Central Nervous system ①
C.N.S

- BRAIN
  - Cerebrum
  - Cerebellum
  - Brain stem
    - Midbrain
    - Pons
    - medulla oblongata
- SPINAL CORD

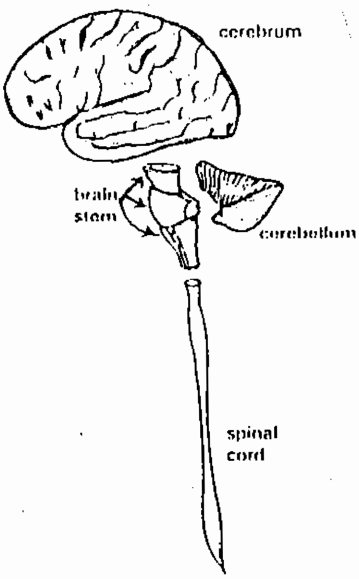

Fig. 1-15. Divisions of the CNS.

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2003

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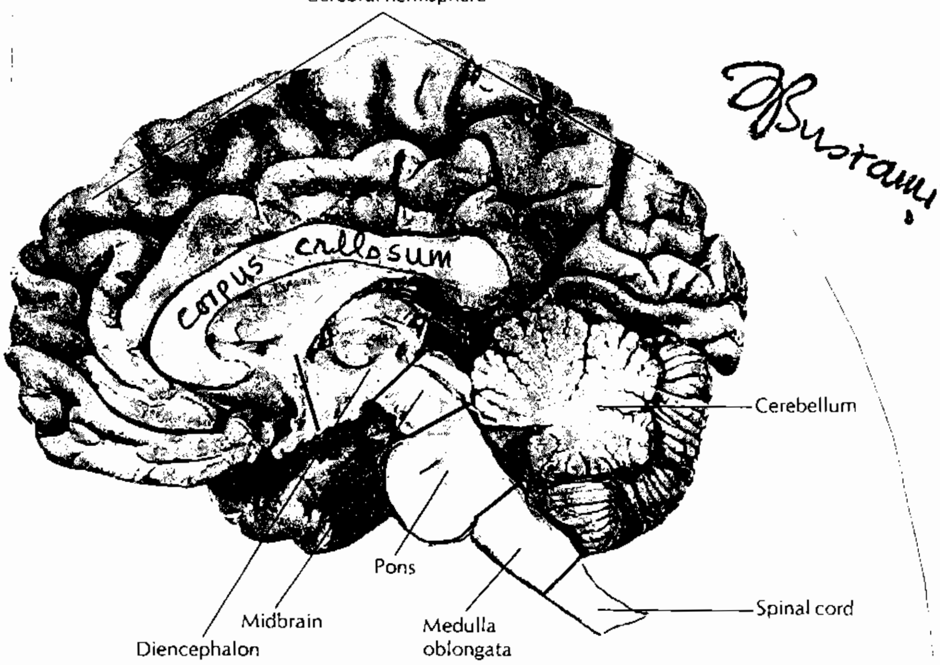

Figure 1-3. Regions of the mature central nervous system, as seen in sagittal section. (×0.5; *photograph kindly provided by Dr. D. G. Montemurro.*)

Developmentally
BRAIN is formed of 3 major Parts:

① **Forebrain** (Prosencephalon)
- Telencephalon (2 cerebral hemispheres)
- Diencephalon: → Thalamus, hypothalamus, Subthalamus

② **Midbrain** (mesencephalon)

③ **hindbrain** (Rhombencephalon)
- myelencephalon (medulla ⓐ oblongata)
- metencephalon
  - Pons ⓑ
  - cerebellum ⓒ

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للطلبة كلية الطب ٢٠٠٩

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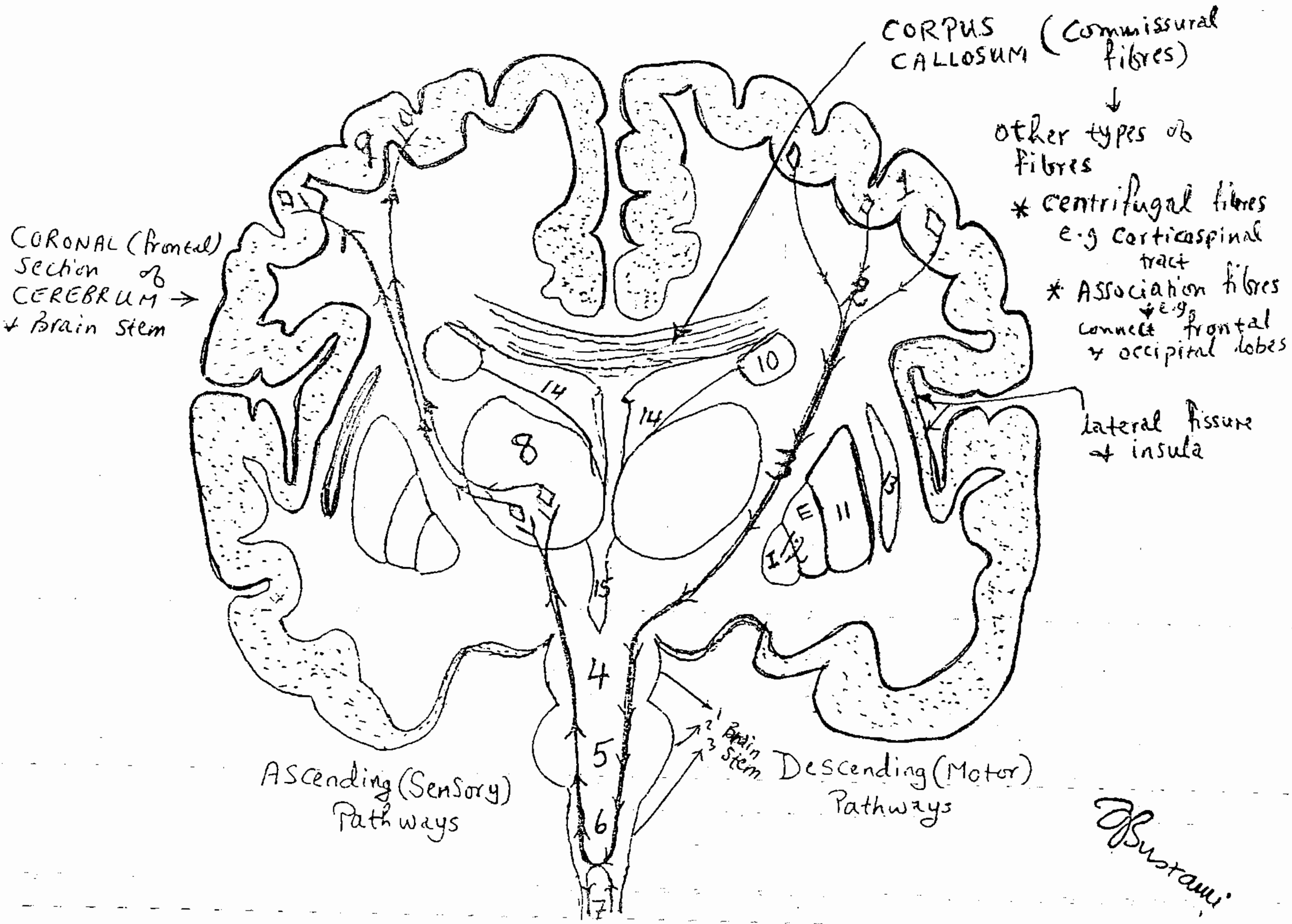

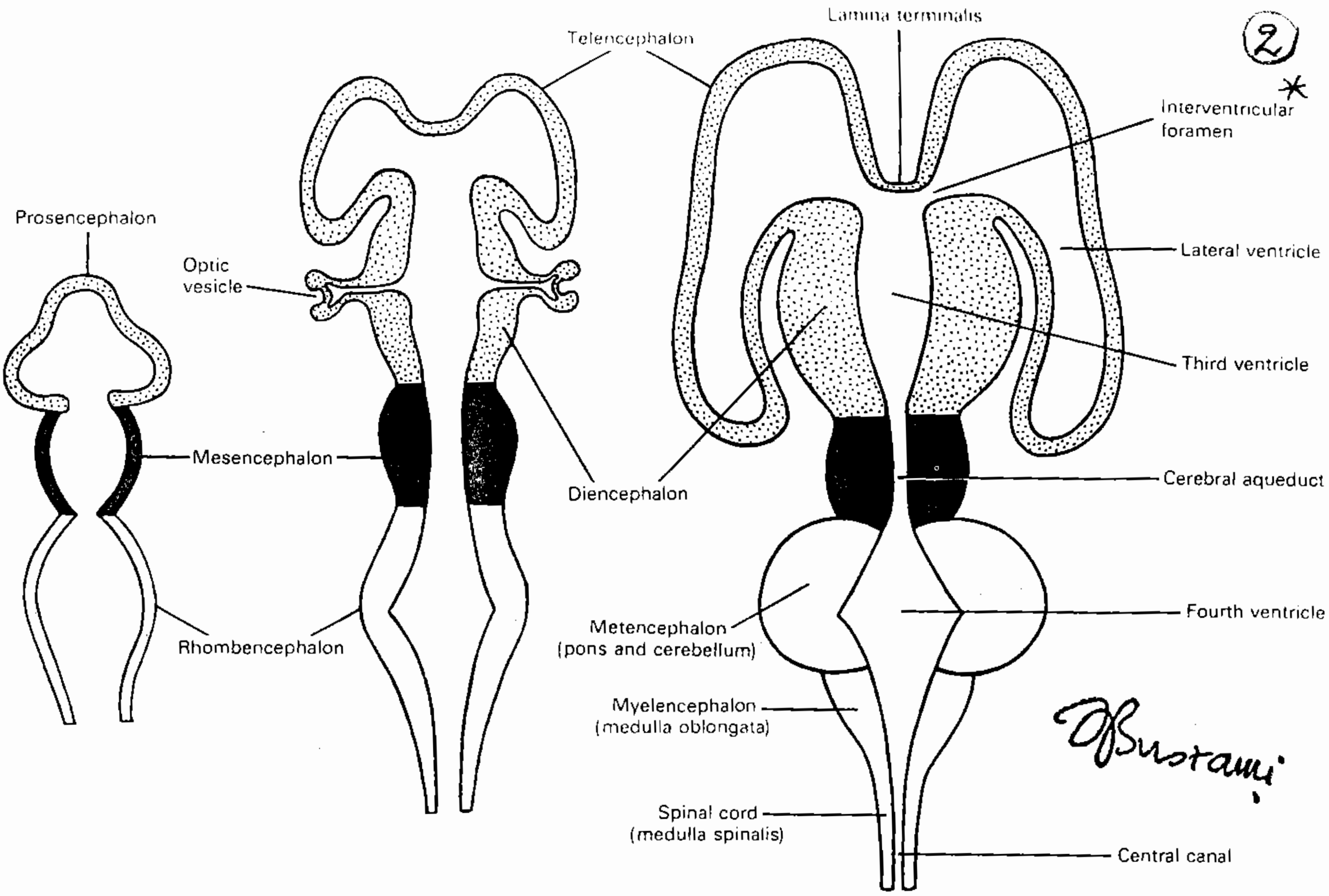

Fig. 1.3 Diagrams of stages in the differentiation of cerebral vesicles and the ventricular system.

Developmentally → 3 brain vesicles < forebrain, midbrain, hindbrain — develop from the rostral (superior) part of the Neural tube → the cavities of these vesicles become the ventricular system of the adult brain as follows :-

1. The cavity of the telencephalon (each cerebral hemisphere) will form the LATERAL VENTRICLE
2. The cavity of the diencephalon (thalamus and hypothalamus) is the Third Ventricle
3. The cavity of the mesencephalon (midbrain) remains a narrow canal called the CEREBRAL AQUEDUCT
4. the cavity of the rhombencephalon (hindbrain) will form the Fourth Ventricle (a cavity bounded by the cerebellum, pons and medulla oblongata)

Nervous System

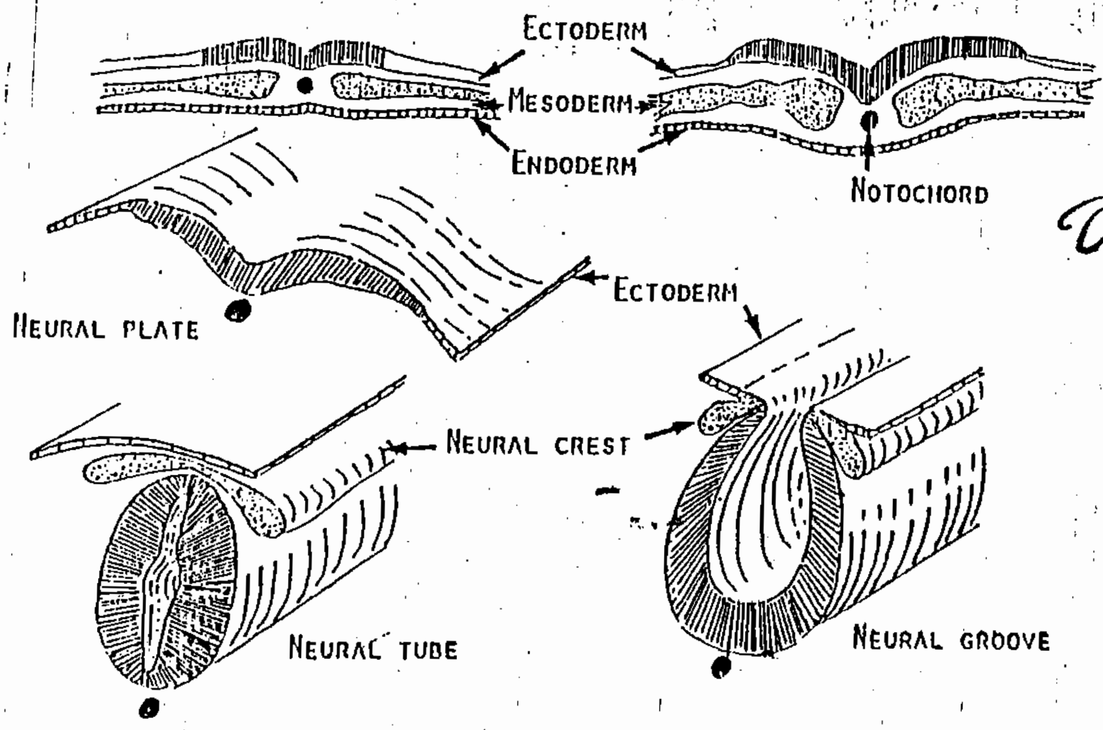

Fig. 21-1. Formation of neural tube.

NEURAL TUBE FORMATION

I. At the beginning of the third week, under the inductive influence of the notochord, the dorsal ectoderm thickens in the midline to form the neural plate (Fig. 21-1).

II. Due to the changes in the shape and size of the neural epithelial cells and the changes in their connections with surrounding cells, the lateral margins of the plate become elevated to form the neural folds.

III. The depression between these folds is known as neural groove.

IV. At about the 25th day the neural folds fuse to form the neural tube. The fusion begins at the fourth somite and progresses rostrally and caudally.

V. For a short time the neural tube remains open at both ends as the rostral and caudal neuropores (Fig. 21-2).

VI. The rostral neuropore closes at about the 25th day, and two days later the caudal neuropore closes.

VII Some cells at the margin of neural fold do not incorporate into the neural tube, and thus form the neural crest.

VIII The neural tube detaches itself from the ectoderm and sinks into the underlying mesoderm.

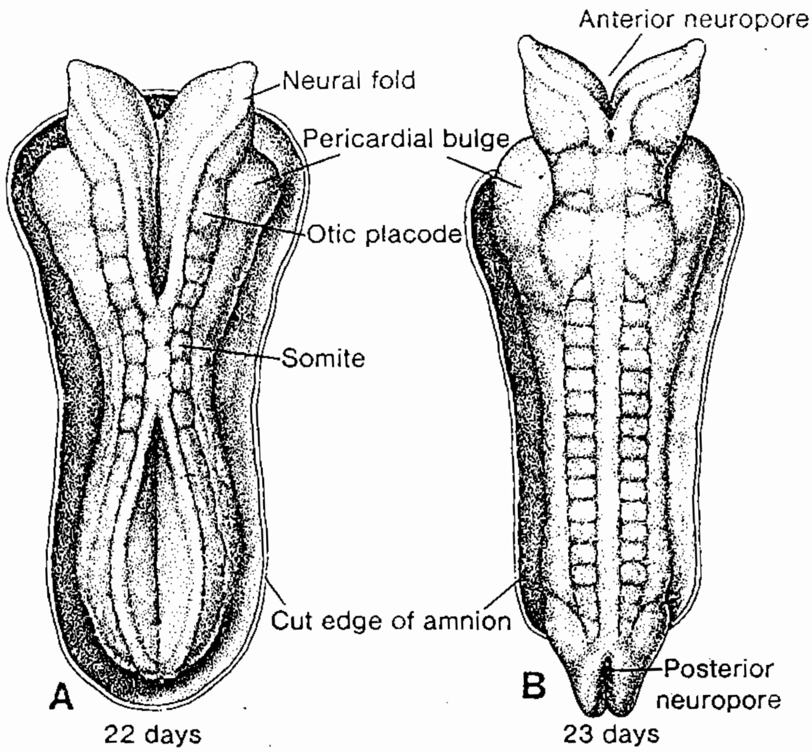

Figure 5-4. A, Dorsal view of a human embryo at approximately day 22. (Modified after Payne.) Seven distinct somites are visible on each side of the neural tube. B, Dorsal view of a human embryo at approximately day 23. (Modified after Corner.) Note the pericardial bulge on each side of the midline in the cephalic part of the embryo.

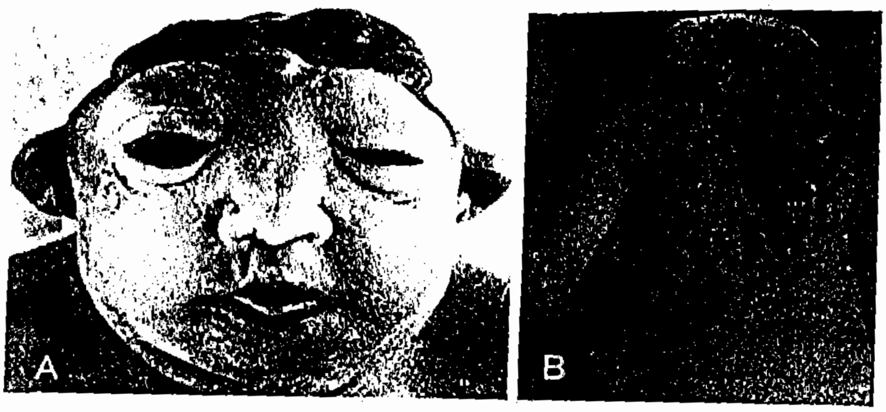

Figure 20-31. A, Photograph of anencephalic child. Ventral view. This abnormality is frequently seen (1:1000 births). Usually the child dies a few days after birth. (Courtesy Dr. J. Warkany. From Warkany J: *Congenital Malformations*. Chicago, Year Book Medical Publishers, 1971. Used by permission.) B, Dorsal view of an anencephalic child with spina bifida in cervical and thoracic segments.

Anencephalus → failure of the cephalic part of the neural tube (anterior neuropore) to close

At birth → the vault of the skull is absent
→ the brain is represented by a mass of degenerated tissue exposed to the surface
→ often → rachischisis (open spinal cord) in the cervical region + the neck is present

* The foetus lacks the control mechanism for swallowing
→ the last 2 months of pregnancy are characterized by hydramnios (2000 ml) + high level of α-fetoprotein (AFP)

* more common in ♀ than ♂ (4 : 1)
* common abnormality (1 : 1000)

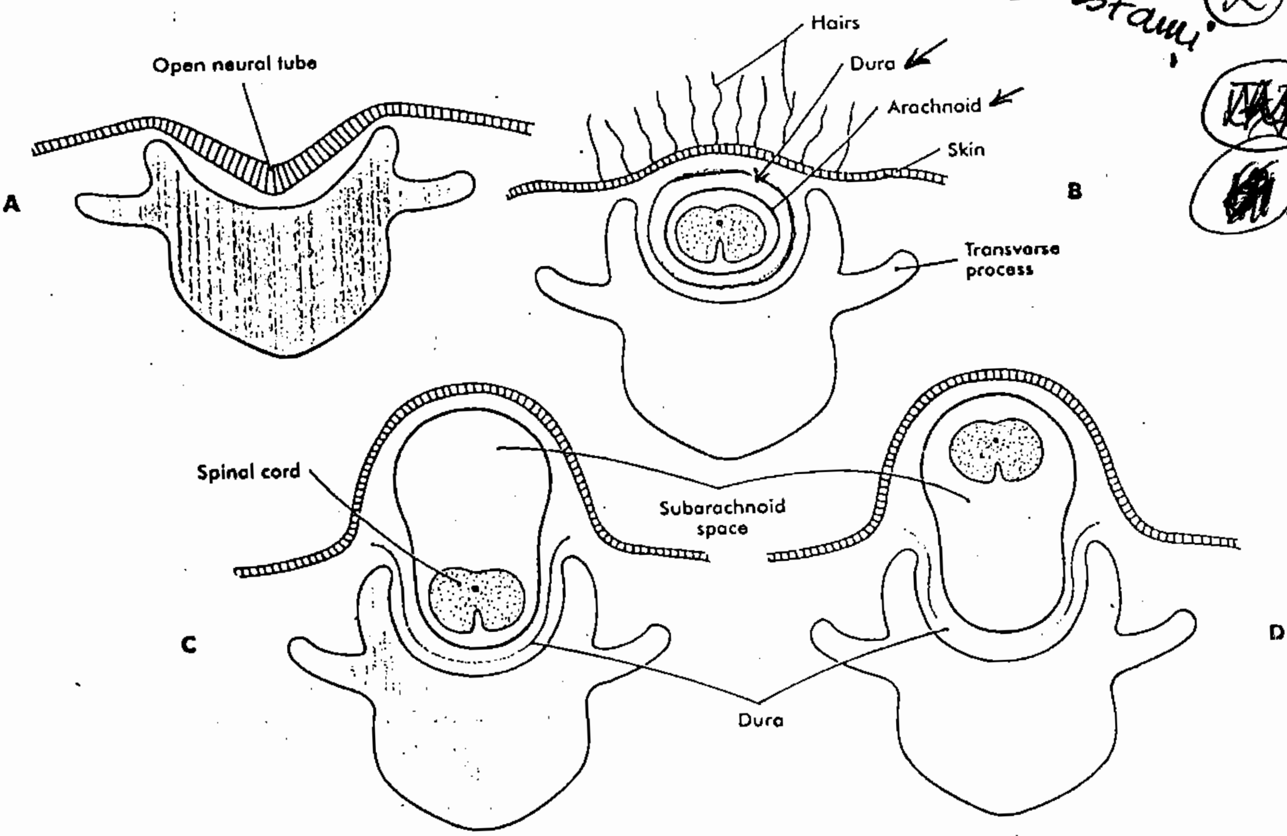

FIG. 12-38 Varities of closure defects of the spinal cord and vertebral column. A, Rachischisis. B, Spina bifida occulta, with hair growth over the defect. C, Meningocele. D, Myelomeningocele.

