of a persistent bitter taste. It is very insoluble in water ($\frac{1}{8000}$), 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 Rhodiæi* 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.

VIII. The Rhinencephal (olfactory bulbs, etc.), §§ 357–372.

IX. The Meninges (dura, arachnoid, pia), §§ 373–409.

X. Bibliography.

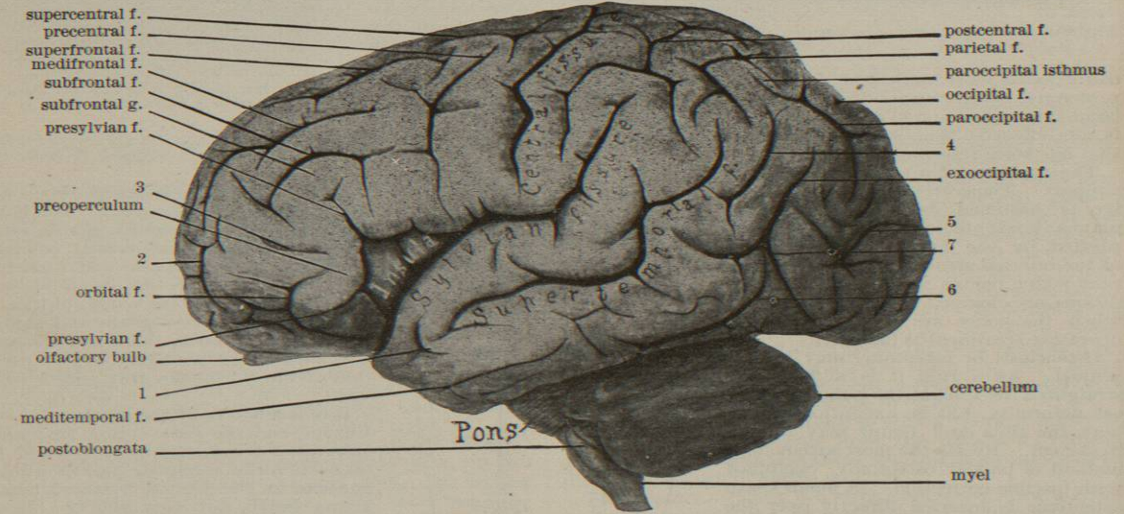


Fig. 663.—Left Side of the Brain of a Male Child at Birth; 478. × 1. The brain was medisected when fresh, and the hemicerebrum spread and flattened considerably while hardening. The specimen is really the right half, but for readier comparison with other specimens and figures a diagram was made (by Mrs. 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.

§ 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

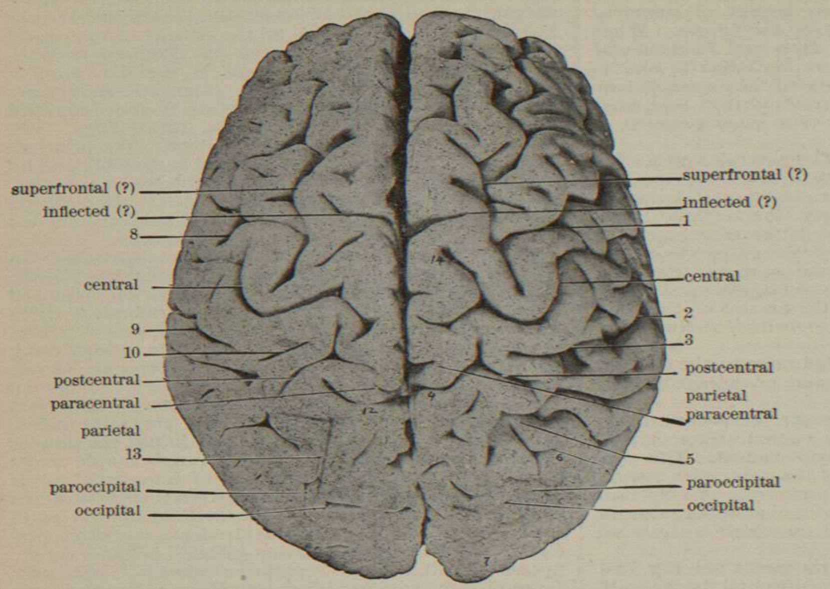


FIG. 664.—Dorsum of the Cerebrum of James Edward Oliver, Professor of Mathematics in Cornell University; aged sixty-six; 3,334. × .57. When removed the brain was firm in texture and weighed (with the piarachnoid but without the dura) 1,416 gm. (49.94 ounces), approximately 50 ounces. It was transected 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.

