *Removing the Brain from Late Fetuses, Still-Borns, or Young Children.*—This is most conveniently done if the cranium and maxillary region are first cut away from the neck and mandible by cutting with coarse-curved scissors from the corners of the mouth to the nape of the neck. The mass thus obtained is compact and may stand upright in liquid.

A. Instruments and materials required. Coarse forceps; coarse-curved scissors for bone: another sharp pair for soft parts: tracer (Fig. 985); nippers (Fig. 986); large scalpel; narrow-bladed scalpel, preferably a probe-pointed bistoury; four vessels, holding about two litres each; two of water; one of preservative; one of saturated brine: if the weight of the brain is to be ascertained (§ 62) the body should be weighed before the head is removed, and there should be provided a fifth vessel of normal salt solution (15 to 2,000).

B. The scalp should be removed completely, together with the ears, and temporal muscles as far as the zygomas.

C. Cranium and dura. In young subjects these adhere closely; hence, contrary to what is recommended with adults, they should be removed together in pieces. With the tracer-point lift the united pericranium (ectal periosteum) and dura near the left margin of the prefontanel (p. 212, § 388), and with the scissors or scalpel slit the tough membrane so as to expose a little of the brain. Grasp the cut edge with the forceps and with the scissors cut out a piece including pericranium, dura, and intervening area of parietal bone. Continue in this way, using the nippers when necessary, until the entire left hemicerebrum is exposed. More and more care will be required to avoid injuring the delicate brain, either by the instruments or the cut edges of bone.

Leaving the falx undisturbed, expose the right hemicerebrum in the same way, but with even more precaution and holding the head so that the left is more or less completely supported in the brine.

D. Proceed then, *mutatis mutandis*, as directed for the adult (§ 60, G).

§ 73. *Removing the Hemicerebrums Separately.*—The following modification of the method just described has some advantages. After the exposure of the left hemicerebrum cut the veins as before. Let the head tilt to the left so as to expose the callosum. Divide it, as directed above, down to the base of the skull; then the left half of the mesencephal; then the infundibulum and optic nerve; and finally dislodge the olfactory bulb.

These last parts are then to be attended to first on the right side; the falx is easily removed, and the hemicerebrum comes out as soon as the veins are cut. The chief objection to this method is the danger of cutting the mesal aspect of one of the frontal lobes.

§ 74. When there are reasons for not mutilating the head, the removal of a child's brain is much less convenient. The body and legs should be wrapped up so as to be held and turned easily. Unless the child can be held by an assistant, it will be found convenient to let it rest in a sort of trough, like a piece of large roof-gutter; or to roll it up in a sheet of lead, which, upon pressure, will flatten so as to maintain any desired position. The tray or trough must be supported at a level with the rim of the vessel of brine, so that the head may hang over into it when desired. Needle and thread must be provided for sewing up the scalp.

§ 75. *Ventral Exposure.*—For some purposes, *e.g.*, when the organ is to be kept entire, or when the nerve-roots are to be retained, the young brain may advantageously be exposed from the ventral side; this aspect should be first studied, as shown in Figs. 672 and 806; then the base of the cranium may be nipped away, or cut with the coarse scissors; it will be well to expose one side completely first, so that any errors detected may be avoided on the other. With care the hypophysis (Figs. 689 and 708) may be retained.

This method is less applicable to adult brains, on account of the thickness of the skull; this, however, may be softened by nitric acid (§ 127).

On February 1st, 1884, the writer removed the cranium of a small monkey (*Midas*, No. 342) by means of a dental engine, working a small saw and a burr. It may be predicted that in time the work now done laboriously with saw and nippers will be accomplished more neatly and expeditiously by some apparatus like the electro-osteotome of the late Dr. M. J. Roberts (*Virginia Medical Monthly*, March, 1887).

§ 76. *Brains of the middle and later gestative periods and at term* are most useful for the comprehension of the early and simple condition of the fissures and of the order of their appearance. The best results are obtained by their prompt removal as described in §§ 72–75, and hardening with some zinc-chloride mixture (§ 89). The arterial injection of such brains rarely preserves them well, and the gyres are commonly so pressed together as to interfere with both the removal of the pia and the recognition of their relations.

§ 77. *Early Fetal Brains, Two to Four Months.*—Unless one has acquired considerable skill in manipulating such delicate objects, these should be hardened in place by one of the following methods, or by a combination of them; a five-per-cent. solution of zinc chloride in alcohol is very effective with embryo brains:

A. Injection of the preservative through the umbilical vein.

B. Immersion; if alcohol, or the above solution, is used the specimen should be suspended in it.

C. Injection of the preservative with a hypodermic syringe both into the body in general and into the cavities of the brain.* The cannula should be pushed through the scalp at the margin of the prefontanel (p. 212, § 388), obliquely latero-ventrad so as to traverse the thin parietes and enter the large frontal portion of the paracele (Figs. 667, 716, 747). The success of the injection is shown by the expansion of the opposite half of the head due to the passage of the liquid through the portas ("foramina of Monro") into the corresponding paracele.

The exposure of such brains must be done under or over alcohol; the cranium and dura must be divided together at each cut (§ 72, C). The operation is tedious, but the results are revelations, no matter how often performed; no specimens are more beautiful or instructive; see Figs. 667, 746, 748.

§ 78. Hydrocephalic brains, and those of fetuses between the second and seventh month, are alinjected in place from the aorta or other artery, and also have the more or less abundant neurolymph replaced by strong alcohol. This direct, entocelian alinjection is done as soon as possible after the arterial has begun; it is most conveniently accomplished by making a slit at one margin of the prefontanel large enough to permit the introduction of a cannula and the escape of liquid at its side. The injection need not be continuous, and, of course, should not be under pressure, but may be repeated at intervals of an hour or two.

§ 79. When a hydrocephalic or fetal brain is wanted for a special object involving the integrity of the entire cerebrum or the complete distention of the metepenceph-

* So far as the writer is aware, this was first done by Professor S. H. Gage, May 17th, 1892, upon specimen 2,947.

alic cavities, then the undesired region is cut away, the desired region left in the cranium, and the alcohol injected through the mesocele, continuously, in order to make up for the non-injection of the arteries.

§ 80. Removed embryo and hydrocephalous brains are relieved from pressure during hardening by inflating the cavities: Fig. 715. The buoyancy of even an adult normal brain is sometimes increased by injecting air into the arteries through a bulb syringe.

§ 81. *Preservative Liquids.*—Alcohol is a perfect preservative, but it bleaches the cinerea, and in any mixture with water strong enough to be effective the brain sinks and becomes distorted. The specific gravity of the mixture may be increased by glycerin, zinc chloride, or other heavy soluble salts (§ 82–84). Strong alcohol may be injected into the cavities and blood-vessels of the brain (§§ 91–108).

§ 82. *Alcohol and Glycerin.*—One of my most perfect and instructive fetal brains (1,820; Fig. 751, p. 187) was first placed in equal parts of alcohol and glycerin; after two days half the mixture was replaced by alcohol; after two days more alcohol alone was used, and this was renewed on the following. The mixture merits systematic trial.

§ 83. *Alcohol and Zinc Chloride.*—A five-per-cent. solution of this salt in ordinary (ninety-five-per-cent.) alcohol is very effective with embryo and fetal brains, whether by injection or immersion.

§ 84. *Ammonium Dichromate.*—Our use of this has not been sufficiently extensive for a general statement, but, at the suggestion of Professor Gage, it was employed in association with alcohol very successfully in the preparation of the specimen represented on pp. 176 and 184 (Figs. 732 and 744). In equal parts of alcohol and water the salt was dissolved in the portion of 2.5 gm. to the litre. In addition to the thorough hardening of the substance and the unusually perfect maintenance of the membranous and plexal attachments, the color differentiation was sufficient, although the subsequent prolonged preservation in alcohol alone has nearly bleached the cinerea. This salt merits further trial in various combinations.

§ 85. *Potassium Dichromate.*—This is the essential ingredient of Müller's liquid (§ 86). Dr. Stroud has determined that, at the temperature of 20° C. (68° F.), a saturated solution of potassium dichromate contains about ten per cent. of the salt; at boiling the per cent. is forty-four. His method of using it is to effect the solution rapidly in boiling water; when cool, enough water is added to float the brain just below the surface.

The specimens in this solution or in Müller's liquid should be kept in the dark, *i.e.*, in metal pans with metal covers, or in a dark room.

As soon as the brain is firm to the touch it may be soaked for a day in water and then in alcohol, at first about forty per cent., then stronger, until the alcohol ceases to be colored, after which it may be kept in alcohol of not less than eighty per cent.*

The alcohol that is so colored may be used for the same purpose with other brains, or for the storage of specimens not requiring it to be either colorless or very strong.

§ 86. *Müller's Liquid.*—This consists of two parts of potassium dichromate and one part of sodium sulphate in one hundred parts of water. Beyond increasing the buoyancy of the liquid, the sodium sulphate seems to have no special value for either microscopic or macroscopic purposes and is often omitted. Sufficient buoyancy may be attained by increasing the per cent. of the essential ingredient (§ 85).

§ 87. *The Incompatibility of Alcohol with Potassium Dichromate.*—A chemist to whom the matter was submitted states that when alcohol and potassium dichromate are mixed in any proportion the salt will be at least partially reduced, and there will also be formed, from the alcohol, various compounds, as acetic acid, acetic aldehyde, etc. These processes take place in either the light or the dark, but more rapidly in the light.

* The specimens may be more completely decolorized by absolute alcohol (W. C. Krauss), by hydrogen peroxide (Unna, *Arch. für mikros. Anat.*, xxx., 48, 1887), or by a one-per-cent. solution of chloral hydrate (Lee, "Microtomist's Vade Mecum").

§ 88. *Zinc-Glycerin Mixture.*—After careful consideration of prior suggestions, and prolonged experimentation, P. A. Fish published (1893, p. 393; 1894, p. 101) the formula of a liquid which, "though not ideal in its effects, seems to answer the requirements of economy, fixation of the structural elements, differentiation of tissue, a minimum amount of distortion, firmness of texture, and rapidity of action.

"The formula is as follows:

Water	400 c.c.
Ninety-five-per-cent. alcohol	400 c.c.
Glycerin	250 c.c.
Zinc chloride	20 gm.
Sodium chloride	20 gm.

"The specific gravity of the mixture should be about 1.04, a little greater than that of the brain itself (1.038). The slightly greater density of the fluid is believed to be more advantageous than otherwise, since it buoys the brain until the tissue has begun to harden and can partially support its own weight. The pressure is nearly enough equal on all sides to prevent any noticeable change of form. It is recommended that the cavities of the brain be filled with the mixture (celinjected) and if practicable the blood-vessels also injected. After an immersion of about three days the specimen should be transferred to equal parts of the foregoing mixture and seventy-per-cent. alcohol for a week or more, where on account of the lesser specific gravity it should rest upon a bed of absorbent cotton; it is finally stored in ninety-per-cent. alcohol."

