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

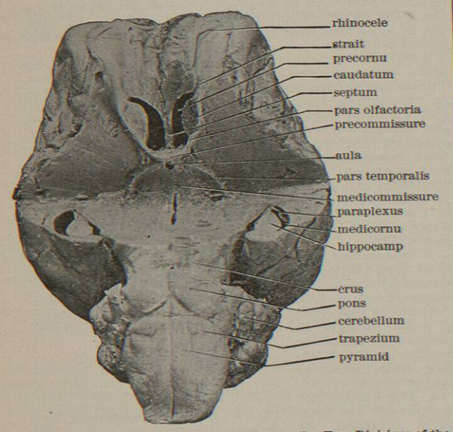


Fig. 792.—Brain of Sheep Dissected to Show the Two Divisions of the Precommissure; 2,653. × .9. Prepared by P. A. Fish. The cerebrum was cut from the ventral side in two planes meeting at about a right angle along the line indicated by the shadow just caudad of the line from the word *medicommissure*. 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.

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.

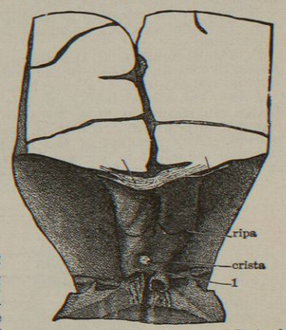


Fig. 793.—The Crista and Adjacent Parts of a Child at Term; 4. × 1.5.

*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.

§ 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 be 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 relative 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:

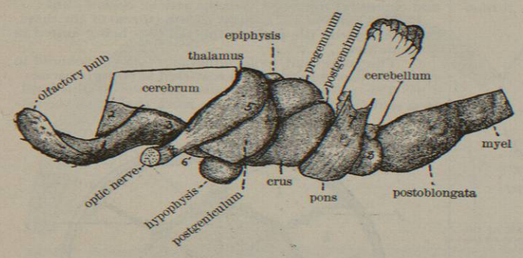


Fig. 794.—Left Side of the Sheep's Brain After the Removal of Portions of the Cerebrum and Cerebellum, So as to Display the Segmental Constitution of the Organ. (From "Physiology Practicums"; compare Fig. 688.)

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.

| | | |
|---|---|---|
| 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 arguments. 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

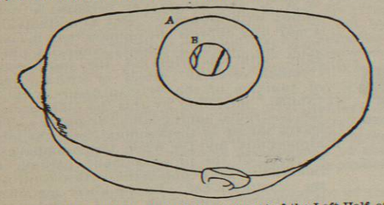

FIG. 795.—Outline of the Dorso-Lateral Aspect of the Left Half of the Head of an Adult Man, with the Brain Exposed in the Region of the Central Fissure; 811. ×.3.

*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




FIG. 796.—The Several Coverings of the Brain Exposed as a Series of Terraces; 811. ×.3. 1, The arachnoid, the ectal layer of the pia-arachnoid; 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 candal 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.

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.

§ 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 cer-

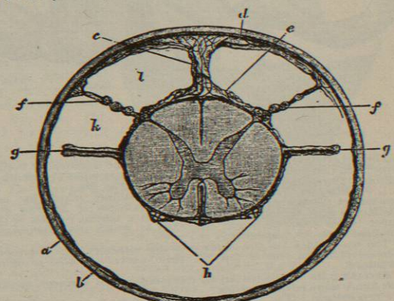


FIG. 797.—Transection of the Myel and Its Meninges in the "Upper" Thoracic Region. (Enlarged somewhat from Key and Retzius, Taf. i., Fig. 7, after Shäfer: Quain, iii., Fig. 182.) *a*, Dura (not the spinal periosteum, but representing the ental layer of cranial dura); *b*, arachnoid; *c*, septum posticum; *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.

vical region, and more or less incomplete farther caudad.*

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

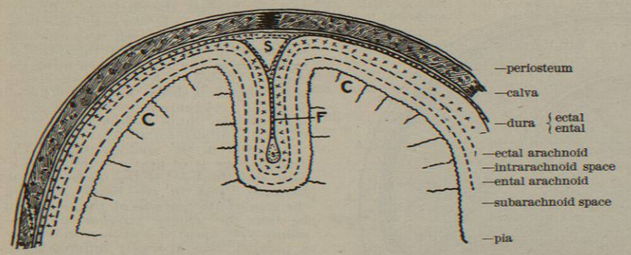


FIG. 798.—Schematic Transection of the Parietal Region of the New Born, to show the Relations of the Meninges to the Cerebrum and Cranium. (From Langdon, 1891.) C, C, Cerebrum; F, falx; S, longitudinal sinus; xxx, subserous connective tissue between the dura and the ectal arachnoid.

*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

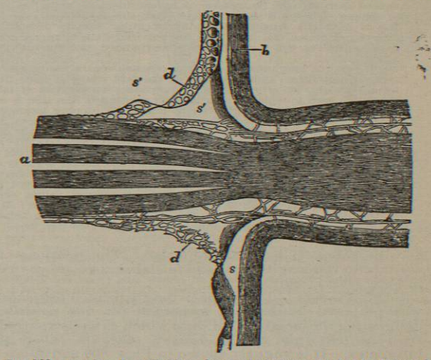


FIG. 799.—Section, Lengthwise, of a Ventral Nerve Root at Its Place of Exit from the Spinal Canal Enlarged. (From Key and Retzius, Taf. i., Fig. 10; after Shäfer: Quain, iii., Fig. 128.) *a*, Four funiculi uniting to constitute the root; *b*, dura reflected upon the root at its emergence through the 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 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.

