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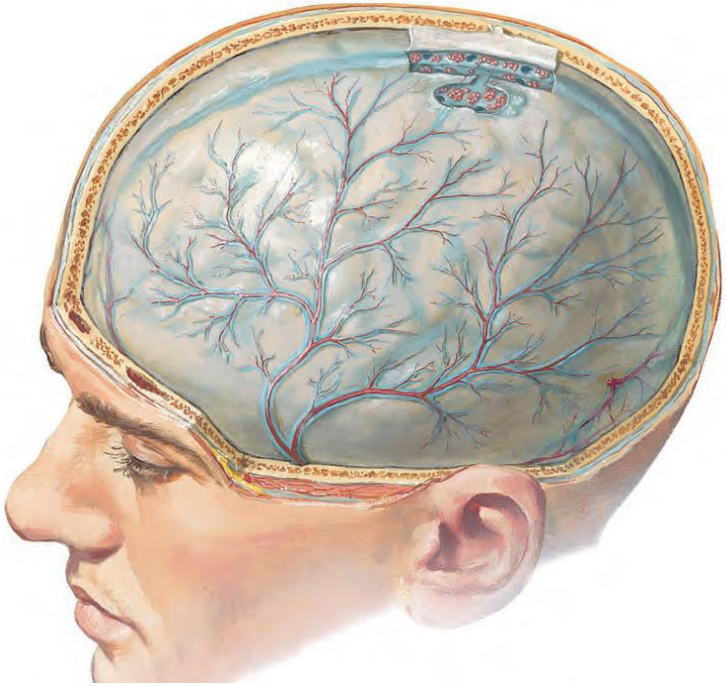
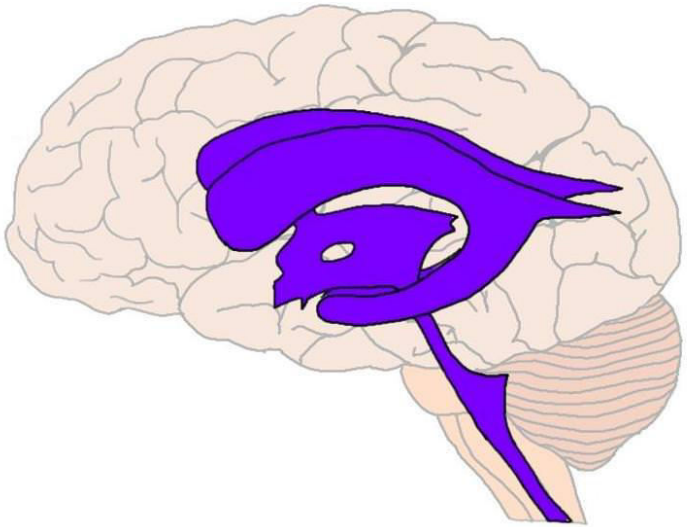
MOOC 1: Central Nervous System

MOOC 2: Peripheral Nervous System





Meninges, Ventricles & Cerebrospinal Fluid (CSF)

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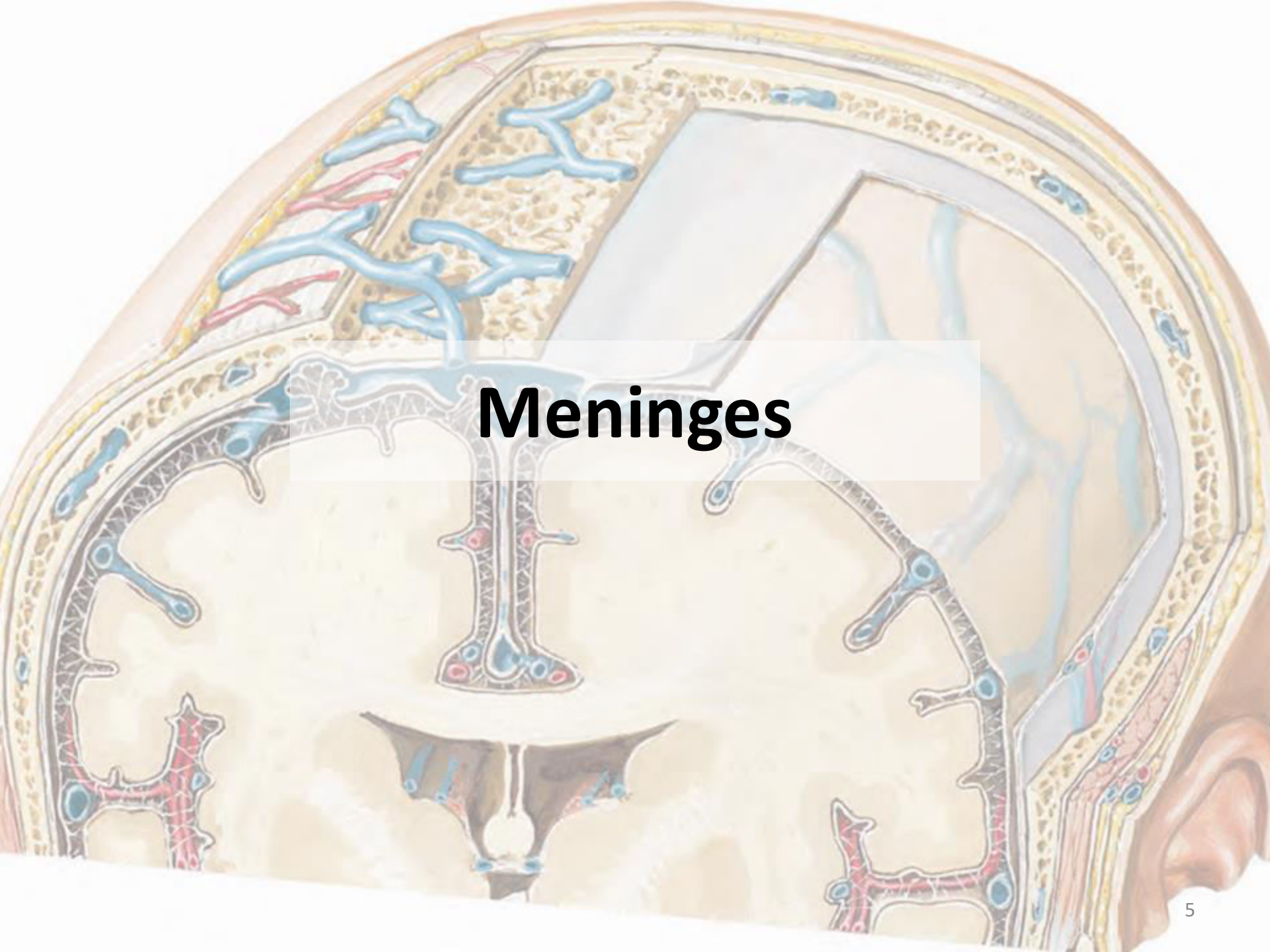
LEARNING OUTCOMES

1. Describe the layers of meninges in relation with brain
2. Describe the layers of meninges in relation with spinal cord
3. Describe the extradural, subdural and subarachnoid spaces
4. Describe the ventricles including their communications
5. Describe site of formation, circulation, absorption and function of cerebrospinal fluid
6. Describe the applied anatomy of meninges and cerebrospinal fluid circulation

Clinical case

- A 23-year-old male comes to the emergency room complaining of 2 days of fever, headache, stiff neck, and general ill feeling. He notes pain on movement of his eyes and sensitivity to light. He had no seizure.

- Upon examination in the ER :
  - He appeared ill and lethargic but easily arousable.
  - He had a fever of 38.5°C. Blood pressure, heart rate, and respirations were normal.
  - With the patient supine the neck was passively flexed. The neck was abnormally stiff (i.e., it did not flex to the normal degree). At the same time as the neck was flexed, his knees flexed slightly.
  - When eye movement was tested, the patient noted his eyes hurt when they moved.
  - Strength, sensation, reflexes, and all other parts of the neurologic and general exams were normal or unremarkable



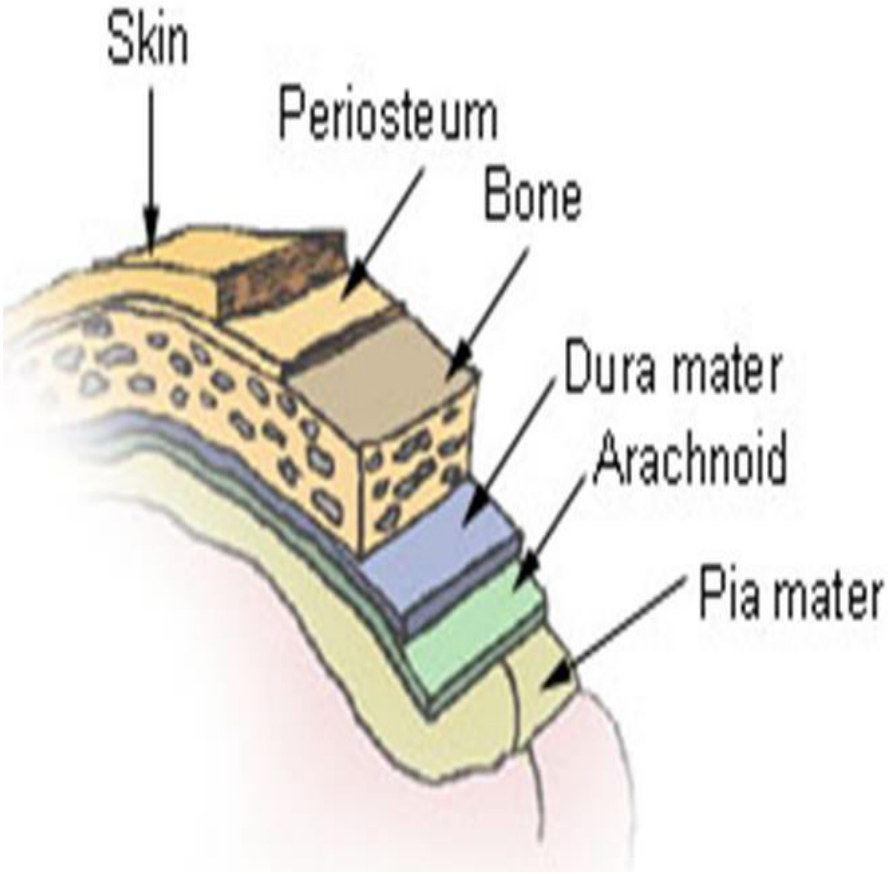
Meninges

What are the meninges?

What are the function of the meninges?