§ 89. *Zinc-Formalin Mixture.*—Two years later Fish published (1895, *a* and *b*) the results of two experiments with an agent then comparatively little known. Referring to the zinc-glycerin liquid he says: "Experiments with formalin (forty-per-cent. formic aldehyde) show that practically as good results may be obtained at less cost when the following mixture is employed:

Water	2,000 c.c.
Formalin	50 c.c.
Zinc chloride	15 gm.
Sodium chloride	100 gm.

The brain is left in the mixture for a week or ten days (a longer stay is not detrimental); when practicable the cavities and blood-vessels are injected with the same to insure a more uniform hardening."

Respecting the subsequent treatment Dr. Fish writes me that he recommends a course slightly different from that indicated in the papers quoted. For storage, a five-per-cent. solution of formalin, *i.e.*, 50 c.c. to 1,000 of water.* In this it may remain indefinitely if properly covered. For museum purposes it may be placed successively for a few days each in alcohol, 50, 70, 90, and 95 per cent.

§ 90. *Saline Alcohol.*—Dr. Stroud, the successor of Dr. Fish, continued experiments with the same important end in view and devised a liquid which dispenses with the irritating zinc chloride, combines the two liquid preservatives, alcohol and formalin, and overcomes the difficulty due to the slight solubility of the sodium chloride in an alcoholic mixture by employing a somewhat larger portion of another salt, sodium acetate. The formula as published in 1896 is as follows:

Sodium acetate	130 gm.
Sodium chloride	110 gm.
Formal [formalin] (forty-per-cent. formaldehyde)	20 c.c.
Alcohol (ninety-five per cent.)	460 c.c.
Water	540 c.c.

Dissolve the sodium acetate and the sodium chloride in the water. Cool and filter, then add the alcohol. With

* As the formalin does not prevent the freezing of the water, cold must be guarded against.

alcohol free of tax the cost is about fourteen cents per litre.

For a human brain is required about 3 litres, *i.e.*, three times the above formula. For a sheep's brain, about 400 c.c., or half the formula.

Brains should remain in brine to soak out the blood for a time dependent on their size. They should remain in the saline alcohol for ten or fifteen days, but a longer period is not harmful. Then they may be transferred to increasing percentages of alcohol.

During the last four years there have been prepared by the saline-alcohol scores of human brains and hundreds of brains of sheep and other animals, and it has proved wholly satisfactory for macroscopic purposes, whether for dissection or permanent preservation. The structural and color distinctions between alba and cinerea are well maintained.

§ 91. Experiments are making with a saline-alcohol in which the components have a simpler ratio, and the results will be announced as soon as practicable.

§ 92. *Entocelian Injection.*—To fill with a hardening and preservative liquid cavities surrounded by flexible walls would seem to be a natural device both for the better preservation of the mass and for the maintenance of the forms and relations of the cavities.*

A small glass syringe may be employed for injecting preservative liquids into the brain cavities, either directly or by attaching a rubber tube and cannula.

§ 93. Seldom, if ever, excepting perhaps with very small or thin-walled specimens (*e.g.*, the brain of *Cryptobranchus* shown on p. 170, Fig. 717) is a single or momentary introduction of the preservative sufficient.

§ 94. *Continuous Injection.*—This involves, first, the elevation of the reservoir of preservative to a height (upon a shelf or at the end of a cord) sufficient to insure steady and adequate pressure; secondly, the avoidance of damage from the clogging or twisting of tubes or the overflow of the liquid that has escaped after traversing the vessels or the cavities. The various requirements may be met by simple arrangement of pinchcocks and flexible wire supports of copper or lead.

§ 95. Without conceding the existence of other natural orifices from the paraceles (lateral ventricles) (p. 171, Fig. 721), both human and animal brains present outlets for the escape of the injected liquid so as to obviate the danger of rupturing the thinner parietes under any pressure that might be required for filling the cavities. With animals the myelocele (central canal of the spinal cord) is pervious through life. With a cat, for example, where 4 cm. of the myel remained attached to the brain, alcohol injected into the diacele (third ventricle) with a syringe escaped from the myelocele in a stream 8 to 10 cm. long, although the orifice of exit was 42 mm. from the tip of the metacele and 66 from the place of injection. With human brains (excepting early stages when the myelocele would probably be sufficiently pervious) there is an ample outlet at the metapore (foramen of Magendie), (p. 154, § 78). The same is the case with apes and some monkeys. Hence the cannula, instead of fitting loosely, may be tied into the infundibulum, or made large enough to fit it closely. In the latter case the cannula may need a rubber collar to prevent its entrance so far as to lacerate the medicommissure or parietes. This precaution may be rendered superfluous by using a cannula which is bent upon itself at a right angle, in the form of a capital letter L turned one quarter way around, thus, ⌐; the shorter arm enters the orifice (for tying in the infundibulum a slight enlargement of the point is desirable); the longer rests upon the base of the brain and has attached to it the tube connected with the syringe or injection reservoir This tube should be short and slender; in the intervals of injecting it may be compressed, or plugged with a glass or cork.

§ 96. Entocelian injection, whether repeated or continuous, may be accomplished from any artificial orifice. The most favorable place is the mesocele (aqueduct) after transection of the brain; the cannula may be selected so as to fit it closely. With the cerebellar portion of the brain the metapore would serve as the outlet; with the cerebral it might be necessary to tie the infundibulum to prevent too ready escape therefrom; with a small stream at a slight elevation above the brain it is probable that any excess would be provided for by oozing along the rima.

§ 97. *Entocelian Alinjection per Luram.*—Four points are to be kept in mind: (1) The smallness of the orifice (Fig. 672), which may be enlarged, if desired, with the probe or by clipping the infundibulum shorter; (2) the general dorso-caudal direction of the passage (Fig. 687); (3) the danger of wounding the parietes, and especially the medicommissure; the cannula should therefore be short, the tube small and flexible, and the cannula pushed through a disc of rubber so as not to enter more than 1 cm.; (4) the weakness of the encephalic substance after death; hence no more pressure should be exerted than suffices to fill the cavities and cause a slight elevation of the tips of the temporal lobes. The alinjection can should be just above the level of the brain, and the cannula fit loosely in the lura so that the excess of alcohol may escape.

§ 98. *Combined Arterial and Entocelian Alinjection.*—This very effectual method of preserving a brain removed in the dura for any macroscopic purpose was employed with the specimens shown in Fig. 720. A separate reservoir must be used for the entocelian alcohol (§ 97), or the branch tube leading to the lura must be small and kept compressed so that—when the cavities are once filled—the flow will be very slight.

§ 99. *Arterial Injection of the Preservative.*—This is somewhat fully described in §§ 101–108, and is exemplified in Figs. 670 and 801. As compared with immersion it has the great advantages of rapidity and thoroughness. Any preservative may be employed, and alcohol may be used at full strength. A low temperature is needless, and even perhaps undesirable.

Barring a slight shrinkage, the natural conditions and relations are maintained.

It must be admitted, however, that sometimes the gyres are somewhat crowded against each other, so that the pial folds are less readily and safely extracted, and the fissural relations less easily determined. This applies particularly to infant brains.

§ 100. This is not the occasion for a complete history of injection processes or for the presentation of claims to originality. The transmission of preservative liquids to the tissues by a constant pressure apparatus connected with the vessels by which blood reached the parts during life is really so simple as well as effectual that it is hard to account for its comparatively infrequent suggestion and adoption. Without previous acquaintance with what had been done by others,* on October 7th, 1883, with the co-operation of Prof. S. H. Gage, I began upon the body of a young chimpanzee (No. 265) an alinjection of the entire body, which was prolonged for ten days and was completely successful. In November, 1885, a manatee (No. 844), 150 cm. long, was prepared in like manner. All the cats used by the general class in physiology are alinjected and packed away till wanted. Still-born children are commonly so preserved, and I recommend that, with alcohol obtained free of tax, all anatomical material in medical dissecting rooms be thus rendered

* The method was first employed by me, as assistant to the late Prof. Louis Agassiz, at Nahant, Mass., in July, 1867, for permanent preparations of great vascular sinuses in rays. Since that time it has been applied in the anatomical laboratory of Cornell University to the preparation and study of hollow organs of all kinds, stomach, cecum, heart, uterus, kidney, and brain. In 1880 I first learned that the injection of alcohol into hearts was advised in 1860 by Hyrtl, and in 1879 by Mojsisovics; the former ascribes the idea to William Hunter. I am not aware that injection of a preservative into the brain cavities was practised or suggested by any one prior to December 14th, 1881, when I employed it upon a child's brain.

* Arterial alinjection of the brain is named or implied by Ecker ("Cerebral Convolutions," p. 45); by Mondino (Trans. Roy. Micros. Society, 1885, p. 904); by Foster and Langley ("Pract. Physiology," p. 215); by Key and Retzius ("Studien," i., p. 104); and by the editors of the tenth edition of "Quain," vol. iii., Fig. 88. It was done in 1863 for Marshall upon a Bushman (Philos. Trans., cliv., p. 501); the dates of its performance for Flower and Owen are mislaid.

innocuous, free from unpleasant odor, and fit for prolonged and thorough examination.

§ 101. *Location of the Arteries.*—Nearly opposite the hyoid bone, or the cephalic margin of the larynx, each common carotid divides into an ectocarotid ("external") and an entocarotid ("internal"). In the adult they differ little in size, but may be distinguished in that the ectocarotid branches at once and lies farther ventrad, while the entocarotid continues unbranched to the cranium and is accompanied by the vagus nerve.

If the neck was severed close to the head the two arteries may be dealt with independently. If at the level of the chin (as in the head shown in Fig. 670) the common carotid may be followed up between the muscles, using the tracer rather than the scalpel as much as possible. But if the neck is entire, and especially if it is to be kept so, the ectocarotid may be exposed as for surgical ligation by an incision along the ventral ("anterior") margin of the sternomastoid from the lobule of the ear. In any case the ligature must be applied close to the bifurcation of the common carotid or the superior thyroid artery may not be included. As to the vertebral artery, unless there are special reasons for not injuring the vertebræ, the transverse process may be nipped away in order to expose the vessel. The cannula is to be inserted in one, and the other tied after the arteries have been cleared. Since the two arteries unite to form the basilar it makes no difference which has the cannula, excepting that there is some convenience in placing it and the carotid cannula on the same side (Fig. 803).

§ 102. *Securing the Cannulas.*—Preferably one cannula is to be inserted in the carotid, whichever is the longer, and another in the vertebral of the same side. Each is to be very securely tied; if there is no shoulder at the cannula point, then tie also around the rubber tubing at its base. All the knots should be the so-called "surgeon's," one end of the thread being passed through twice instead of once; W. and G., Fig. 41.

§ 103. *Clearing the Vessels.*—Inject "normal salt solution" (sodium chloride, 15 gm.; water, 2 litres) into a vertebral and entocarotid artery (preferably on the same side) until the liquid runs clear from the other arteries. Place in the alinjection can about 5 litres of twenty-two-per-cent. alcohol, strained through absorbent cotton or filter paper; raise the can to about 1 metre. In connecting the tubes let all air bubbles escape. Small arteries that leak must be tied or secured with *serres-fines.* The liquid should escape in six to eight hours and be quite bloody. If the last of it is nearly free from blood, the strong alcohol may be used; if not, repeat, using half the quantity of twenty-two-per-cent.