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.

II. GENERAL CONSTITUTION OF THE BRAIN.—§ 14. *Definition.*—The *brain* (Gr., ἐγκέφᾰλος; 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,

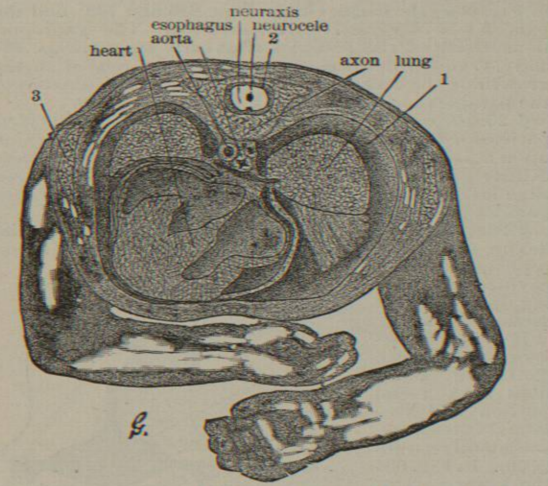


FIG. 665.—Caudal Aspect of a Thoracic Transection of a Fetus About 3.9 cm. from Nates to Bregma, and Estimated at Ten Weeks; 2,139. × 4. 1, Thorax, part of the ventral or hemal cavity; 2, spinal canal, part of the dorsal or neural cavity; 3, scapula.

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 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

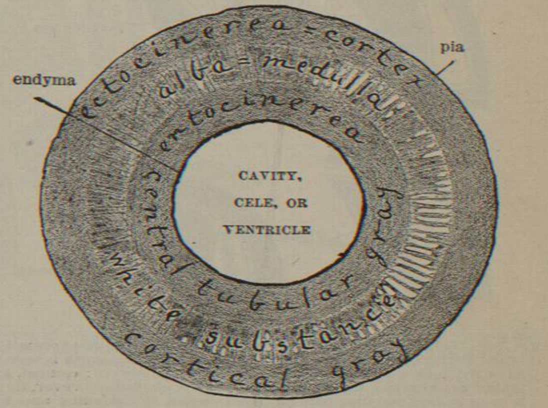


FIG. 666.—Schematic Transection of the Brain, representing the topographical relations of the two kinds of nervous substance, the white, which is fibrous and conducting, and the gray, which is cellular as well as fibrous, and dynamic in function. The entocinerea is primary, and alone exists in the myel; 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

* 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, xlv., p. 7.

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.

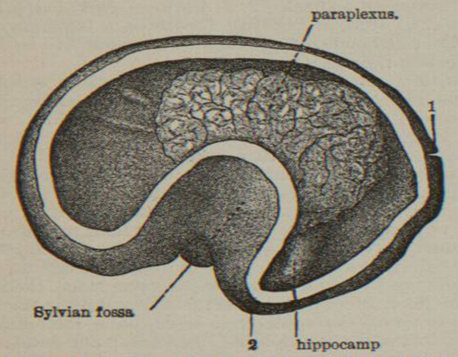


FIG. 667.—The Left Hemicerebrum of a Fetus (Measuring 6 cm. from Bregma to Heel, and Estimated at Twelve Weeks), Opened from the Lateral Aspect; 340. × 3. 1, A fissure; 2, tip of temporal lobe.

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 non-vascular; but provision is made for the practical introduction of blood-vessels into the encephalic cavities by

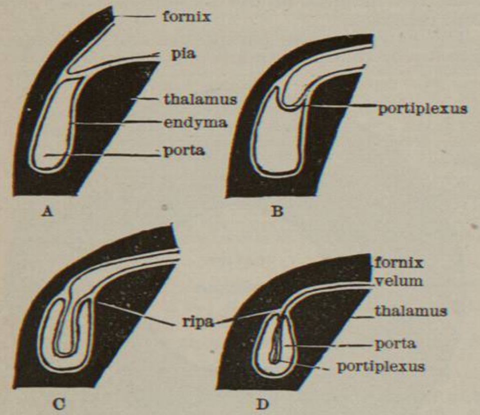


FIG. 668.—Schematic Representations of Four Stages in the Formation of the Portiplexus, as a Type of Plexuses. At A the porta is seen to have the following boundaries: cephalad, the fornix; caudad, the thalamus: ventrad, the junction of the two; dorsad, however, there is merely the endyma passing from 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.

