Surface Projections of Abdominal Viscera

These projections are useful for **clinical examination, surface marking, radiological orientation, and surgical anatomy**. The patient is usually placed **supine**, with the anterior abdominal wall exposed and the midline identified.

1. Stomach

- **Cardia:** approximately **T11**, about 2–3 cm to the left of the median plane.
- **Pylorus:** approximately **L1**, just to the right of the median plane.
- **Greater curvature:** extends from the left 5th intercostal region downward and medially to the pyloric region.
- **Fundus:** reaches the **left 5th intercostal space**, just below the left diaphragm.

2. Liver

- **Upper border:** follows approximately the **5th intercostal space** on the right, crosses the xiphisternal region and reaches the left 5th intercostal space.
- **Lower border:** normally follows the right costal margin from approximately the **9th costochondral junction** toward the xiphisternum, then continues toward the left costal margin.
- The liver is mainly in the **right hypochondrium and epigastrium**, extending into the left hypochondrium.

3. Fundus of Gallbladder

- Surface projection: **tip of the right 9th costal cartilage**, at or near the intersection of the **right midclavicular line with the costal margin**.
- Clinically important as the site of **gallbladder tenderness**.

4. Spleen

- Lies deep to the **9th, 10th and 11th ribs** on the left.
- Long axis corresponds approximately to the **10th rib**.
- Its medial end is directed toward the vertebral column and its lateral end approaches the midaxillary line.
- Normally, the spleen is **not palpable below the left costal margin**.

5. Duodenum

- **First part:** approximately **L1**, extending from the pylorus toward the right.
- **Second part:** descends on the right side of the vertebral column from approximately **L1 to L3**.
- **Third part:** crosses horizontally at approximately **L3**.

- **Fourth part:** ascends from L3 toward the **duodenojejunal flexure at L2**, just left of the midline.

6. Pancreas

- Lies approximately at the level of **L1–L2 vertebrae**.
- **Head:** lies within the C-shaped curve of the duodenum.
- **Neck:** approximately anterior to the portal vein formation.
- **Body:** crosses the midline toward the left.
- **Tail:** reaches the **splenic hilum**.

7. Ileocaecal Junction

- Surface projection: **right iliac fossa**, approximately at the junction of the **medial two-thirds and lateral one-third of a line joining the right ASIS to the umbilicus**.
- This is close to **McBurney's point**, although McBurney's point specifically represents the surface marking classically used for the **base of the appendix**.

8. Kidneys

The renal surfaces are projected onto the posterior abdominal wall:

Right kidney

- Approximately **T12–L3**.
- Slightly lower than the left kidney because of the liver.

Left kidney

- Approximately **T11–L2**.

Renal hilum

- Approximately at the level of **L1**, near the transpyloric plane.

Renal angles

- The kidneys extend laterally from the vertebral column toward the **12th rib** region.

9. Root of Mesentery

The root extends obliquely:

- **Superiorly:** from the **duodenojejunal flexure at L2**, just left of the vertebral column.
- **Inferiorly:** to the **ileocaecal junction/right iliac fossa**.

It crosses structures including the **third part of the duodenum, abdominal aorta, inferior vena cava, right ureter and right gonadal vessels**.

Practical Demonstration Sequence

For an MBBS surface-anatomy demonstration, mark these landmarks in sequence:

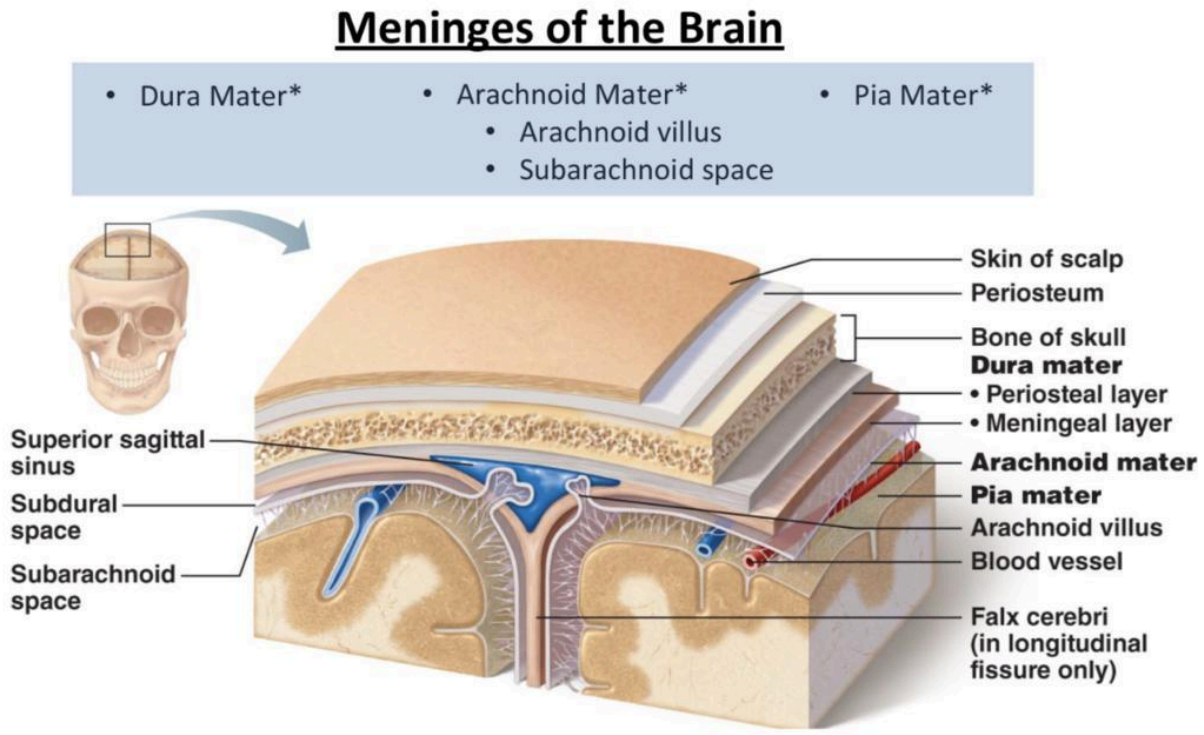
Midline → costal margins → xiphisternum → umbilicus → ASIS → right midclavicular line → 9th costal cartilage → McBurney's point → T11–L3 renal levels → L1–L3 duodenal levels → oblique root of mesentery.