§ 104. The strong (ninety-five-per-cent.) alcohol may now be used at the same pressure; it will pass through at a rate varying from one-third to eight-tenths of a litre per hour, and be reduced to seventy-five or eighty per cent. At the end of the third day, and perhaps earlier, the strength of the alcohol will be but little reduced; the pressure may then be lessened by lowering the can to one-half the height. By the sixth day the loss in strength may be no more than three per cent., and the discoloration insignificant. The alinjection may then be discontinued, and the head medisected (§ 109) or otherwise prepared. If desired, a colored injection mass may be thrown into the arteries of either the face (ectocarotids) or the brain (entocarotids and vertebrals), or all.

§ 105. *Turning the Head.*—There are reasons for believing that the position of a head under injection should be changed daily, in order that no one region of the cerebral surface shall be more than twenty-four hours in close contact with the cranial wall.

§ 106. *Repeated Alinjection.*—It is probable that the injection of, say, 1 litre of ninety-five-per-cent. alcohol, morning, noon, and night, for a week would harden a brain very well, but accurate experiments on this point have not been made as yet under the writer's observation. If it be tried especial care should be taken to exclude air bubbles (§ 107), to keep the brain wholly submerged or its base covered with a layer of absorbent cotton dipping into the alcohol. Such injections may be made conveniently with an ordinary rubber-bulb syringe. Repeated injection will conduce to the preservation of the celian parietes and of the plexal attachments, but is less effectual than continuous for maintaining the size and form of the cavities.

§ 107. *Exclusion of Air Bubbles during Arterial Injection.*—This is accomplished by letting the alcohol run until no bubbles appear either in the cannula or in a glass tube which is introduced near the can. The can itself should always be at a higher level than the adjoining tube, especially when it is lowered for the introduction of fresh alcohol, since bubbles are then most apt to be formed; on this account the tube should be of ample length.

§ 108. *Filtration.*—Whatever liquid is to be injected into the encephalic vessels must be carefully filtered through filtering paper, or through absorbent cotton crowded into the pipe of a funnel. This necessity applies to unused alcohol as well as to that which has already passed through tissues.

§ 109. *Medisection of the Head.**—Determine the plane of section by the following mesal points, some of which, of course, are subject to variation: (1) Interval between the central incisors in each jaw; (2) dimple at tip of nose; (3) occipital protuberance (inion); (4) myel; (5) vertebral centrum; (6) notch in cephalic margin of larynx; (7) dimple of chin; (8) middle of top of head. This last is ascertained by carrying a piece of inelastic cord over the top of the head, securing each end in an auditory meatus by crowding cotton in with it, and then finding the middle of the cord. At each mesal point make a short but deep incision. Knot one end of a cord long enough to surround the head and neck at the meson; place the knot entad of the central maxillary ("upper") incisors, and carry it over the nose, head, neck, and chin, back to the mandibular incisors, between which it may be secured by a wedge or otherwise. With the arthrotome divide the scalp, etc., along one side of the cord. Remove the cord, and at the occipital convexity (about at the line from 7 in Fig. 670) bore a hole at the meson deep enough to permit a screw to be firmly fixed.

§ 110. *Adjusting the Head.*—Place the head in the saw-box and mark with a pencil the points where the bottom and one side are in contact with the occipital region and the vertex; at these points bore a hole in the kerf large enough to admit one of the screws. Replace the head in as nearly as possible the same position; pass the spatula through the kerf above the hole in the side opposite the vertex, and adjust the head so that the end of the spatula is in the cut in the scalp. While steadied in that position pass the gimlet or awl through the hole and bore into the skull for a short distance, 3 to 5 mm.; insert the screw at this point. Repeat the operation for the occipital region. This screw should bring the head firmly against the bottom of the box. If it is necessary or desirable to remove the head in order to bore the holes, when the head is replaced the holes may be found by means of the probe end of the tracer.

§ 111. *Packing.*—Draw through the kerfs in the two sides a cord just large enough to fit tightly, and pull it down so that it coincides with the cut in the skin of the face. Pack the cotton first in the angle between the two screws; then under the neck, keeping the whole constantly adjusted by means of the thread and the kerf at the neck side of the box. When firmly packed, pour over the cotton some water until no more is absorbed.

§ 112. *Sawing.*—Remove the cord from the kerf; insert the saw so that the handle is close to the side of the box, and make the first few strokes by drawing only—then

* The following instruments and materials should be provided: Saw (§ 140); saw-box (§ 141); scalpel, the handle of which is smoothly rounded; small, narrow-bladed scalpel, arthrotome, and tracer; two screws, slender rather than thick, and 5–8 mm. longer than the thickness of the side and bottom of the saw-box; gimlet to fit the screws; short, stout awl, medium size; spool of stout saddler's thread; spatula; cotton, or cotton waste or tow or bits of cotton cloth, previously soaked in water and well squeezed, enough to fill the saw-box quite firmly; large agate pans or other suitable vessels; jars and alcohol.

saw in the usual way; a fine stream of alcohol (any per cent. above forty-eight) should irrigate the blade during the entire operation. The back of the saw should be retained as long as possible, and screws not removed until nearly reached by the saw. Let a *gentle stream* of water flow over the sawn surfaces.

§ 113. *Removal of Either Half of the Hardened Brain.**—A. Remove the falx and falcula (*falx cerebelli*). At the base divide the infundibulum close to the tuber, leaving the hypophysis to be removed separately. Note the location of the optic nerve, and divide by carrying the scalpel point latero-cephalad from the infundibulum for 1 to 2 cm., close to the dura, lest the olfactory crus be injured. Dislodge the olfactory bulb with the syringotome, turn it just over the margin of the hemicerebrum, and secure it by a small pin at either side.

B. *Transection of the Hemicerebrum.*—Recognize, if possible, the dorsal end of the central fissure, nearly dorsad of the splenium. Place a strip of paper or a cord across the hemicerebrum between points about 5 mm. caudad of the fissure and the splenium. The half-head should be in alcohol or the blade should be flooded. The vertex should be toward the operator. Note on the empty half-head the angle formed by the tentorium with the meson, or observe on the preparation in hand. Push the scalpel into the brain close to the tentorium, and with a gentle sawing movement carry its point as far as it will go; continue the movements dorsad, making sure that the broad edge of the haft of the scalpel does not bruise the brain. The completion of the transection is announced by the loosening of the occipital region. Probably the greatest difficulty will be the division of the extreme ventral part. To remove the occipital part, push the probe end of the tracer or a very narrow-bladed scalpel into the brain 10–12 mm. caudad of the section plane, near the tentorium and between two fissures; the direction should be dorso-laterad at an angle of 45°, thus nearly perpendicular to the ental surface of the cranium toward which it is pointing. Dislodge the tip of the occipital lobe by coaxing with the scalpel handle; lift the whole piece slightly with the inserted instrument; it will come out for a certain distance, and then be checked by veins, which may be divided with scissors.

C. *Mesencephalic Transection.*—From Figs. 706 and 708 note that (1) the crusta projects considerably ventrad of the mesal cut surface and (2) that the greatest width of the crus is not more than 15 mm. Hold the scalpel with the flat side at an angle of about thirty degrees with the meson, let the ink mark be at the ventral margin of the crus, and cut dorsad with sawing strokes. Place the specimen so that the depths of the incision are illuminated, and divide whatever may appear; the hemicerebrum will float up, and be readily removed if the dorsal margin be first disengaged and the prominence of the temporal lobe kept in mind.

D. *Removal of the Metepencephal.*—If the tentorium is to be retained, divide it by cutting laterad from a point just caudad of the angle between the natural, curved margin and the cut, straight margin; it is more convenient to remove it entirely. The half-head may now be placed upon a tray and supported, or held by an assistant. Crowd the edge of the round scalpel handle between the dura and the myel for 2–3 mm., beginning at whatever point a slight interval already exists, and continue the separation by gentle, yet firm pressure; special difficulties will be encountered at and near the occipital foramen, requiring perhaps the scalpel edge. Do the same for the cerebellum and pons, keeping in mind the natural curvatures of the surfaces and the locations of the larger nerves, especially the trifacial, the auditory and facial. Specific directions are hardly needed or possible for the rest of the operation.

§ 114. *Arterial Alinjection of a Brain in the Dura.*—If the dura has been retained, at three places upon each side, frontal, temporal, and cerebellar (or occipital if the metepencephal has been removed), pin to the dura pieces of broad, stout tape (or strips of cloth 2 to 3 cm. wide) 10 to 15 cm. long. In place of pins there may be used garment-clasps with serrated edges.

§ 115. For temporary purposes, *e.g.*, examination of the base, preparation for injection, and the single injection of a mass, etc., the brain, supported as directed in §§ 18–19, may be steadied and raised or lowered as required, within any vessel of appropriate size. If of wood, the strips of cloth may be secured by tacks (artists' "thumb tacks" are most convenient); if of glass or metal then an elastic band (*e.g.*, a rubber ring from a jar, or an elastic tape) may be stretched about the rim and the strips passed under it. The vessels must be washed out (§ 103), and the small arteries tied or secured with *serres-fines*.

§ 116. *Dry Preparations.*—The methods of making these have been considered by Fish, who has also devised improvements. The following abstracts are largely derived from his papers, 1893, 1894, and 1897.

§ 117. *Fish's Improved Castor-oil Method.*—The value of this is attested by Figs. 983 and 984, and by numerous excellent preparations in the museum of Cornell University, brains, infant limbs, and entire small animals. "The essential factor is the complete dehydration of the specimen." If originally hardened in any other than an alcoholic mixture it is placed successively for at least one week each, in fifty-per-cent. alcohol, seventy, eighty, and ninety-five per cent. If carried through too hurriedly there will be more shrinkage. It is then placed in oil of turpentine until translucent, the time required varying according to the size of the specimen. The superfluous turpentine is then allowed to drain off for a few hours and the specimen is placed in castor oil. Here it may remain indefinitely or until all the tissues are thoroughly infiltrated. Draining off the superfluous oil requires a day or two and the specimen then receives a coat of an alcoholic solution of white shellac with a camel's-hair brush. This is repeated at short intervals until the surface is firm and glossy.

FIG. 983.—Right Side of the Brain of a Monkey, *Macacus cynomolgus*, Prepared by the Castor-Oil Method. × 1. (From Fish, 1893.)

§ 118. *Laskowsky's method* is here translated from the abstract in the *Neurologisches Centralblatt*, vi., 341–342:

A. Rinse the fresh specimen in water to remove blood.

B. Place in a mixture of water, 100 parts; alcohol (ninety-five-per-cent.), 20 parts; boric acid, 5 parts; let it remain in a cool place [for at least three days; time not given].

C. Remove the pia.

D. In a saturated solution of zinc chloride in alcohol let the brain remain five or six days; the bottom of the vessel should be covered with cotton.

E. For fifteen to twenty days soak in a mixture of glycerin, 100 parts; alcohol, 20 parts; carbolic acid, 5 parts; boric acid, 5 parts.