Meninges

- The brain & spinal cord are surrounded by meninges, which is composed of 3 layers :
  - Dura mater
    - Outermost layer & thickest
  - Arachnoid mater
    - Middle layer & attaches to inner surface of dura
  - Pia mater
    - Innermost layer & attaches to the surface of brain and spinal cord



Meninges : Dura mater

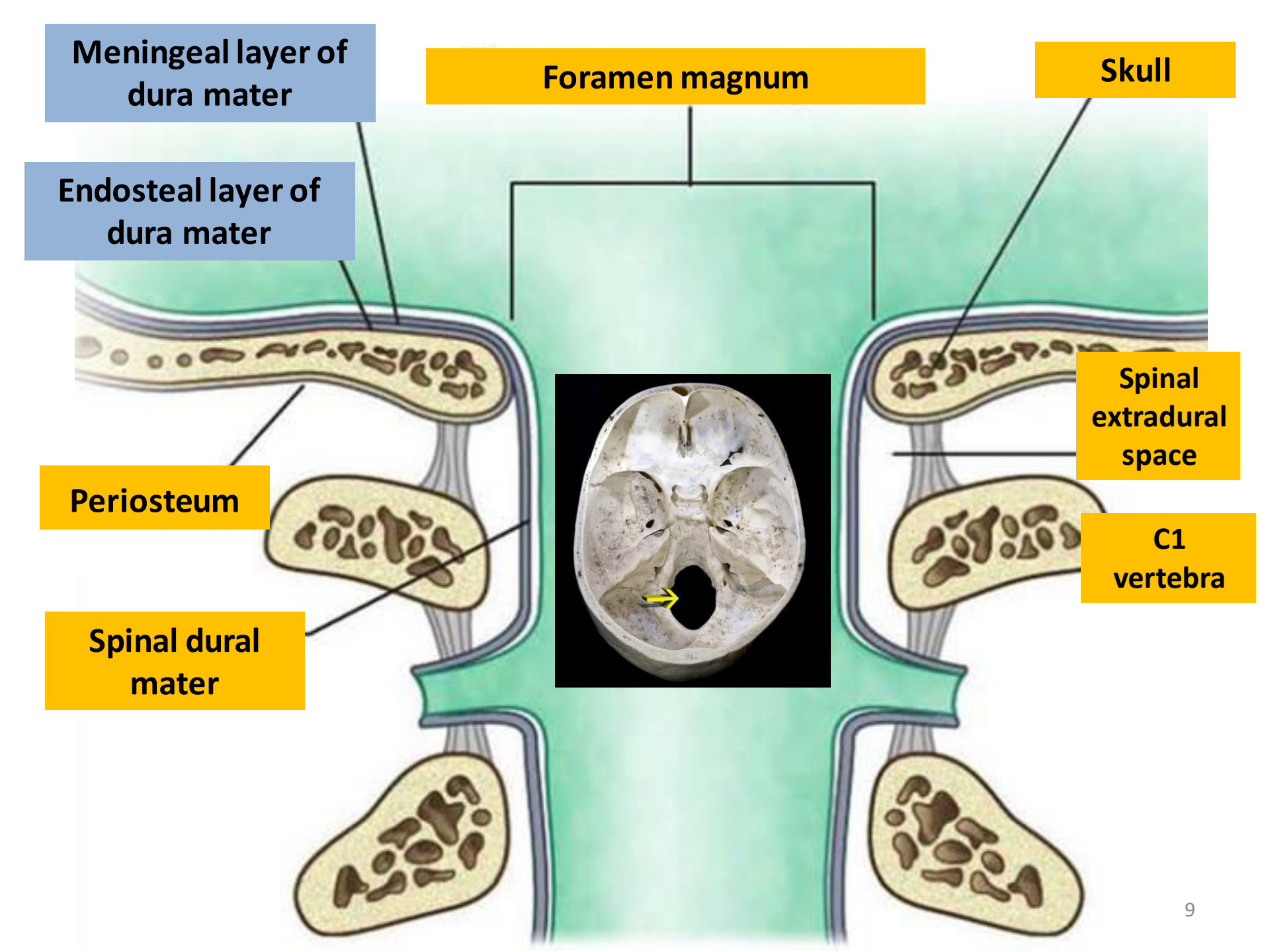
- The dura mater of the brain is composed of 2 layers :

Endosteal layer (outer) :

- Lines the inner surface of the skull
- At the foramen magnum, it does not become continuous with the dura mater of the spinal cord
- Continuous with the periosteum on the outside of the skull bones around the margins of all the foramina in the skull

Meningeal layer (inner) :

- Dura mater proper → dense, strong fibrous membrane
- Continuous through the foramen magnum with the dura mater of the spinal cord
- It provides tubular sheaths for the cranial nerves as the latter pass through the foramina in the skull.


Meningeal layer of dura mater
Foramen magnum
Skull
Endosteal layer of dura mater
Spinal extradural space
Periosteum
C1 vertebra
Spinal dural mater

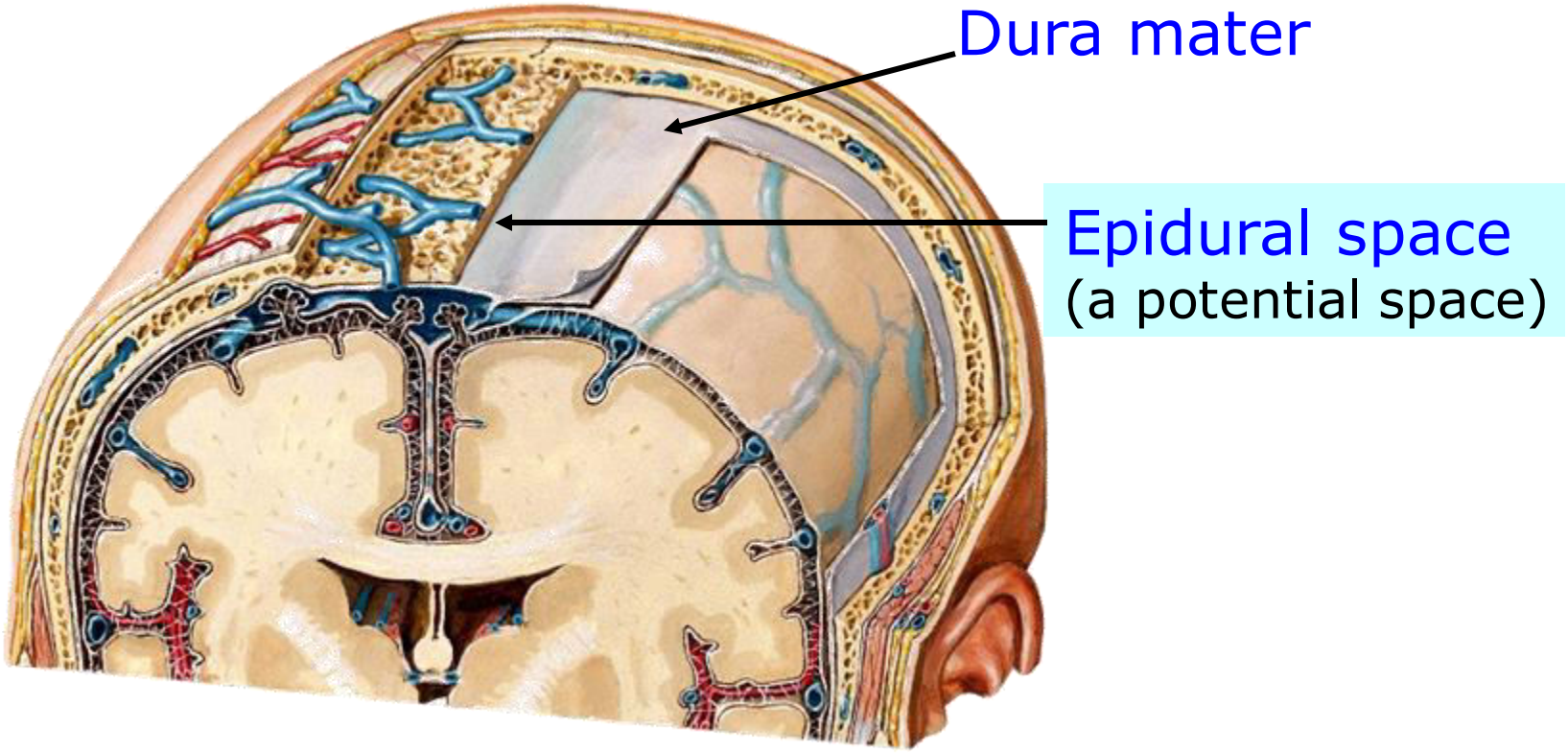
Meninges : Dura mater

- These 2 layers are closely held together except at dura venous sinuses

- Dura mater of spinal cord is single layer – consists of **meningeal layer** only
  - Spinal dura extends down till lower border of 2nd sacral vertebra

Meninges : Dura mater

- Between the dura mater and the bone of the skull/vertebrae is a space called epidural space
  - It is a **potential** space between the dura and skull but a **real** space between the spinal dura and vertebrae surrounding the spinal cord

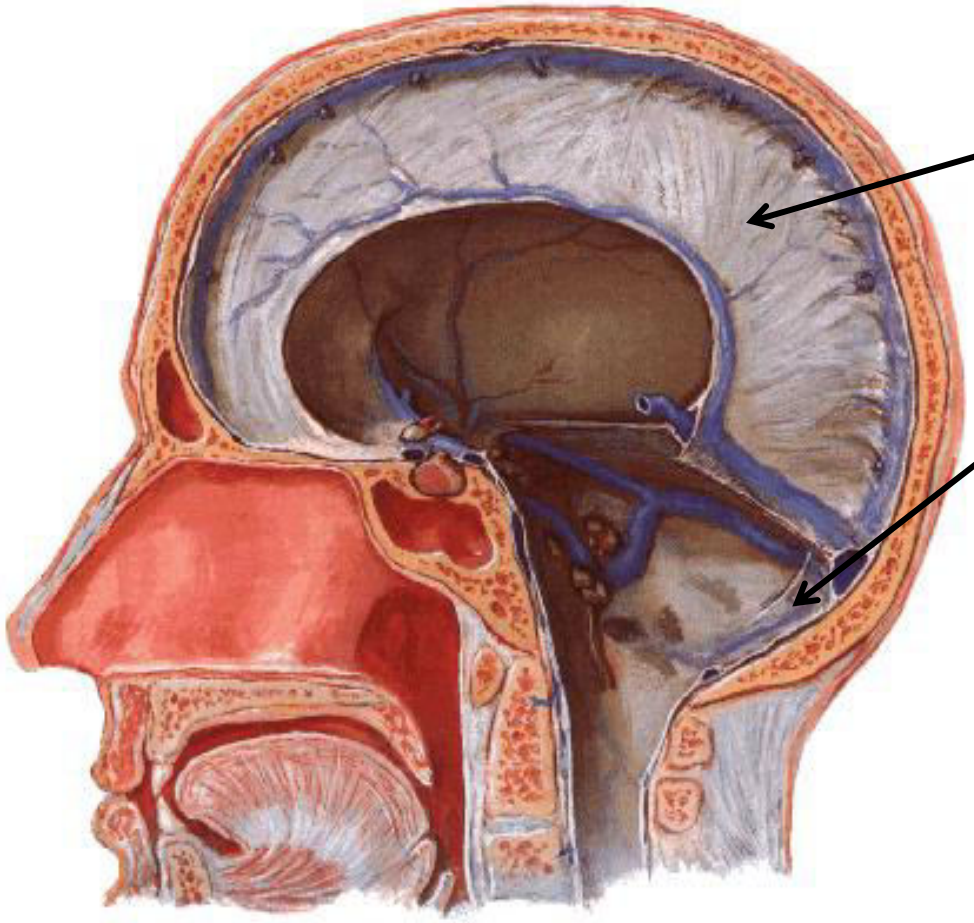


Dural folds

- Meningeal layer sends inward four septa (dural folds) , which divide the cranial cavity into freely communicating spaces