This gives students a clinically useful map of the **stomach, hepatobiliary system, spleen, duodenum, pancreas, ileocaecal region, kidneys and mesentery**.

Meninges — Layers, Extent and Modifications

The **meninges** are three connective-tissue membranes that surround and protect the **brain and spinal cord**. From outside inward, they are:

1. **Dura mater**
2. **Arachnoid mater**
3. **Pia mater**



DURAL FOLDS OF THE BRAIN

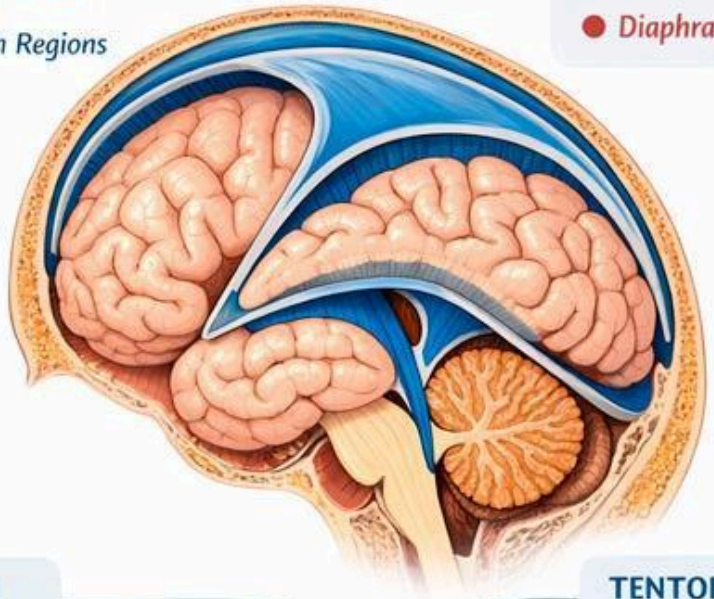
WHAT ARE DURAL FOLDS?

Extensions of the dura mater that separate and support parts of the brain.

- ✓ *Provide Protection*
- ✓ *Stabilize the Brain*
- ✓ *Divide Brain Regions*

MAIN DURAL FOLDS

- *Falx Cerebri*
- *Tentorium Cerebelli*
- *Falx Cerebelli*
- *Diaphragma Sellae*



FALX CEREBRI

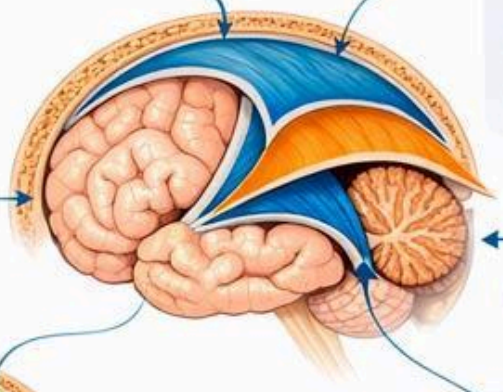
Separates the two cerebral hemispheres.

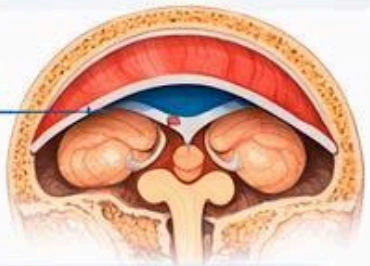
TENTORIUM CEREBELLI

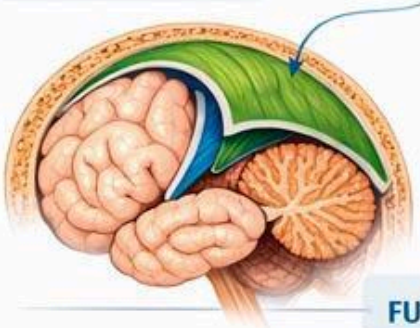
Supports and separates the cerebellum from the occipital lobes.

FALX CEREBELLI

Divides the two cerebellar hemispheres.







DIAPHRAGMA SELLAE

Covers the pituitary gland.