† The following instruments and materials should be provided: A pan to contain the half-head (about 11 × 4 in.), half full of alcohol of forty-eight to fifty-six per cent., this strength sufficing to float the separated pieces so that they may be extricated without injury (of course, water would do this, but would rapidly soften the brain); a large scalpel, the blade at least 5 cm. long and the haft 1.5 to 2 cm. more—a round-pointed "shoe knife" will serve; a medium-sized scalpel, marked with ink across the blade on each side 15 mm. from the tip; syringotome. Unless one is very familiar with the topography of the parts a model or preparation of the hemiencephal is desirable, also a hemicranium of the same side—if possible two, one dry, the other wet, with the falx, tentorium, etc. (Figs. 670, 800, 801).

F. Let it dry in the air, protected from dust.

The specimen is claimed to retain its natural volume, distinction of color, and elasticity.

§ 119. A *temporary* dry preparation for demonstrative purposes has been recommended by Lenhossek (*Anat. Anzeiger*, 1887, ii., 3–17; also *Amer. Nat.*, xxii., 858–859). A thoroughly hardened alcoholic specimen, when needed

FIG. 984.—Transection of the Brain of a Sheep, Prepared by the Castor-Oil Method, and Exhibiting the Differentiation of the Alba and Cinerea. × 1. (From Fish, 1893.)

for demonstration, is dried in soft linen [or absorbent cotton], and coated with a thin layer of celloidin with a soft brush. The celloidin dries in a few minutes, forming a thin and transparent yet tough membrane. After two hours' exposure the brain will begin to shrink and should be returned to alcohol.

§ 120. *Starch-Injection Mixture.*—Of the mixture first proposed by Pansch, the following modification has been devised by S. H. Gage and the writer:

Dry starch powder....................	100 c.c.
Chloral hydrate.......................	10 gm.
Water..................................	50 c.c.
Alcohol (ninety-five per cent.)..........	50 c.c.
Glycerin...............................	25 c.c.
Coloring matter.	

After thoroughly mixing the mass it should be filtered through one or two thicknesses of wet cheese cloth. To prevent the starch from settling, the cloth should be tilted from side to side or the mass may be stirred during the filtration. If the mass is not freshly prepared for every injection, the stock mass should be filtered occasionally to remove hair or any other object that might clog the cannula.

Among the colors that are available, probably vermilion, red lead, ultramarine, Berlin blue, chrome orange, yellow, or green, is preferable.

§ 121. *A Fine, Gelatin Injection-Mass.*—The following ingredients represent about 2 litres, enough for a human brain; gelatin may be used instead of the glue, and no egg would then be needed, but it costs three or four times as much: Best clear glue, 200 gm. (about 7 ounces); carmine, 20 gm. (about 0.7 ounce); glycerin, 240 c.c. (about 8 fluidounces); alcohol, 80 c.c. (about 3 fluidounces); strong ammonia, 30 c.c. (about 1 fluidounce); acetic acid (50 per cent.), 30 c.c. (about 1 fluidounce); one egg. Grind the carmine to a paste with a little water; mix the ammonia with 250 c.c. (about 8 fluidounces) of water, add the carmine paste, and filter through filter paper. Place the glue in a clean dish and cover with cold water; after two or three hours pour off the unabsorbed water, and melt the softened glue. Beat the white of an egg well and mix it with the glue. Heat until it begins to bubble, then filter through fine flannel. Add the coloring liquid to the glue while warm. Neutralize the ammonia by stirring in the acid, a little at a time, until there is no distinct odor of either the acid or the ammonia. Until one has had considerable experience it will be necessary to close the ammonia and acid vials, let a current of air sweep over the mixture, and then determine the presence of the odor. Blue litmus paper may be used until there is no distinct coloration of the band formed by absorption just above the line made by the mass itself. Mix the alcohol and glycerin and add to the mass. Unless, as with a freshly killed animal, the injection is made before the body has cooled, the part to be injected must be heated, in water, to 40° C. (about 105° F.).

§ 122. *Alcohol.*—Unless otherwise specified, the alcohol mentioned in this article is of the usual strength, ninety-five per cent. The admixture of alcohol with water in the following proportions gives various percentages: Alcohol 6, water 1 = 84 per cent.; 5 : 1 = 82; 4 : 1 = 78; 3 : 1 = 75; 2 : 1 = 67; 1.5 : 1 = 62; 1.25 : 1 = 60; 1.1 : 1 = 55; 1 : 1 = 48; 1 : 1.25 = 45; 1 : 1.5 = 42; 1 : 2 = 35; 1 : 3 = 30; 1 : 4 = 22; 1 : 5 = 18.

§ 123. *Obtaining Alcohol Free of Tax for Scientific Purposes.*—Blank forms for this and all the information required may be obtained from collectors or deputy collectors of United States Revenue or from manufacturers of alcohol. See U. S. Revised Statutes, Section 3297, Treasury Circulars of July 2d, 1886, and March 26th, 1889, and New York *Medical Journal*, March 30th, 1889.

§ 124. The surface of a fresh brain is never exposed to strong alcohol without a previous wetting with salt solution or water.

§ 125. The alcohol in which brains are stored is maintained at *not less than eighty-two per cent.* upon the alcoömeter scale of Tralles (§ 126). Weaker alcohol is employed for the immersion of fresh brains, for soaking out the dark coloring matter from brains that have been hardened in Müller's liquid, or for the preservation of other specimens requiring a less strength.*

§ 126. *Alcoömeter* (*Alcoholometer*).—This form of hydrometer, for determining the percentage of alcohol in a given liquid, should be marked with Tralles' scale. With the slender jar for containing the tested liquid, the cost is about $2.50, but its employment is to be recommended upon the ground of ultimate saving of alcohol.

§ 127. *Dilute Nitric Acid.*—This is useful for softening the cranium of infants or small animals so as to permit cutting with knife or scissors. A ten-per-cent. solution is sufficient. Ordinary commercial acid is about sixty per cent.; the desired reduction is accomplished by adding five parts of water to one of the acid by weight, or seven of water by volume. The specific gravity of the mixture is about 1.057. In any mixture the per cent. of acid may be determined by the method recommended by Fresenius, second American edition, p. 688.

§ 128. *Storage of Hemicerebrums.*—The human hemicerebrum is a somewhat bulky mass, and may occupy a six-by-eight-inch Whitall & Tatum jar (Fig. 990). Sometimes both halves of a cerebrum may be accommodated, although the undivided cerebrum or entire brain commonly requires a nine-by-eight-inch jar.

The most favorable method of storing several hemicerebrums is in jars nine inches in diameter and of any desired height. The specimens are set in tiers of three, their dorsal convexities against the sides of the jar. Successive tiers are so placed that a hemicerebrum rests upon the interval between two below. There will be a central vacancy which, if the jar is to be transported, may be filled with absorbent cotton; the alcohol (ninety-five per cent.) should be introduced last.

§ 129. *Transportation of Fresh Brains.* — Without affirming the impossibility of transporting a fresh brain safely in a bed of cotton or other soft material, I have found it much better to employ a liquid of approximately its own specific gravity, about 1.04. The most easily prepared is brine, nearly saturated. Nor is it best to put in cotton or other material. The brain should just float, without pressing upon the bottom of the pail or rising above the surface. The cover of the pail may be secured with strips of surgeon's plaster.

In cool weather a journey of two or three days may be safely accomplished. In warm weather, if the brain is well cooled in advance and the smaller pail set in a larger and surrounded with rather large pieces of ice, a day's

* The "economics of alcohol" is treated somewhat fully in W. & G., pp. 111–130.

journey may be accomplished safely. Such open packages should be plainly marked "Specimens of Natural History. This side up with care." (See also p. 206.)

§ 130. *Other Liquids.*—It must be remembered that while brine supports the brain and thus averts mechanical injury, and while it retards decomposition, it is not strictly a preservative of nervous tissue. Hence, especially if the weather is warm or transportation is to occupy more than a few hours, it is well to place the brain at once in a liquid which will not only support but preserve it. Several such are enumerated in §§ 81–90.

§ 131. *Transportation of Hardened Brains.*—Already hardened brains may be transported either in a small pail of alcohol with cotton as a padding; or in a soldered box; or in a jar (the rubber of which must then be well covered with vaseline *to be afterward removed*); * or simply wrapped in alcoholic cotton covered with paper and oiled silk, or rubber sheeting, and packed in a box with soft material. Glass and metal packages are always enclosed in wood † or corrugated pasteboard.

§ 132. *Removal of the Pia.*—The early removal of the pia ‡ has been already recommended, § 40. I have seen some otherwise valuable cerebrums materially injured by faulty methods, and a few suggestions are here offered.

A. Begin with the central fissure, if it can be recognized, and at about the middle of its length. Apply the coarse forceps so that their approaching points move in the direction of the length of the fissure; pinch up a fold of pia; with the scissors snip at either side of the fold so as to raise it a little; then carry the forceps, held in the same way, more deeply into the fissure, not more than 1 cm. deep, and attempt to draw out the intrafissural fold of pia. If successful, continue to pull *lengthwise of the fissure*, cutting the pia at either side whenever necessary.

B. Most of the other fissures may be dealt with in the same way; but some, notably the occipital and calcarine, are very deep, and arteries traverse them which must usually be cut more than once.

C. The Sylvian fissure is not only deep, but spreads laterad over the insula, and there are several arteries. Rather than run the risk of tearing the adjoining gyres it is better to remove only so much pia as easily separates, leaving the rest and the arteries until one of the operculums can be cut off and afterward replaced.

D. While removing the pia or studying the lateral fissures of young or fetal brains, breaking is avoided and divarication of the gyres facilitated if the hemicerebrum is placed on its meson on a piece of thick Manila paper (such as is used for the portfolios), which is sufficiently firm to support the organ and yet yields so as to permit the exposure of the fissural depths. When the mesal surface is studied the specimen should rest in a thick bed of cotton.

§ 133. *Prevention of Drying.*—The strong alcohol in which brains are preserved (eighty per cent. and upward) evaporates rapidly while the brain is exposed, as in examination or dissection. It may be dipped in the alcohol occasionally, or—which is preferable with delicate specimens—the alcohol may be allowed to drip gently upon it from a pledget of absorbent cotton. When a specimen only partly submerged in alcohol has to be left for a short time, drying may be prevented by covering it with a thin layer of cotton, one end of which dips into the liquid.

§ 134. *Dissection of the Brain.*—As commonly practised this contrasts strongly with the examination of the rest of the body. With the latter dissection is universal, and sections are seldom made or even studied; § but with the former, sections, macroscopic or microscopic, are the rule, and dissections, careful, prolonged, and thorough, are nearly unknown in medical schools. Like the preponderance of osteology over neurology, the difference is due to the "nature of things"; but like many other natural conditions it may need modification.