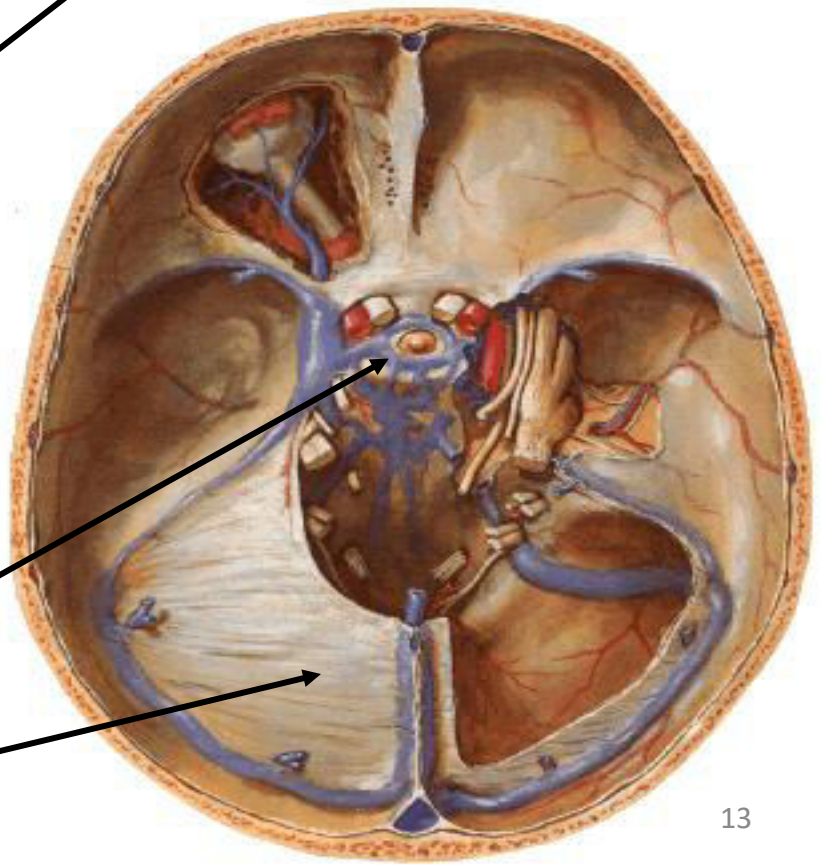
- The function of these septa is to restrict the displacement of the brain associated with acceleration and deceleration, when the head is moving

Dural folds



Falx cerebri

Falx cerebelli

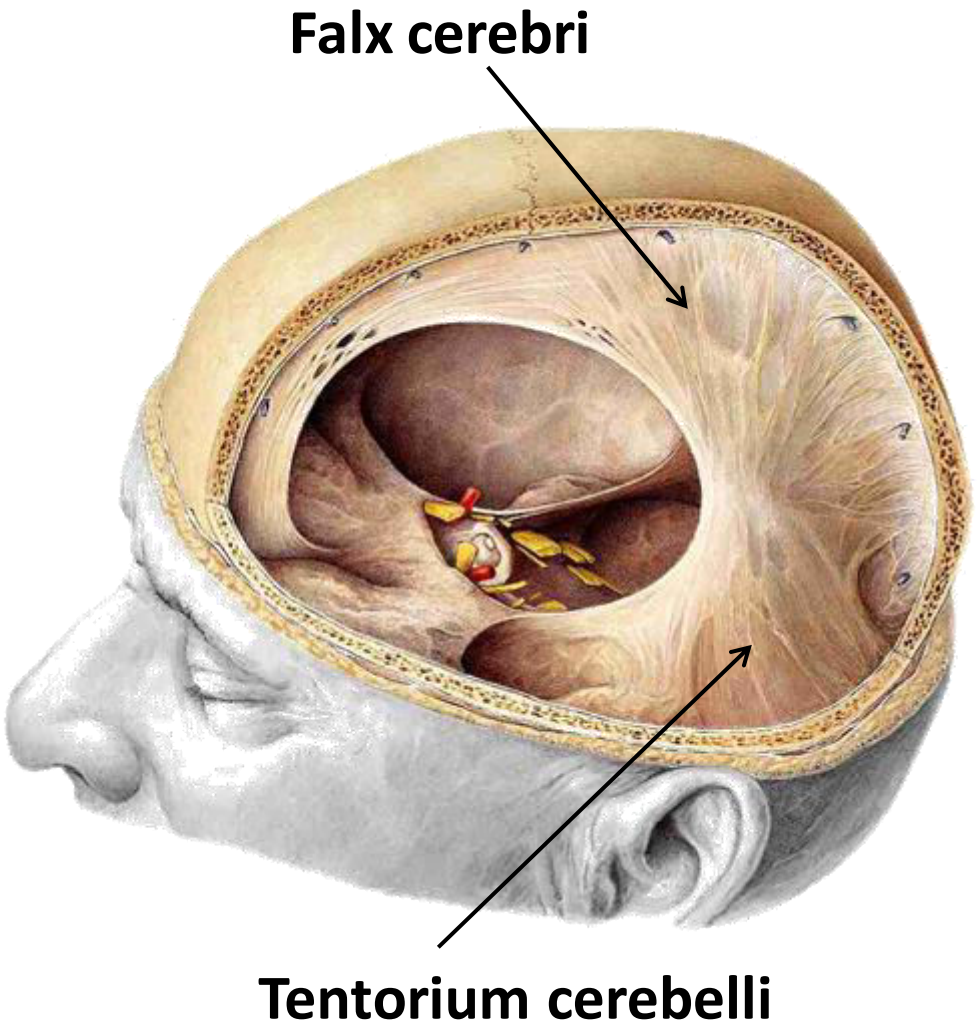


Diagphragma sellae

Tentorium cerebelli

Dural folds : (1) Falx cerebri

- Sickle-shaped downward projection of meningeal dura mater
- Passes between the two cerebral hemispheres
- Attachment :
  - Anterior : crista galli of the ethmoid bone and frontal crest of the frontal bone.
  - Posteriorly : attached to and blends with the tentorium cerebelli.



Dural folds : (1) Falx cerebri

- Enclosed 3 structures:

1) Superior sagittal sinus

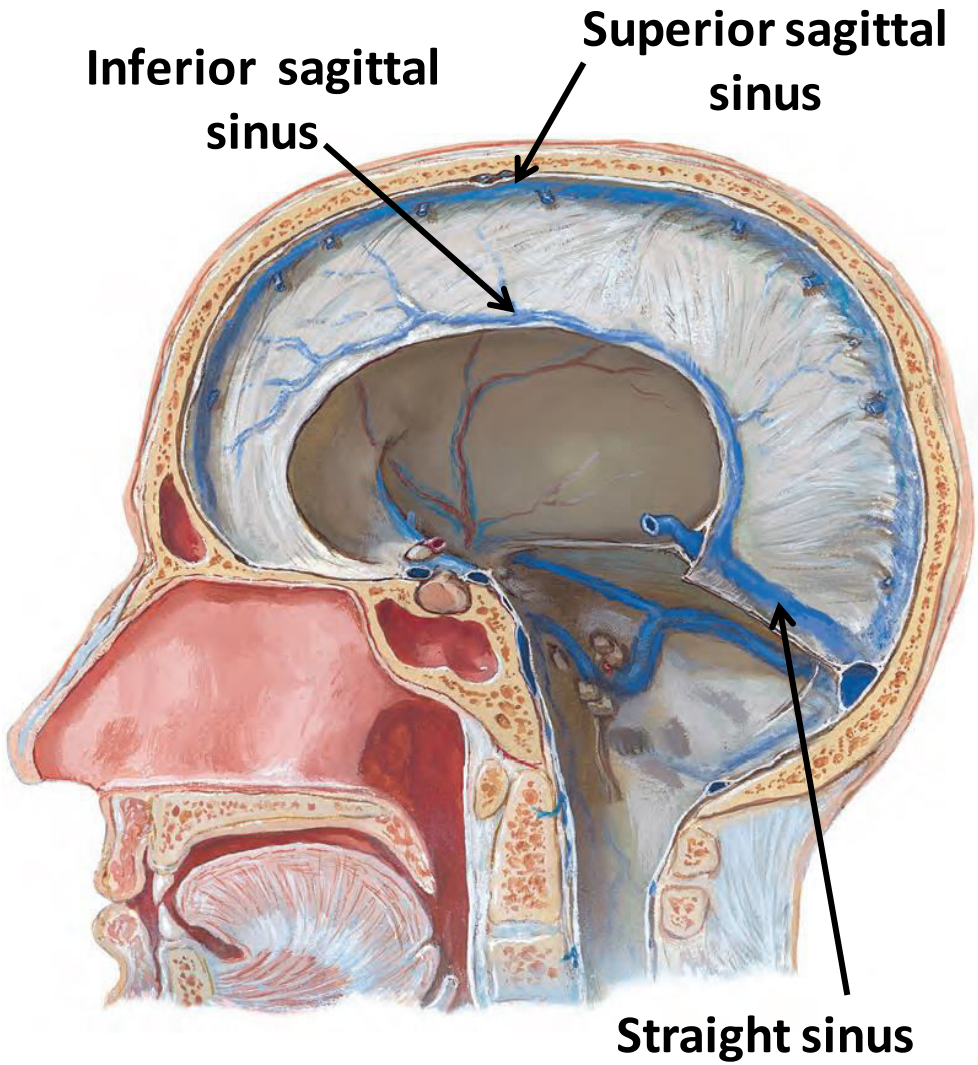
- run in its upper fixed margin

2) Inferior sagittal sinus

-runs in its lower concave free margin

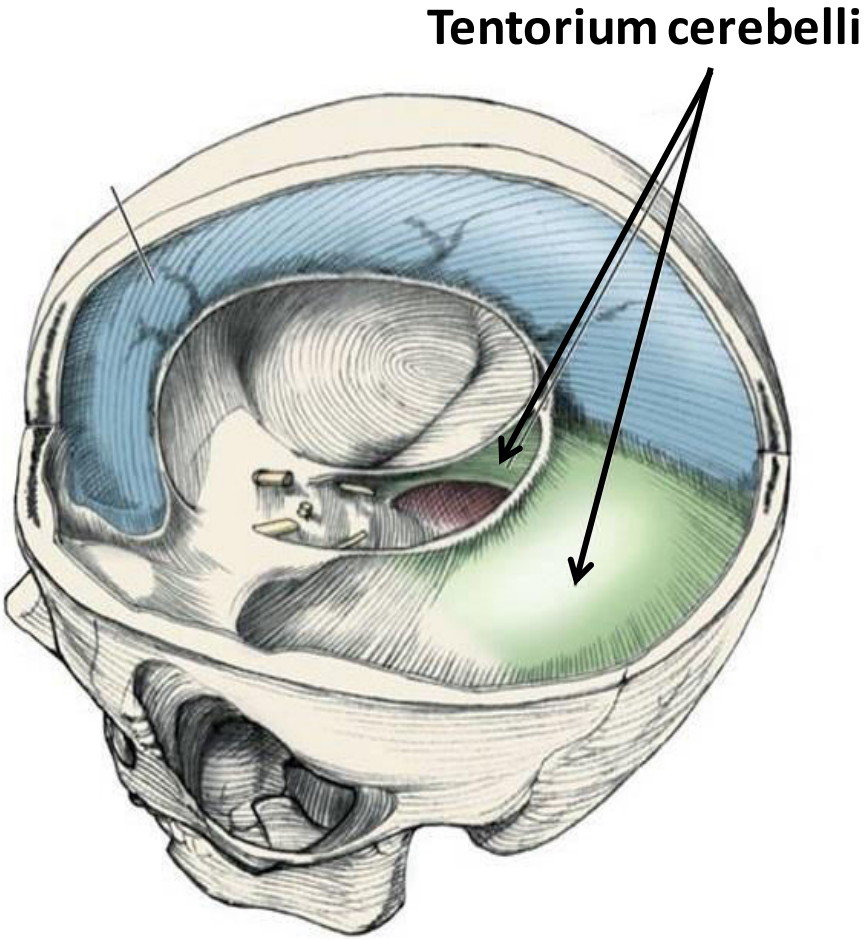
3) Straight sinus

-along its attachment to the tentorium cerebelli



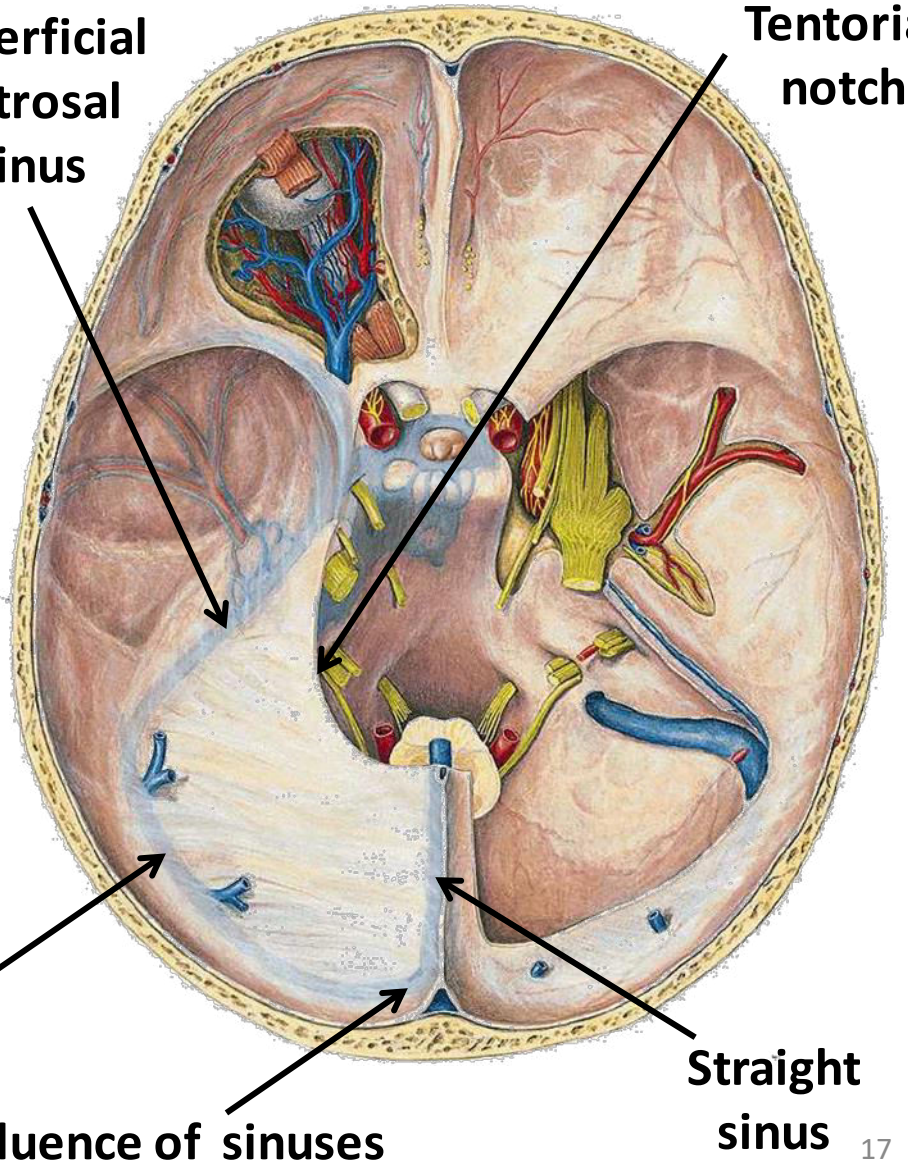
Dural folds : (2) Tentorium cerebelli

- Crescent-shaped fold of the dura mater that forms the roof for posterior cranial fossa
- Separates the cerebellum and occipital lobe
- Attachment :
  - Anterior : anterior and posterior clinoid processes
  - Posterior : to the occipital bone along the grooves for the transverse sinuses
  - Lateral : superior border of the petrous part of the temporal bone



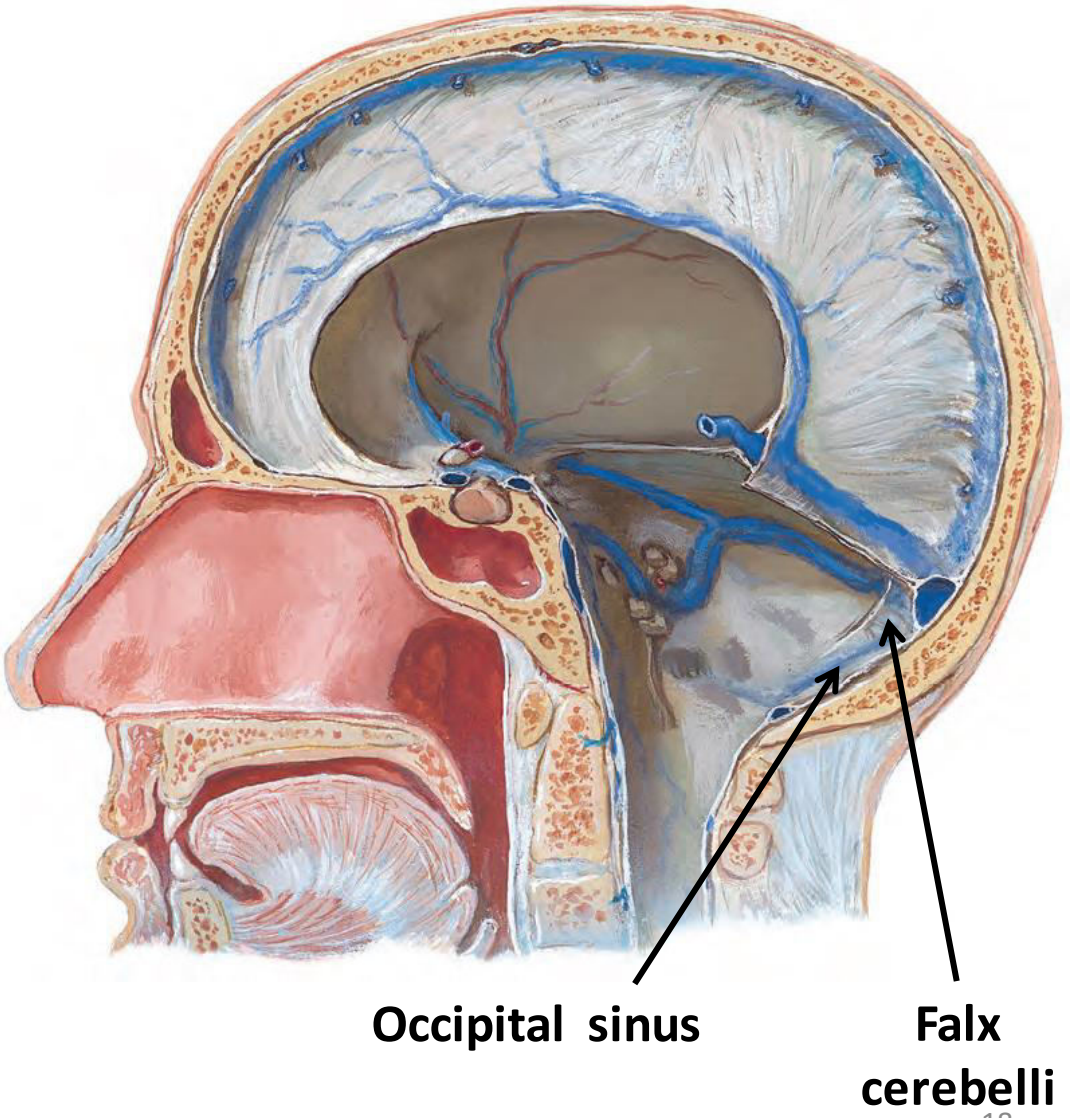
Dural folds : (2) Tentorium cerebelli

- Its free border is concave & is called **tentorial notch** for the passage of the midbrain
- Is related to the straight sinus, transverse sinus, superior petrosal sinus & confluence of sinuses