Other Closure Defects

A defect in the formation of the bony covering overlying either the spinal cord or brain can result in a graded series of structural anomalies. In the spinal cord, the simplest defect is called **spina bifida occulta** (Fig. 12-38, *B*). The spinal cord and meninges remain in place, but the bony covering (neural arch) of one or more vertebrae is incomplete. Sometimes the defect goes unnoticed for many years. The site of the defect is often marked by a tuft of hair. The next most severe category of defect is a **meningocele**, in which the dura mater may be missing in the area of the defect and the arachnoid layer bulges prominently beneath the skin (Fig. 12-38, *C*). The spinal cord, however, remains in place, and neurological symptoms are often minor. The most severe condition is a **myelomeningocele**, in which the spinal cord bulges or is entirely displaced into the protruding subarachnoid space (Figs. 12-38, *D* and 12-39). Because of problems associated with displaced spinal roots, neurological problems are commonly associated with this condition.

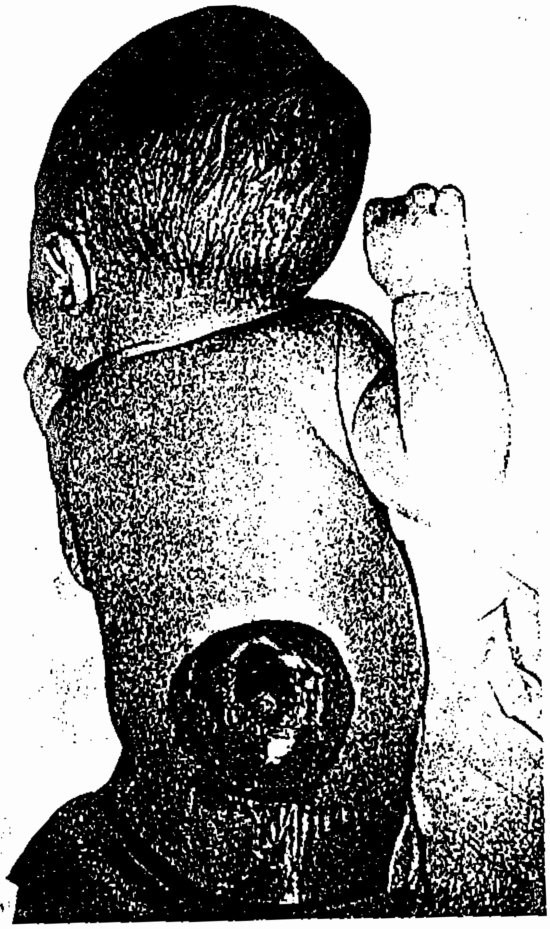

FIG. 12-39 Infant with a myelomeningocele and

FIG. 12-37 Fetus with a severe case of rachischisis. The brain is not covered by cranial bones, and the light-colored spinal cord is totally exposed. (Courtesy Mason Barr, Ann Arbor, Mich.)

A number of the closure defects can be diagnosed by the detection of elevated levels of alpha-fetoprotein in the amniotic fluid or by ultrasound scanning.

Defects in Closure of the Neural Tube

Failure of closure of the neural tube occurs most commonly in the regions of the anterior and posterior neuropore, but other locations are also possible. In this condition the spinal cord or brain in the affected area is splayed open, with the wall of the central canal or ventricular system constituting the outer surface. A closure defect of the spinal cord is called rachischisis and, in the brain, cranioschisis. Cranioschisis is incompatible with life. Rachischisis (Fig. 12-37) is associated with a wide variety of severe problems, including chronic infection, motor and sensory deficits, and disturbances in bladder function. These defects commonly accompany anencephaly (see Fig. 8-4), in which there is a massive deficiency of cranial structures.

Myelination in the Spinal Cord

In the spinal cord the nerve fibers are heavily myelinated or slightly myelinated. The myelin sheath is formed and maintained by the *oligodendrocytes* of the neuroglia. The cervical portion of the cord is the first part to develop myelin, and from here the process extends caudally. The fibers of the anterior nerve roots are myelinated before those of the posterior nerve roots. The process of myelination begins within the cord at about the fourth month, and the sensory fibers are affected first. The descending motor fibers are the last to myelinate, which process does not begin until term; it continues during the first 2 years of postnatal life.

Myelination in the Brain and the Onset of Function

Myelination in the brain begins at about the sixth month of fetal life but is restricted to the fibers of the basal ganglia. Later the sensory fibers passing up from the spinal cord myelinate, but the progress is slow so that at birth the brain is still largely unmyelinated. In the newborn there is very little cerebral function; motor reactions such as respiration, sucking, and swallowing are essentially reflex. After birth the corticobulbar, corticospinal fibers, and the tectospinal and corticopontocerebellar fibers begin to myelinate. This process of myelination is not haphazard but systematic, occurring in different nerve fibers at specific times. The corticospinal fibers, for example, start to myelinate at about 6 months after birth, and the process is largely complete by the end of the second year. It is believed that some nerve fibers in the brain and spinal cord do not complete myelination until puberty.

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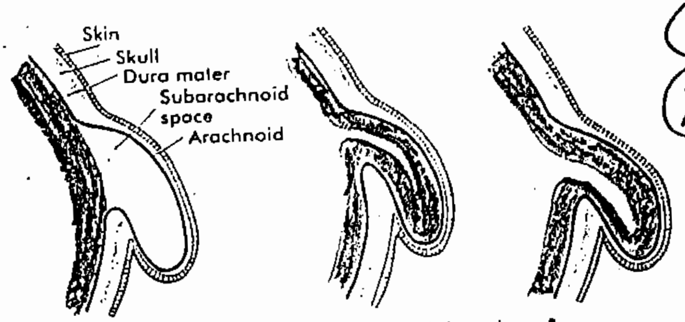


FIG. 12-40 Herniations in the cranial region. **A**, Meningocele. **B**, Meningoencephalocele. **C**, Meningohydroencephalocele.

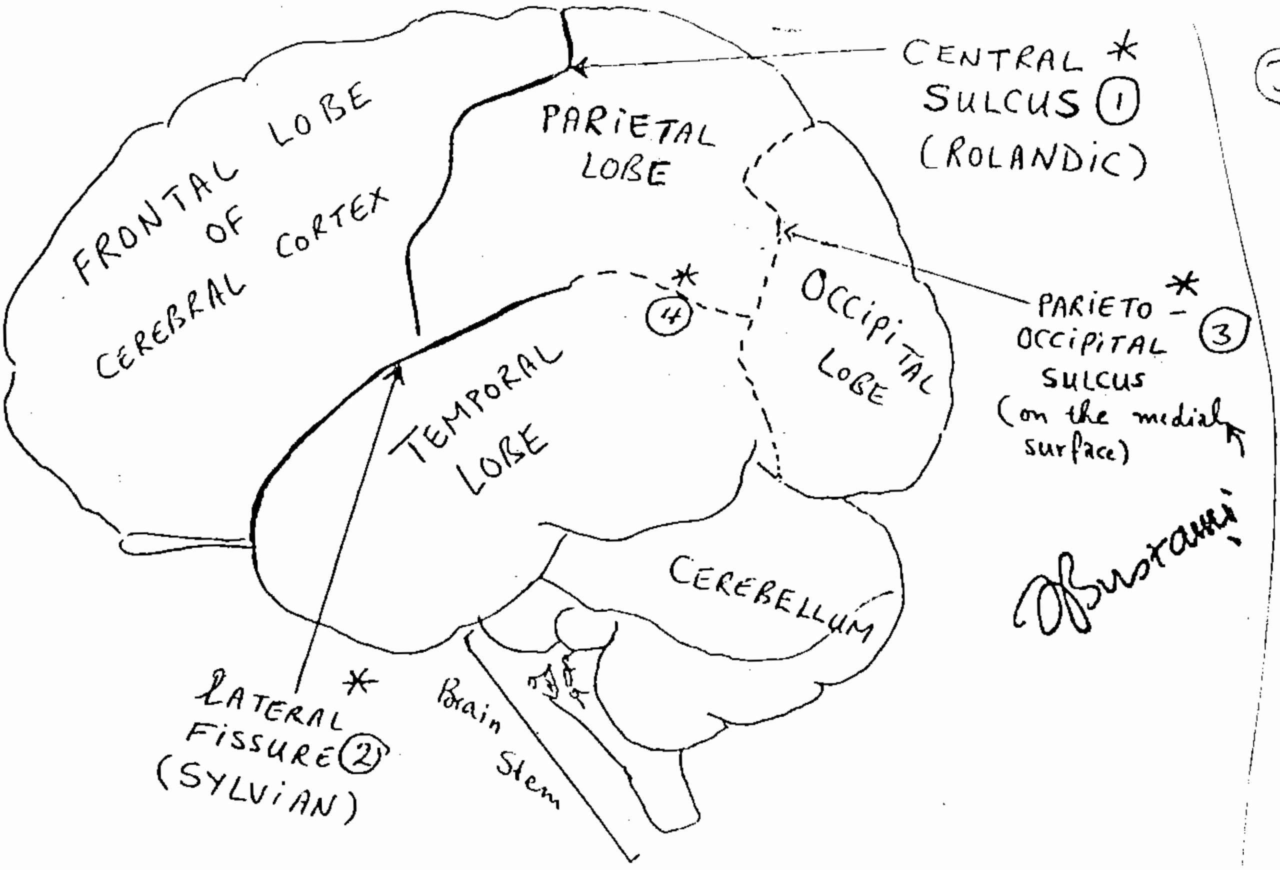
A similar spectrum of anomalies is associated with cranial defects (Figs. 12-40 and 12-41). A **meningocele** is typically associated with a small defect in the skull, whereas brain tissue alone (**meningoencephalocele**) or brain tissue containing part of the ventricular system (**meningohydroencephalocoele**) may protrude through a larger opening in the skull. Depending on the nature of the protruding tissue, these malformations may be associated with neurological deficits. The mechanical circumstances may also lead to secondary hydrocephalus in some cases.

Microcephaly is a relatively uncommon condition characterized by underdevelopment of both the brain and the cranium (see Fig. 10-9). Although it can result from premature closure of the cranial sutures, in most cases its etiology is uncertain.

Many of the functional defects of the nervous system are poorly characterized, and their etiology is not understood. Studies on mice with genetically based defects of movement or behavior due to abnormalities of cell migration or histogenesis in certain regions of the brain suggest there is likely a parallel spectrum of human defects. **Mental retardation** is common and can be attributed to many causes, both genetic and environmental. The timing of the insult to the brain may be late in the fetal period.

FIG. 12-41 Fetuses with (A) an occipital meningocele and (B) a frontal encephalocele.
(Courtesy Mason Barr, Ann Arbor, Mich.)

③



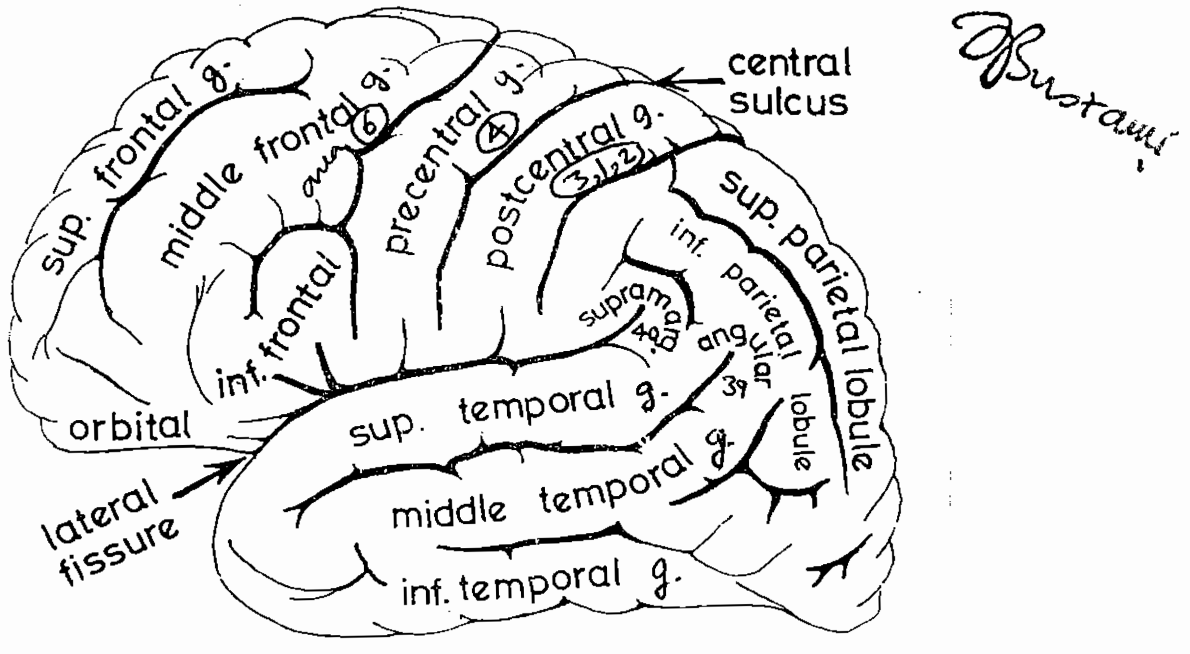


Fig. 48 The gyri of the ateral surface of the cerebral hemisphere.

precentral gyrus (frontal lobe) = area 4 = Primary motor cortex

Premotor cortex (frontal lobe) = area 6

Supplementary motor area (SMA) = medial extension of area 6

Postcentral gyrus (parietal lobe) = area 3,1,2 = Somatic sensory cortex or Somasthetic cortex

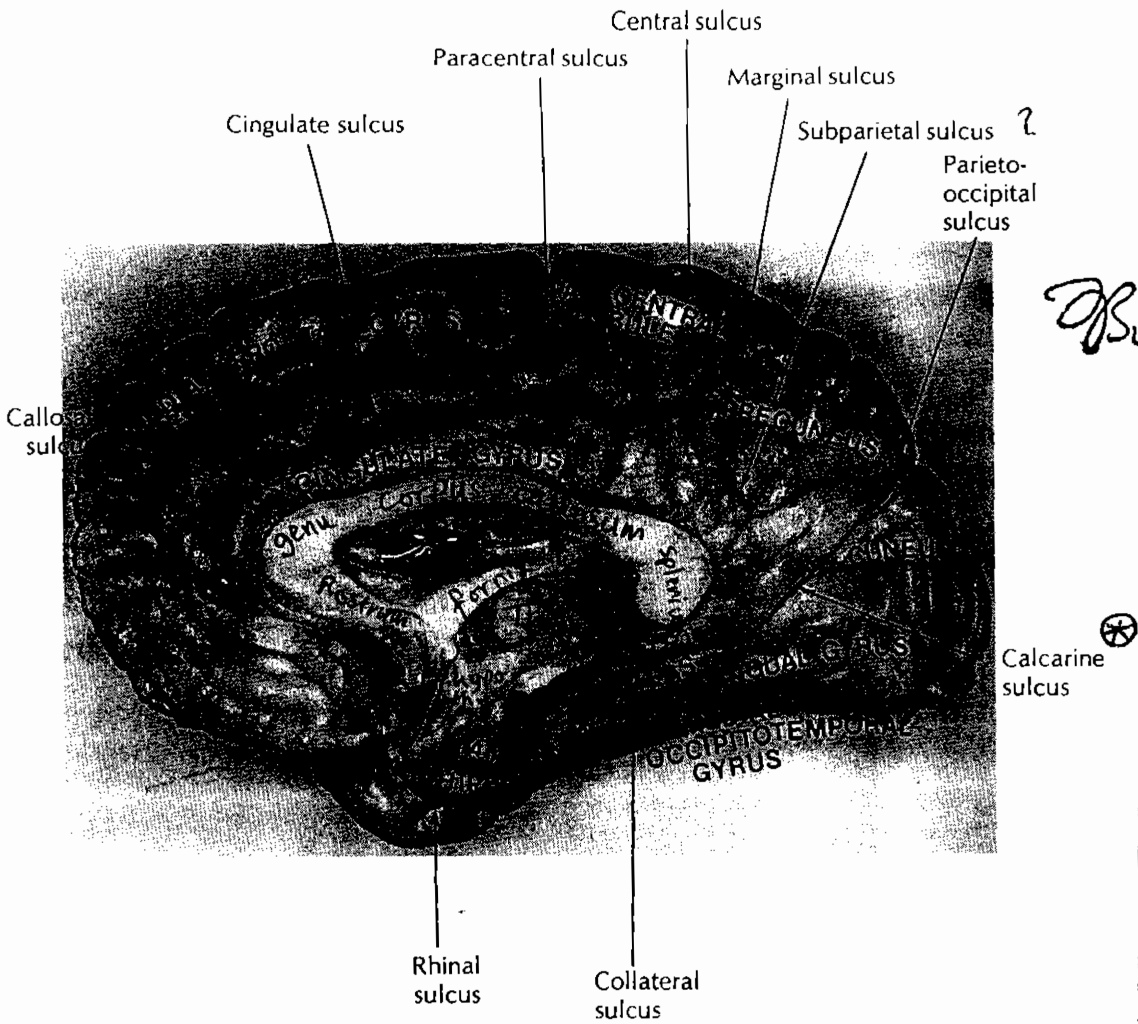


Figure 13-5. Gyri and sulci on the medial and inferior surfaces of the right cerebral hemisphere. (A) Uncus. (B) Isthmus (retrosplenial cortex) connecting the cingulate and parahippocampal gyri. (× 0.63)

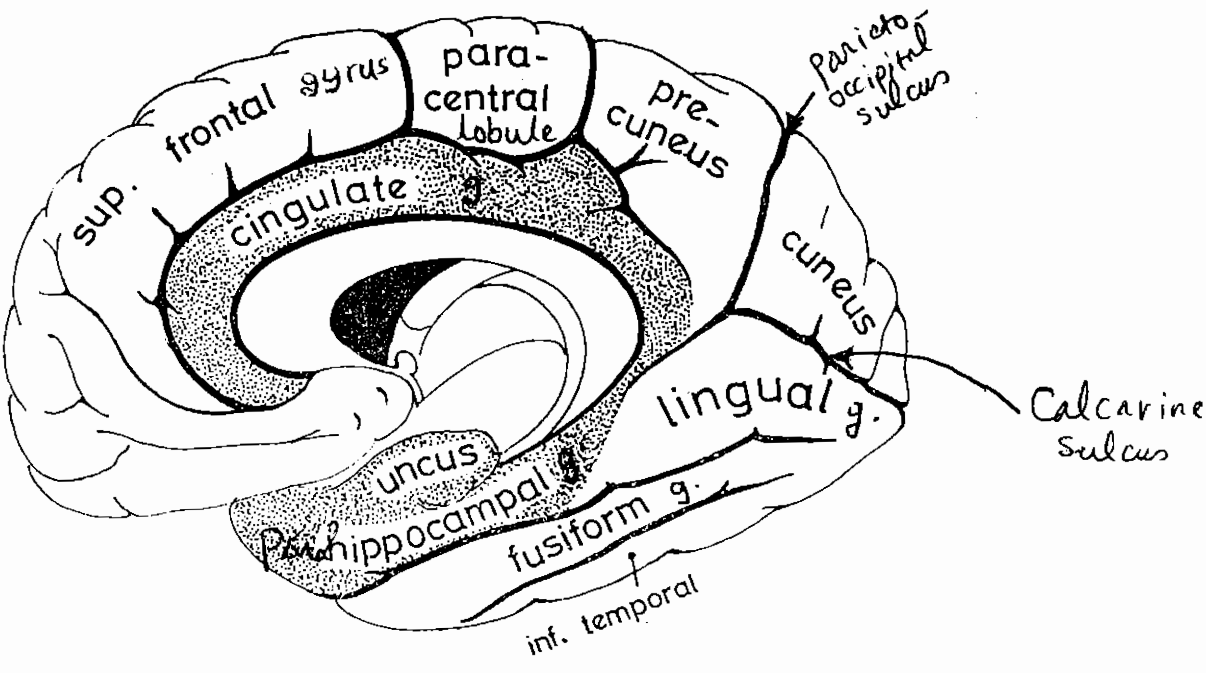


Fig. 53 The gyri of the medial surface of the cerebral hemisphere
(The different parts of the limbic lobe are shaded)

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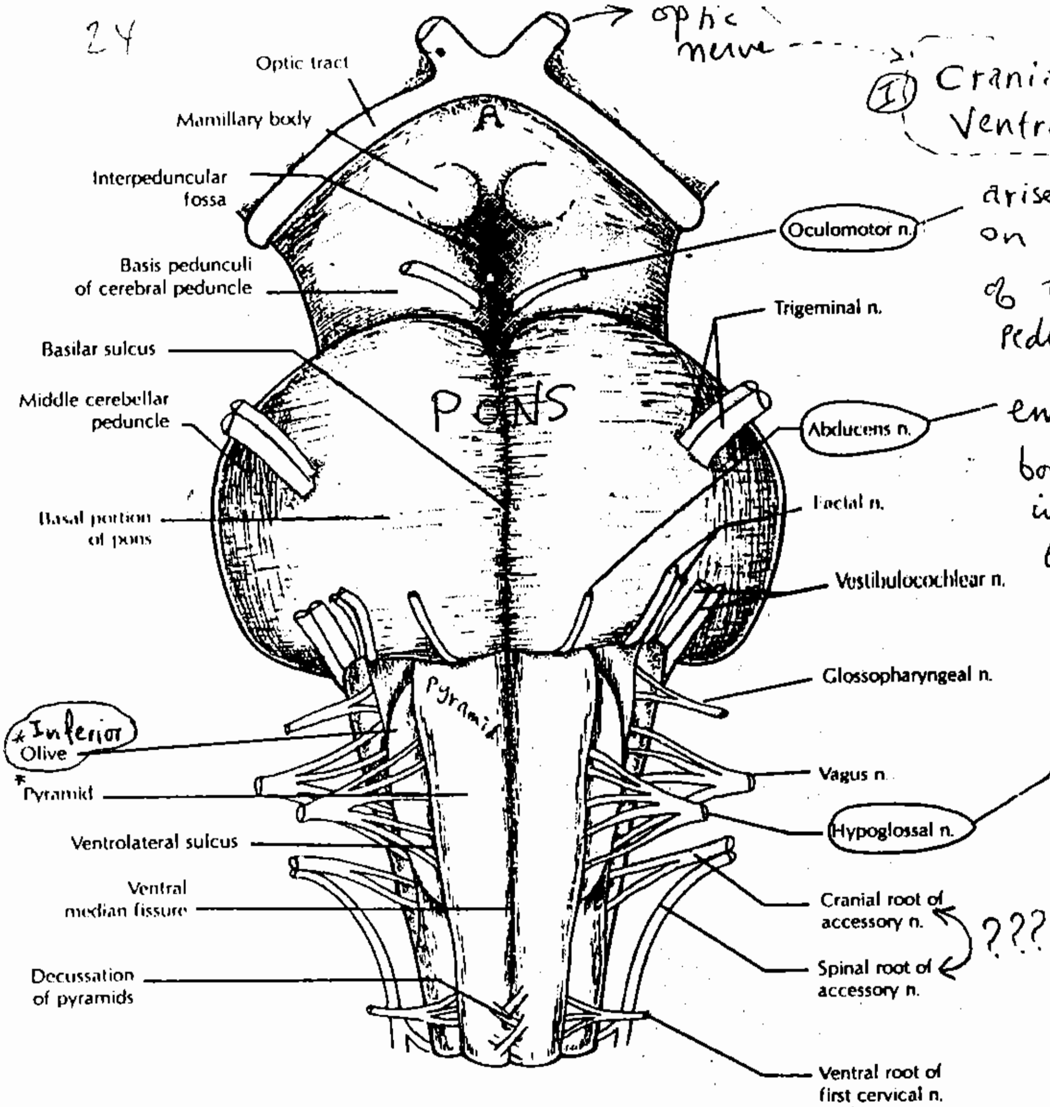

Figure 6–1. Ventral aspect of the brain stem.