FUNCTIONS OF DURAL FOLDS



Brain Protection

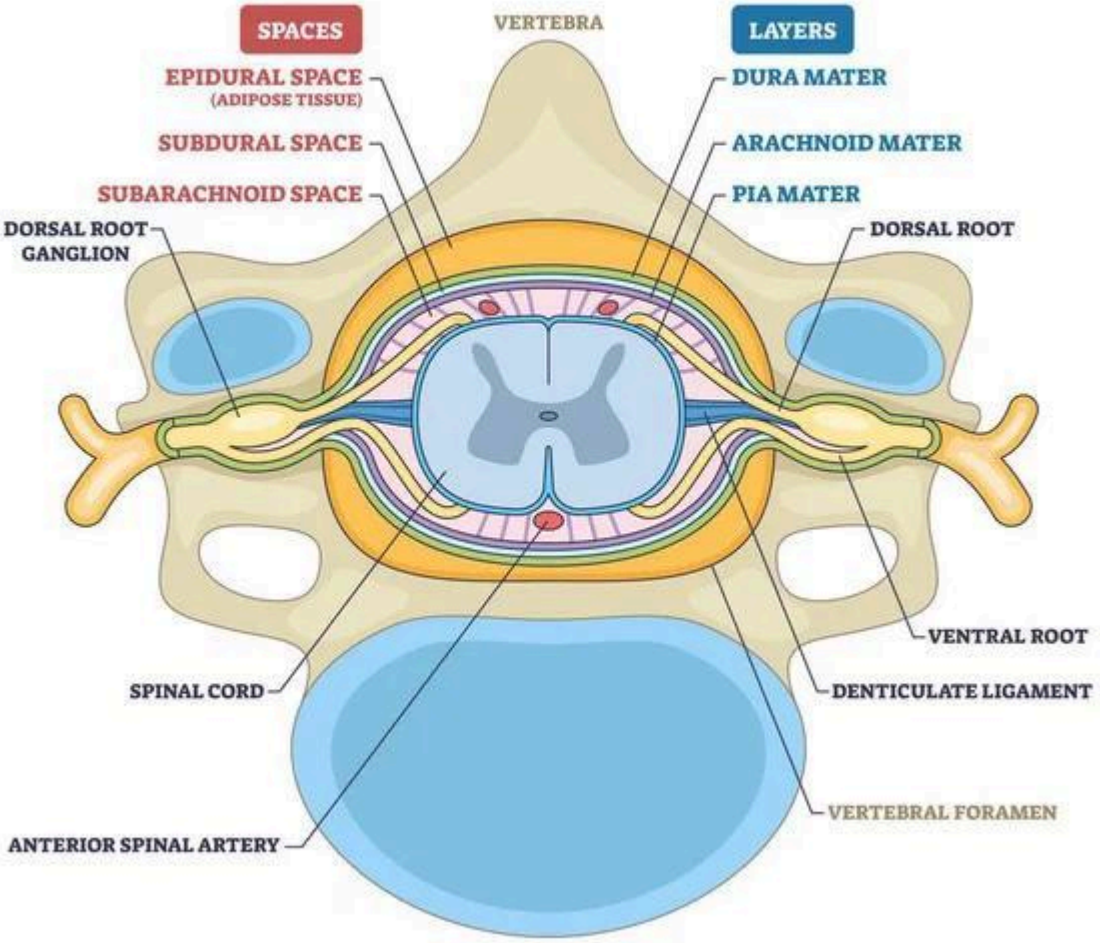


Structural Support

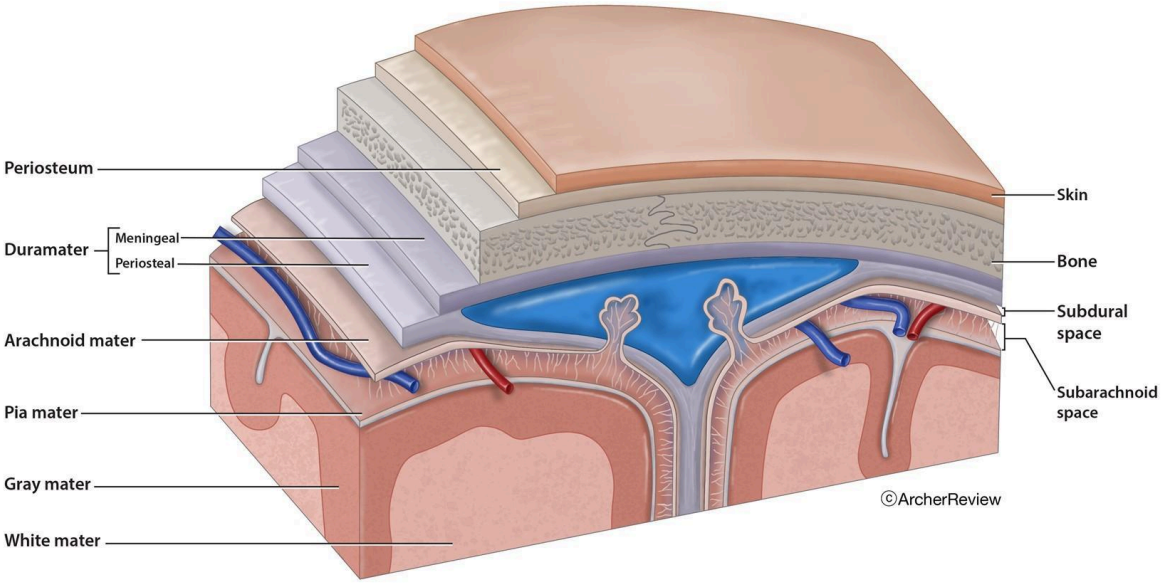


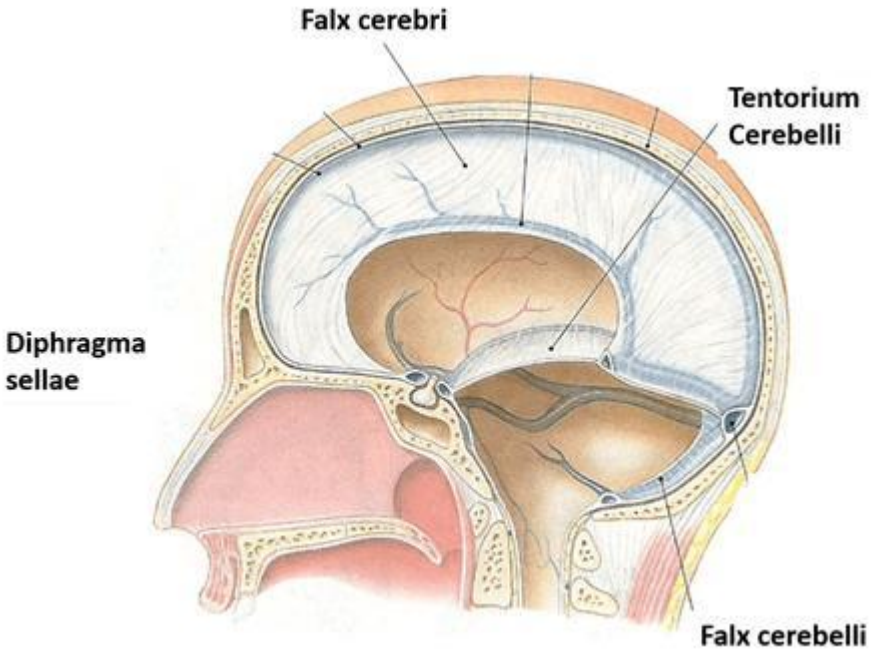
Division of Brain Areas

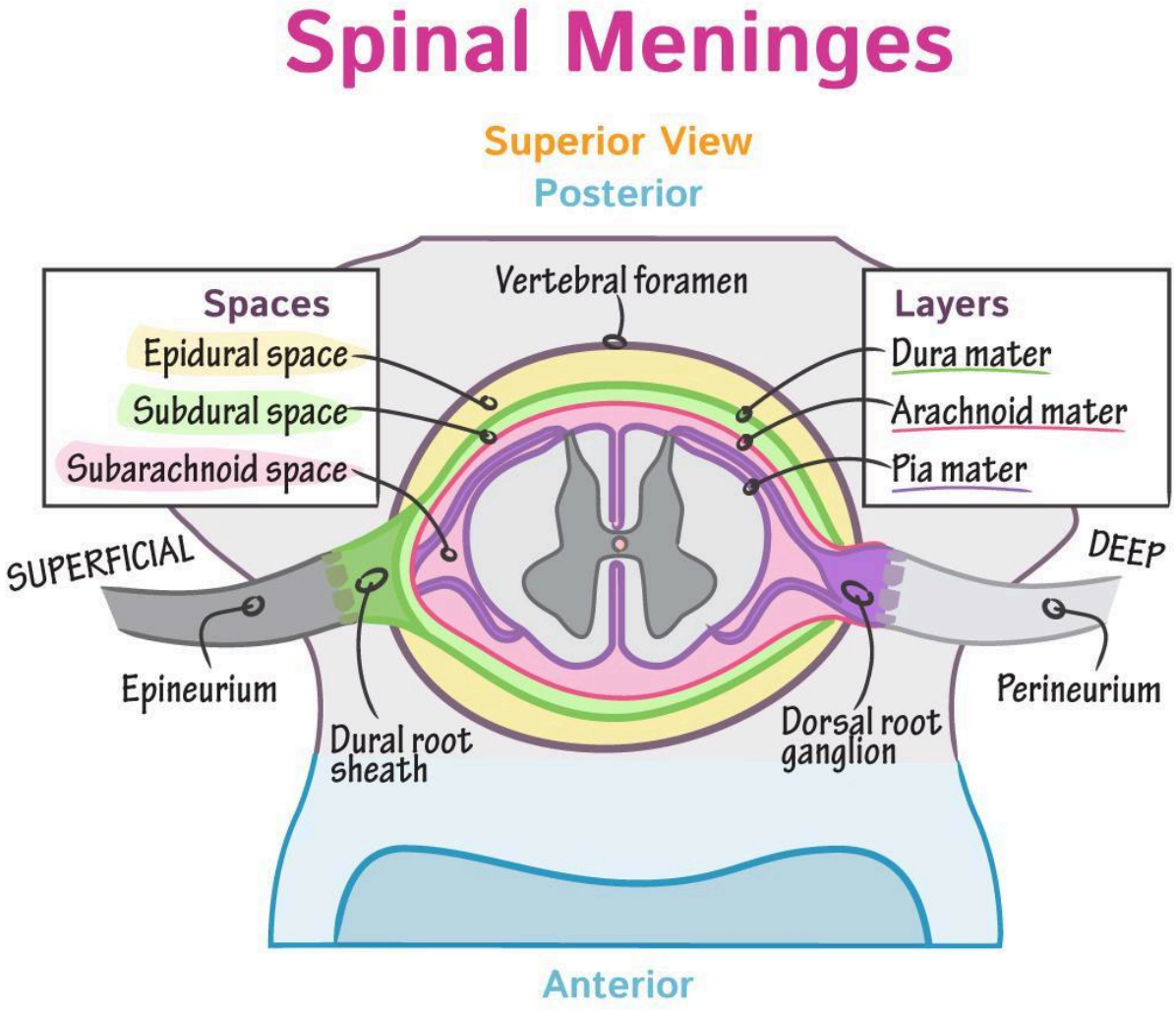
SPINAL MENINGES LAYERS



Layers of the Meninges







1. Dura Mater

Dura mater is the outermost, tough, fibrous meningeal layer.

Cranial dura

It has **two layers**:

- **Periosteal layer** — attached to the inner surface of the skull.
- **Meningeal layer** — continues through the foramen magnum as spinal dura.

The two layers separate in places to form **dural venous sinuses**.

Extent

- Attached to the cranial bones.

- At the **foramen magnum**, the meningeal layer continues as spinal dura.
- It also extends along cranial nerves for a short distance and forms their dural sheaths.

Modifications — dural folds

The meningeal layer forms four major folds:

Dural fold	Location / function
Falx cerebri	Between the two cerebral hemispheres
Tentorium cerebelli	Separates cerebrum from cerebellum
Falx cerebelli	Between the two cerebellar hemispheres
Diaphragma sellae	Roof of hypophyseal fossa; surrounds pituitary stalk

These folds contain venous sinuses along their attached margins.