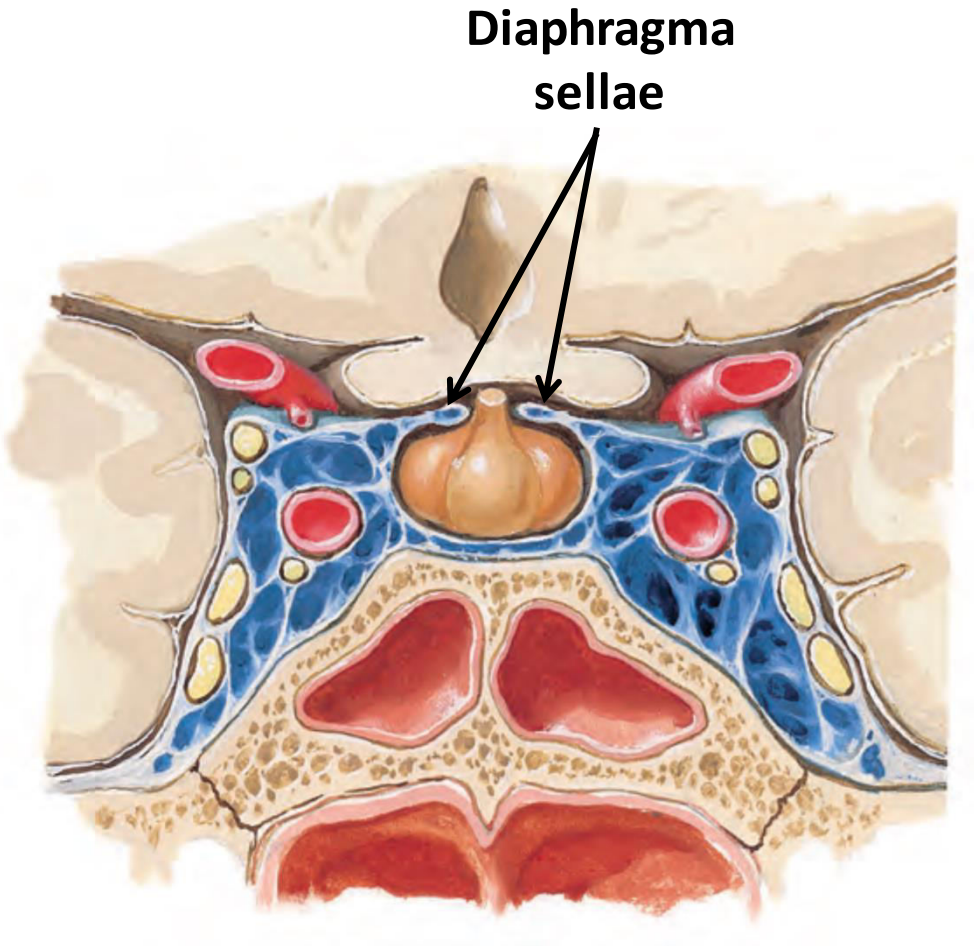
Dural folds : (3) Falx cerebelli

- Small, sickle-shaped fold of dura mater
- Attached to the internal occipital crest
- Located between the two cerebellar hemispheres
- Posterior fixed border contains the occipital sinus



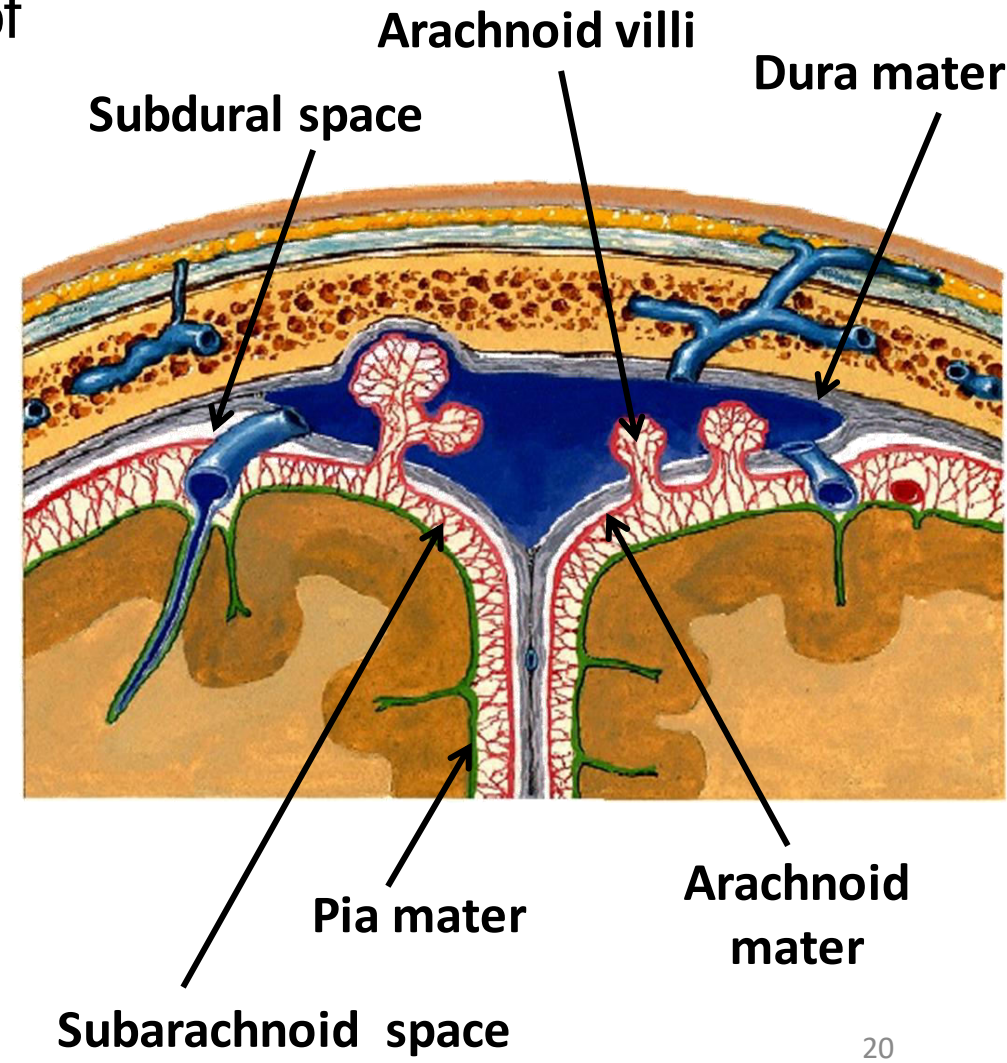
Dural folds : (4) Diaphragma sellae

- A small, circular fold of dura mater that forms the roof for the sella turcica
- A small opening in its center allows passage of the stalk of the pituitary gland



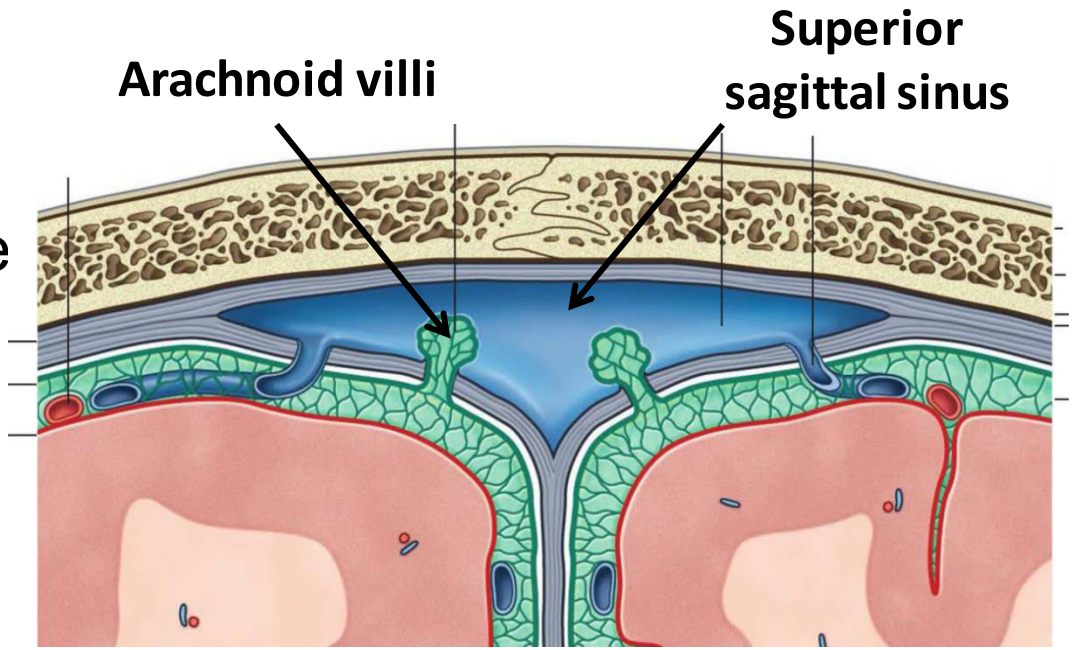
Meninges : Arachnoid mater

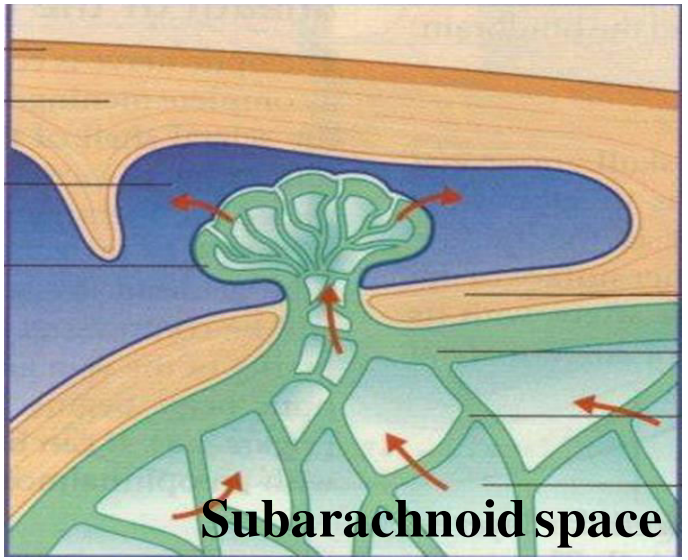
- Thin, avascular membrane that lines the inner surface of the dura mater
- Located between the dura and pia mater
  - Separated from dura by subdural space (a potential space)
  - Separated from pia by subarachnoid space (contain CSF)
- Arachnoid projects into the venous sinuses to form arachnoid villi.



Arachnoid villi

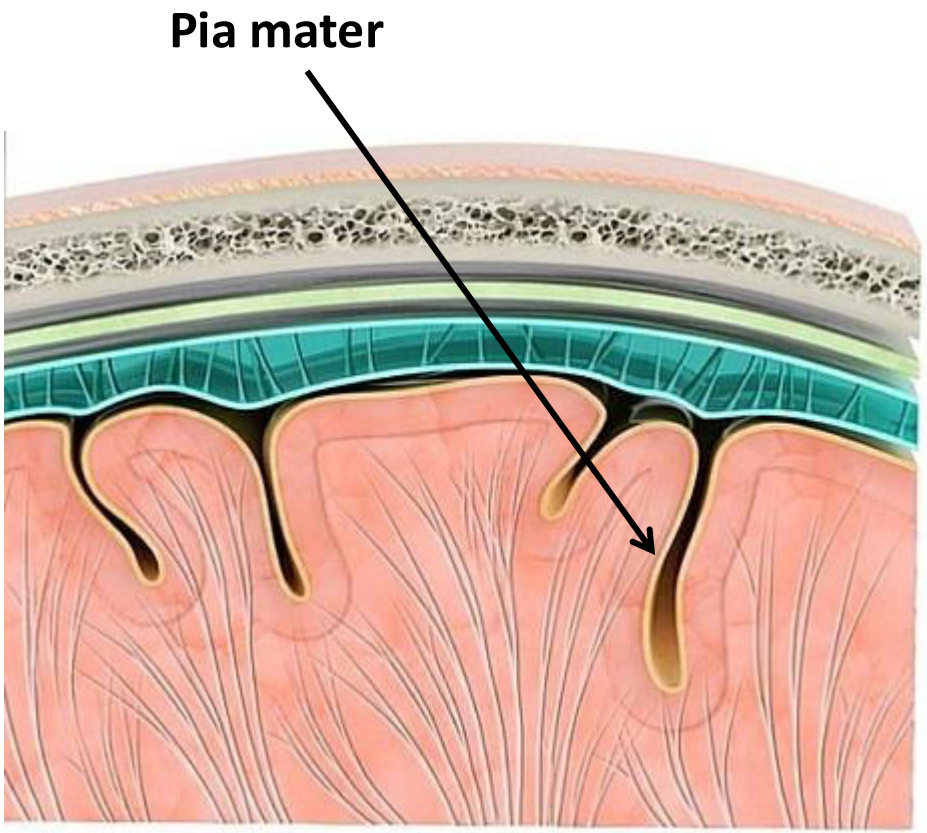
- Small specialized portion of arachnoid membrane
- Most numerous along the superior sagittal sinus
- Collection of arachnoid villi are called **arachnoid granulations**
- Sites where the cerebrospinal fluid diffuses into the bloodstream
- The space in the center of each villus is continuous with subarachnoid space





Meninges : Pia mater

- A vascular membrane covered by flattened mesothelial cells
- Covering the gyri and descending into the deepest sulci
- The cerebral arteries entering the substance of the brain carry a sheath of pia with them
- Forms the **tela choroidea** of the roof of the third and fourth ventricles of the brain
- Fuses with the **ependyma** to form the choroid plexuses in the lateral, third, and fourth ventricles of the brain



What is tela choroidea ?