(I) Cranial nerves with Ventral attachments (3, 6, 12 of 5)

- Oculomotor n.: arises from the groove on the medial aspect of the crus cerebri (basis pedunculi) → Midbrain
- Abducens n.: emerges at the inferior border of the pons immediately lateral to the pyramid
- Hypoglossal n.: formed by a row of rootlets which arise from the anterior aspect of the medulla in the groove between the pyramid & the olive

(II) Cranial nerves with lateral attachment → 5; 7, 8; 9, 10, 11

* The trigeminal nerve (the largest of the cranial nerves) attached to the junction of the pons with the middle cerebellar peduncle and consists of 2 roots < a larger posterolateral sensory root; a smaller anteroposterior motor root

(7 & 8) * Facial & vestibulocochlear nerve → These 2 nerves with the small nervus intermedius inbetween emerge on the inferior border of the pons posterior to the olive N.B the facial nerve is motor while the nervus intermedius carries its sensory and parasympathetic fibres. It lies anterior to the vestibulocochlear nerve

(9, 10, 11) * Glossopharyngeal, Vagus & accessory nerves → These nerves arise as a vertical series of rootlets from a groove posterior to the olive in the medulla oblongata

(III) Cranial nerves with dorsal attachment → Trochlear nerve

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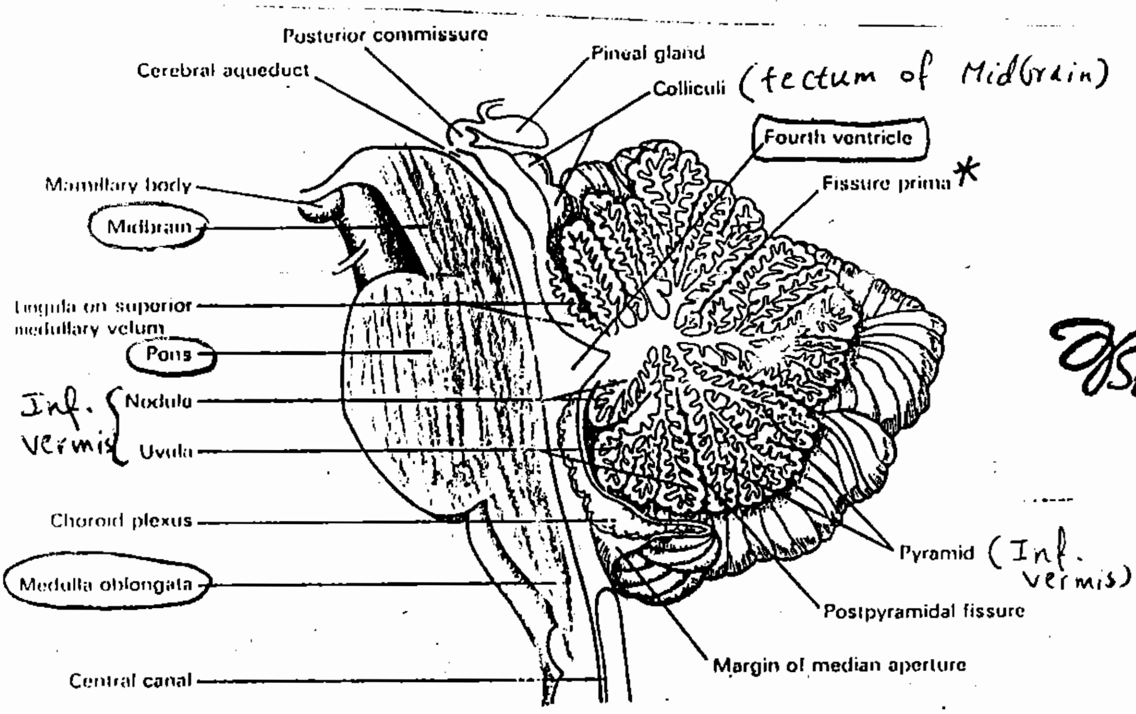

Fig. 7.3 Median sagittal section of the cerebellum and brainstem

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- Brainstem
  - Midbrain
  - Pons
  - medulla oblongata

- The contents of each part of the brainstem ← ???
  - → Ascending and descending tracts
  - → nuclei of certain cranial nerves
    - 3 + 4 → in midbrain
    - 5, 6, 7, 8 → in Pons
    - 9, 10, 11, 12 → in medulla
  - → certain nuclei
    - Red nucleus in midbrain
    - substantia gelatinosa " "
  - → RETICULAR FORMATION ←
  - → certain vital centres within RF

- hindbrain
  - cerebellum
    - Median part → Vermis
    - 2 lateral parts → 2 cerebellar hemispheres
  - Pons
  - medulla oblongata

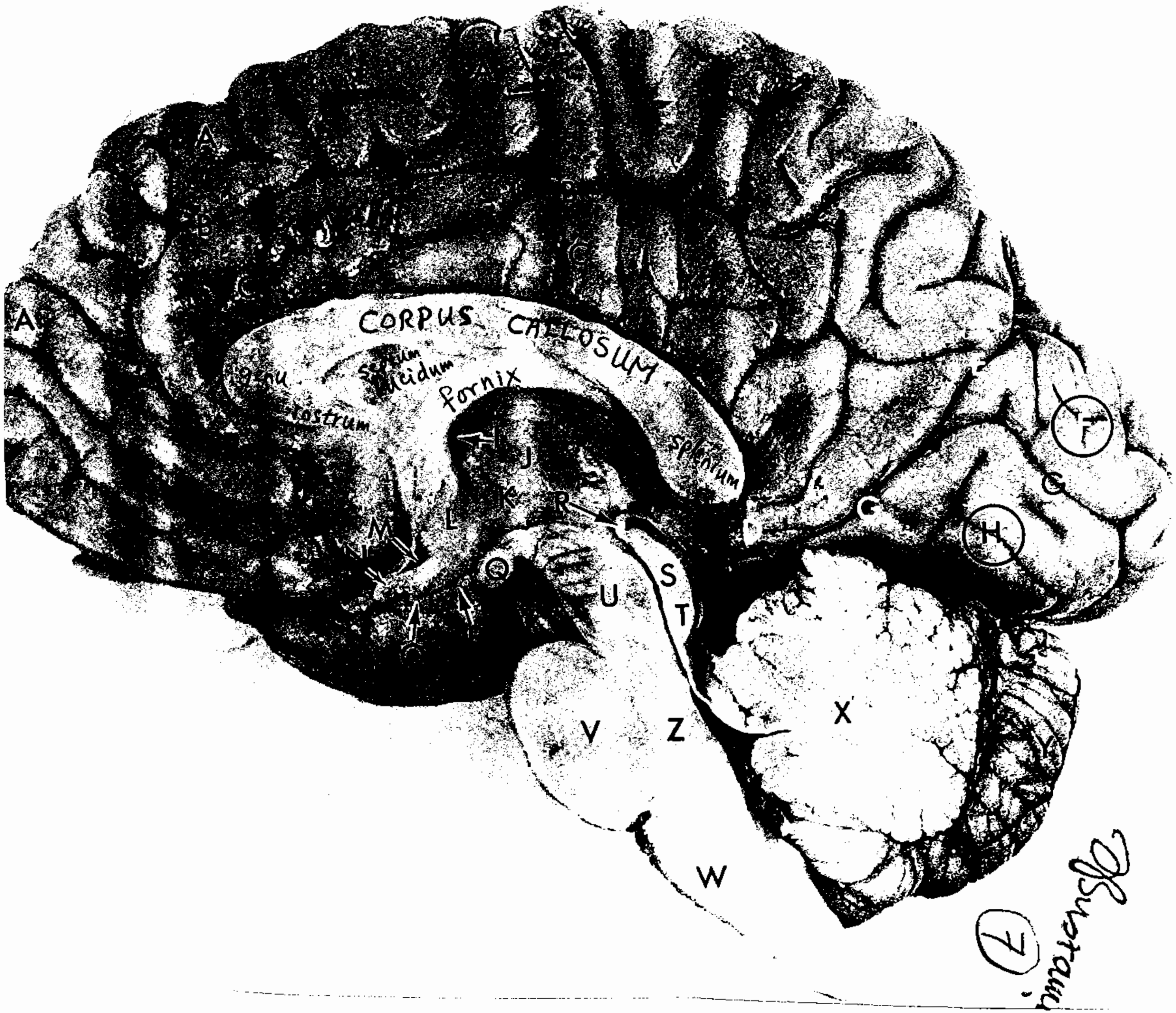
- 4th ventricle
  - cavity of hindbrain
  - boundaries
    - Anteriorly - Posterior surface of Pons & upper part of medulla
    - Posteriorly → cerebellum (indirectly)

Figure 75 **Medial view of the brain, arachnoid and pia mater removed. Median section (×1.5)**

A. Medial frontal gyrus
B. Cingulate sulcus
C. Cingulate gyrus
D. Isthmus of cingulate gyrus
E. Parieto-occipital sulcus
F. Cuneus
G. Calcarine sulcus
H. Lingual gyrus
I. Interventricular foramen
J. Thalamus
K. Hypothalamic sulcus (position of)
L. Hypothalamus
M. Optic recess of third ventricle
N. Optic chiasma
O. Infundibulum and infundibular recess of third ventricle
P. Tuber cinereum
Q. Mamillary body
R. Posterior commissure
S. Superior colliculus } Tectum of midbrain
T. Inferior colliculus }
U. Cerebral peduncle of midbrain
V. Pons (anterior or basilar part)
W. Medulla
X. Cerebellum (vermis)
Y. Cerebellum (hemisphere)
Z. Pons (tegmentum or posterior part)

Can you locate:

Corpus callosum (rostrum, genu, trunk, splenium)
Fornix
Anterior commissure
Pineal recess of third ventricle
Cerebral aqueduct
Fourth ventricle
Pineal body



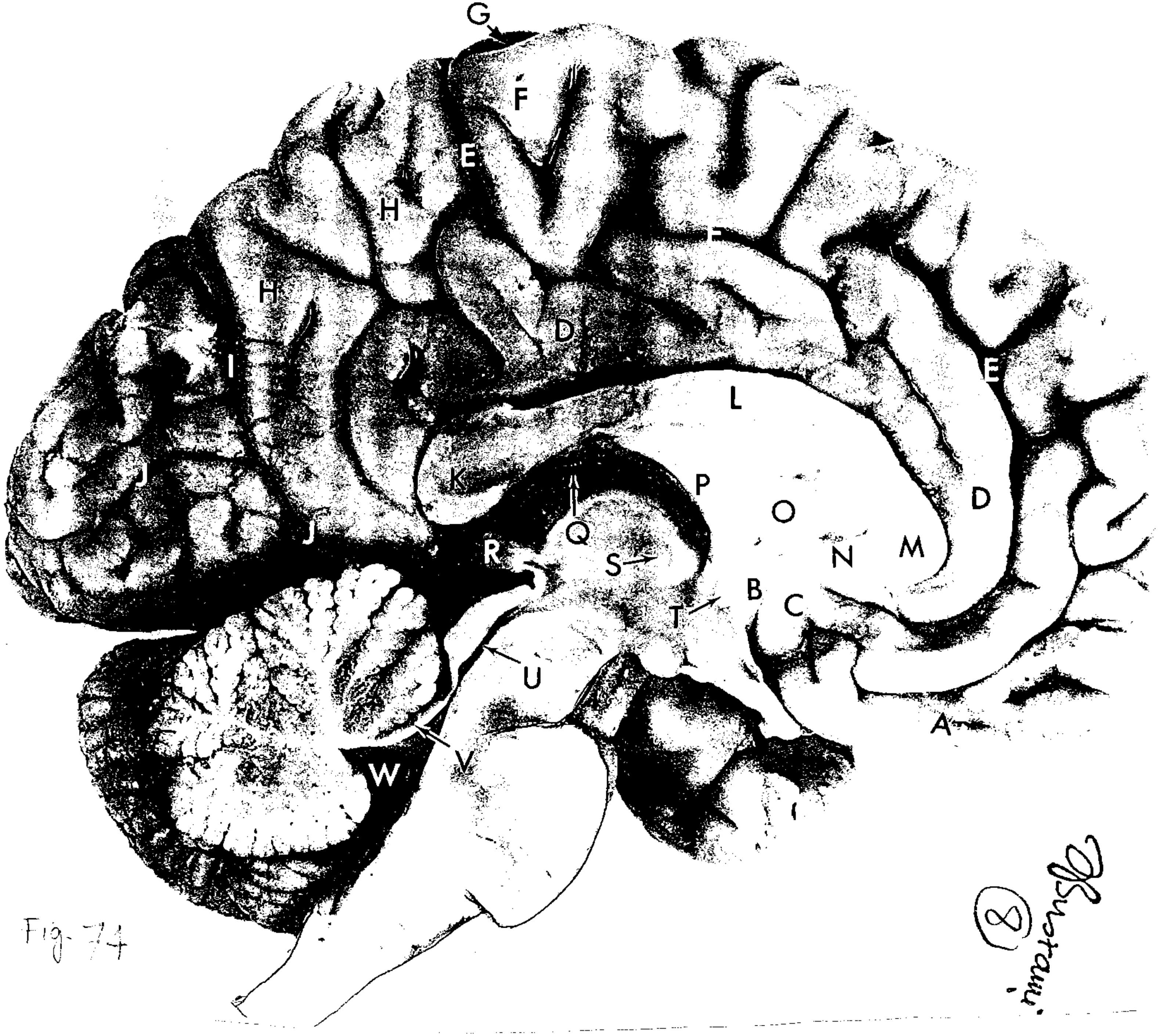


Fig. 7.4

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Figure 74 Medial view of the brain, arachnoid and pia mater removed. Median section (×1.5)

A. Straight gyrus (gyrus rectus)
B. Paraterminal gyrus
C. Subcallosal area
D. Cingulate gyrus
E. Cingulate sulcus (and its marginal ramus)
F. Paracentral lobule
G. Central sulcus
H. Precuneus
I. Parieto-occipital sulcus
J. Calcarine sulcus
K. Splenium of corpus callosum
L. Trunk of corpus callosum
M. Genu of corpus callosum
N. Rostrum of corpus callosum
O. Septum pellucidum
P. Body of fornix
Q. Choroid plexus of lateral ventricle
R. Pineal body
S. Interthalamic adhesion
T. Anterior commissure
U. Cerebral aqueduct
V. Superior medullary velum
W. Fourth ventricle

Can you locate:

Medial frontal gyrus
Cuneus
Lingual gyrus
Interventricular foramen
Thalamus and hypothalamus
Optic nerve and chiasma
Optic recess of third ventricle
Midbrain (cerebral peduncle and tectum)
Pons
Medulla
Posterior commissure

Normal T1-weighted MRI scan

(10)

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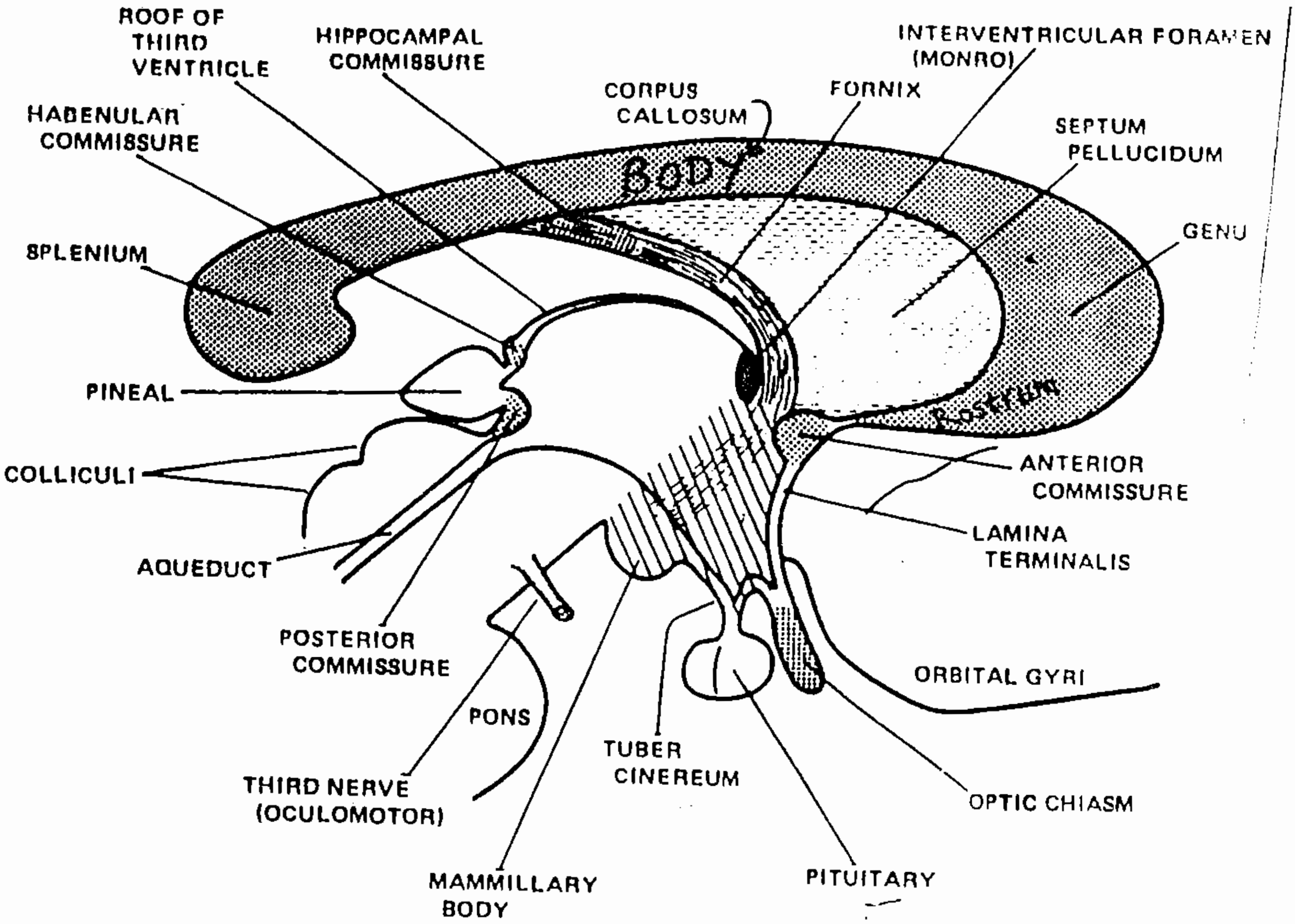

ROOF OF THIRD VENTRICLE
HIPPOCAMPAL COMMISSURE
INTERVENTRICULAR FORAMEN (MONRO)
CORPUS CALLOSUM
FORNIX
HABENULAR COMMISSURE
BODY
SEPTUM PELLUCIDUM
GENU
SPLENIUM
PINEAL
Rostrum
COLLICULI
ANTERIOR COMMISSURE
LAMINA TERMINALIS
AQUEDUCT
POSTERIOR COMMISSURE
ORBITAL GYRI
PONS
TUBER CINEREUM
THIRD NERVE (OCULOMOTOR)
OPTIC CHIASM
MAMMILLARY BODY
PITUITARY

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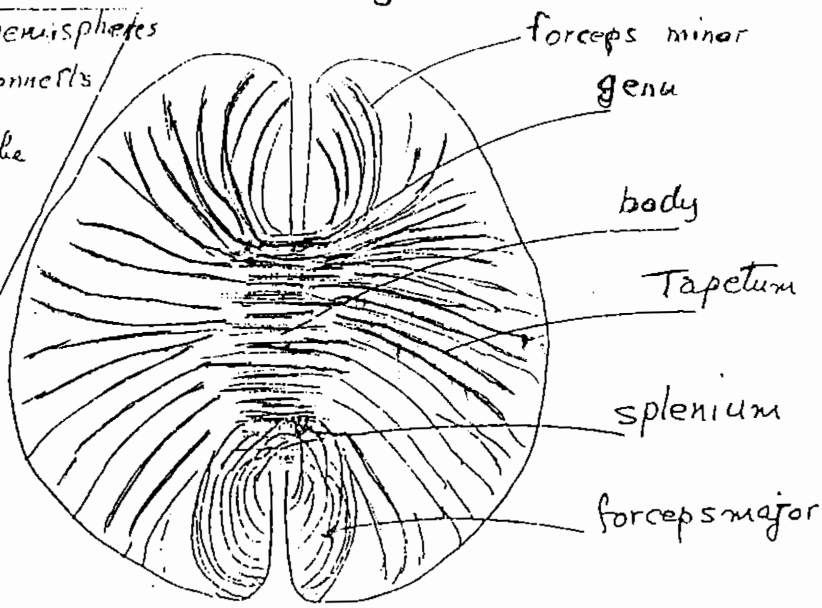
White matter of Cerebrum

I Corpus Callasum: Large commisural fibres

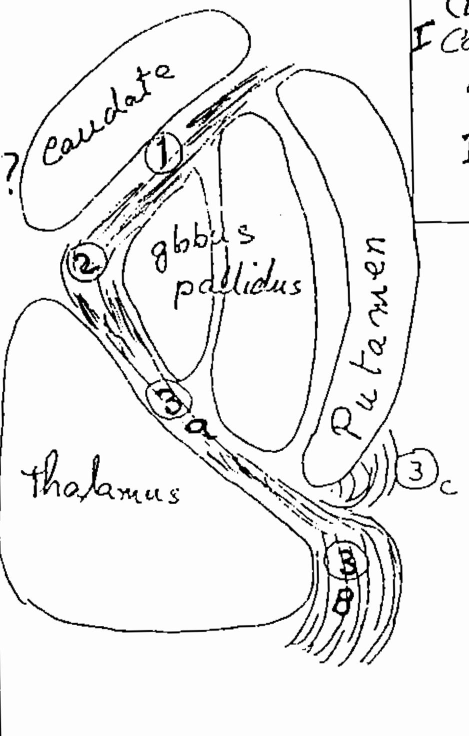
- Connect the two hemispheres
- Froceps minor connects the two frontal lobes
- Tapetum connects the two pariatal and two temporal lobes
- Forceps major connects the two occipital lobes.