---

2. Arachnoid Mater

The **arachnoid mater** is a thin, delicate, **avascular** membrane lying deep to the dura.

It does **not closely follow the contours of the brain**; instead, it bridges across sulci.

Extent

- Covers the brain and spinal cord.
- At the **foramen magnum**, it continues as spinal arachnoid mater.
- It ends inferiorly around the level of **S2**.

Important modifications

A. Subarachnoid space

- Lies between arachnoid and pia.
- Contains **CSF**, major arteries and veins, and trabeculae.
- It surrounds both brain and spinal cord.

B. Subarachnoid cisterns
Where the arachnoid bridges over larger irregularities, the subarachnoid space becomes enlarged.

Important cisterns include:

- **Cisterna magna**
- **Pontine cistern**

- **Interpeduncular cistern**
- **Chiasmatic cistern**

C. Arachnoid granulations

- Small projections of arachnoid into the dural venous sinuses.
- Particularly prominent along the **superior sagittal sinus**.
- Important for absorption of **CSF into the venous system**.

---

3. Pia Mater

The **pia mater** is the innermost, very thin and highly vascular meningeal layer.

Extent

- Closely invests the entire surface of the brain.
- Follows the **gyri and sulci**.
- Continues over the spinal cord.

Modifications

A. Tela choroidea

- Pia-related vascular membrane contributing to the formation of the **choroid plexus**.

B. Denticulate ligaments

- Lateral extensions of spinal pia mater.
- Attach the spinal cord to the dura.
- Approximately **21 pairs**.
- Located between the anterior and posterior roots of spinal nerves.

C. Filum terminale

- A slender prolongation of pia mater from the conus medullaris.
- Descends within the dural sac and ultimately attaches to the coccyx.
- Helps anchor the spinal cord.

Important spaces

Space	Location	Contents / significance
Epidural space	Outside dura	Fat and venous plexus in vertebral canal; potential space in cranium

Subdural space	Between dura and arachnoid	Potential space
Subarachnoid space	Between arachnoid and pia	**CSF, vessels and trabeculae**

Clinical correlations

- **Epidural hematoma** — blood between skull and dura, commonly associated with middle meningeal artery injury.
- **Subdural hematoma** — blood between dura and arachnoid, commonly due to tearing of bridging veins.
- **Subarachnoid hemorrhage** — blood enters the CSF-containing subarachnoid space.
- **Lumbar puncture** — CSF is usually obtained from the lumbar subarachnoid space, commonly at **L3–L4 or L4–L5**, below the termination of the spinal cord.

Quick identification for practical examination

Outside → inside:

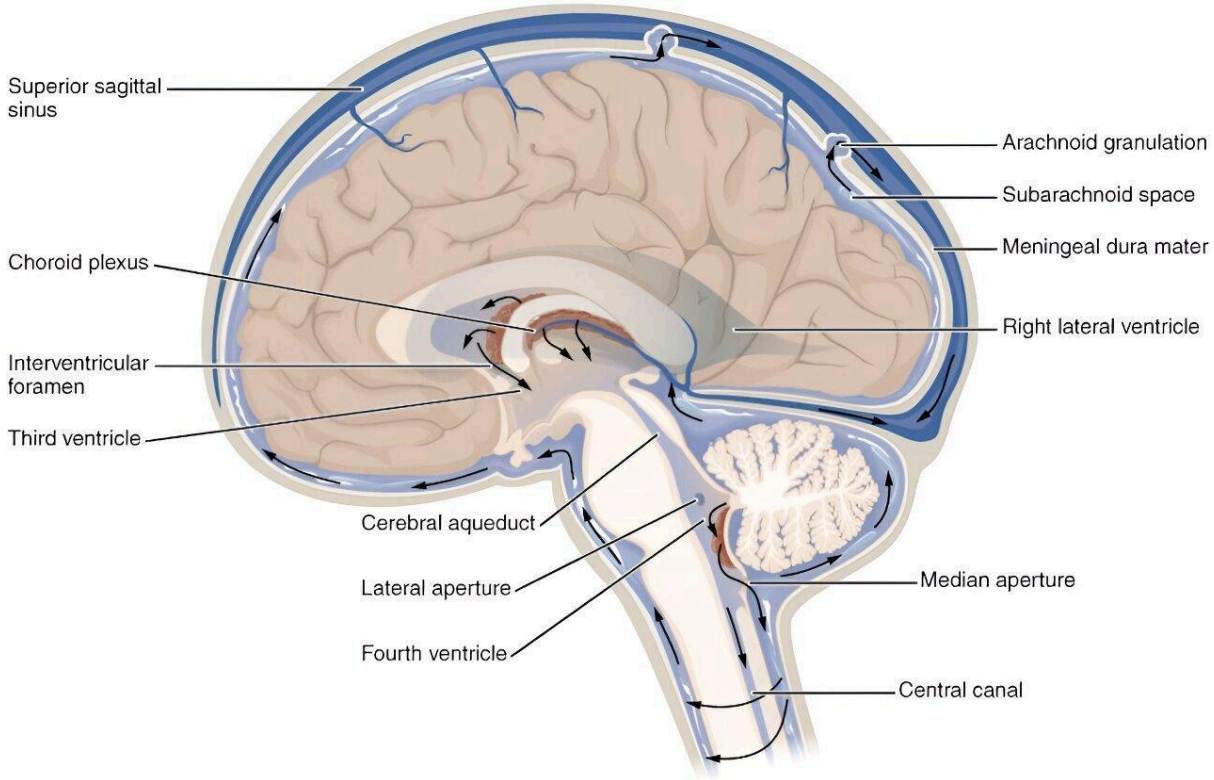
Skull → Dura → Arachnoid → Subarachnoid space/CSF → Pia → Brain