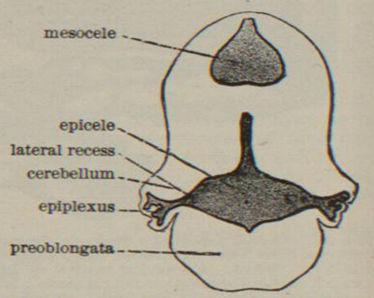


FIG. 669.—Transection of the Brain of an Embryo Rabbit, Sixteen Days Old. × 9. (From Kölliker.)

§ 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

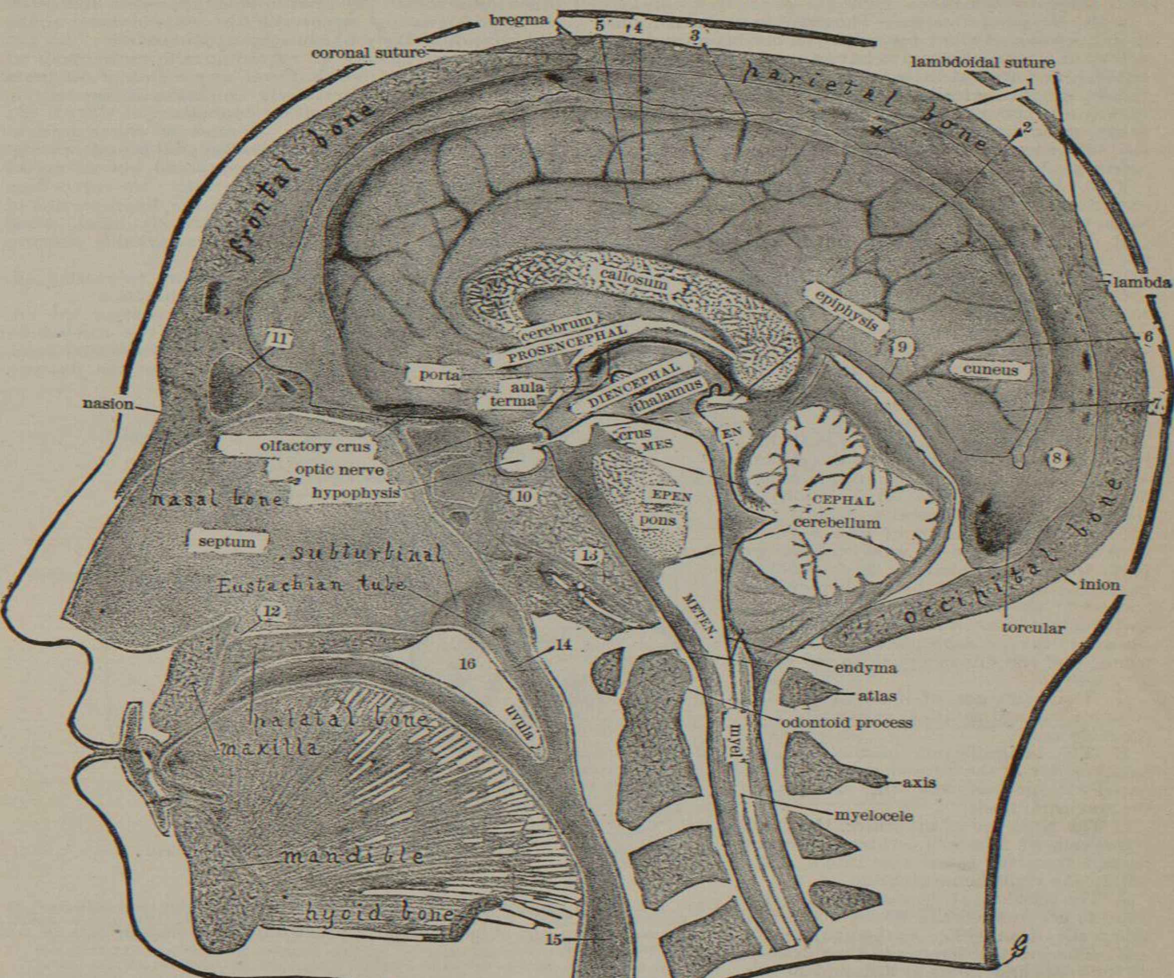


FIG. 670.—Mesal Aspect of the Right Half of an Adult Head, the brain hardened in place by continuous alinjection; 811. × .7. (This was the head of William Menken, who was hanged for murder in July, 1885; the specimen was shown at the American Neurological Association in 1886, and at the American Laryngological 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, basioccipital bone; the basisphenoid has 10 upon it, but the two bones 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 are 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 be 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*.