II Projection fibres

Internal capsule

1. Ant. limb: Contains
   a) fronto pontine fibres
   b) ant. thalamic fibres
2. Genu: Corticobulbar ??
3. Post. limb: three parts
   a) Lentiform part:
      1. Corticospinal tract.
      2. Sensory radiation (middle thalamic fibres)
   B) Retrolentiform part
      1. visual radiation
      2. occipito pontin
   C) Sub lentiform part
      1. auditory radiation
      2. temporo pontine



Corpus striatum (Basal ganglia)

I Caudate (head-body and tail).

II lentiform (Putamen and globus pallidus

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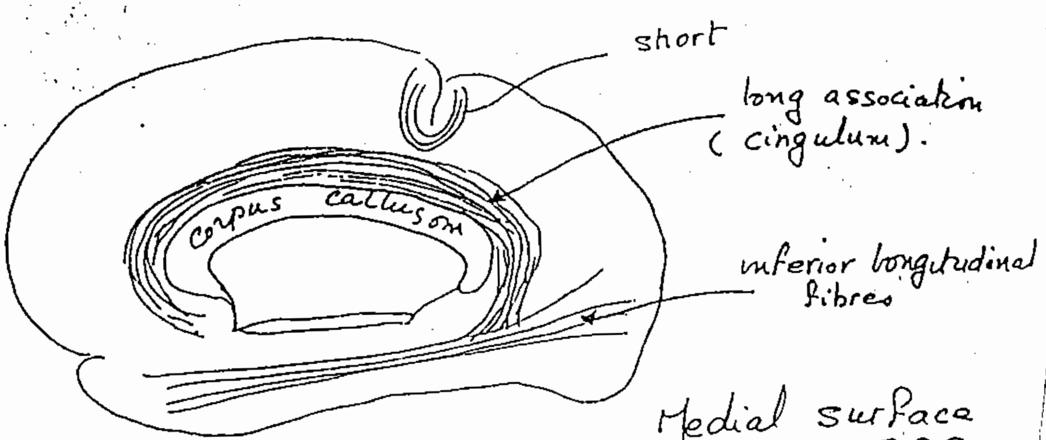
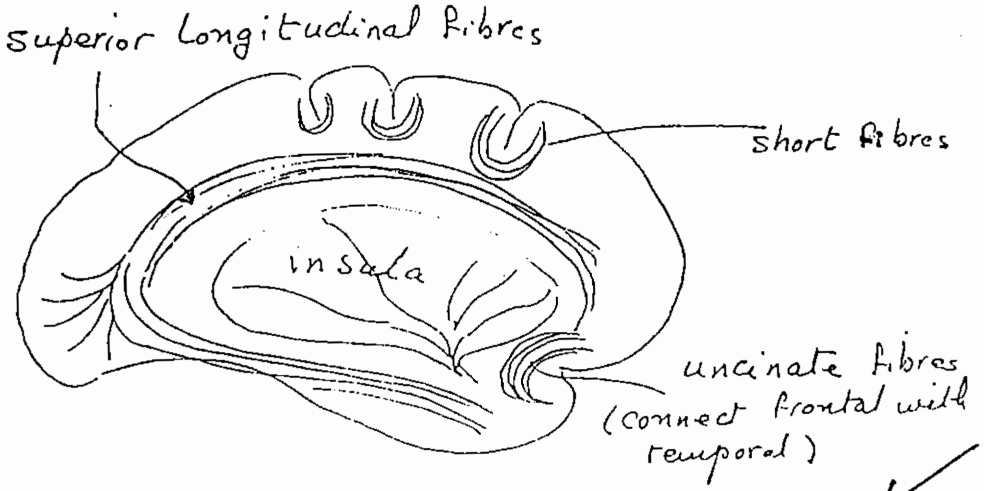
III Association fibres : are the fibres that connect the gyri of hemisphere
- short : From one gyrus to another.
- long : Connect the gyrus with a very large number of other gyri of the same hemisphere



Medial surface



Superior Lateral surface

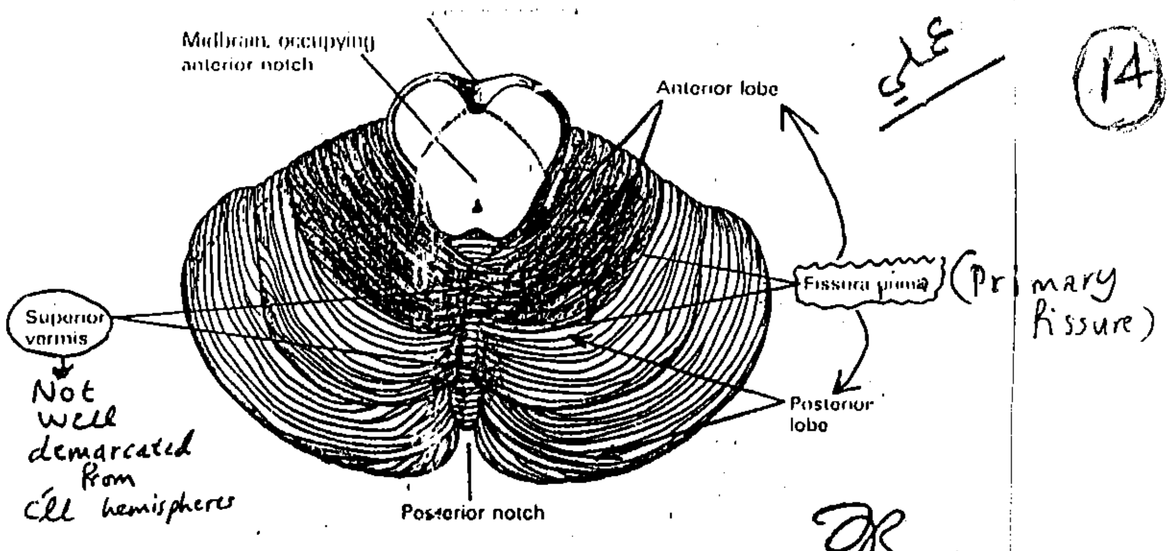


Fig. 7.1 Superior surface of the cerebellum.

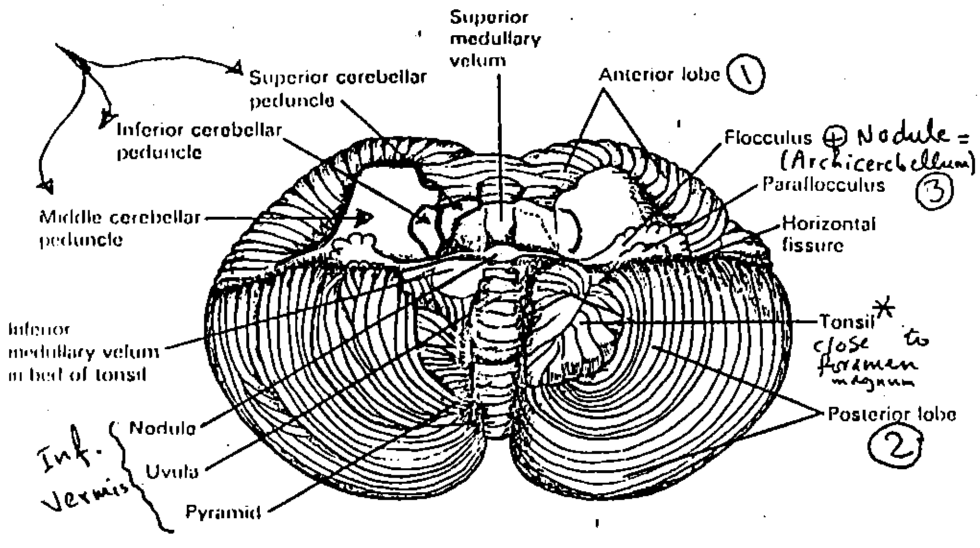


Fig. 7.2 Anteroventral surface of the cerebellum. The right tonsil of the cerebellum has been removed to show the inferior medulary velum.

Cerebellar peduncles (see Figure 1.7)

1. Inferior cerebellar peduncle

- connects the cerebellum to the medulla.
- consists of two divisions:

a. Restiform body

- is an afferent fiber system containing:
  - **(1) Dorsal spinocerebellar tract**
  - **(2) Cuneocerebellar tract**
  - **(3) Olivocerebellar tract**

b. Juxtarestiform body

- contains afferent and efferent fibers:
  - **(1) Vestibulocerebellar fibers (afferent)**
  - **(2) Cerebellovestibular fibers (efferent)**

2. Middle cerebellar peduncle

- connects the cerebellum to the pons.
- is an afferent fiber system containing **pontocerebellar fibers** to the neocerebellum.

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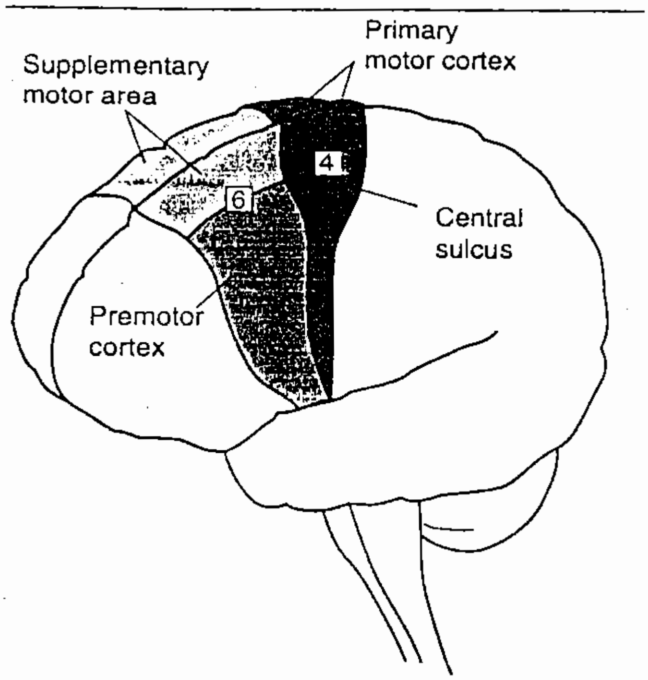
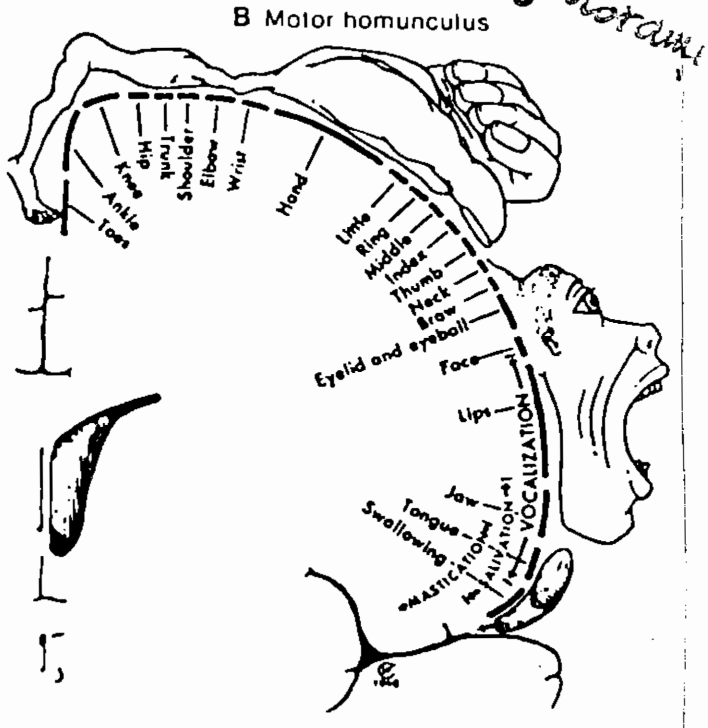
Fig. 12-4. Motor areas of the cerebral cortex.





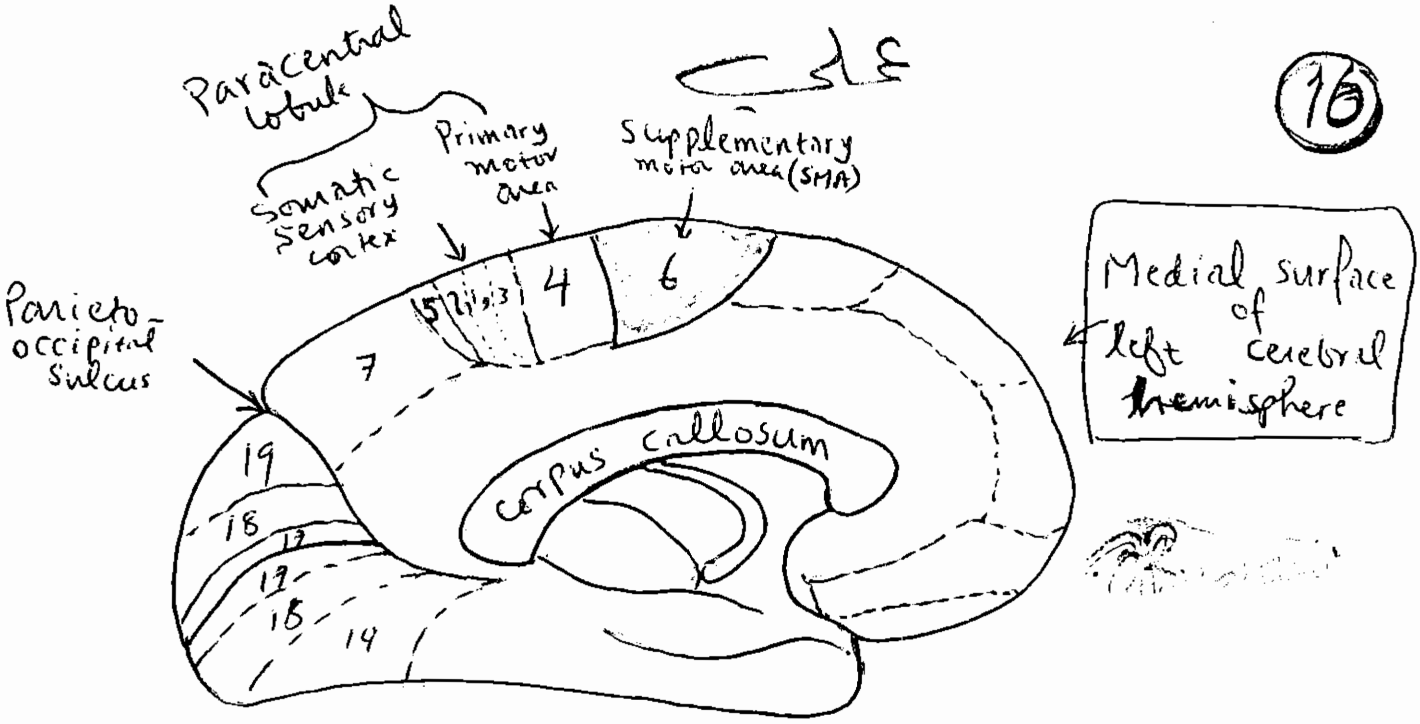
B. Motor areas

1. Primary motor cortex (area 4)

- is located in the **precentral gyrus** and in the anterior part of the **paracentral lobule**(on the medial surface) → lower limb + sphincters
- * contributes to the corticospinal tract.
- is somatotopically organized as the **motor homunculus** (see Figure 23.2*B*). → (Face + limbs) are represented here
- contains the giant cells of Betz in layer V.
- stimulation results in contralateral movements of voluntary muscles.
- ablation results in a **contralateral upper motor neuron lesion.**
- bilateral lesions of the paracentral lobule (e.g., parasagittal meningiomas) result in **urinary incontinence.**
- lesion in area 4 → flaccid paralysis of distal muscles of limbs + hypotonia + decreased muscle stretch reflexes → when the sphere of lesion is increased to include premotor area 6 (in which trunk and axial muscles are represented) → loss of control over brainstem centres generates a state of spasticity that overshadows flaccidity

2. Premotor cortex (area 6)

- is located anterior to the precentral gyrus.
- * contributes to the corticospinal tract.
- plays a role in the **control of proximal and axial muscles;** it prepares the motor cortex for specific movements in advance of their execution.
- stimulation results in adversive movements of the head and trunk and flexion and extension of the extremities.
- plays a role in planning + execution of movement
- lesion → appearance of (grasp response) → look at page 24

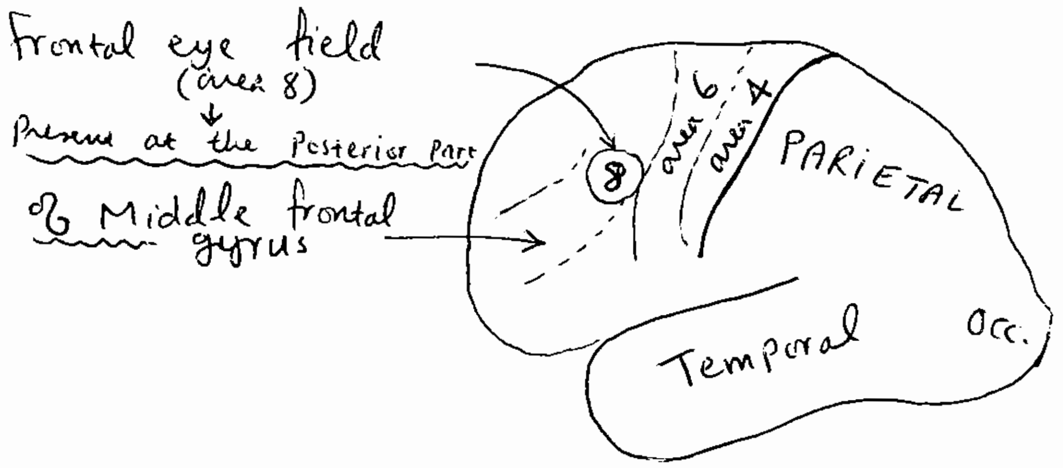


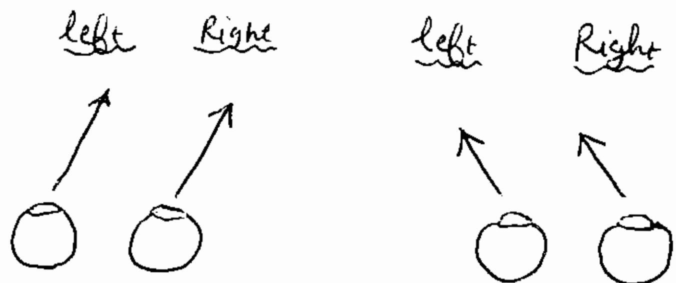
3. Supplementary motor cortex (area 6)

–is located on the medial surface of the hemisphere anterior to the paracentral lobule.

*–contributes to the corticospinal tract.

–plays a role in **programming complex motor sequences** and in co**ordinating bilateral movements;** it regulates the somatosensory input into the motor cortex.





Destructive lesion of Rt. frontal eye field → conjugate deviation of the eyes toward the side of the lesion (Rt.)