Key identifying features:

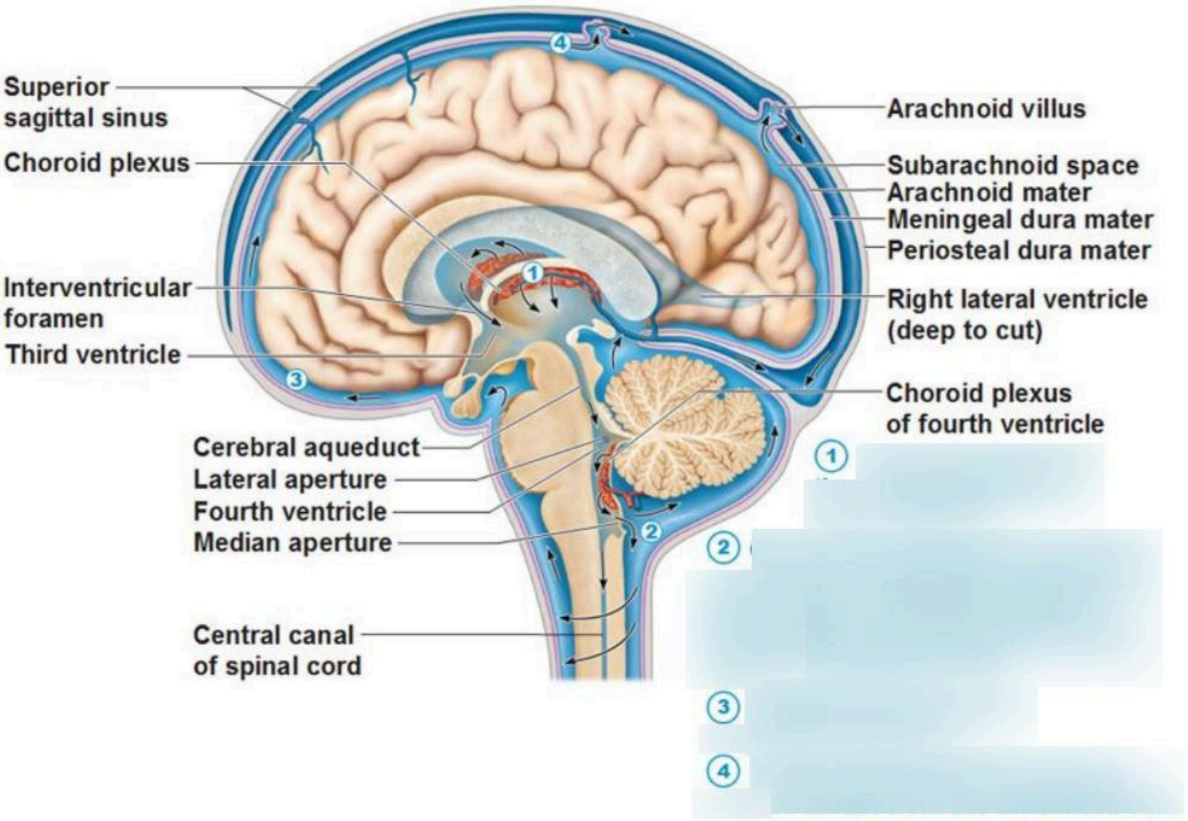
- **Dura:** tough, thick, forms dural folds and venous sinuses.
- **Arachnoid:** thin, avascular, bridges sulci; forms cisterns and arachnoid granulations.
- **Pia:** vascular, closely adherent to CNS; forms denticulate ligaments and filum terminale.

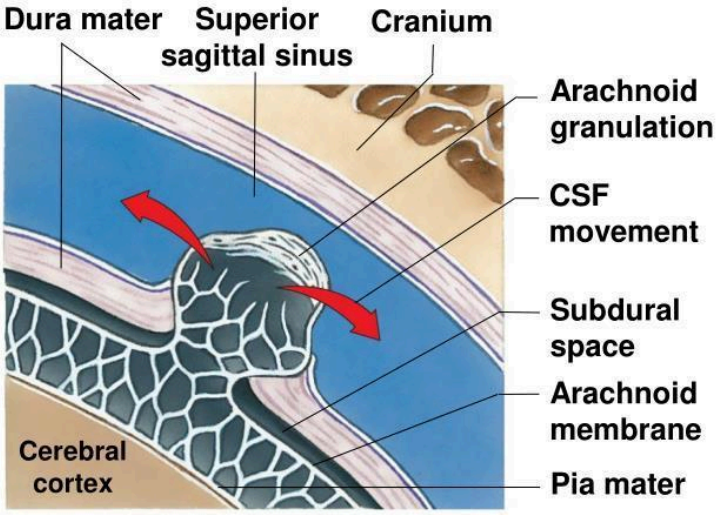
Cerebrospinal Fluid (CSF): Formation, Circulation, Absorption and Applied Anatomy

Cerebrospinal fluid (CSF) is a clear, colorless fluid that surrounds the brain and spinal cord. It provides **mechanical protection, buoyancy, chemical stability, and a pathway for removal of metabolic waste**.