The advantages of sections for surgical, pathological, and regional study are obvious; they are easily made, even with the fresh adult human brain, especially by means of the apparatus devised by Professor Dalton.* If the human brain were like that of the frog or opossum, with the several segments of approximately equal size, and nearly upon the same plane, the common method would be more appropriate for macroscopic study. But, in view of the extreme cranial flexure and the overlapping of certain segments by others, the objections to sections are as follows:

1. They present plane surfaces which do not naturally exist in the brain.
2. They are almost invariably oblique with respect to the axis.
3. They commonly include more than one encephalic segment, and are, therefore, so far as the beginner is concerned, apt to be more confusing than instructive.
4. They present the parts in contiguity rather than continuity.†

The foregoing objections apply to all sections. A macroscopic section, especially of a brain which has had the cavities alinjected, presents the advantage of exhibiting in perspective enough of the natural contours of parts to facilitate their recognition and comparison.

Admitting, then, that sections have their uses, what is urged is, not that section-making be practised less, but dissection more.

§ 135. *Preliminary Dissection of Alcoholic Brains.*—I am yearly more convinced of its importance on four grounds:

A. The brain is a complex organ and at the best perplexing; the simpler features of form, location, and relation to cavities are morphological, while color, like histological composition, has a physiological significance.

B. The fresh brain is less easy to dissect neatly, and requires constant support against its own weight, whereas the alcoholic may be held in any position and carved like cheese.

C. The beginner should advance cautiously, and therefore slowly, and the medical student is especially liable to interruption. The fresh brain remains fresh but a very short time, while the alcoholic is in itself imperishable. Leisure means not only more careful dissection, but also the taking of notes and the making of drawings; hence all the arguments which I have advanced (W. and G., pp. 55, 56) in favor of preliminary anatomical work upon a small animal, which may be kept in alcohol for an indefinite time at slight expense, apply to all alcoholic brains in general, and to those of moderate size in particular.

D. After repeated dissection of alcoholic preparations, the anatomist is better qualified to manipulate the fresh brain and to appreciate its beauty. The last word is used advisedly, for, however unattractive may be "subjects" and pathological "cases," the most exacting artistic sense can hardly fail of satisfaction with the soft white and gray and pink of the newly extracted brain. Resting securely in its calva, for him who has been disciplined by prolonged experience with the "pickled" organ, there are few more attractive, stimulating, or nourishing articles of intellectual pabulum than a fresh brain "upon the half shell."

§ 136. *Dissection.*—Whether fresh or hardened, I be-

* Vaseline will prevent the leakage of alcohol or other liquid; but, like oils and grease, it disintegrates rubber; hence the rubber rings should be thoroughly cleansed from it after use.

† For mailing alcoholic specimens contained in vials of not over four-ounce capacity, see circular of the Denison Manufacturing Company, New York City, as to "liquid mailing boxes." See also a paper by F. T. Gordon, *Medical Record*, lvii., 696.

‡ It is understood that this includes the arachnoid, which on most parts of the cerebrum adheres closely to the pia; Fig. 796.

§ Notwithstanding the example and opportunity offered by works like Braune's "Atlas of Topographical Anatomy" and Dwight's "Frozen Sections of a Child" and "Anatomy of the Head."

* "Topographical Anatomy of the Brain," Philadelphia, 1885, vol. i., pp. 4–10; abstracts in New York *Med. Record*, February 15th, 1879; July 31st, 1880.

† Solly's vigorous reprobation refers particularly to horizontal slicing: "It is unfortunate indeed that candidates for the medical diploma are still very generally required to describe the appearances presented by the brain dissected, or rather destroyed, by the old method of slicing—a method most unphilosophical in its conception, and totally inadequate to impart any real information in regard to the structure of the brain."

lieve the first step should be to slice off the dorsal parts of the cerebrum to near the level of the callosum and the next the exposure of the paraceles as described in connection with Fig. 735.

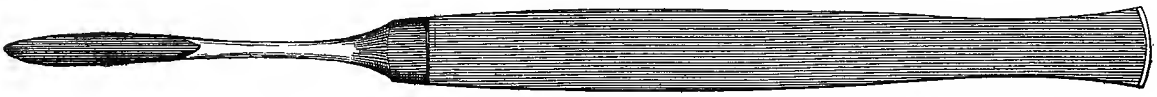
The occipital lobes may then be cut off opposite the splenium and one or both medicornua followed to the tip of the temporal lobe.

The next object should be to remove the overlapping parts of the cerebrum from the subjacent diencephal (and so much as may remain of the other segments) so as to obtain a view of the ventral aspect of the splenium and fornix. These may be transected a little caudad of the portas.

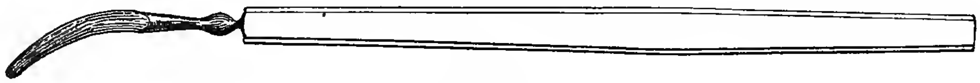
There will then appear the velum, with the epiphysis. If the velum be lifted carefully there will be recognized the attachments along the dorso-mesal curvature of the thalami which are commonly ignored but insisted upon in Fig. 732.

A transection through the portas will give a view of their boundaries, of the cephalic aspect of the medicommissure, and of the caudal surface of the fornix and the precommissure; most of the other features are more easily examined upon the mesal aspect of the medisected brain.

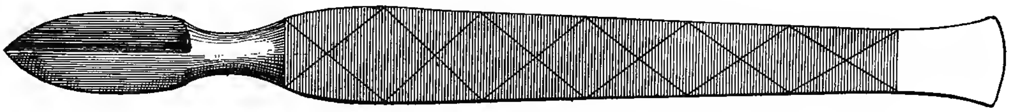
Somewhat full directions for dissection are given by Edinger. Complete directions are desirable, accompanied by figures indicating the appearances presented at each



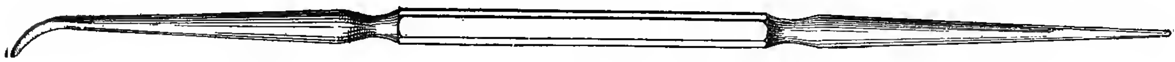
Blunt-Pointed Scalpel.



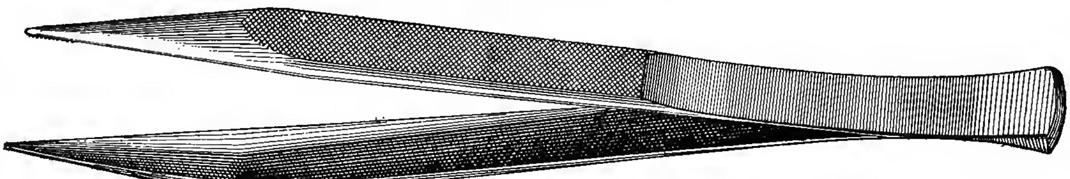
Syringotome.



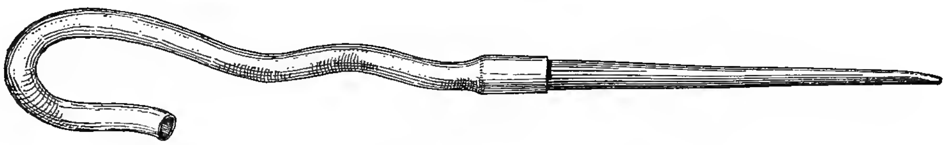
Arthrotome.



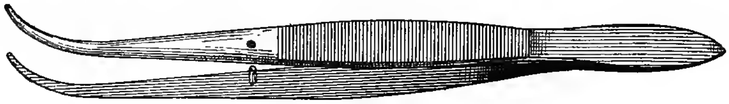
Tracer.



Coarse Forceps.



Flexible Blowpipe.



Fine Curved Forceps.

FIG. 985.—Some of the Instruments Useful in the Removal or Dissection of the Brain. All of actual size. (From "Anatomical Technology.") The two upper are eye-knives; the syringotome is commonly called *canaliculus knife;* it is of great use for exploring orifices, the porta ("foramen of Monro") and the metapore ("foramen of Magendie"), and for dealing with membranes and plexuses where a point or a prominent edge might do injury; it has been my favorite instrument since 1866. The tracer may be employed sometimes in place of the more costly syringotome, but its chief use is in isolating nerves and vessels by tearing the connective tissue. Most forceps are too stiff and soon tire the hand or hinder delicacy of manipulation; the coarse "Coxeter" forceps represented have the blades excavated so as to be lighter than usual. The flexible blowpipe is most readily made by attaching to a piece of rubber tubing, 30 to 40 cm. long, the smaller half of the metal blowpipe commonly sold with dissecting instruments. The length of the tube enables the object inflated to be held at a convenient distance from the eye; since inflation is temporary injection, the advantages of witnessing the effects are obvious. A larger volume of air may be utilized by using the larger half of the metal pipe, and glass cannulas of any size may be employed. The arthrotome has the handle continuous with the blade, and one edge of the blade is rounded, excepting near the tip; it is practically a cartilage knife. The fine curved forceps represented have the points simply serrated; but for the removal of the pia from the brain surfaces, and especially from the depths of fissures, a pair with interlocking teeth, like those of artery forceps, will be found very useful.

stage, such as I have framed for the brains of the cat (W. and G.) and sheep ("Physiology Practicums").

§ 137. *Instruments.*—The instruments employed in the removal or dissection of the brain (§§ 50, 136) should, as a rule, be reserved for that purpose. If used in ordinary dissection their points and edges should be attended to without delay. Some of the less familiar instruments are shown in Fig. 985.

§ 138. *Probe-Pointed Curved Bistoury.*—This is practically a longer and stronger syringotome (Fig. 985), the cutting edge being about 5 cm. (2 in.) long, ending in a probe point. The curve is less than that of the syringotome. It replaces the latter in the dissection of the entire human brain, and it is particularly applicable to transecting the brain through the mesencephal, to tracing the medicornu, and to slitting the arachnoid in following the Sylvian or other deep fissures.

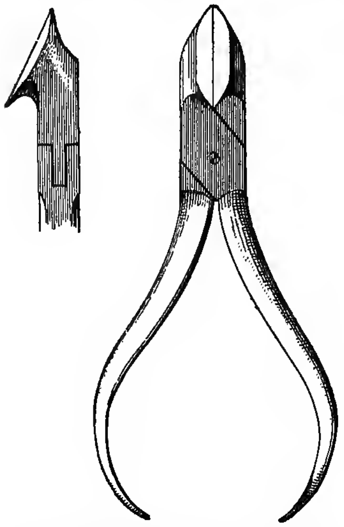


FIG. 986.—Diagonal Side-Cutting Nippers. A little less than actual size. From "Anatomical Technology." This is the smallest size of the English make (Stubs'), and for most purposes should have the handles lengthened by pieces brazed on. The German and Swiss instruments (for sale by large hardware dealers) are less highly finished and costly, but answer nearly as well. Of these, seven sizes are made, ranging in length from 10–20 cm. (4–8 inches), and in price from 60c. to $1.50. Surgical bone forceps and dental wedge-cutters have a spring between the handles and are more expensive. The nippers are most serviceable for removing the calva of infants and fetuses and of small animals. In use they must cut or squarely break the bone; the pulling and tearing to which one naturally resorts will inevitably tear the brain or its meninges.