Stimulation (irritative lesion) of frontal eye field → conjugate deviation of eyes to the opposite side (in the diagram stimulation of Rt. frontal eye field)

Bustani

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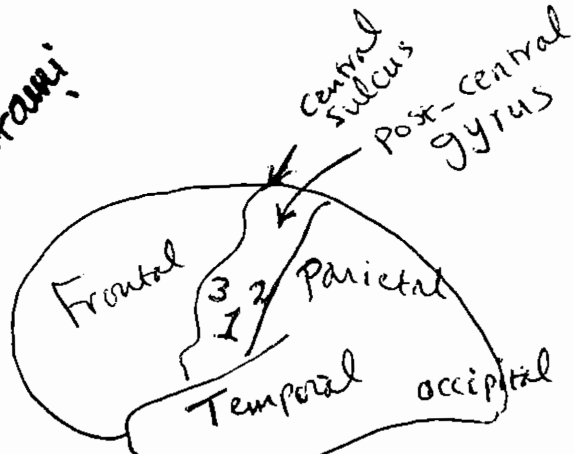
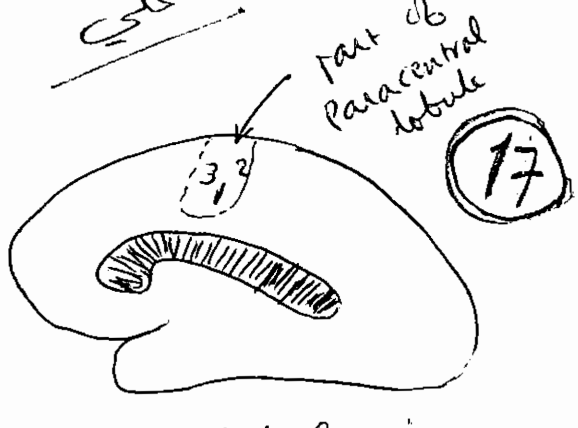
(17)



lateral view



Medial view

- Primary Somatosensory cortex (area 3, 1, and 2)
- location → in the Post-central gyrus (Parietal lobe) and in the posterior part of the paracentral lobule (on medial surface)
- Somatotopically organized as the **Sensory homünculus**

→ The contralateral half of the body is represented in a precise but disproportionate manner in the somatosensory cortex I

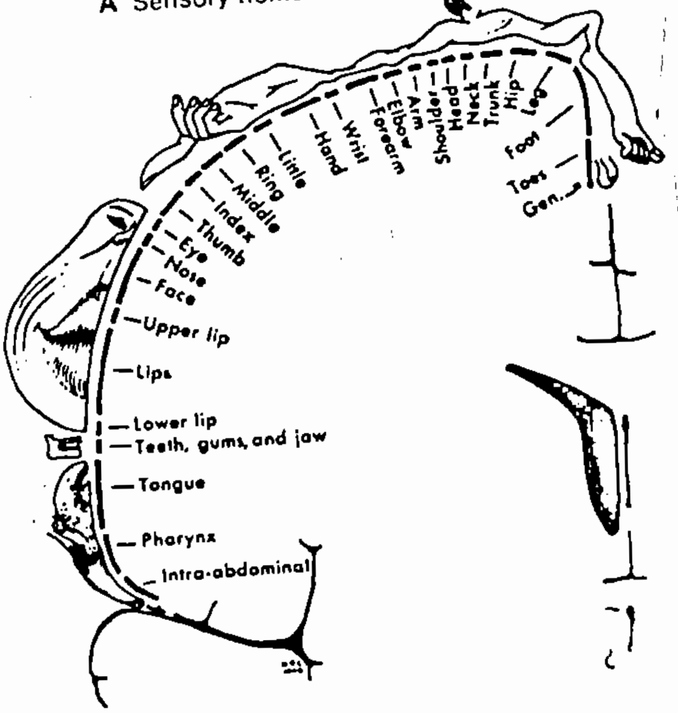
↓

The representation of the (face, lips, hand, thumb, index finger) is disproportionately large in comparison with their relative size in the body ⟹ This is a reflection of the functional importance of these parts in Sensory function.

↓

The 1ry Somatosensory cortex is formed of functional units which are modality specific → each Unit is in the form of a vertical column of cells

A Sensory homunculus

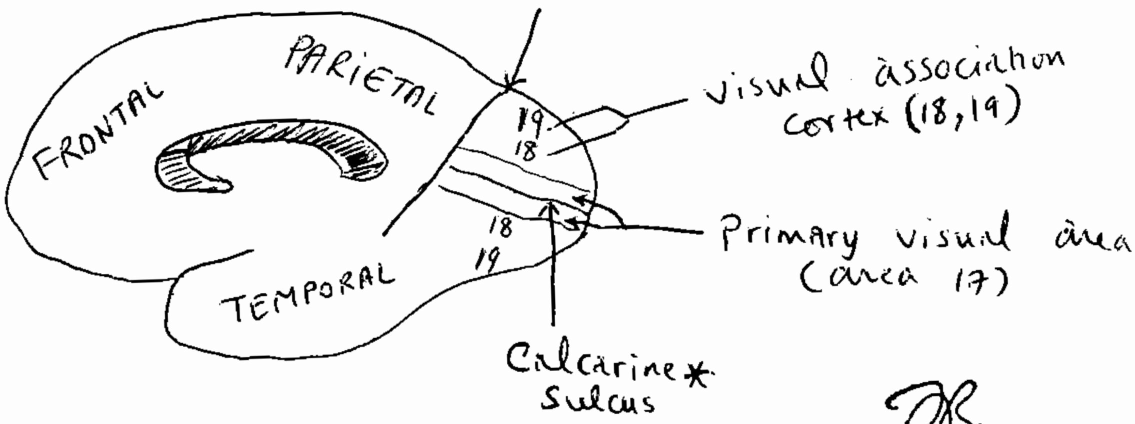


- Neurons within a cortical unit are activated by the same peripheral Stimulus and are related to the same receptive field e.g area 3 is activated by cutaneous Stimuli (Pain, temperature, touch) Whereas area 2 receives proprioceptive impulses (from muscles, tendons & joints)

(3b + 1 = cutaneous input) (3a + 2 = proprioceptive)

Bustami

Lesion of area 3,1,2 (Primary Somatosensory area)
→ contralateral loss of all types of sensations, Soon, however pain & temperature sensations will return → It is believed that pain & temperature sensations are determined at thalamic level Whereas {source, severity, quality} of such sensations are perceived at Postcentral gyrus (3,1,2)



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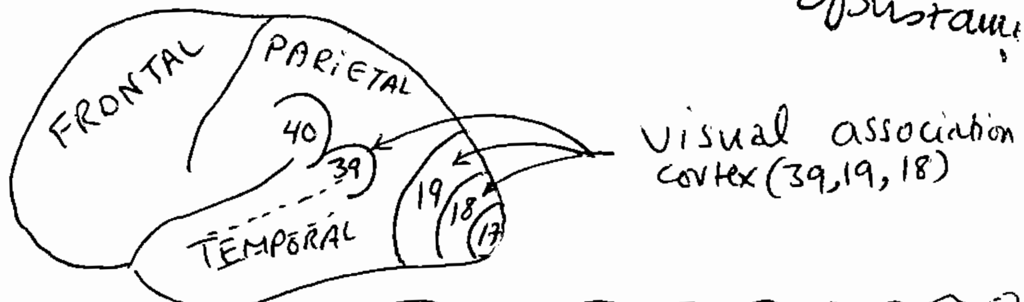
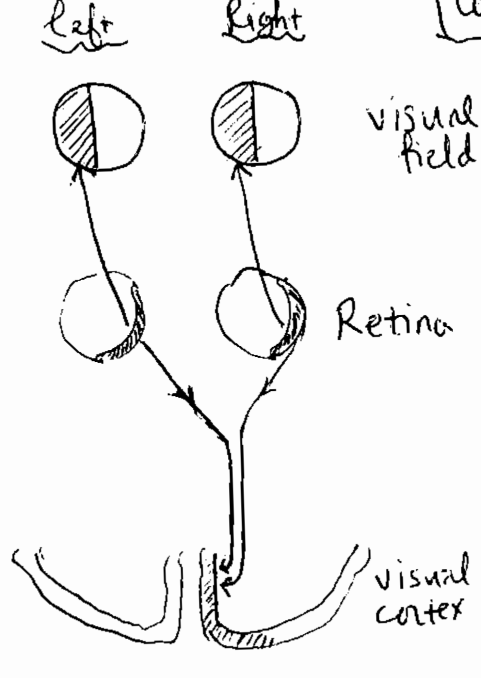


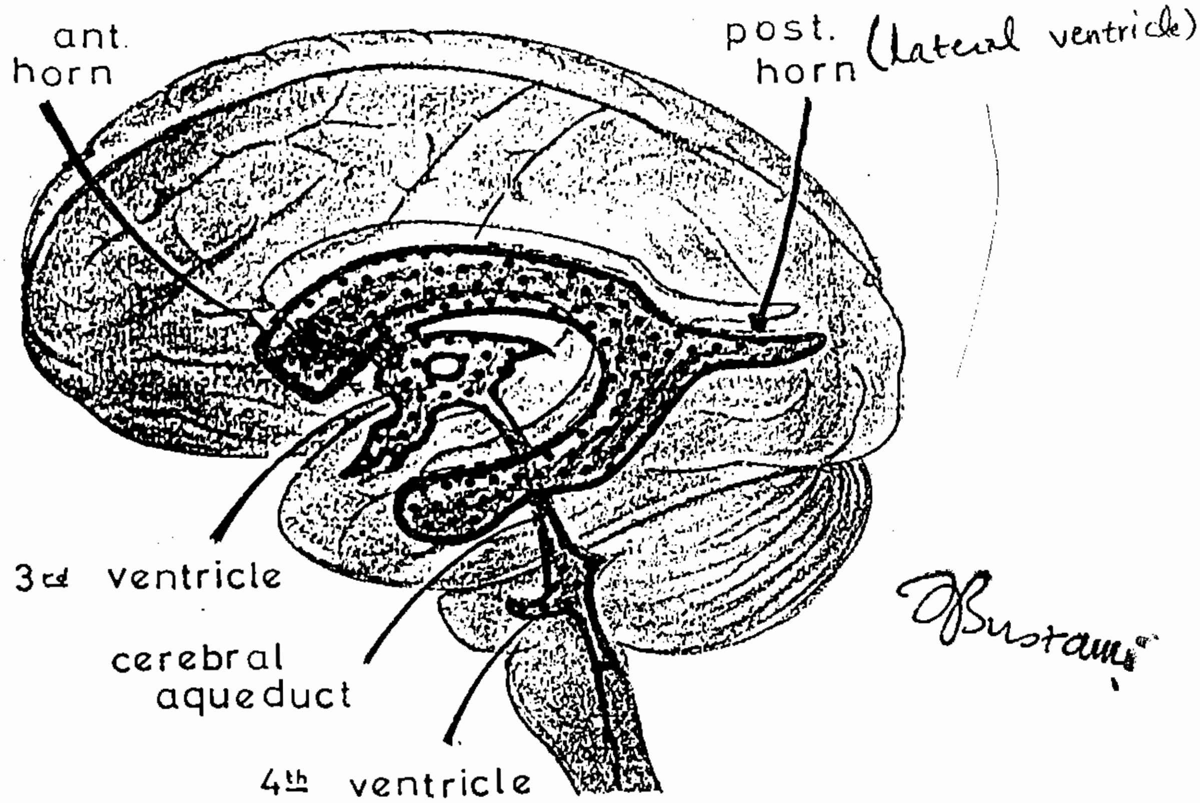
Visual cortex → Cuneus (above) + lingual gyrus (below) the Calcarine sulcus

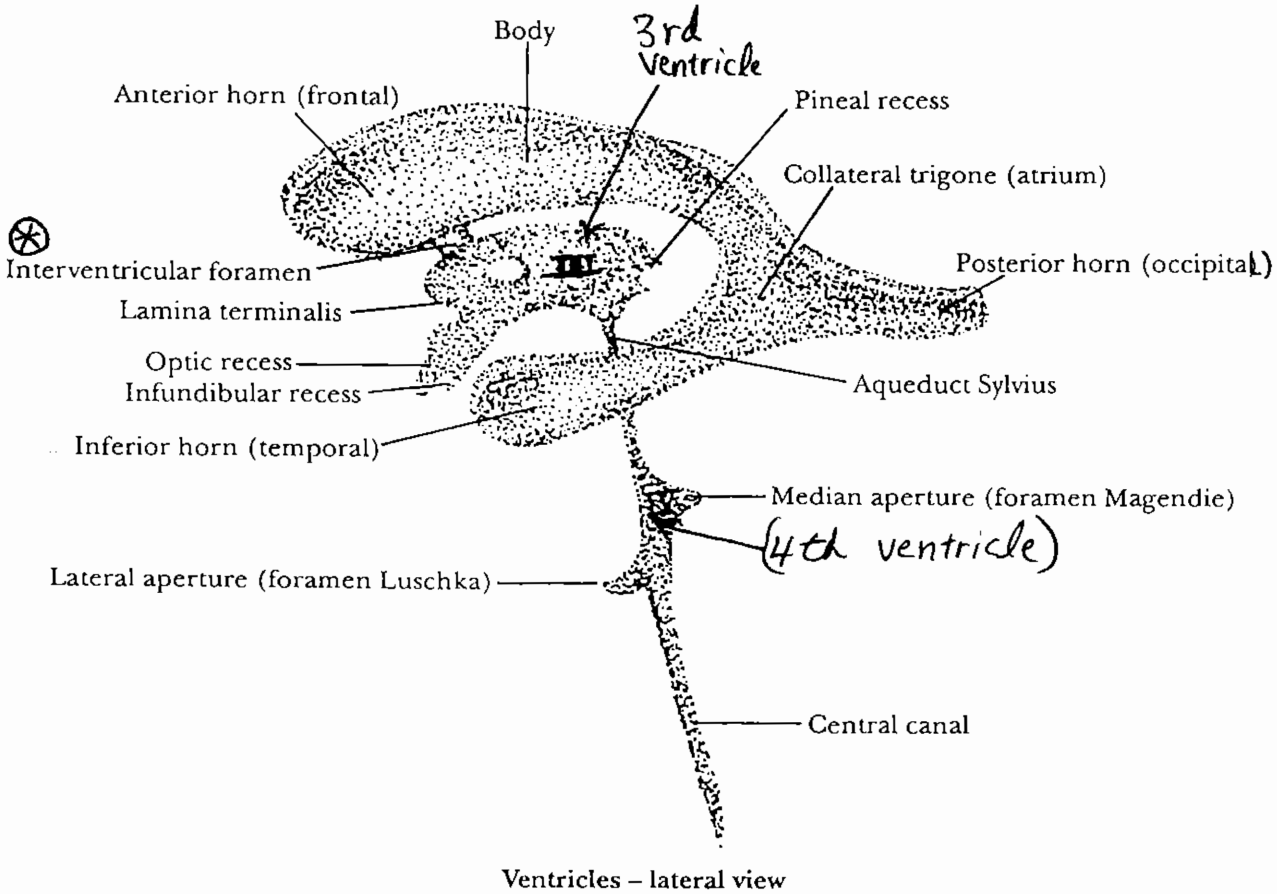


- Each Primary visual cortex receives fibres from the ipsilateral half of each retina which convey information about the contralateral half of the visual field
- lesion of area 17 → Defects in visual field
- lesion of areas 18,19 → visual agnosia (patient is able to see objects but is unable to recognize them)

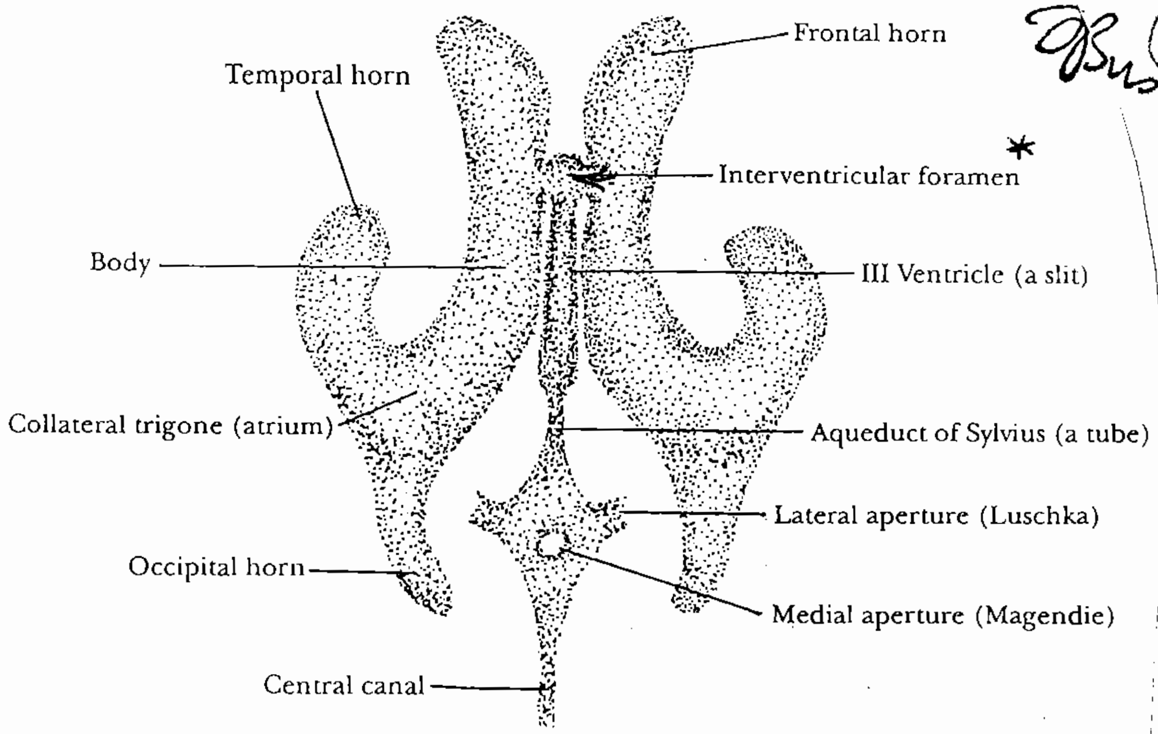
The Cerebrospinal Fluid, the Ventricles of the Brain, and the Brain Barriers

(19)





Ventricles – lateral view



Ventricles – dorsal view

TABLE 3–6. Composition of CSF

[CSF] ≈ [Blood]	[CSF] < [Blood]	[CSF] > [Blood]
Na^+	K^+	Mg^{2+}
Cl^-	Ca^{2+}	Creatinine
HCO_3^-	Glucose	
Osmolarity	Cholesterol*	
	Protein*	

* Negligible in CSF.

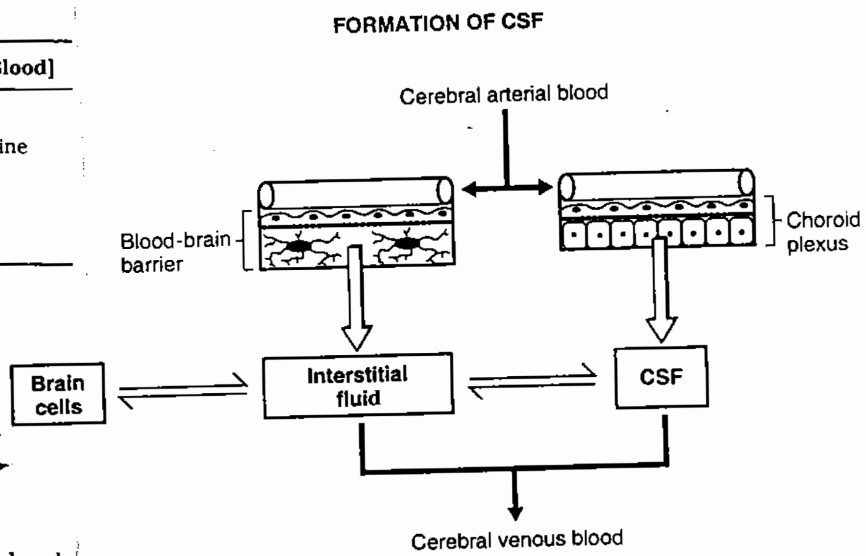


FIGURE 3–35. Mechanism for production of cerebrospinal fluid. CSF, cerebrospinal fluid.

The barrier between cerebral capillary blood and CSF is the **choroid plexus**. This barrier consists of three layers: capillary endothelial cells and basement membrane, neuroglial membrane, and epithelial cells of the choroid plexus. The choroid plexus epithelial cells are similar to those of the renal distal tubule and contain transport mechanisms that move solutes and fluid from capillary blood into CSF.