Circulation of Cerebrospinal Fluid (CSF)

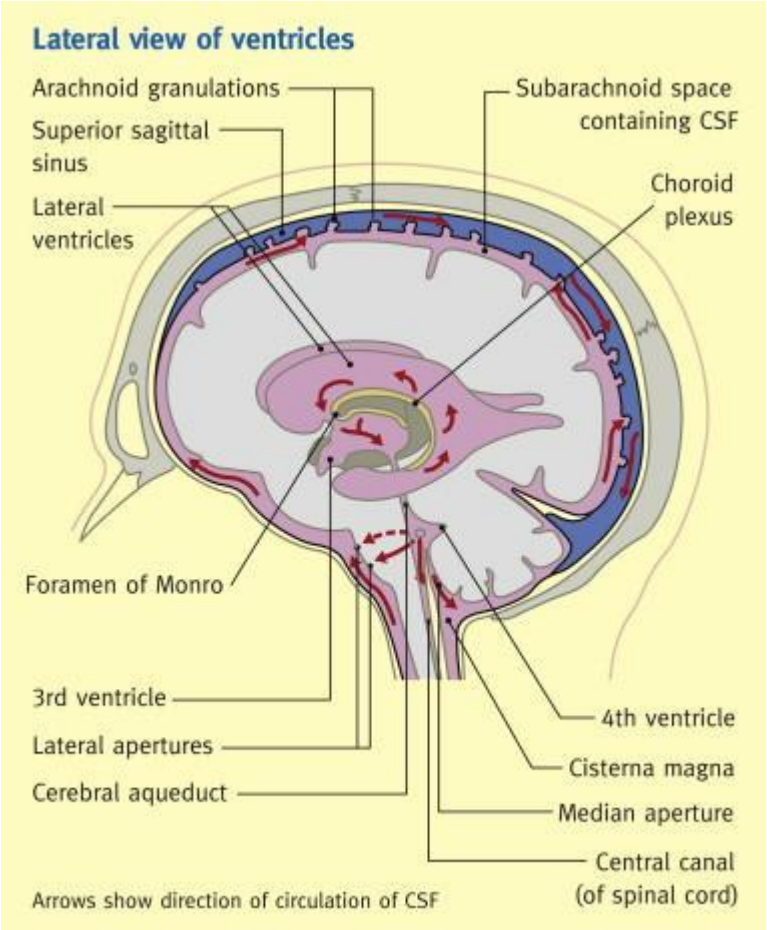




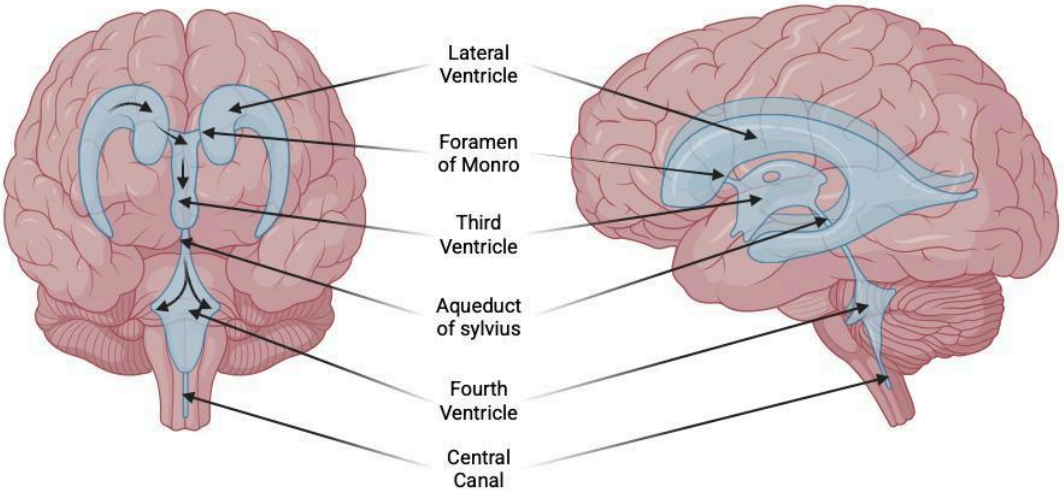
An arachnoid granulation, the site at which cerebrospinal fluid is absorbed into the venous circulation

Figure 13.2 4

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Circulation of Cerebrospinal Fluid

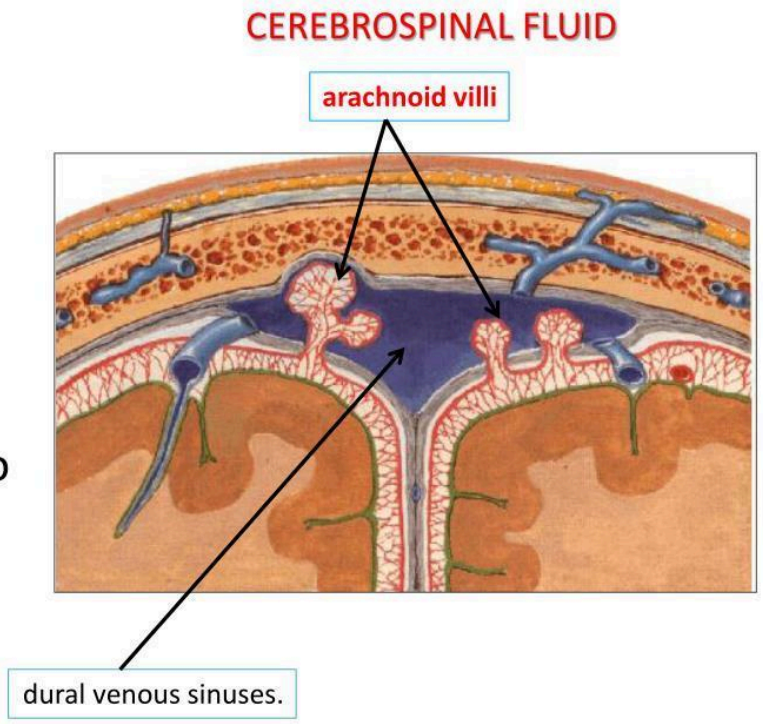


Coronal View

Sagittal View

❑ **Reabsorbed** into the venous system along;

- **arachnoid villi, and**
- **arachnoid granulation**
- that project into the dural venous sinuses, mainly superior saggital sinus.