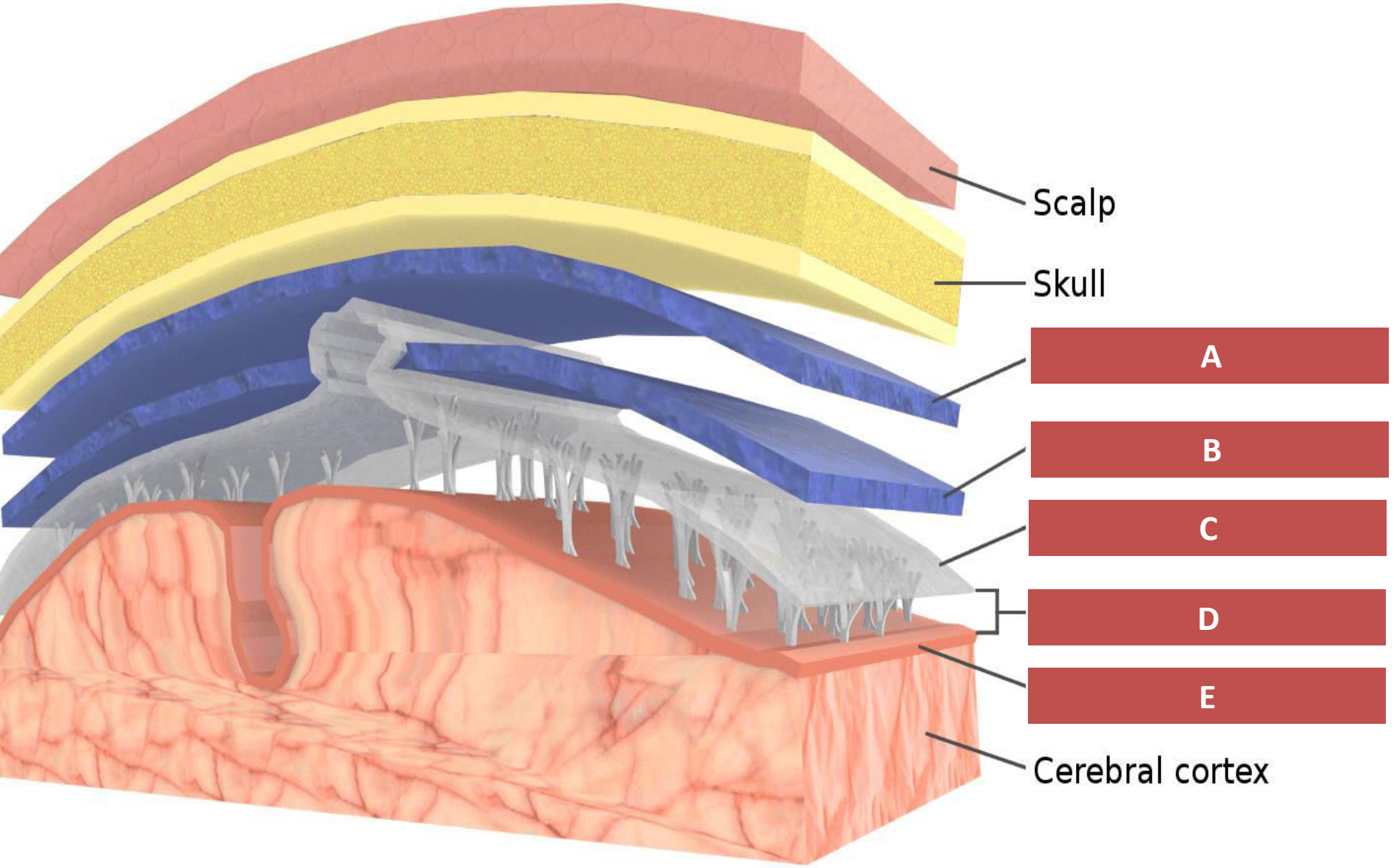
Spaces between meninges

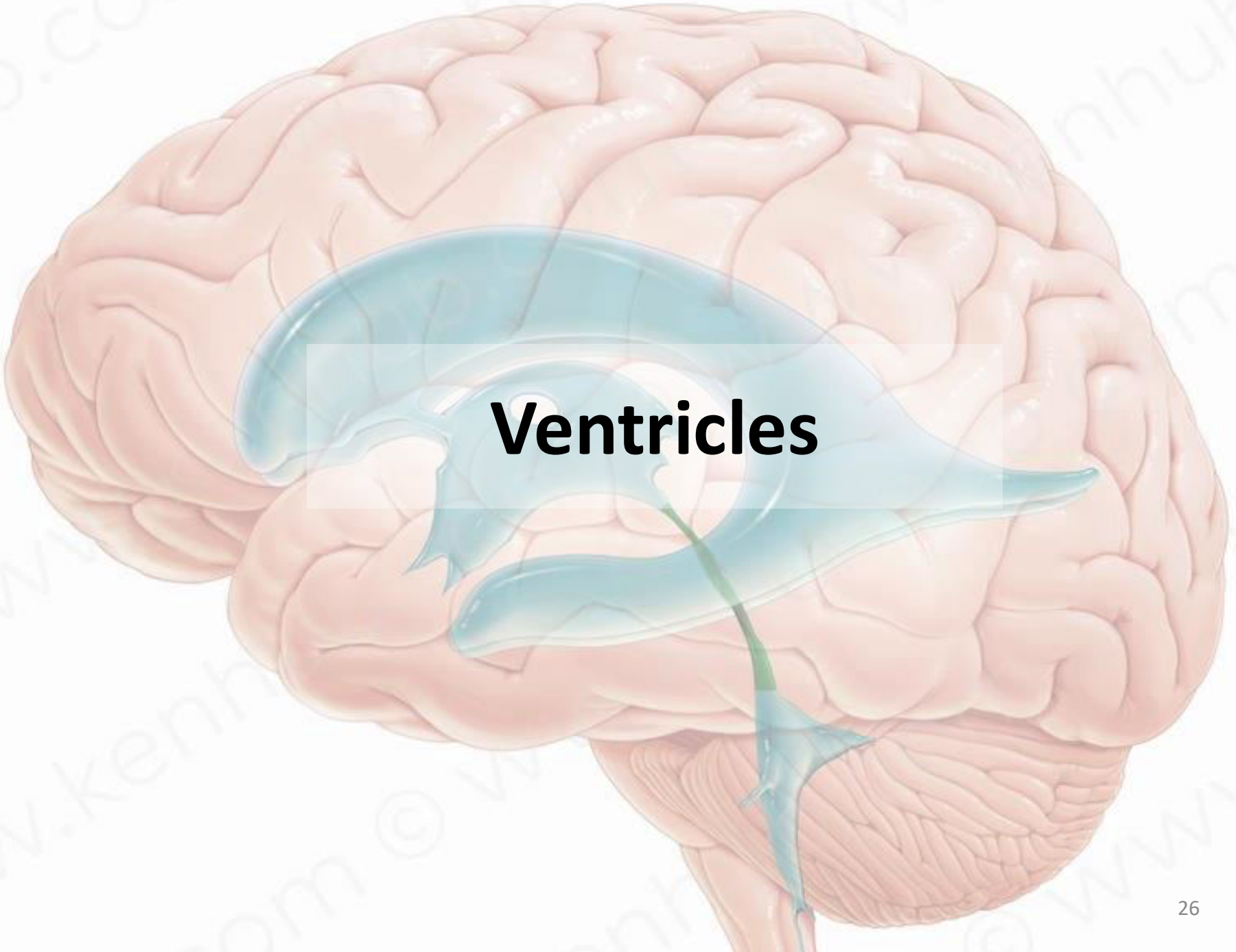
Space	Location	Content
Epidural	Between dura and bony skull & vertebrae	Cranial epidural is a potential space Spinal epidural contains fat tissue & venous plexus
Subdural	Between dura and arachnoid mater	Potential space
Subarachnoid space	Between arachnoid and pia maters	Contain CSF & large blood vessels

Differences of cranial & spinal meninges

DIFFERENCES	CRANIAL	SPINAL
SPACES:		
Epidural	*Potential*	*Present*
Subdural	*Potential*	*Potential*
SAS	*Present*	*Present*
DURA	*2 layers* *1) Outer endosteal* *2) Inner meningeal*	*1 layer* *Inner meningeal*
DURAL INFOLDINGS & SINUSES	*Present*	*Absent*
ARACHNOID	*same*	*same*
PIA MATER	*same*	*same*