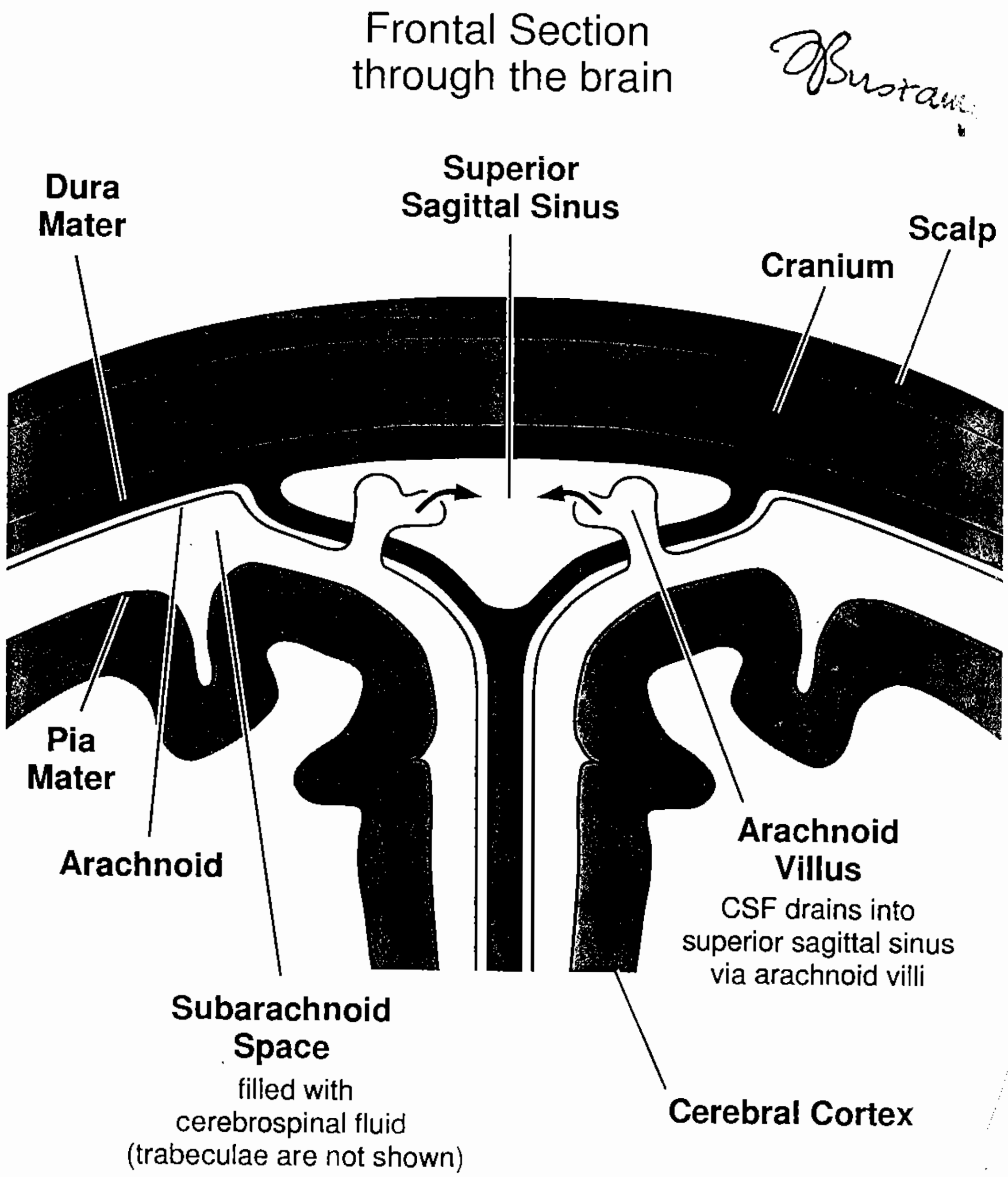
The barrier between cerebral capillary blood and interstitial fluid of the brain is the **blood-brain barrier**. Anatomically, the blood-brain barrier consists of capillary endothelial cells and basement membrane, neuroglial membrane, and glial end feet (projections of astrocytes from the brain side of the barrier). Functionally, the blood-brain barrier differs in two ways from the analogous barrier in other tissues. (1) The junctions between endothelial cells in the brain are so "tight" that few substances can cross *between* the cells. (2) Only a few substances can pass *through* the endothelial cells: Lipid-soluble substances (e.g., oxygen and carbon dioxide) can cross the blood-brain barrier, but water-soluble substances are excluded.

Formation of CSF

CSF is formed by the epithelial cells of the choroid plexus. Transport mechanisms in these cells secrete some substances from blood into CSF and absorb other substances from CSF into blood. Molecules such as protein and cholesterol are excluded from CSF because of their large molecular size. On the other hand, lipid-soluble substances such as oxygen and carbon dioxide move freely and equilibrate between the two compartments. Thus, depending on the transport mechanisms and the characteristics of the barrier, some substances are present in higher concentration in CSF than in blood, some are present at approximately the same concentration, and some are present in lower concentration in CSF than in blood. Many substances readily exchange between brain interstitial fluid and CSF (see Figure 3–35), thus the compositions of interstitial fluid and CSF are similar to each other but different from blood. Table 3–6 compares the composition of CSF and blood.

MENINGES :
Dura Mater, Arachnoid, & Pia Mater

21

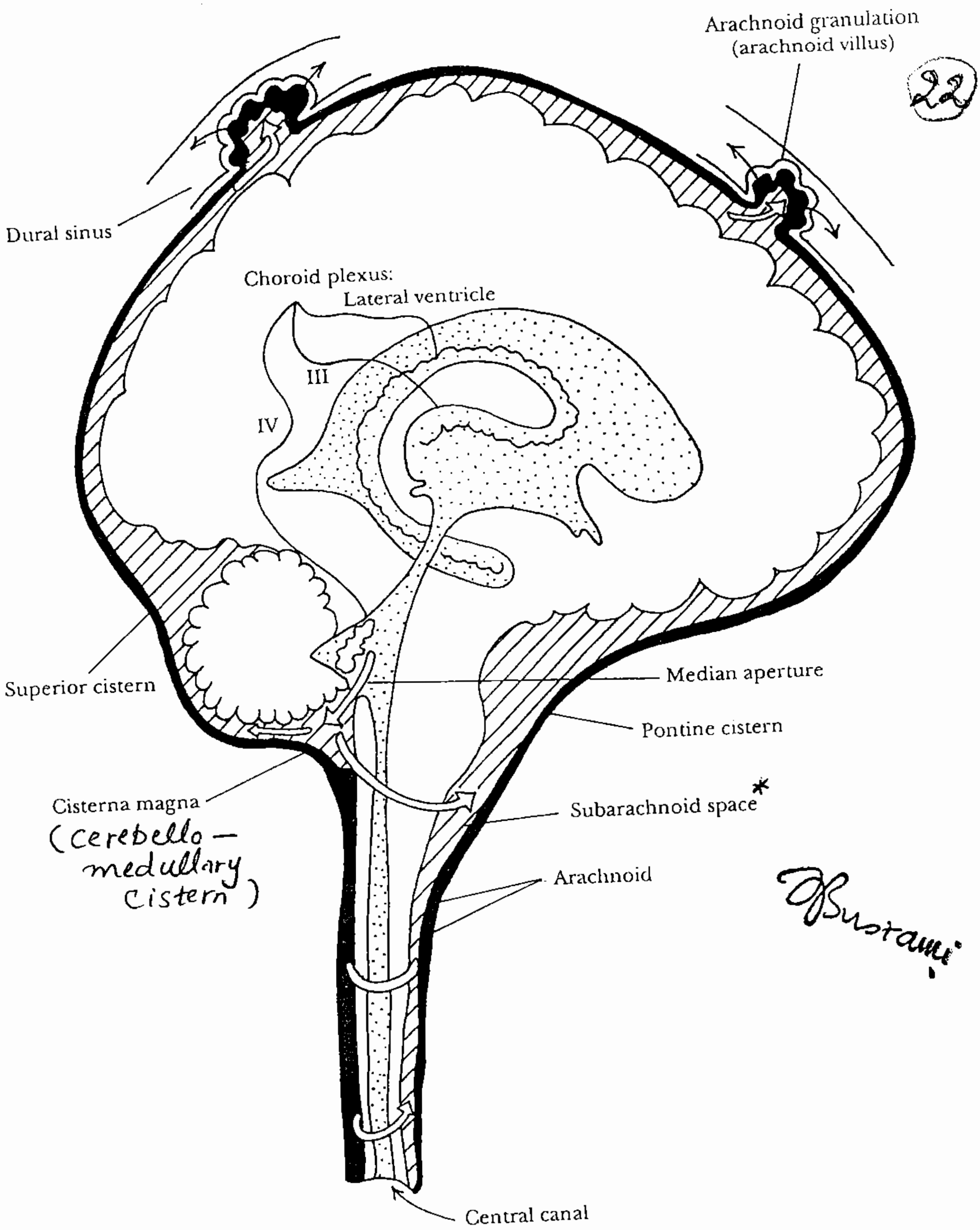


ABSORPTION OF CEREBROSPINAL FLUID

The cerebrospinal fluid is absorbed into the **arachnoid villi** that project into the dural venous sinuses, especially the **superior sagittal sinus** (Fig. 17-1). The arachnoid villi are grouped together to form **arachnoid granulations.** Each arachnoid villus is a diverticulum of the subarachnoid space that pierces the dura mater.

Absorption of cerebrospinal fluid into the venous sinuses occurs when the cerebrospinal fluid pressure exceeds that in the sinus. Studies of the arachnoid villi indicate that fine tubules lined with endothelium permit a direct flow of fluid from the subarachnoid space into the lumen of the venous sinuses. Should the venous pressure rise and exceed the cerebrospinal fluid pressure, compression of the villi closes the tubules and prevents the reflux of blood into the subarachnoid space.

Some of the cerebrospinal fluid is absorbed directly into the veins in the subarachnoid space and escapes through the perineural lymph vessels of the cranial and spinal nerves.

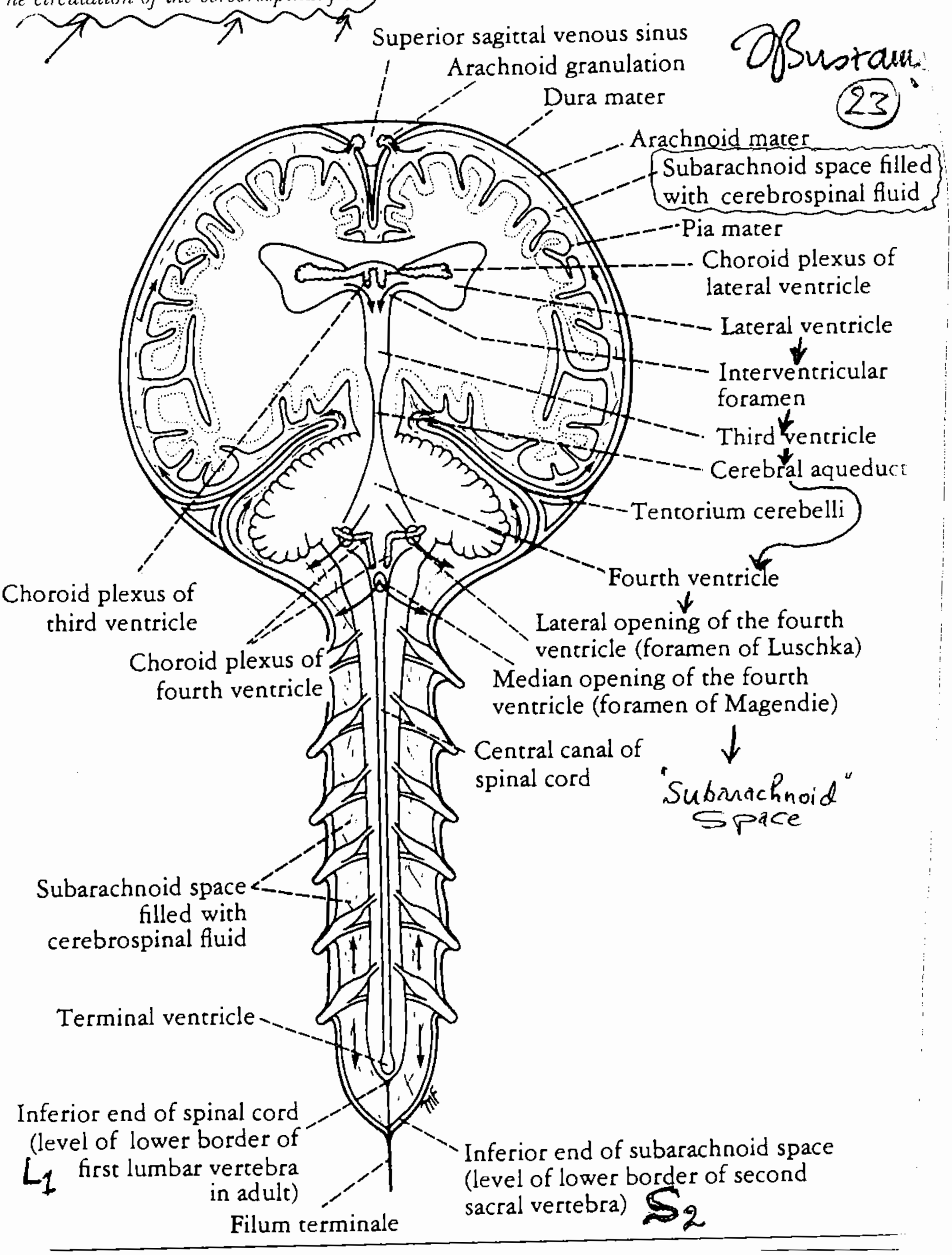


SUBARACHNOID SPACE

The subarachnoid space is the interval between the arachnoid mater and pia mater and envelops the brain and spinal cord (Fig. 17-1). The space is filled with cerebrospinal fluid and contains the large blood vessels of the brain. Inferiorly, the subarachnoid space extends beyond the lower end of the spinal cord and invests the **cauda equina.** The subarachnoid space ends below at the level of the interval between the second and third sacral vertebrae.

Subarachnoid Cisterns. In certain locations around the base of the brain, the arachnoid does not closely follow the surface of the brain so that the subarachnoid space expands to form cisterns. The **cerebellomedullary cistern** lies between the cerebellum and the medulla oblongata, the **pontine cistern** lies on the anterior surface of the pons, and the **interpeduncular cistern** lies on the anterior surface of the midbrain between the crura cerebri.

The circulation of the cerebrospinal fluid



CIRCULATION OF CEREBROSPINAL FLUID

The fluid passes from the lateral ventricles into the third ventricle through the interventricular foramina (Fig. 17-1). It then passes into the fourth ventricle through the cerebral aqueduct. The circulation is aided by the arterial pulsations of the choroid plexuses.

From the fourth ventricle, the fluid passes through the median aperture and the lateral foramina of the lateral recesses of the fourth ventricle and enters the subarachnoid space. The fluid then flows superiorly through the interval in the tentorium cerebelli to reach the inferior surface of the cerebrum (Fig. 17-1). It now moves superiorly over the lateral aspect of each cerebral hemisphere. Some of the cerebrospinal fluid moves inferiorly in the subarachnoid space around the spinal cord and cauda equina. The pulsations of the cerebral and spinal arteries and the movements of the vertebral column facilitate this flow of fluid.

Papilledema = oedema of the optic nerve head

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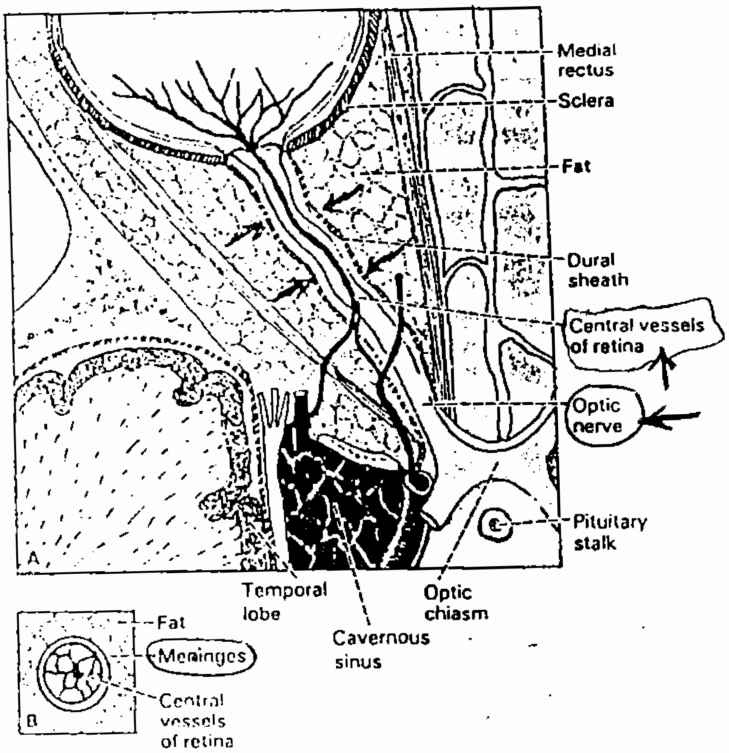


Fig. 29-13 A, horizontal section of the orbit. B, transverse section of the optic nerve.

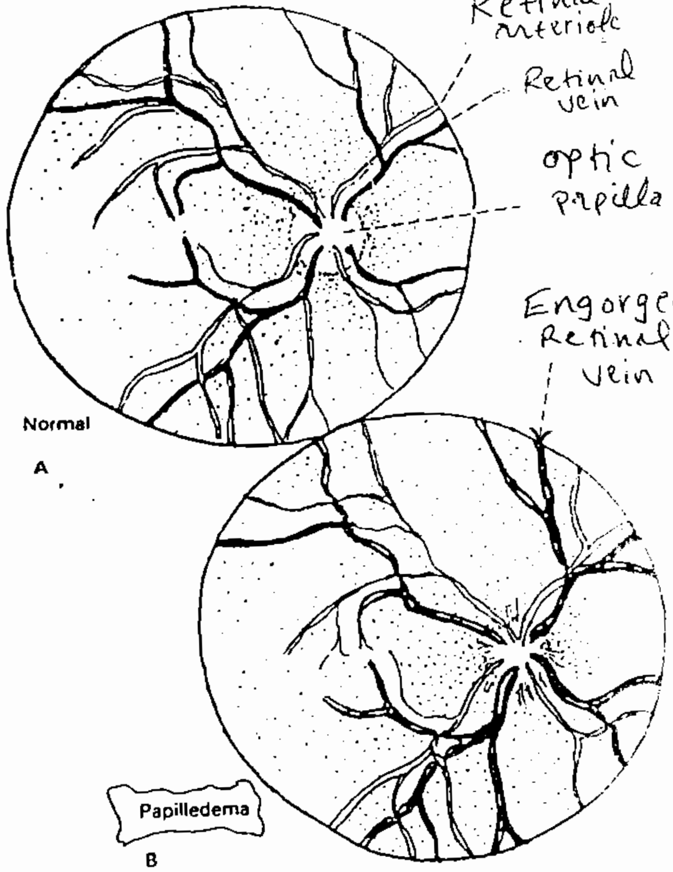


Fig. 29-12 A, normal fundus oculi. B, papilledema.

Extensions of the Subarachnoid Space. A sleeve of the subarachnoid space extends around the optic nerve to the back of the eyeball. Here the arachnoid mater and pia mater fuse with the sclera. The central artery and vein of the retina cross this extension of the subarachnoid space to enter the optic nerve and they may be compressed in patients with raised cerebrospinal fluid pressure. Small extensions of the subarachnoid space also occur around the other cranial and spinal nerves.

The Pressure of the Cerebrospinal Fluid

Any obstruction to the normal passage of cerebrospinal fluid causes the fluid to back up in the ventricles and leads to a general increase of intracranial pressure. After the pressure has been elevated for some time, usually a matter of days or weeks, the effect can be seen by inspecting the fundus of the eye with an ophthalmoscope. Due to the high pressure inside the sleeve of dura mater which surrounds the optic nerve, the retinal veins are dilated and the optic nerve head (optic disc) is pushed forward above the level of the retina. This is known as *papilledema*, or *choked disc*. If papilledema has persisted for a long time, the fibers of the optic nerve will be damaged and the disc assumes a chalk-white color instead of the normal pale pink.

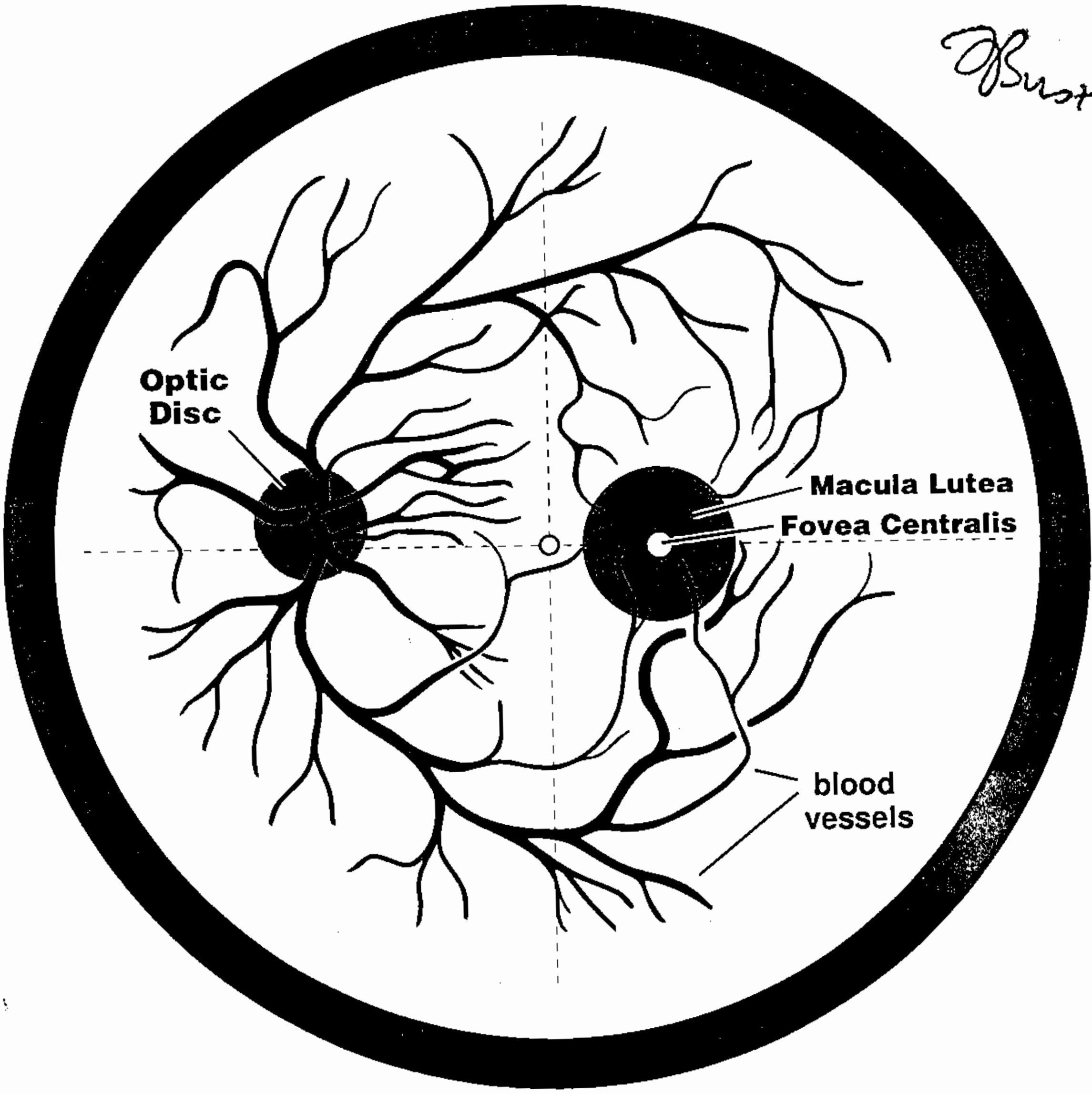
RETINA
left eyeball as seen through an ophthalmoscope (fundus exam.)