§ 139. Besides the instruments shown in Figs. 985 to 987, the following, more familiar, are indispensable: Scalpels of three sizes: large for sections; medium for ordinary dissection; small ("Charrière") for finer dissection. Scissors, curved flatwise, three sizes. A hand lens, tripod magnifier or "linen tester." A bone-chisel, or ordinary chisel of moderate width, or even a screw-driver sharpened slightly. A syringe, metal, or rubber bulb. Absorbent cotton; if common cotton is used it must be first thoroughly wet in alcohol or water. Cannulas, rubber tubing, and the **Y**-tubes or **T**-tubes for branching of injection tubes may be had of dealers. The smaller end of a straight "medicine dropper" makes a fair cannula.

FIG. 987.—Steel-Handled Spatula. × 0.5. (From catalogue of Whitall, Tatum & Co.) This (or a palette-knife, or round-ended shoe-knife, ground thin so as to be flexible) is indispensable for detaching the dura when the calva is to be removed.

The methods of making and securing cannulas, and of making injections, are detailed in "Anatomical Technology," pp. 137–148. Cheap and efficient pinch-cocks may be had in the form of the wooden, spring clothes-pin, which may be variously attached to the wire cranes or used independently upon the tubes.

§ 140. *Saws.*—There is no special advantage of the expensive surgical or anatomical saw over the ordinary carpenter's instrument; it should be kept sharp and well-set, and used for no other purpose. For dividing the cranium any small saw will answer, but the edge should be rather wide so as to make a broad kerf. For medisection of the head, however, the saw should be very large, fine toothed, thin (*i.e.*, make a narrow kerf), have a removable back, and be very sharp and free from rust.

§ 141. *Saw-Box.*—This (which might be called a macrotome) is a coverless box made of boards about 2.5 cm. (1 in.) thick, and with the following inside dimensions: length, 30 cm. (12 in.); height, at middle, 25 cm. (10 in.) sloping to 15 cm. (6 in.) at the ends; width, according to the length of the neck attached to the head, 25–40 cm. All the parts must be accurately squared and put together with screws. The sides should go outside the bottom and ends, and the bottom have a cleat at each end. Each side is to be divided squarely at the middle of its length by a saw of the same thickness as that with which the head is to be cut; the bottom also is to be sawn to the depth of 1–2 mm. When finished the box should be thoroughly oiled, inside and out, with linseed or olive oil, to prevent warping when it is wet.

§ 142. *Head-Rest for the Removal of the Brain.*—The following description and figures (988, 989, and 982) are from the paper of B. B. Stroud (1900, *b*) who devoted much time to the device. The apparatus was shown at the meeting of the Association of American Anatomists in Washington, May 2d, 1900.

"This apparatus was devised for the purpose of holding the head firmly with the base of the cranium horizontal. This enables the base of the skull to serve as a shallow tray in which the brain is supported during its removal. The subject lies upon the belly, being supported by adjustable clamps fitting into the auditory meatuses, and the head naturally assumes a position in which the long axis of the cerebrum is nearly horizontal. Repeated trials in the neurological laboratory at Cornell University this spring have shown that with a maximum of convenience to the operator there is a minimum of danger of rupturing the cranial nerves and certain delicate structures of the brain itself, which are frequently torn when the usual methods are employed. Fig. 988 shows a general view of the apparatus. Fig. 989 shows details of construction. In Fig. 982 it is represented in use.

"The device consists of a baseboard *A* to which is attached at right angles a second board *B*. Both are of seven-eighths-inch oak. Professor Wilder suggested that the upright board should be hinged to the base for con-

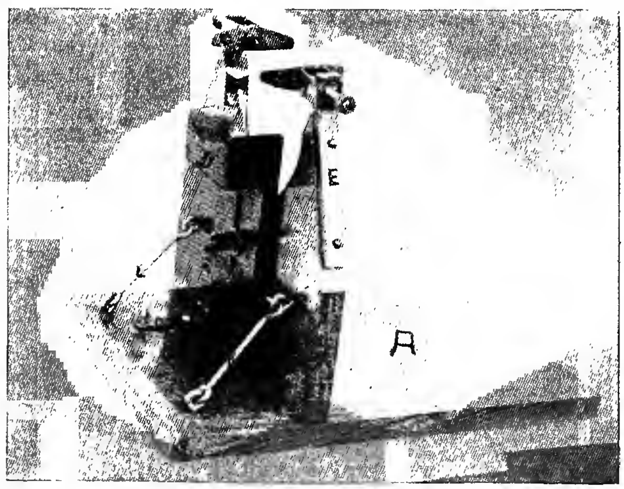


FIG. 988.—Head-Rest for the Removal of the Brain. Devised by B. B. Stroud. A, Baseboard; B, upright board, hinged to A and secured by hooks. (From Stroud's paper, 1900, *b*; see Figs. 982 and 989.)

venience in storage and transportation. This is a very valuable improvement.

"The upright *B*—Figs. 988 and 989, A—has a middle emargination and the sides are cut at an angle as shown in Fig. 989, A. The chin-rest *D* is hollowed upon the top to fit the chin. It slides in a shallow groove 0.5 cm. ($\frac{1}{4}$ in.) deep, cut in *B*, and is adjustable by means of the thumbscrew. The two lateral bars *E* are of iron. They project 3.5 cm. ($1\frac{1}{4}$ in.) above the board *B*, and serve to support the two jaws *F* and *G*.

"The two clamps for grasping the head, Fig. 982, shown in detail in Fig. 989, B, consist of the jaw *F*, the guides

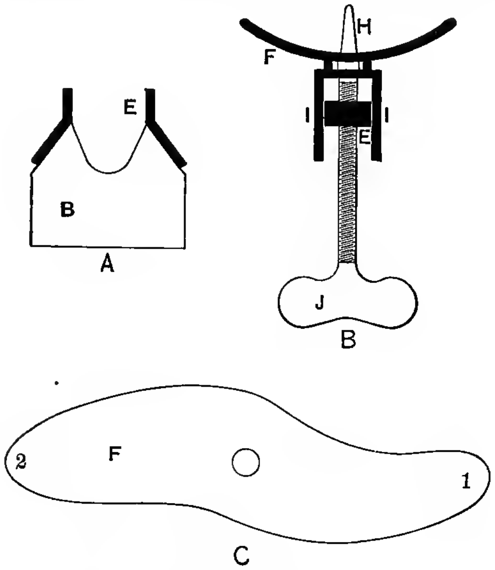


FIG. 989.—Portions of the Head-Rest. A, the upright board, with its side irons, *E*. B, One of the two clamps for grasping the head. C, improved form of the jaw-piece, *F*.

I, and the screw *J*, which pierces *F* in the form of a spike *H*, 2 cm. ($\frac{3}{4}$ in.) long, to enter the auditory meatus. A flat head *J*, Fig. 989, *B*, is more convenient for turning the screw than the round milled head shown in Fig. 988. The jaw *F* is bent flatwise to fit the curve of the skull and grasp it dorsad of (posterior to) the mastoid process. The other end is curved downward, to fit under the zygoma and thus hold the head more firmly. The guides *I* are made from one piece of steel bent in the form of a rectangle and made to fit very closely to the top of the side iron *E*. They and the curved form of *F* prevent a disagreeable rocking motion of the head. *F* is firmly riveted to *I* by means of four double-headed rivets. The upright *B* is held in position by the two hooks *K* and *L*." *

* For the convenience of those who may desire to construct the head-rest the detailed specifications are here reproduced: *A* and *B* are made of $\frac{7}{8}$-in. oak. *A* is 30 x 40 cm. (12 x 18 in.). *B* is 30 x 26 cm. (12 x $10\frac{1}{4}$ in.). It is cut as indicated in Fig. 989, A. The middle cut is 15 x 13 cm. (6 x 5 in.). The front side contains a groove $\frac{1}{8}$ in. deep and $3\frac{5}{8}$ in. wide to receive the chin support *D*. *D* is of oak 5 x 9 x 17 cm. (2 x $3\frac{1}{2}$ x $6\frac{3}{4}$ in.). The top is hollowed out to fit the chin 4.5 cm. One and seven-eighths in. from the top it is cut down so as to be only .5 in. thick. There is a slot in the middle to accommodate a set screw for fastening it at the different heights. *E* is an iron bar, 17 x 2 x 1 cm. ($6\frac{3}{4}$ x $\frac{3}{4}$ x $\frac{3}{8}$ in.), and is bent at a point 3.5 cm ($1\frac{1}{2}$ in.) from the top so as to be perpendicular to the base *A*. *F* is of $\frac{3}{16}$ in. steel, 9 x 3 cm. ($3\frac{1}{4}$ x $1\frac{1}{4}$ in.) and formed as shown in Fig. 989, B and C; 1 is the front end shaped so as to fit under the zygoma; 2 is the rear end and grasps the temporo-occipital bone dorsad of the mastoid process. The clamps *I* are made of $\frac{3}{8}$-in. steel 12 x 2.5 cm. ($4\frac{3}{4}$ x 1 in.) and bent as shown in Fig. 989, B. The screw *J* operates the jaw *F*. It is made of $\frac{5}{16}$-in. iron 4 in. long. It has a shoulder which is received between *F* and *I*. The spike *H* projects one inch beyond *F* to be inserted into the auditory meatus. A flat head is more convenient than the round one shown in Fig. 988. All sharp edges should be rounded and smoothed to avoid accidental injury to the operator's hands.

§ 143. *Agate-Ware Pans.*—The brain anatomist will find most convenient, and in the end most economical, one or two "nests" of iron pans, "enamelled," so as not to rust, with plates of the same for covers. For the largest size (11 × 4 in.) covers of glass or metal must be provided; this size will accommodate a half head.

§ 144. Butter jars, 10 × 10 cm., or 10 × 20 cm., with tin screw-cap, parchment lined, are sold by the Excelsior Package Co., 49 Warren Street, New York. They are very convenient for temporary storage or for transportation.

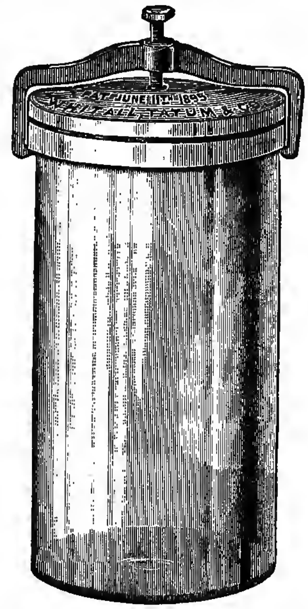


FIG. 990.—Specimen Jar, with Glass Top, Rubber Ring, and Clamp. (Made by Whitall, Tatum & Co., New York.) Fourteen sizes are made, ranging from three to nine inches in diameter, and of various lengths. The size here shown is 6 × 12, and will receive a half brain or the two halves of a medisected cerebrum; for undivided brains and for medisected heads the size 9 × 8 suffices. These two sizes cost, respectively, $10 and $18 a dozen. The prices given in the catalogue are subject to a discount of fifty per cent.

§ 145. *Labelling Specimens.*—Much of the real value of a specimen depends upon its identification as being a certain part of a certain brain, taken from an individual of a certain age, sex, and nationality, and preserved in a certain way. Even if the possessor has so few specimens that he feels sure of remembering the entire history of each, his death would abolish the source of information. I have observed surprising instances of carelessness in this regard, even upon the part of some who should set an example of scientific accuracy.