1. Formation of CSF

CSF is produced mainly by the **choroid plexuses** of the ventricular system.

Approximately:

- **70%** is produced by the choroid plexuses.
- The remainder comes from other sites, including the ependymal and brain interstitial compartments.

The choroid plexus is formed by:

- Highly vascular connective tissue core derived from pia mater
- Fenestrated capillaries
- Specialized **choroid plexus epithelial cells** derived from ependyma

The blood–CSF barrier regulates movement of substances from blood into CSF.

Main sites of choroid plexus:

- Lateral ventricles
- Third ventricle
- Fourth ventricle

Average CSF production is approximately **500 mL/day** in an adult, while the total CSF volume at any one time is approximately **150 mL**.

---

2. Circulation of CSF

The pathway can be remembered as:

Lateral ventricles → Foramina of Monro → Third ventricle → Cerebral aqueduct → Fourth ventricle → Foramina of Magendie & Luschka → Subarachnoid space → Arachnoid granulations → Dural venous sinuses

Stepwise pathway

1. Lateral ventricles

CSF is produced largely by the choroid plexus in the lateral ventricles.

↓

2. Interventricular foramina (foramina of Monro)

CSF passes from each lateral ventricle into the:

↓

3. Third ventricle

It then flows through the:

↓

4. Cerebral aqueduct (aqueduct of Sylvius)

The narrow cerebral aqueduct connects the third and fourth ventricles.

↓

5. Fourth ventricle

CSF leaves the fourth ventricle through:

- **Median aperture (foramen of Magendie)** → median opening
- **Lateral apertures (foramina of Luschka)** → paired lateral openings

↓

6. Subarachnoid space

CSF enters the subarachnoid space surrounding the brain and spinal cord.

Some collects in enlarged subarachnoid spaces called **cisterns**, including the **cisterna magna**.

↓

7. Arachnoid granulations

CSF is ultimately returned to the venous circulation through arachnoid granulations, particularly into the **superior sagittal sinus**.

---

3. Absorption of CSF

The major classical route of CSF absorption is through **arachnoid villi/granulations** into the dural venous sinuses.

Mechanism

When CSF pressure exceeds venous pressure:

Subarachnoid CSF → arachnoid villi/granulations → dural venous sinus → venous blood

The arachnoid granulations therefore function as **one-way valves**, allowing CSF to enter the venous system while limiting reflux of blood into the subarachnoid space.

There are also recognized **lymphatic/glymphatic pathways**, including drainage associated with meningeal lymphatic vessels, particularly along dural venous sinuses.

---

4. Functions of CSF

Mechanical protection

CSF provides a cushioning effect and protects the brain and spinal cord from trauma.

Buoyancy

It reduces the effective weight of the brain, allowing the brain to be supported within the cranial cavity.

Chemical stability

It provides a relatively controlled environment for neuronal function.

Waste clearance

CSF participates in movement and clearance of metabolites from the CNS.

Transport

It facilitates distribution of certain signaling molecules and other substances within the CNS.

---

5. Applied Anatomy

A. Hydrocephalus

Hydrocephalus is abnormal accumulation of CSF within the ventricular system, usually associated with ventricular enlargement.

1. Non-communicating (obstructive) hydrocephalus

There is obstruction within the ventricular pathway.

Important sites include:

- **Cerebral aqueduct** → enlargement of lateral and third ventricles
- **Foramen of Monro** → enlargement of the corresponding lateral ventricle
- Fourth-ventricular outlet obstruction → enlargement of the ventricular system upstream of the obstruction

2. Communicating hydrocephalus

The ventricular pathways remain open, but CSF absorption is impaired, commonly at the level of the arachnoid granulations or related CSF-resorption pathways.

B. Lumbar puncture

CSF can be obtained by introducing a needle into the **lumbar subarachnoid space**, commonly at:

L3–L4 or L4–L5

This is below the usual termination of the spinal cord, which is around **L1–L2 in adults**.

It is used for:

- CSF analysis
- Diagnosis of meningitis
- Subarachnoid hemorrhage assessment
- Certain inflammatory and neurological disorders
- Measurement of CSF opening pressure

C. Raised intracranial pressure

Excessive CSF accumulation can increase **intracranial pressure**.

Clinical manifestations may include:

- Headache
- Vomiting
- Papilledema
- Altered consciousness
- Visual disturbances

Severe and rapidly increasing intracranial pressure may cause **brain herniation**, which is a neurological emergency.

D. Meningitis

Inflammation of the meninges may alter CSF composition.

CSF examination can help distinguish different causes of meningitis by assessing:

- Opening pressure
- Cell count and differential
- Protein
- Glucose
- Microbiological findings

E. CSF leak

A breach of the skull base or meninges may result in **CSF rhinorrhea** or **CSF otorrhea**.

This is clinically important because communication between the subarachnoid space and the exterior can provide a route for infection, including meningitis.

Practical/Exam Summary

Formation:
Choroid plexus → ventricular CSF

Circulation:
Lateral ventricle → Foramen of Monro → III ventricle → Cerebral aqueduct → IV ventricle → Magendie & Luschka → Subarachnoid space

Absorption:
Subarachnoid space → Arachnoid villi/granulations → Dural venous sinuses

Important applied anatomy:

1. Hydrocephalus
2. Lumbar puncture
3. Raised intracranial pressure
4. Meningitis and CSF examination
5. CSF rhinorrhea/otorrhea