(25)

Optic Disc
(blind spot)
blood vessels & optic nerve
enter and exit here

Fovea Centralis
concentration of cones
for color vision &
high visual acuity

Bustami



The most common cause of papilledema is a tumor of the brain compressing some part of the ventricular system. Tumors far removed from the ventricles may not produce obstruction until they reach very large size. A tumor of the cerebellum generally exerts pressure on the roof of the fourth ventricle, and, since it is confined within the posterior fossa by the semi-rigid tentorium cerebelli with little room for expansion, it is likely to cause early obstruction to the flow of cerebrospinal fluid through the fourth ventricle. Tumors near the orbital surface of one frontal lobe may compress the optic nerve and produce optic atrophy in that eye, while the other eye develops

papilledema from generalized elevation of pressure as the tumor expands in size, the Foster Kennedy syndrome. Other cardinal signs of brain tumor in addition to papilledema are persistent headache and vomiting. The headache is probably caused from the stretching of nerve endings in the dura mater. Irritation of the vagal nuclei in the floor of the fourth ventricle accounts for nausea and vomiting.

FUNCTIONS OF THE CEREBROSPINAL FLUID

Tbe cerebrospinal fluid serves as a protective cushion between the central nervous system and the surrounding bones. The close relationship of the fluid to the nervous tissue and the blood enables it to serve as a reservoir and assist in the regulation of the contents of the skull. The cerebrospinal fluid is an ideal physiological substrate and probably plays an active part in the nourishment of the nervous tissue; it almost certainly assists in the removal of products of neuronal metabolism. The secretions of the pineal gland possibly influence the activities of the pituitary gland by circulating through the cerebrospinal fluid in the third ventricle.

HYDROCEPHALUS

Hydrocephalus is an abnormal increase in the volume of the cerebrospinal fluid within the skull. If the hydrocephalus is accompanied by a raised cerebrospinal fluid pressure, then it is due to either (1) an abnormal increase in the formation of the fluid, (2) a blockage of the circulation of the fluid, or (3) a diminished absorption of the fluid. Rarely, hydrocephalus occurs with a normal cerebrospinal fluid pressure and in these patients there is a compensatory hypoplasia or atrophy of the brain substance.

BLOOD-BRAIN BARRIER

The blood-brain barrier protects the brain from toxic compounds. In the newborn child or premature infant, where these barriers are not fully developed, toxic substances such as bilirubin can readily enter the central nervous system and produce yellowing of the brain and **kernicterus.**

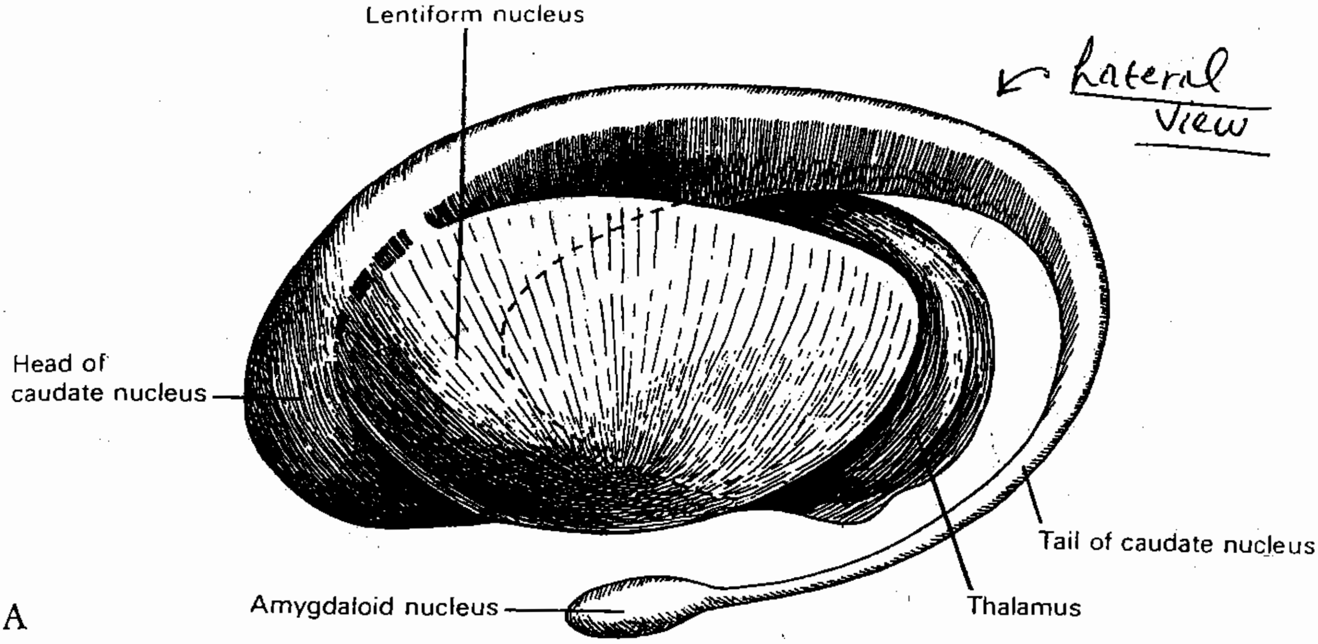
In certain situations, however, it is important that the nerve cells be exposed without a barrier to the circulating blood. This enables neuronal receptors to sample the plasma directly and to respond and maintain the normal internal environment of the body within very fine limits. There is no blood-brain barrier in the pineal gland, the hypothalamus, the posterior lobe of the pituitary, the tuber cinereum, the wall of the optic recess, and the area postrema at the lower end of the fourth ventricle.

The blood-brain barrier is formed by the tight junctions between the endothelial cells of the blood capillaries. In those areas where the blood-brain barrier is absent, the capillary endothelium contains fenestrations across which proteins and small organic molecules may pass from the blood to the nervous tissue.

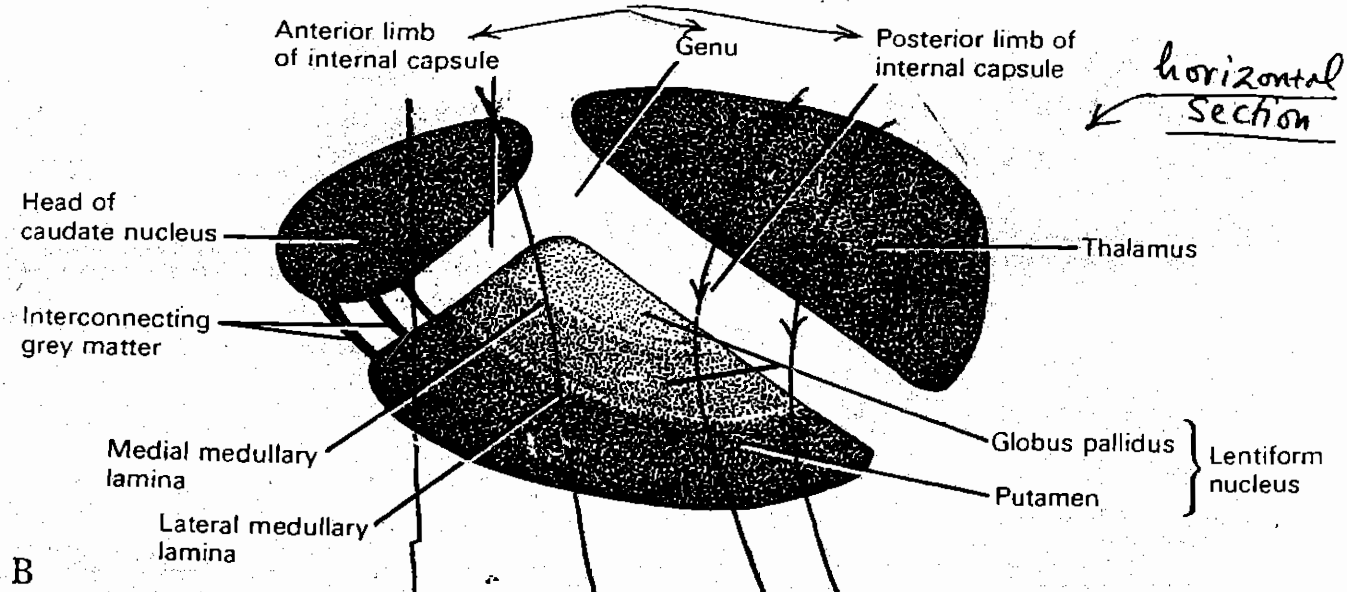
Basal ganglia & Thalamus

Bustami

← Lateral view



← horizontal section

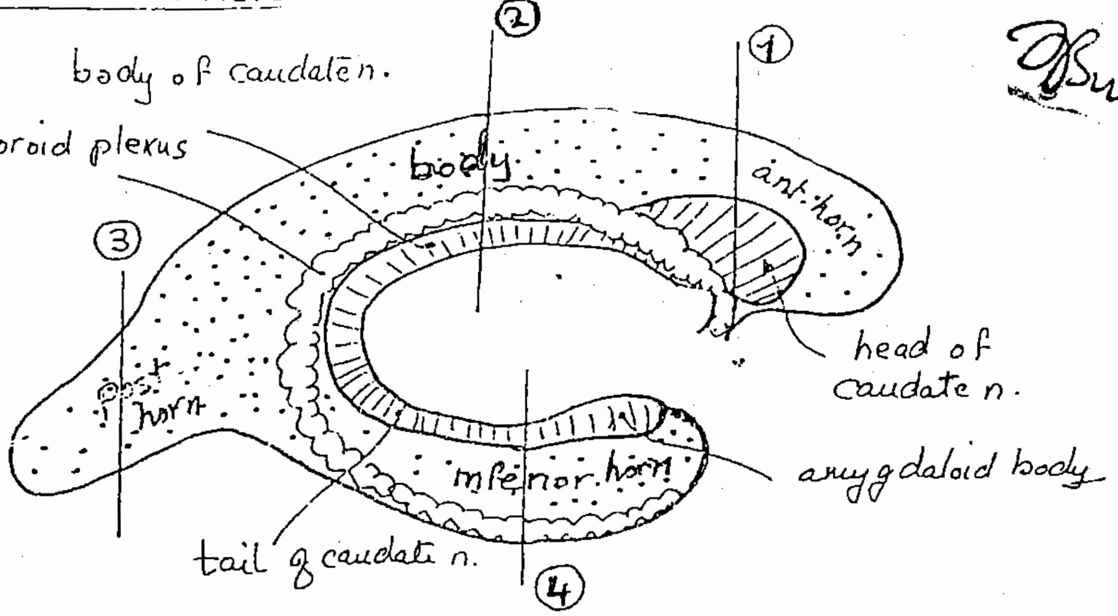


Level of: CR Section (I) | CR Section (II) | CR section (III)

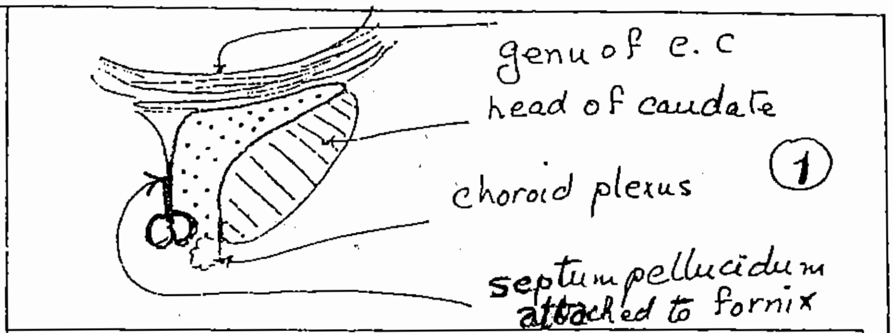
Section passes through: Caudate & Putamen | Caudate, Putamen & globus pallidus | Thalamus, (+) Putamen (+) (−) globus pallidus

Bustami

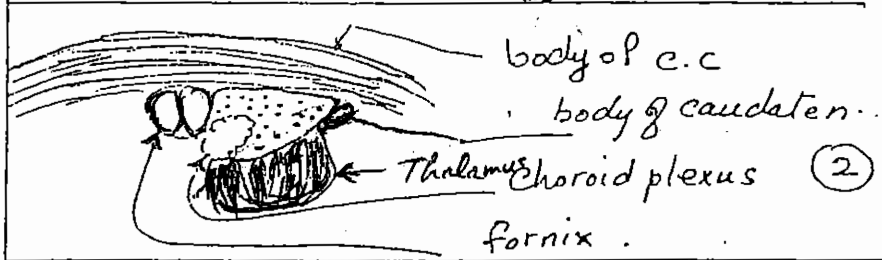
Lateral Ventricle



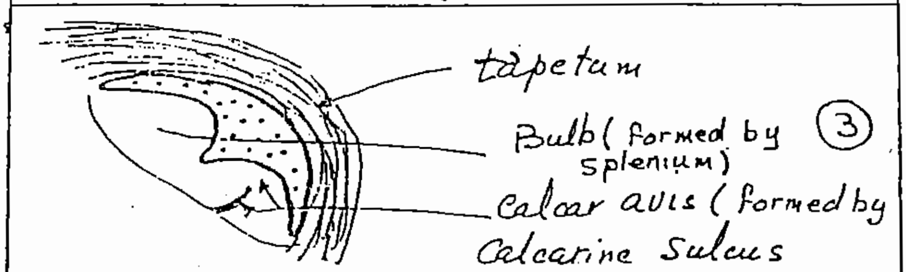
① **ant. horn** Boundaries
- Sup.: genu of corpus C.
- med: Septum pellucidum and fornix.
- lat: head of caudate and choroid plexus



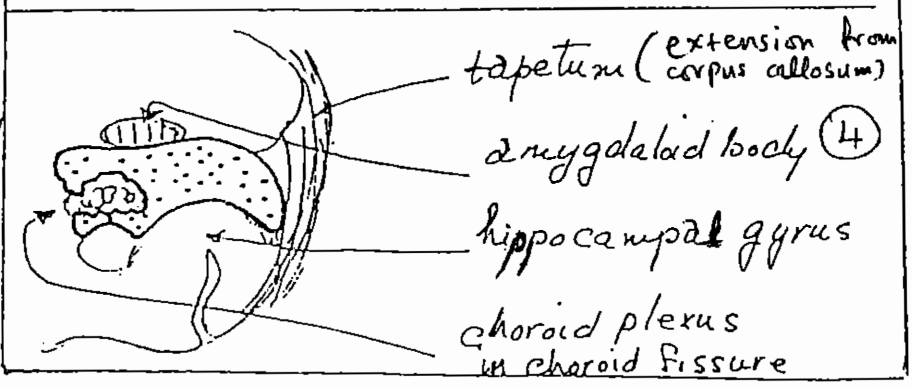
② **Body**: Boundaries
- Sup: body of corpus c.
- med: fornix
- floor: – body of caudate
  – Thalamus



③ **Posterior horn**: Boundaries
- Sup. & lateral: tapetum
- medial: bulb and calcar avis



④ **Inferior horn**: Bound:
- Sup: tail of caudate n. and amygdaloid body
- medial: choroid fissure and plexus
- Lateral: tapetum



Bustami

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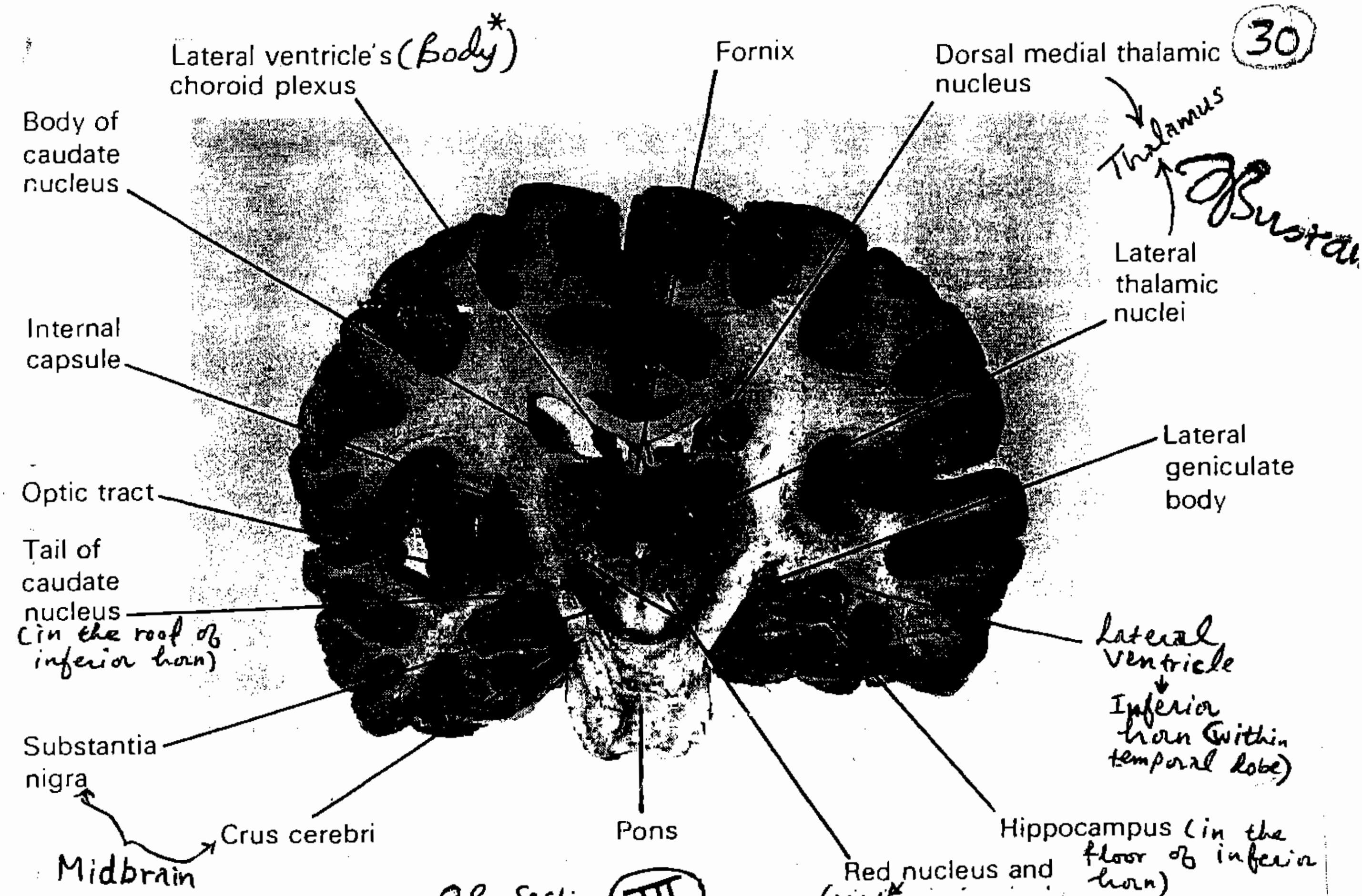
Fig. 9.3 Coronal section of the cerebrum through the anterior horns of the lateral ventricles. (Mulligan's stain, 0.6 natural size.)



CR Section (III)

CORONAL SECTION of the BRAIN passing through cerebrum, brainstem and 2 parts of the lateral ventricle (body and inferior horn)

↓

Notice that the CRUS CEREBRI of midbrain is continuous Rostrally (superiorly) with the internal capsule (motor part) and caudally with the basilar part of Pons → Remember that the crus cerebri contains Pyramidal fibres (corticospinal & corticobulbar) as well as CORTICO-PONTINE fibres (from cerebral cortex to Pontine nuclei)

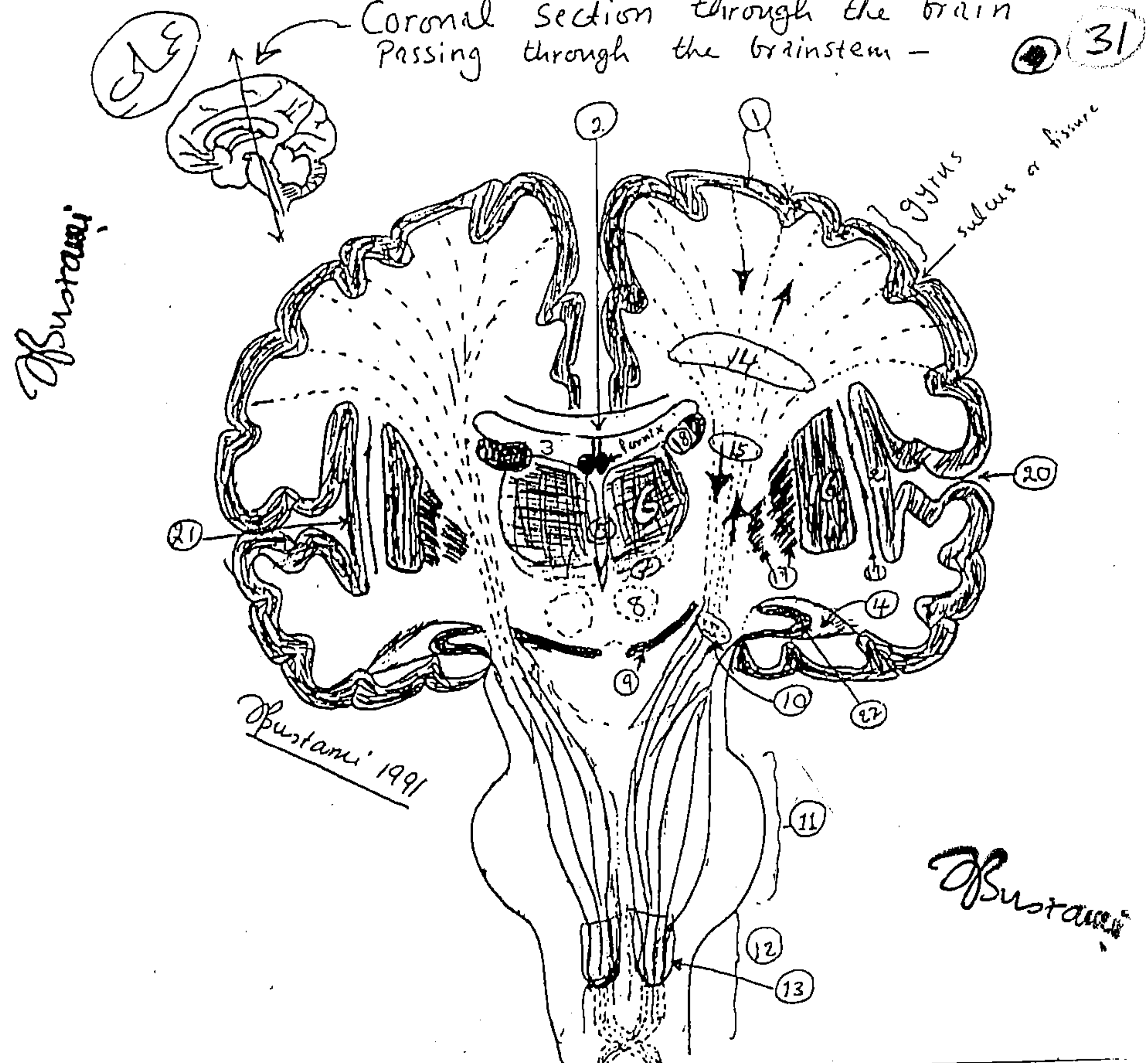
- What are the structures present at the floor of the body of lateral ventricle? → body of caudate n., thalamus

- Functions of Hypothalamus?