Were the specimen never to be removed from the jar in which it alone is kept, the object could be accomplished by inserting the label in the jar or attaching it thereto; but this is rarely an adequate precaution, neither is it often possible to state all the desirable data upon a label attached to the specimen itself. The most satisfactory plan tried is *the adoption of a serial number for each brain.*

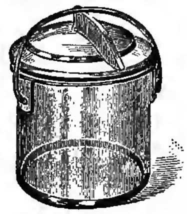


FIG. 991. — Landenberger's Specimen Jars. These have a rubber ring and a glass top retained by a wire. The smaller size is 3 × 3 in., capacity 6 oz. (180 c.c.); the larger, 3 × 4 (high), capacity 10 oz. (300 c.c.). 25 N. Thirteenth Street, Philadelphia.

§ 146. *All Specimens are Numbered.*—As soon as received every brain is assigned a number which permanently designates it and all parts into which it may at any time be divided; the same number pertains to all notes, photographs, and drawings of it.

§ 147. Sometimes, as with entire brains or half-brains, it is possible to attach with a cord a metal (sheet block tin, stamped) number. But commonly the numbers are written with India ink * upon bits of parchment and attached by small (ribbon) pins. †

§ 148. For purposes of dissection, photographing, or drawing it may sometimes be necessary to remove the label, but ordinarily it should be affixed to some other region, so that there may be no possibility of misplacement.

* Good pencil marks last a long time in alcohol, but ordinary black ink is speedily washed out.

† In time ordinary pins corrode and may break the brain substance when withdrawn; pins of aluminum or silver should be available at a moderate cost.

§ 149. *Distinctive Labels.*—The ready recognition of cerebrums belonging to groups may be provided for as follows:

A. The sexes are distinguished by using quadrangular labels for males and circular ones for females.

B. Presumed normal white brains have white labels; Africans (of all shades), gray; murderers and other criminals, red; insane and idiots, blue.

§ 150. *Immediate Records are Made.*—No one's memory is conceded to be infallible. All data concerning a brain not obtainable from the specimen itself are recorded without delay under the number assigned to it; *e.g.*, the sex, age, known, believed or estimated, race, known or supposed weight when fresh, donor, mode of initial preservation, weight or bodily condition of the individual, and his character or mental state.

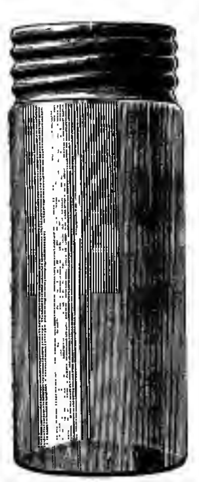


FIG. 992.—Tall, Round, Screw-Capped Jar, with Nickel-Plated Caps, Cork-Lined. Three sizes, viz.: four ounces, eight ounces, and sixteen ounces. (Whitall, Tatum & Co., New York.) Answers well for dry or non-volatile contents or for the temporary storage of alcoholic specimens.

§ 151. *Card Catalogue.*—The basis of the records of each brain is a card bearing the number of the specimen at an upper corner. Upon the face of the card are written the data mentioned in § 150; also, or continued upon the back, the numbers of negatives, and references to published figures or descriptions; suggestions of points to be elucidated are commonly put on paper slips.*

§ 152. Drawing is insisted upon.† These drawings should be, primarily at least, in outline only; shading, like charity, "covereth a multitude of sins."

§ 153. In beginning the study of a difficult region, the student is advised to determine at once some prominent feature as a landmark, as a "base," so to speak, "of intellectual supplies," from which he may explore in any direction, and to which he may return when doubts arise.

§ 154. No observation involving either complex manipulation or novel results is published until it has been submitted to at least one other trained observer.

§ 155. It is freely admitted that rarely, if ever, is all possible information gained from a specimen at one examination or by a single observer; hence specimens are preserved.‡

§ 156. *Methods of Representing the Brain.*—The following considerations and suggestions apply more or less directly to all natural history illustrations, but with especial force to the human brain, on account of its softness when fresh, the difficulty of preserving it, the great size of the entire organ, the minuteness of certain portions, the large number of recognizable parts within a small area, the continuity of all, the contiguity of some which are otherwise associated but remotely, the intermixture of two differently colored substances, the complicated relations of the meninges to each other, to the vessels, and to the cavities, and the preponderance of curved and oblique contours over straight lines and planes.

§ 157. *Importance of Orientation.*—With all organs, but especially with the brain, it is essential that the location of the region represented be easily recognized; otherwise details may be unappreciated or even misapprehended. So far as possible, therefore, less familiar parts should be accompanied by such as are unmistakable. It might seem that useless expense was incurred by the publishers of Bourgery and Jacob's magnificent plates in the introduction of faces artistically drawn and colored; but even the expert neurologist is guided in the comprehension of the relative position of brain parts by reference to the apparently superfluous facial outlines.

§ 158. *Enlargement of Complex Regions.*—It often happens that the same section or dissection includes regions that are comparatively simple, and others that are very complex; shown upon a single scale, either the complex parts are unintelligible, or the total is undesirably and needlessly large. Hence, just as the histologist aims first to obtain a general view of all the parts in their gross relations, and then focuses a higher power upon a selected region, so the delineator of encephalic structures should give first a view of the whole, if only an outline, and then an enlargement of complex parts to any extent required for their complete elucidation; he can hardly make this enlargement excessive. Compare, *e.g.*, Quain's figures, 258 and 290, and Figs. 669, 670, 671, and 695 in this volume.

§ 159. Terminal and limiting parts, membranes, and apparently atelic (functionless) parts and conditions should be distinctly shown, or the insufficiency of their representation admitted. "The little things of the brain" might well form the subject of an entire article. From the standpoints of physiology and medical practice such parts as the terma, valvula, crista, epiphysis, hypophysis, and habena, and such conditions as the reflection of the endyma upon the plexuses, and the dorsal limitation of the porta, are of comparatively slight importance. But their morphological significance is, at least in some cases, inversely to their functional activity, and they cannot be ignored without endangering the success of any attempt to understand or explain the structure of the brain.

§ 160. Anatomical figures should be something more than pictures conveying a general and vague idea. Where is there an adequate representation of the relation of the diatela to the habena, and of the cephalic end of the latter? From the published figures could any student be expected to comprehend the locations and boundaries of the "foramina of Monro" or of "Magendie"? The tenia is easily enough shown as a white band throughout most of its course, but where are its extremities accurately delineated? Any one can see the caudate prolongation of the striatum, but representations of its termination at the tip of the medicornu are as rare as are figures of the extremity of the filum terminale. Even so considerable a part as the flocculus is seldom figured in such a way as to display either its form or its attachment.

§ 161. The avoidance of the morphological incongruities and deficiencies which are to be detected in nearly every portrayal of encephalic anatomy demands the admission of three propositions, which are mere truisms in themselves, but radical affirmations when contrasted with their almost universal non-recognition in anatomical works:

1. Every part, organ, membrane,* or surface is either

* My own use of slips of convenient size for notes and drawings and descriptions began in 1867 while I was assistant in comparative anatomy at the (Agassiz) Museum of Comparative Zoology at Cambridge, Mass. The slips were about three by five inches. When the first United States postal card was issued that size (13.5 × 7.6 cm., 5.25 × 3 in.) was adopted. But the subsequent introduction of other sizes has invalidated that standard, and the common and increasing employment of the catalogue card of the Library Bureau (7.5 × 12.5 cm. or 3 × 5 in.) may render it desirable to adopt that size for notes as well. Brief accounts of the "slip system of notes" are given in *Science*, January 16th, 1885, and in Wilder and Gage.

† Every student of any branch of natural history should compel himself to learn to draw, however slight may be his inherited artistic capacity. Not merely the laboratory students in Cornell University, but the members of the large general classes in physiology and zoology are required to make drawings of entire animals, and of the parts exposed in their dissections.

‡ The time has not yet come, and indeed shows no signs of approach, when I can look at even a familiar brain preparation without learning a new fact, gaining a better insight into what was already known, or receiving an impulse toward some special inquiry. A good example of the desirability of preserving specimens for later scrutiny is furnished in my last paper, 1900, *a* (see p. 196).

* So essential is the exemplification of celian circumscription and endymal continuity that the endyma should be represented by a distinct and rather heavy line, continuous excepting at the metapore; see p. 152, Fig. 687.

limited or continuous with some other part. If limited, its limits must be defined; if not, its extension must be indicated.

2. Every cavity is either open or closed. If closed, the continuity of its parietes must be demonstrated; if open, its communications must be shown.

3. Every elongated part has a middle and two extremities; not only the former, but the latter must be represented.

§ 162. Figures—original ones especially—should be multiplied and descriptions reduced. In descriptive anatomy, whether human or comparative, the text should be subordinate to the illustrations. Some treatises (Charles Bell, Meckel, Milne-Edwards, etc.) seem to have been prepared upon the idea that the description is essential and the figures merely supplementary; on the contrary, words should be employed only when pictures will not suffice—that is, for explanation, commentary, generalization, hypothesis, and manipulative directions.

The arguments for the multiplication of figures may be summarized as follows:

1. A figure is usually a guaranty that something like the object represented has been seen, at least by the artist, and that a certain amount of time has been devoted to its contemplation.

2. The information conveyed by a figure is more real, and likely to be more lasting, than that which is expressed in words. In respect to reality and impressiveness, the sources of knowledge may be ranked as follows, in an ascending scale: (1) Description; (2) picture; (3) model; (4) object seen; (5) object handled; (6) object personally prepared. The picture is thus intermediate in value between the thing itself and a description of it.

3. A figure, if clear and properly placed, is more readily understood than a description, and a saving of time is thus effected. It may be easier for the author to write than to draw, or even than to supervise a drawing, but his personal inconvenience or loss of time should not outweigh the gain to his readers. This applies particularly to dictionaries, cyclopedias, and journals, which are commonly read or consulted in haste. Editors and publishers would find eventual profit in offering to authors the fullest encouragement to employ illustrations so far as possible and curtail their descriptions in proportion. That it is rather the exception than the rule for such encouragement to be offered is probably due to several causes: (*a*) Publishing houses have usually a staff of printers who must be employed, whereas the various processes involved in the making of pictures are commonly done outside at extra expense; (*b*) authors too often content themselves with carelessly made copies of "stock figures" instead of insisting upon original representations of objects prepared by themselves. Hence, on the one hand, the exceptionally liberal publisher is liable to get a poor return for any allowance made for drawings, and, on the other, the exceptionally painstaking author is apt to be told that, at best, the engraving will be done if he will furnish the drawings; and, if he cannot draw himself, their cost is likely to deter him from their introduction. In short, all the existing conditions work to the disadvantage of the reader, who gets but a "pennyworth of [pictorial] bread to a monstrous deal of [verbal] sack."

Before this state of things can be amended the authors of books and papers must see clearly the importance of illustration; to paraphrase an epigram as to the making of an index, the drawings should be made or personally superintended by the author, even if some one else has to write the text.