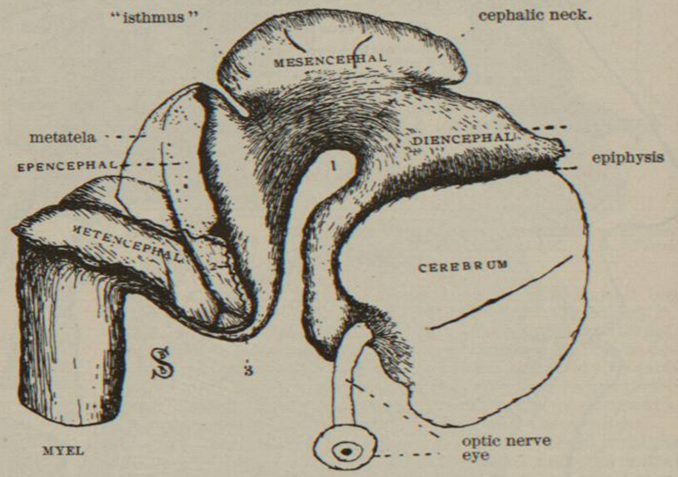


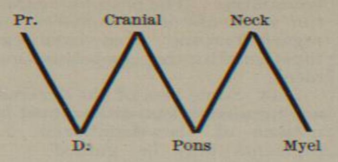
FIG. 671.—Right Side of the Brain of an Embryo 22 mm. Long and Estimated at Eight Weeks; 2,652. × 7. Prepared and drawn by B. B. Stroud (1899, *a*). 1, Cranial flexure; 2, torn edge of the metatela; 3, pons flexure. The olfactory bulbs are not shown. See § 37.

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 illustrate 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.

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 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,

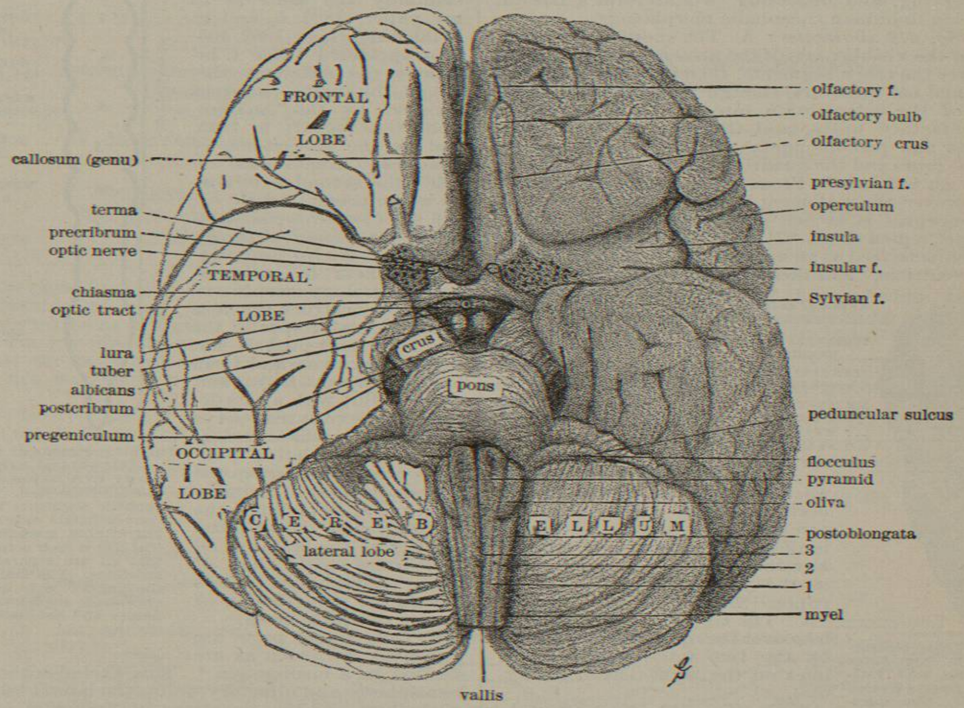


FIG. 672.—Base (Ventral Aspect) of the Brain. From Henle, Edinger, and nature. × .7. 1, Ventral ("anterior") column; 2, line between the ventral and lateral column; 3, ventrimesal fissure.

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.

* 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.