↓

HOMEOSTASIS

Coronal section through the brain Passing through the brainstem — (31)



(1) cerebral cortex (sulci & gyri) (2) corpus callosum e.g of commissural fibres connecting the 2 cerebral hemispheres (3) body of lateral ventricle (4) inferior horn of lateral ventricle (5) third ventricle (between the 2 thalami) (6) thalamus (7) hypothalamus (8) Red nucleus (in midbrain) (9) substantia nigra (in midbrain) (10) crus cerebri (basis pedunculi) of midbrain → continuous rostrally with motor part of internal capsule (12) medulla oblongata (11) Pons (13) Pyramid (within medulla) (14) corona radiata (15) internal capsule (16) Putamen (17) globus pallidus N.B 16 + 17 = Lenticular nucleus (18) Caudate nucleus (19) claustrum (20) lateral fissure (21) insula

Bustami

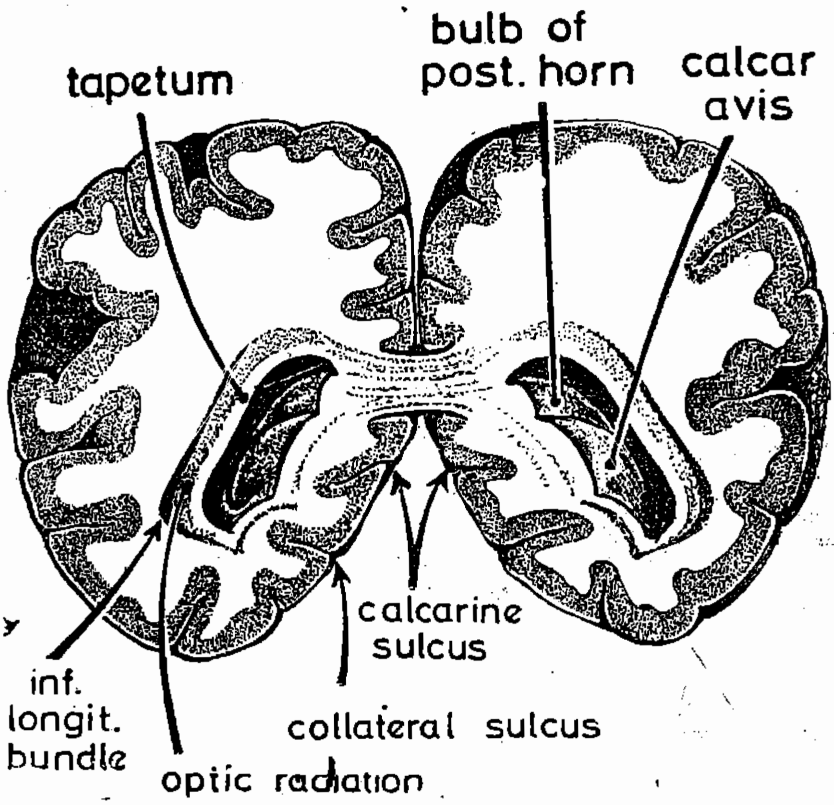


Fig. 73

Cross section through the post. horns of the lateral ventricle

Notice → Roof and lateral wall of the Posterior horn are formed by the tapetum (extension from corpus callosum) however, lateral to this there is part of the Retrolentiform part of internal capsule which contains the fibres of optic radiation

→ Medial wall is formed by:
bulb → extension from splenium
Calcar avis → formed by Calcarine fissure

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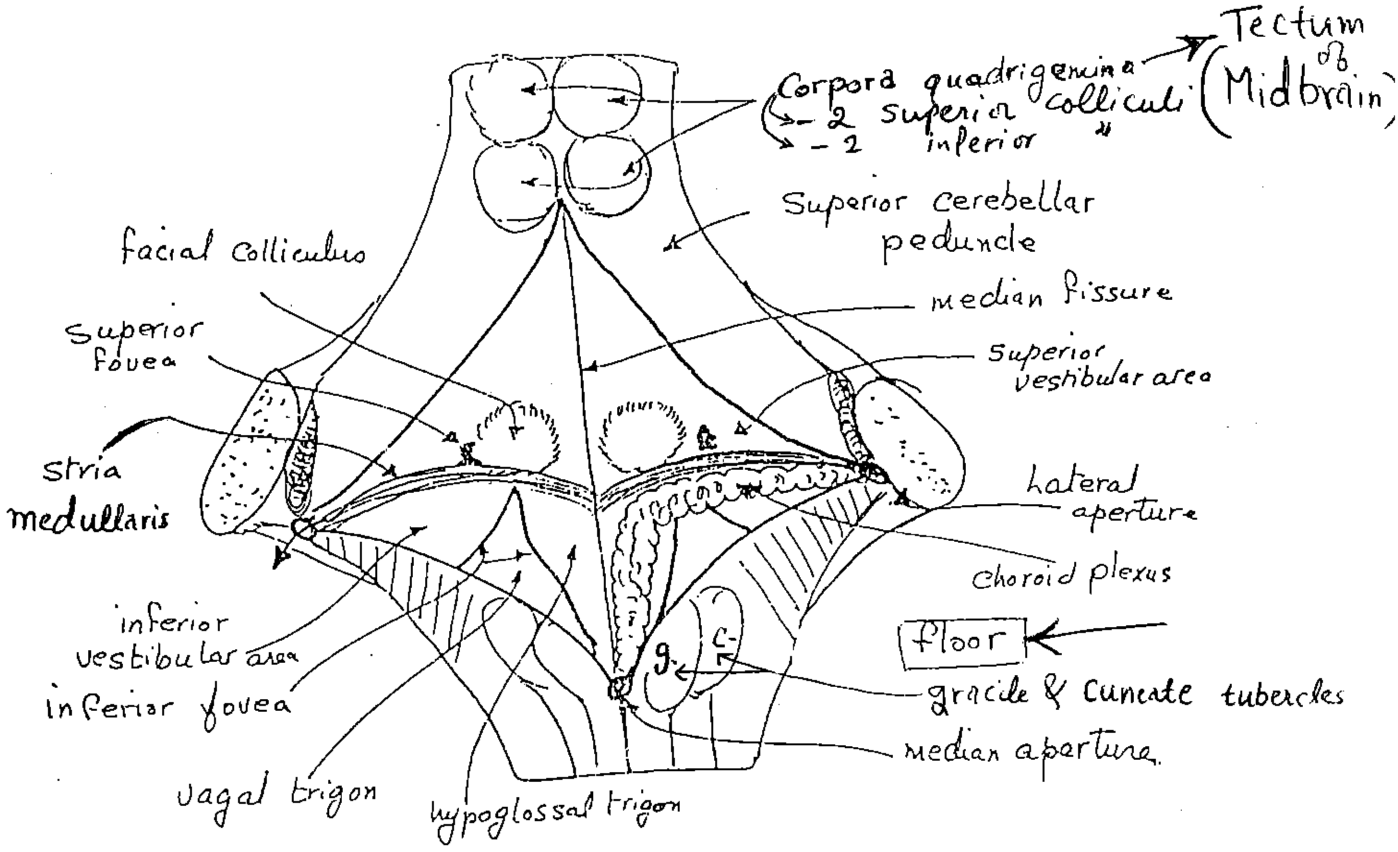
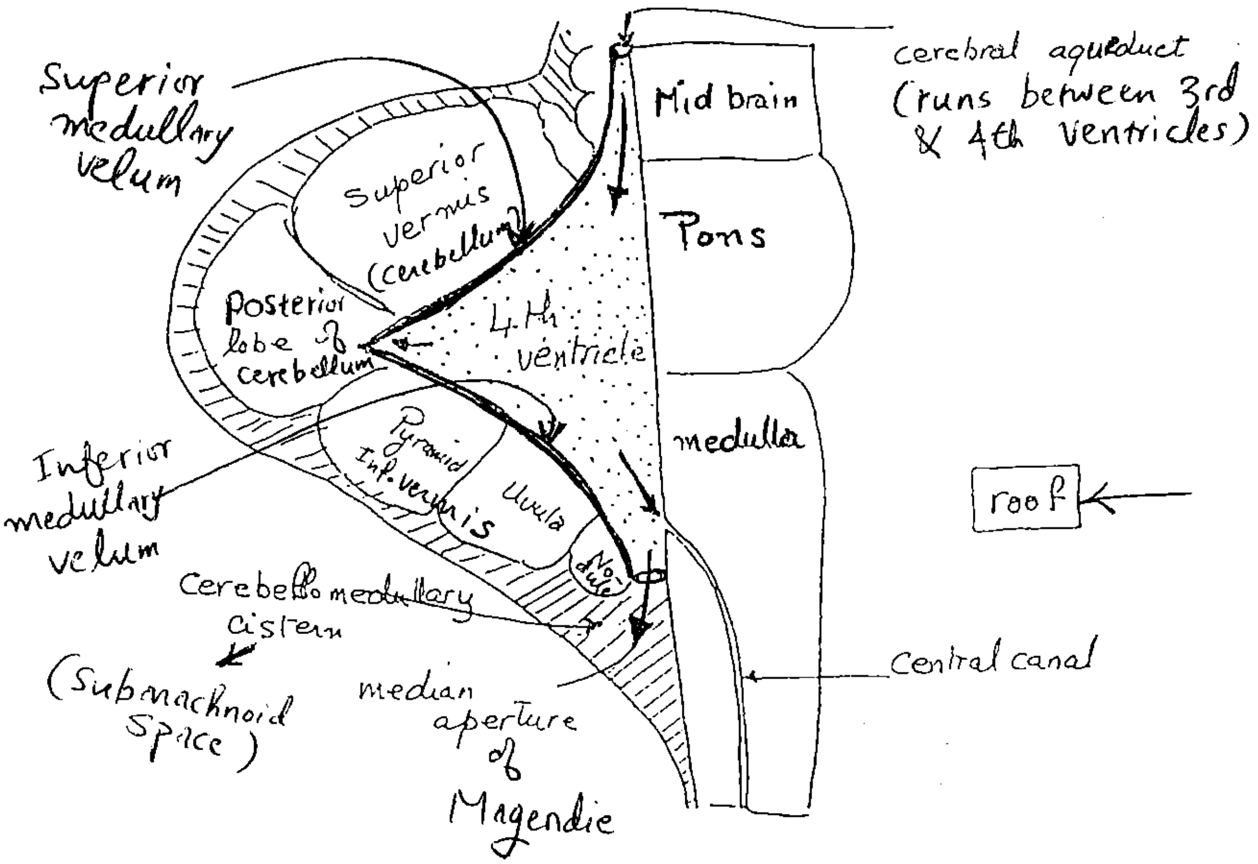
Bustami

Fourth ventricle :





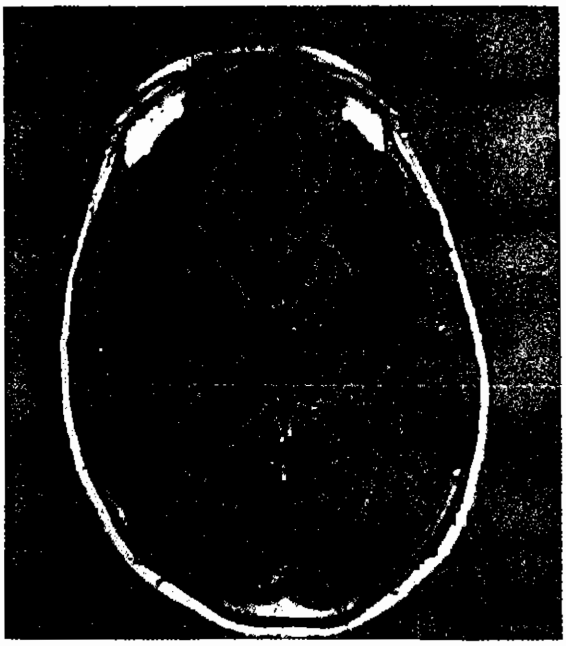


Fig. 10.13 **Horizontal (axial) magnetic resonance image of the living brain.**
(Courtesy of Dr. A. Jackson, Department of Diagnostic Radiology, University of Manchester.)

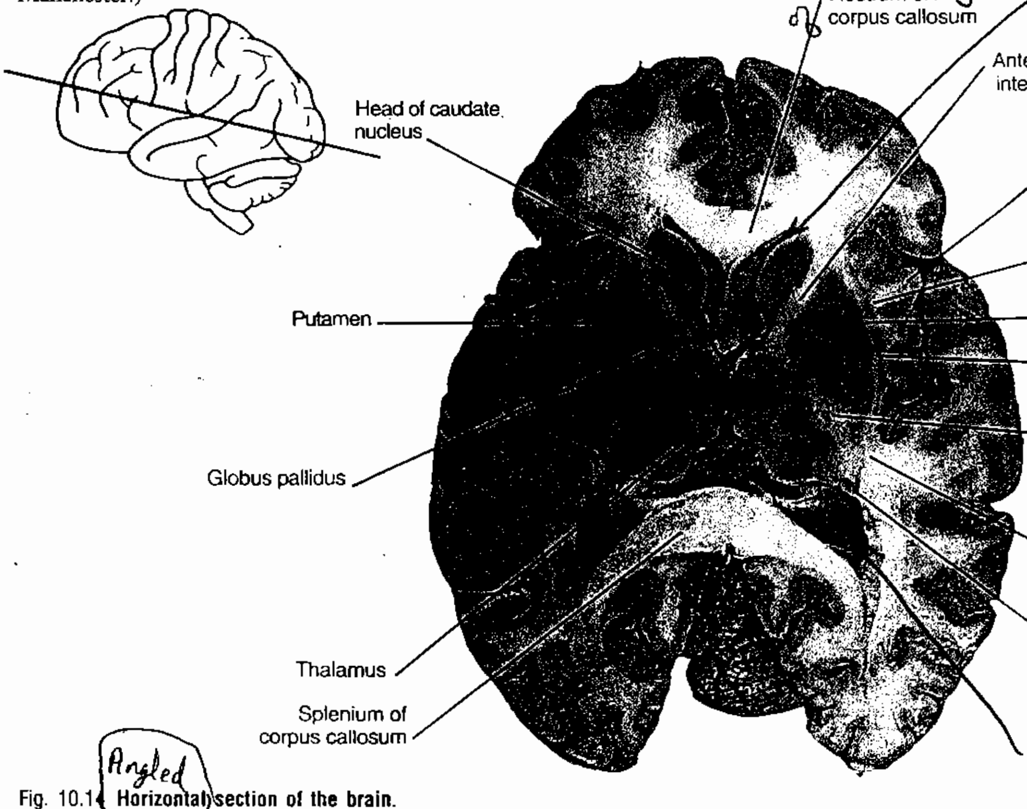
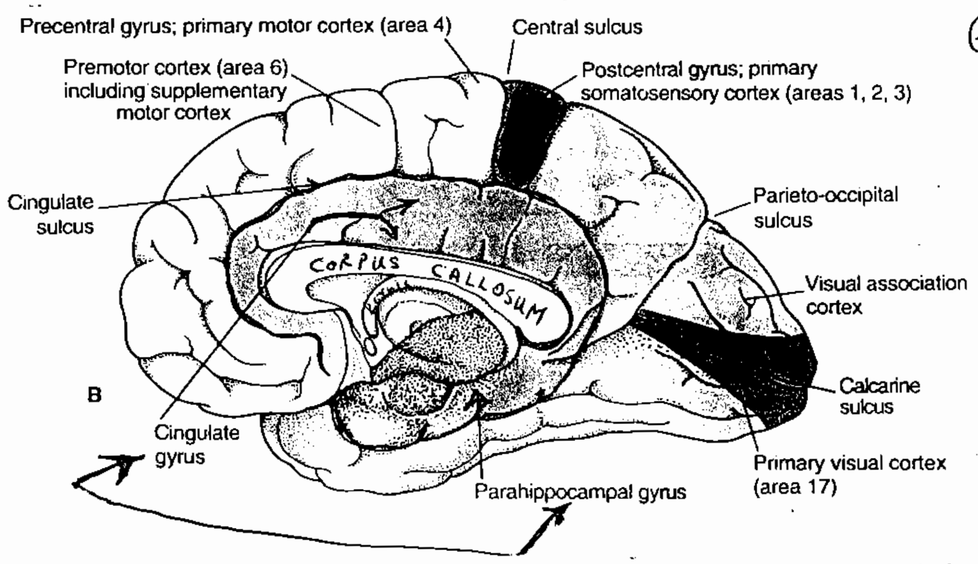


Fig. 10.14 Angled **Horizontal section of the brain.**

Angeled horizontal section of Brain passing through CEREBRUM, basal ganglia, thalami, 2 parts of Lateral ventricle (ant. & post. horns), 2 parts of corpus callosum (genu & splenium)

Median Sagittal Section of the brain showing the medial surface of the cerebral hemisphere

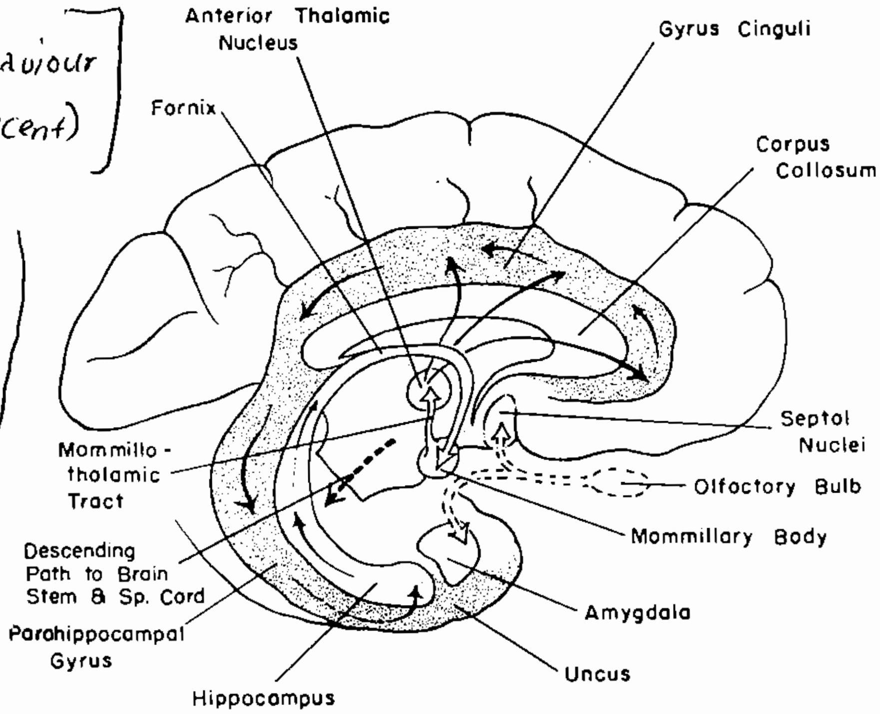


(*) Notice the continuity between the cingulate gyrus and the parahippocampal gyrus.

Bustan

Remember that the limbic lobe is part of the limbic system ⇓ [Emotional behaviour & Memory (recent)] ⇓ Bilateral lesions in hippocampus & amygdaloid ↓ long term memory is Retained but recent memory is impaired ↓ Korsakoff's Syndrome

The major afferent connection of the hypothalamus is the *fornix*, a conspicuous tract ending in the *mammillary nuclei*. The fornix arises from the *hippocampus*, which is formed by an infolding of the inferior surface of the temporal lobe along the line of the hippocampal fissure. Fibers of the fornix proceed backward on the ventricular surface of the hippocampus, then arch forward under the corpus callosum. The fornix completes its nearly ring-shaped course by turning downward and back to reach the mammillary body (Fig. 40). The efferent connection of the mammillary body is the *mammillothalamic tract*, a prominent bundle of fibers passing directly to the



anterior nucleus of the thalamus. The anterior thalamic nucleus sends fibers to the *cingulate gyrus*, which is the long gyrus next to the corpus callosum on the medial aspect of the cerebrum. The cingulate gyrus encircles the corpus callosum and, in its posterior part, is continuous through a narrowed strip (the isthmus) with the *parahippocampal gyrus*, the most medial convolution of the temporal lobe. Together the cingulate gyrus, isthmus, parahippocampal gyrus, and the uncus, an eminence near the front of the hippocampal gyrus form a ring of cortex known as the *limbic lobe* of the brain (see Fig.