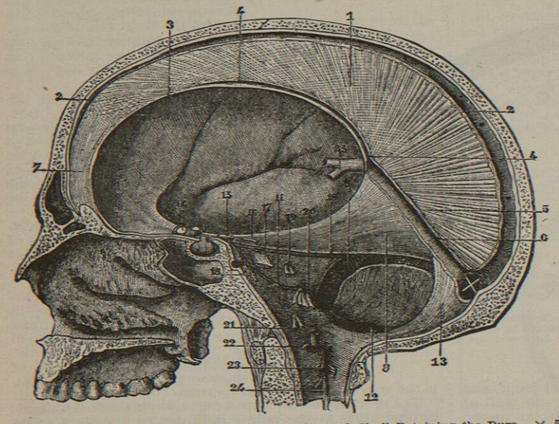

FIG. 800.—Mesal Aspect of Right Half of Medisected Skull Retaining the Dura. ×.5. (From Sappey, ill., Fig. 462; after Shäfer: Quain, ill., Fig. 129.)

*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), ill., 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).

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 tentorial 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*

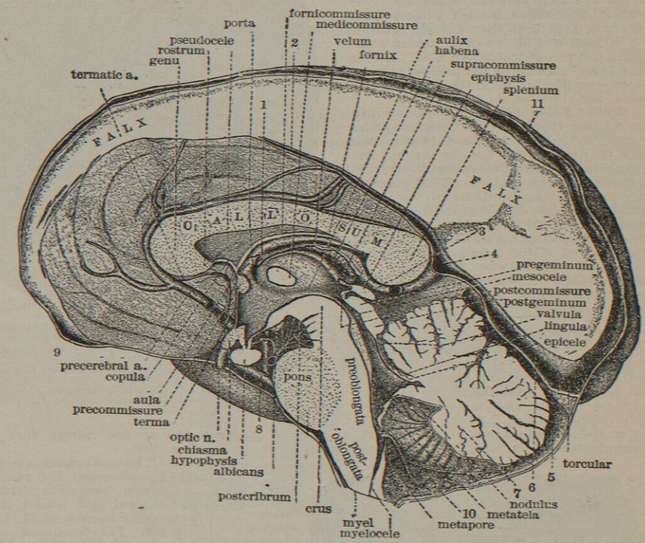


FIG. 801.—Mesal Aspect of the Right Half of the Brain of an Adult White Man; 376. ×.65. 1, Auliplexus; 2, falcial sinus; 3, right velar vein; 4, orifice of Galen's vein into the tentorial sinus; 5, falcula (or "cerebellar falx"); 6, tentorial sinus; 7, uvula, a mesal division of the cerebellum; 8, tuber ("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 6 and 7 it becomes attached to the cerebellar pia-arachnoid; 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 forniccommissure 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.

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 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

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*),

* 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.

*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 in-


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.

trafissural fold, as in the left central and the part of the right central crossed by the line.

B. The usual relation of the central fissures to the paracentrals on both sides.

C. The usual relation of the left paracentral fis-

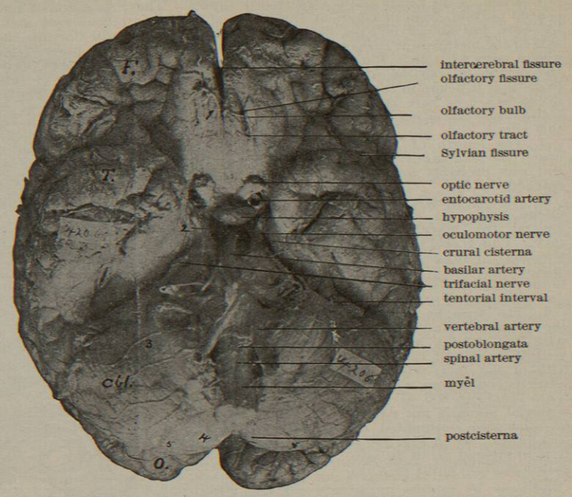


FIG. 803.—Base of the Brain of a Man Estimated at Sixty-Five Years, Before the Removal of the Piarachnoid and Blood-Vessels; 4,206. × .5. 1, Between the meson and the right olfactory bulb and opposite the point where the arachnoid ceases to pass directly from one hemicerebrum to the other and is carried 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.

sure to the dorsal fork of the postcentral (compare Fig. 769).

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 circum-

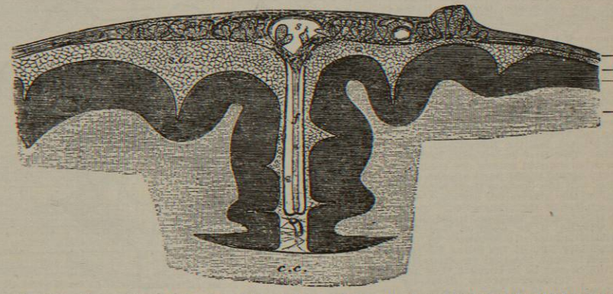


FIG. 804.—Transection of the Dorsal, Mesal Region of the Cerebrum, to Show the Meninges and Arachnoidal Villi. Slightly enlarged. (From Key and Retzius, Taf. xxix., Fig. 4; after Shafer: Quain, iii., Fig. 134.)

*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.

scription 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*,

* 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.