4. Figures usually occupy less space than descriptions conveying an equal amount of information. This means condensation, convenience, and economy in the present, and a due consideration for our successors in the not far distant future. Exact data are not accessible, but no thoughtful and public-spirited person (unless he be a publisher or printer) can contemplate without concern the logical results of the present rate of book-making activity.

§ 163. Borrowed figures should be fully credited, and all modifications, whether of size or features, explicitly stated. To copy is to compliment, but unacknowledged copying is theft, and unspecified change is misrepresentation.

The ill effects of omitting to state the source of a figure are two: (1) The originator loses credit to which he is justly entitled; (2) the reader may be seriously misled by the apparent duplication of some really unique feature or the confirmation of an error. For example, in the representations of the meson of the cat's brain by Leuret (Leuret et Gratiolet, Pl. V., Fig. 2), the pseudocele ("fifth ventricle") is made even more extensive than in man, reaching almost to the splenium. The figure is reproduced, without credit or correction, in Mivart's "The Cat" (Fig. 129). Whoever remarks the coincidence in respect to the pseudocele, but fails to note that one figure is simply a copy of the other, may naturally infer that the feature in question is normal, or at least not anomalous.

On the other hand, if informed that three of Mivart's figures (125, 126, 129) were copied from Leuret, the student might conclude that the representation of the base of the brain (Fig. 128) was derived from the same source. This would be most injurious to the reputation of Leuret, for the figure in question displays several features (the size and direction of the hypophysis, the disconnected fissure on the temporal lobe, the relations of the pons to the trifacial and abducens nerves) which it is safe to say never were observed in a feline brain.

Nor is it enough to give the sources of figures in a list, or in the preface, as in Huxley's "Vertebrated Animals"; so great is the labor of preparing an original figure that the acknowledgment of it should be equally as explicit as that of a verbal quotation.

Finally, in the case of modified figures, it needs but a moment's reflection to see that nothing short of an accurate statement of the nature and extent of the alteration can insure full justice to the originator.

§ 164. Drawings should be made as notes. In many cases an outline* drawing, even if hastily made, would convey to the maker, or any one else, at a future time more prompt and complete information than could be embodied in writing covering the same space. But the general employment of sketches, in addition to words, or in place of them, can hardly be looked for until children are taught to draw the intelligible objects about them before they are drilled in the making of the—to them—unmeaning pot-hooks of the alphabet.

§ 165. Figures should be more frequently employed in preliminary or incomplete publication. Probably one of the reasons for the comparative infrequency of pictorial representations of normal, abnormal, and pathological structures, especially in journals, is the difficulty, often the impossibility, of preparing a detailed figure in time for publication. But this need not prevent the early appearance of a figure, if only in outline, illustrating one or more points of greatest importance.

§ 166. Figures should be based upon photographs. Photography enables the anatomist to (*a*) record the appearances of perishable specimens, or of such as are in course of dissection; (*b*) insure the proper perspective; (*c*) save time and labor upon the part of the draughtsman, and thus either reduce the cost of the drawings or render a larger number attainable.

It is seldom that a single anatomical preparation is so perfect as to display all that is needed, and yet present no superfluous parts; often, too, certain points are to be brought out with "diagrammatic clearness," others being subordinated or omitted altogether. Hence, as a rule, the photograph forms rather the basis for the completed figure, and two or more similar preparations may be required for the elucidation of all the desired features.†

* There is a general and almost unconquerable predilection for shaded drawings. However advantageous shading may be in ordinary art as an element of finished pictures, and when merely a general effect is desired, in anatomical figures correct outlines are essential, and shading should be deferred until the last.

† A chief obstacle to the employment of photographs as a basis for figures of brains and embryos has been the difficulty of supporting such delicate objects within range of the camera in its usual horizon-

§ 167. Figures should be placed so as to be most readily understood and instructively compared. In comparing pictures of two or more houses, ships, or stoves, the architect, ship-builder, or dealer places them in such positions with regard to one another and his own eyes as may minimize the effort at mental transposition. If asked the principle on which he acts, he will probably say that no principle is needed, that he simply follows nature, experience and common sense.

With few exceptions it seems to be reserved for those whose business is the contemplation of natural objects, who are credited with more than the average degree of intelligence, and who have at command the recorded experience of centuries, to disregard a matter whose simplicity is equalled only by its importance. In most works there is an utter absence of system. Seldom, indeed, are symmetrical figures placed otherwise than with the meson coinciding with that of the observer, but even this would be less likely to confuse than the apposition of transections of a subcylindrical mass like the myel with the dorsum above in one case and below in another.*

The prevalent careless in this regard may be ascribed to three sources : (*a*) The still too common idea that illustrations are of secondary importance ; (*b*) the fact that most figures have been copied and thus placed without regularity, as in the original : (*c*) some time and trouble are required to reverse them.

§ 168. *General Rules for the Placing of Figures.*—These rules are based upon a consideration of the whole subject. There is probably no one of them to which exceptions may not exist ; but such exceptions should always have a well-defined reason and not occur through inadvertence.

1. Figures should be coadjusted so as to facilitate comparison with one another and with typical structures in normal positions.
2. The dorsal side should be uppermost.
3. Direct views are to be preferred to oblique, though the latter are at times indispensable ; *e.g.*, Figs. 720, 769 and 775.
4. Symmetrical figures, or parts thereof, should be so placed that the meson is vertical, *e.g.*, Figs. 664, 672, and 682.
5. When there is no choice between the right and left sides, the latter should be represented.
6. Of medisected organs, unless there is special reason for choice, the mesal aspect of the right half is to be shown,†

§ 169. *Designation of Parts upon Figures.*—The full technical names of parts should be given if possible. From the purely artistic point of view, of course, any extraneous line upon a picture is a disfigurement. But if it be once admitted that the primary object of an anatomical drawing is to convey accurate information, then, unless the shaded figure can be duplicated in an outline (as in Tiedemann, Vicq d'Azyr, and Dalton), there should be no sacrifice of the essentiat to the accessory.

It may be a question whether the names should be upon the parts (as in Gray), or at the sides of the figure and connected with the parts by lines (Gegenbaur). Upon the whole the latter method seems preferable, especially if the technical names are used.

tal, or nearly horizontal, position. This obstacle is wholly removed by the photographic table devised by Professor Gage and used by us in Cornell University since 1873. With this the camera may be readily adjusted to any angle, and brought into a vertical position so as to cover an object lying upon cotton, or in alcohol, or even alive in water. The apparatus is described and figured in *Science*, April 11th, 1884.

* The common disregard of uniformity in this respect was made the subject of a communication by a medical professor to the Association of American Anatomists at its meeting in December, 1892.

† If the fuller discussion of this subject in the New York *Medical Journal*, August 2d. 1884, be consulted, the following corrections should be made :

Explanation of Fig. 57, last line, transpose *antimesal* and *symmesal*.

Fig. 59 for *antimesal* read *symmesal*.

Fig. 64, for *symmesal* read *antimesal*.

§ 170. Abbreviations should represent technical terms ; they should be uniform throughout the work, and be placed at the sides of the figure.

Four methods of designating parts by abbreviations have been employed : 1, By numbers and non-significant and ununiform letters, which may or may not be explained in the text (Owen) ; 2, by non-significant characters, uniform only in part, and explained at a distance from the figure (Reichert) ; 3, by uniform and significant, but partly vernacular abbreviations (Parker) ; 4, by uniform technical abbreviations (W. and G.)

The advantages of uniformity in the use of abbreviations are obvious, but it is by no means easy to avoid the charge of ambiguity. Where uniformity is not attempted, care should at least be taken to avoid the same abbreviation for the names of parts which are liable to be taked for one another. For example, in Schwalbe's two representations of the lateral aspect of the crura and adjacent parts (Figs. 280, 281) not only are opposite sides shown for no good reason, with some differences of detail which are puzzling rather than instructive ; not only is the pons designated in one by *p* and in the other by *po*, and the tractus opticus by *to* in one and *tr.o* in the other ; but the letters *tp* stand for the *tænia pontis* in Fig. 280, and in Fig. 281 for the *tractus peduncularis transversus* [cimbia]. Since these parts are similar in general appearance and direction, and only one appears in each figure, it is doubtful whether any but the most expert anatomist, thoroughly familiar with this somewhat obscure region, could escape at least a temporary misapprehension.

§ 171. Abbreviations should be explained in alphabetical order. The "practical" business man would exclaim, "Of course, how else should they be?" An "unscientific" child would adopt the alphabetical order with letters as he would the order of notation with numbers. But the super-scientific writer, especially if he be a German, scruples not to save a few moments of his own time at the expense of others, by giving the verbal equivalents of ten (Huxley, Fig. 19), fifteen (Balfour, ii., Fig. 271), twenty (Quain, Fig. 263), twenty-five (Schwalbe, Fig. 279), forty (Meynert [Stricker], Fig. 253), or even fifty-eight (Marchand, *Arch. f. mik. Anat.* xxxvii., 331, 332) abbreviations, either in no recognizable order at all or as they occur upon the figure.* The time wasted by each consulter of the figure (not to mention the effect of just indignation) would nearly equal what it would have cost the author to place the abbreviations in alphabetical sequence. *Burt G. Wilder.*

BIBLIOGRAPHY.

Donaldson, H. H., 1894 : Preliminary Observations on Some Changes Caused in Nerve Tissue by the Reagents Commonly Employed to Harden Them. Journ. of Morphology, 1894, pp. 122–126.

Fish, P. A., 1893 : Brain Preservation, with a Résumé of Some Old and New Methods. The Wilder Quarter-Century Book, pp. 385–402, 1 plate.

——, 1894 : Abstract of the foregoing. Journ. Nerv. and Mental Disease, February, 1894, pp. 101–103, plate.

——, 1895, *a* : Formalin for the Preservation of Brains. Preliminary Note. Journ. Comp. Neurology, v., 125–128, July, 1895.

——, 1895, *b* : The Use of Formalin in Neurology. Proc. Amer. Micros. Society, xvii., 319–330.

——, 1897 : The Mummification of Small Anatomical and Zoological Specimens. Proc. Ass'n Amer. Anat., December, 1897, pp. 59–61.

Strond, B. B., 1897 : On Brain Preservation. Proc. Ass'n Amer. Anat., 1897. pp. 30–32.

——, 1900 : a New Head-Rest for the Removal of the Human Brain. Proc. Ass'n Amer. Anat., May, 1900, pp. 10–14, five figures.

Wilder and Gage, 1892 : Anatomical Technology as Applied to the Domestic Cat, third edition, from the second revised, O., pp 600, 130 figures, and 4 lithographic plates.

Wilder, B. G., 1896, *g* : The Desirability and the Feasibility of the Acquisition of Some Real and Accurate Knowledge of the Brain by Precollegiate Scholars. Amer. Soc. Naturalists, December, 1896. Science, vi., 902–908, Dec. 17th, 1897, 3 figures.

* Even more objectionable is the omission of the original pagination upon the reprints of papers. The printer does not always realize the conditions and the author often remembers when it is too late.