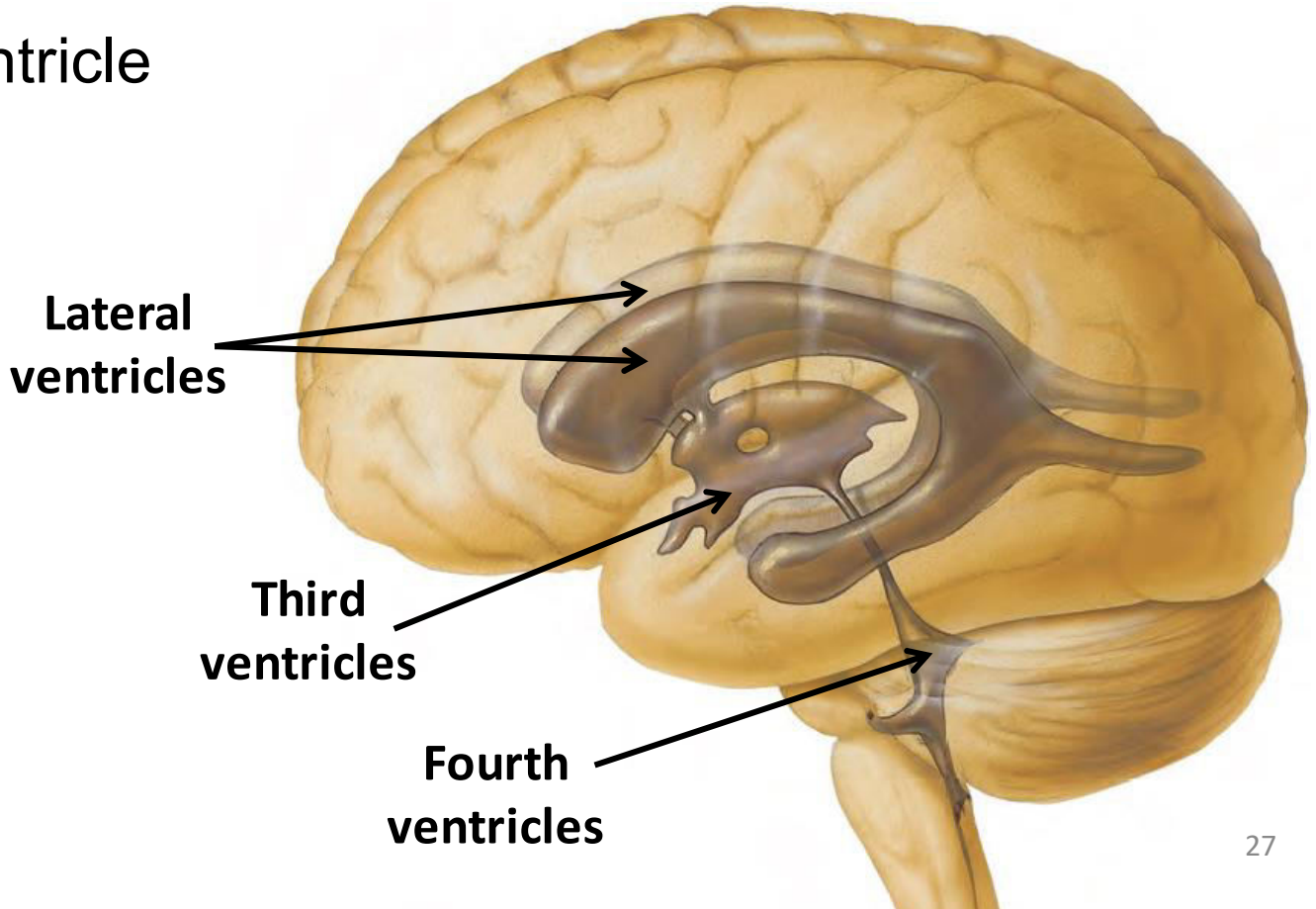
LET'S TAKE A BREAK QUIZ




Ventricles

Ventricles

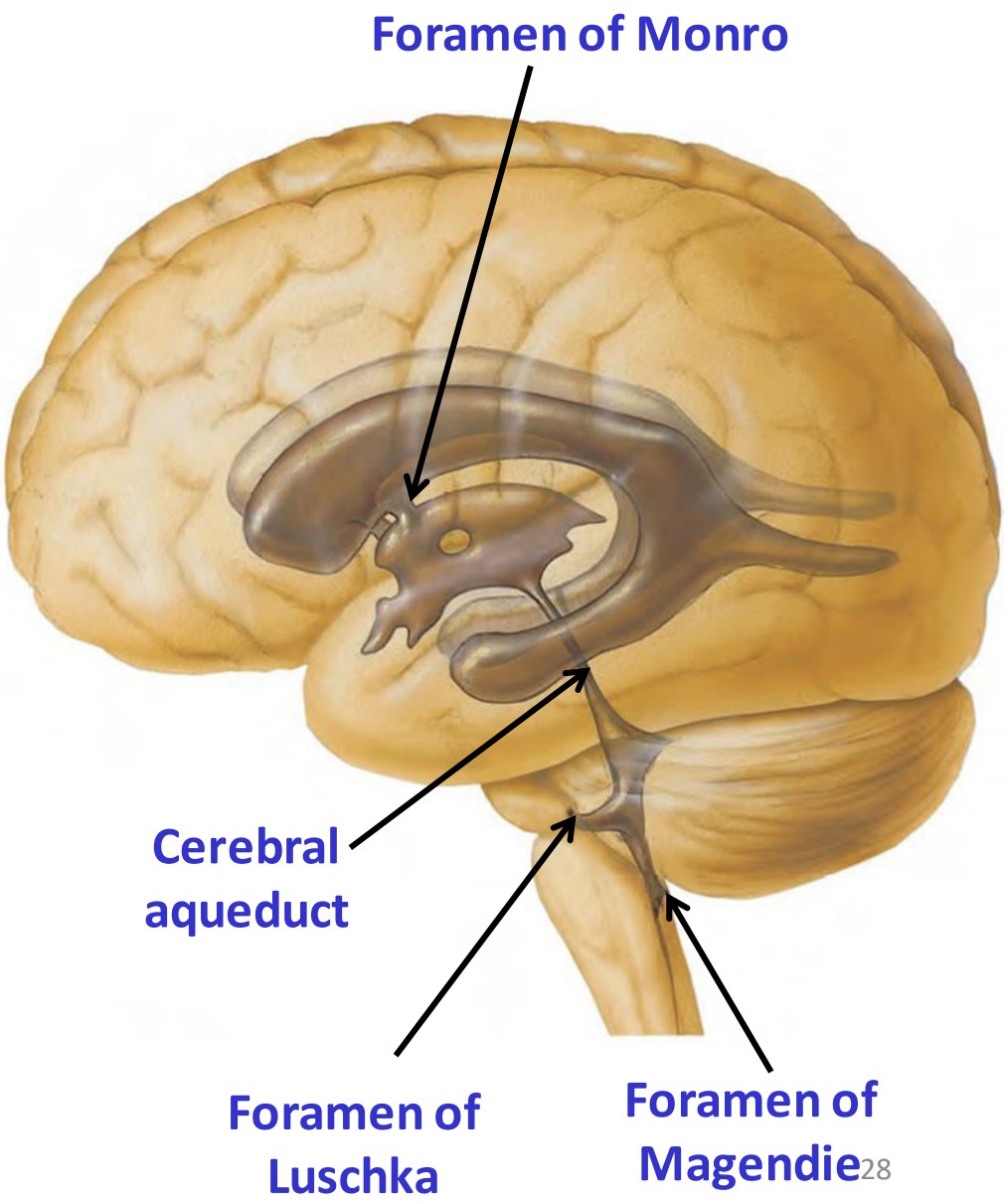
- Brain contains 4 cavities known as ventricles. They are
  1) Lateral ventricle (right & left)
  2) Third ventricle
  3) Fourth ventricle



Ventricles

These 4 ventricles communicate with each other and with subarachnoid space

- Lateral ventricle communicates with third ventricle through interventricular foramen (foramen of Monro)
- Third ventricle communicates with fourth ventricle through cerebral aqueduct (aqueduct of Sylvius)
- Fourth ventricle communicates with subarachnoid space through foramen of Magendie & foramen of Luschka



Lateral Ventricles

- C-shaped cavity that separated by the **septum pellucidum**
- Located in the right and left cerebral hemispheres
- Is subdivided into 5 segments

  1) Anterior (frontal) horn
  - lies anterior to interventricular foramen

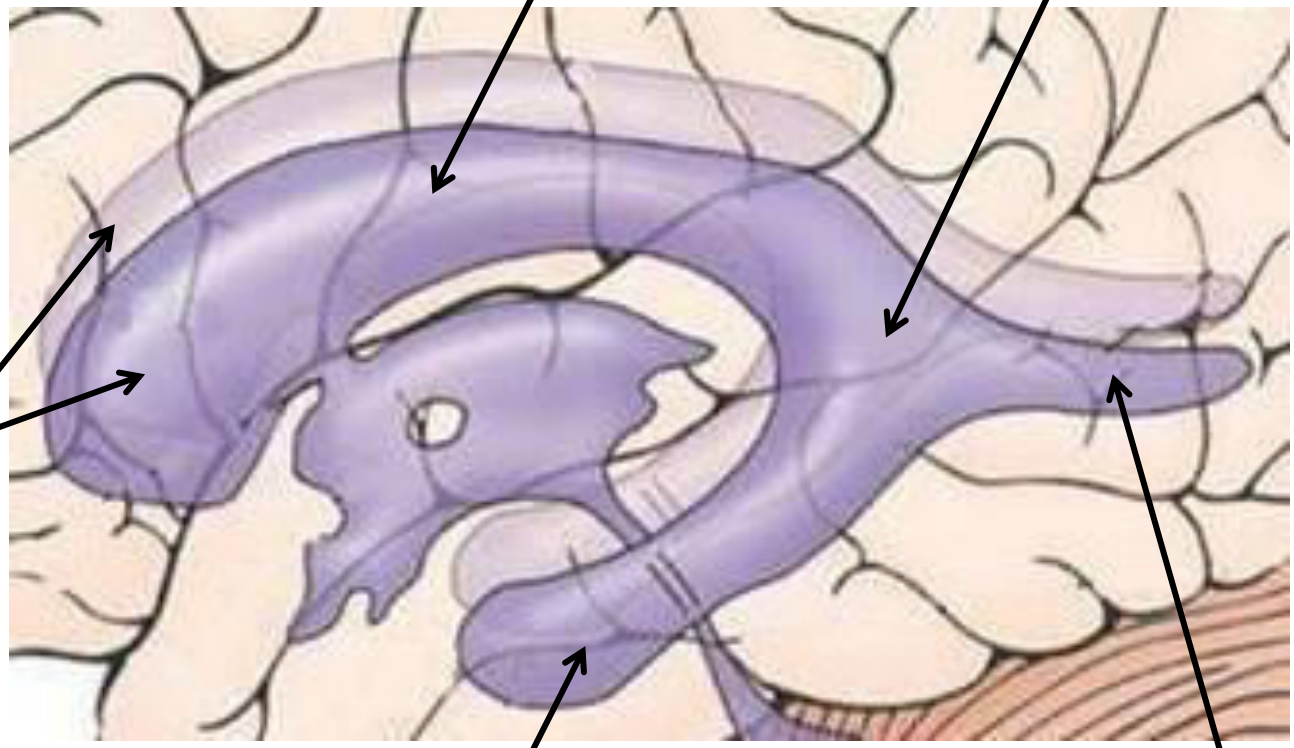
  2) Body
  - extend from intervenricular foremen to atrium

  3) Atrium (trigone)
  - is the area of confluence of the posterior part of the body with the posterior and inferior horns

  4) Posterior (occipital) horn
  - extends from atrium backward toward the occipital pole

  5) Inferior (temporal) horn
  - extends from atrium downward & forward into temporal lobe

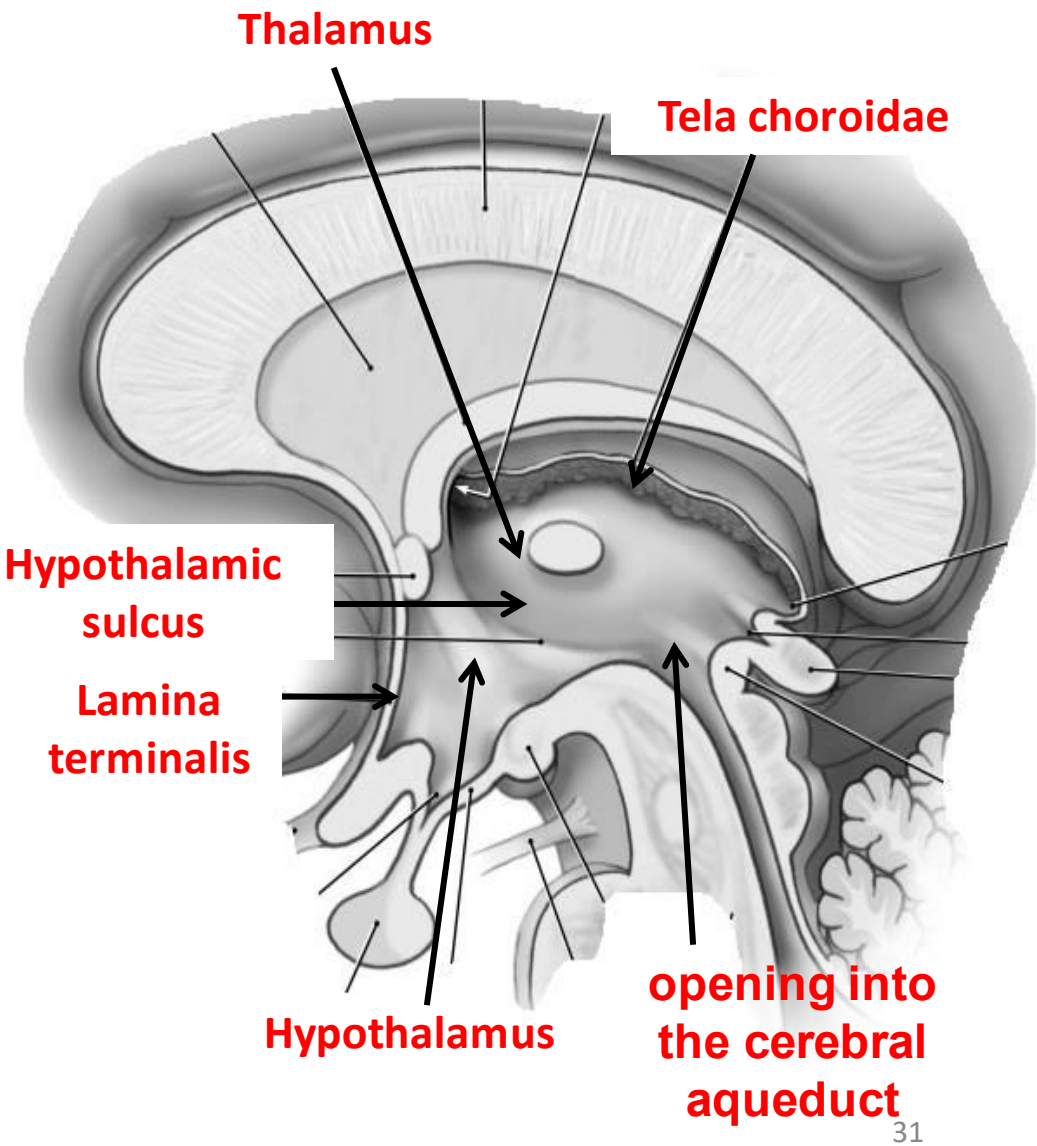
Lateral Ventricles



Third Ventricles

- Slit-like cavity located between two thalami and hypothalamus

- Boundaries :
  - Anterior wall : formed by lamina terminalis
  - Posterior wall :formed by the opening into the cerebral aqueduct
  - Lateral wall : formed by the medial surface of the thalamus superiorly and the hypothalamus inferiorly separated by hypothalamic sulcus
  - Superior wall : formed by tela choroidae

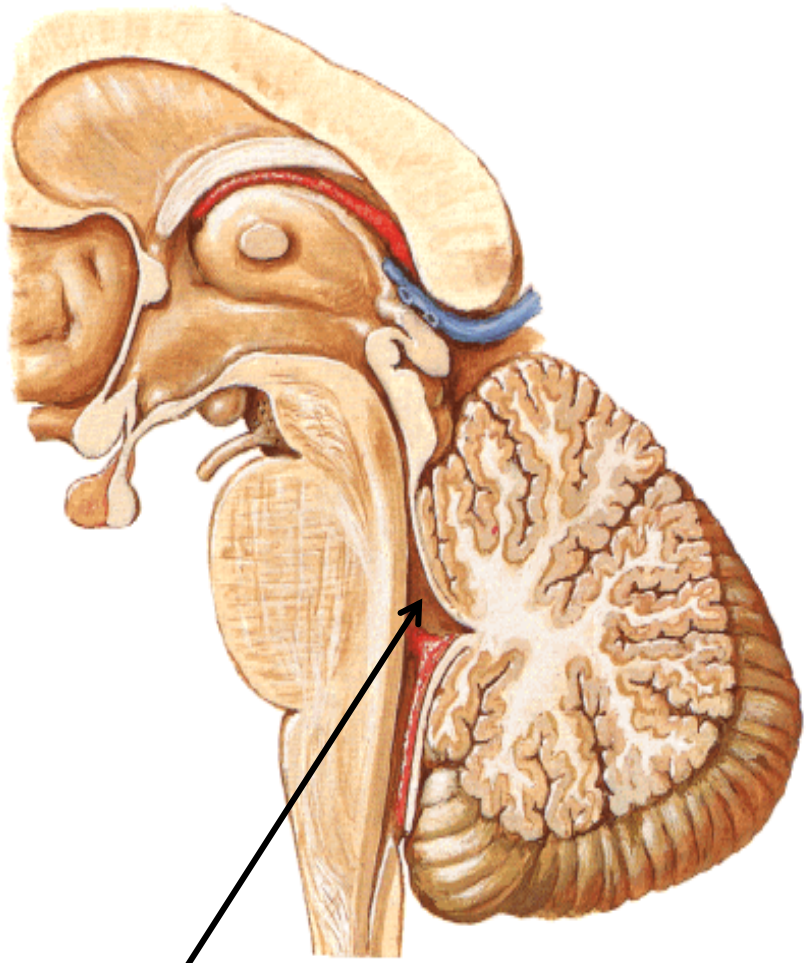


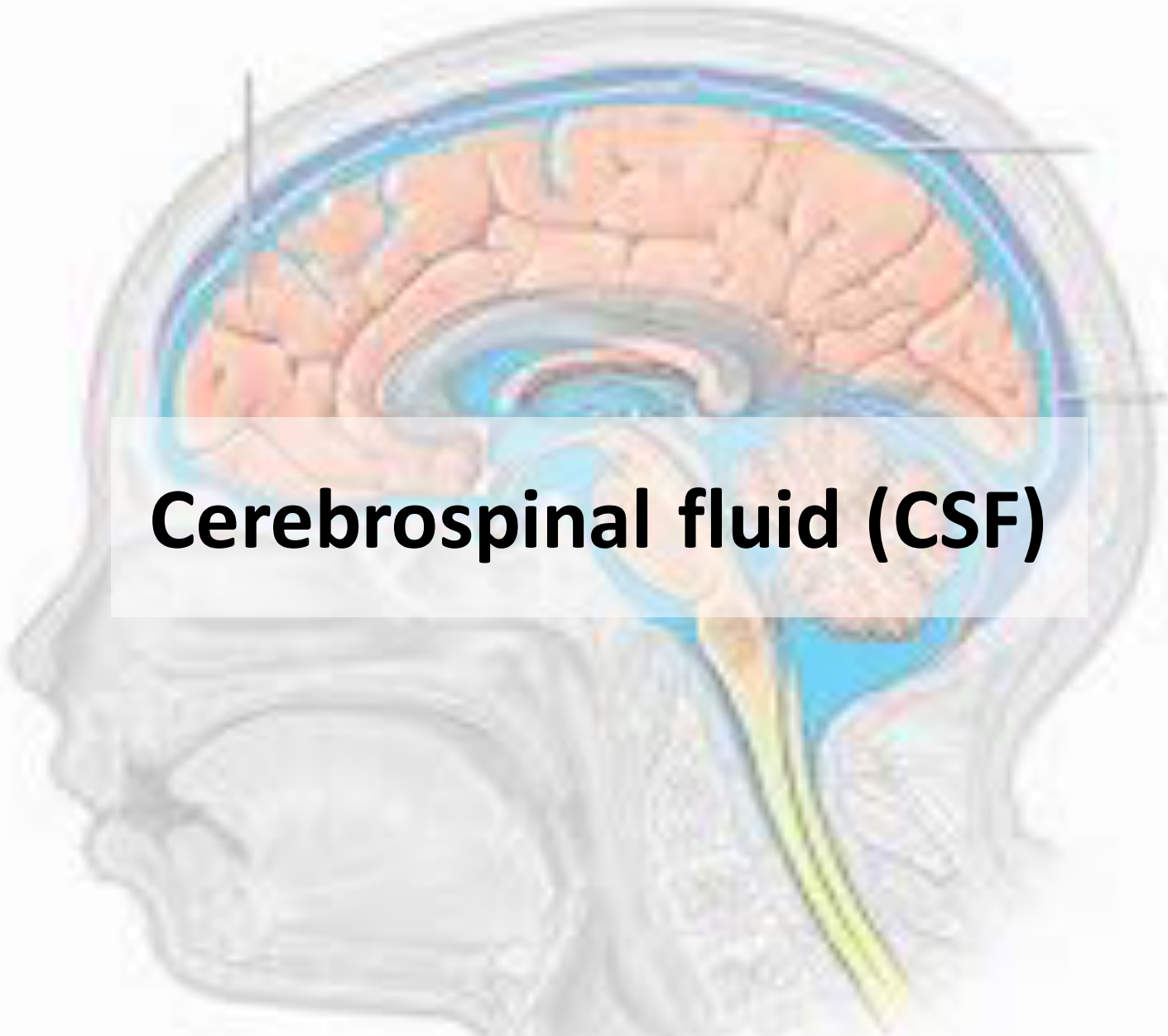
What is tela choroidae?

Thin, highly vascularized portion of the pia mater that give rise to the choroid plexus

Fourth Ventricles

- Irregularly shaped space lies between anterior surface of cerebellum and posterior surface of pons & medulla
- Communicates with subarachnoid space through 3 foramina – foramen of magendie & 2 foramen of luschka
- Continuous with the central canal of the spinal cord





Cerebrospinal fluid (CSF)

What is CSF?

- Clear, colorless fluid found in ventricles and subarachoid space of the brain/spinal cord
- Average volume in adult is 140 ml
  - most of the fluid (80 ml) in cranial subarachnoid space
  - 30 ml in ventricle, 30 ml in spinal subarachnoid space
- CSF composition differs slightly from plasma – has lower protein & glucose level& contain very few cells
- CSF is formed by choroid plexuses and reabsorbed by arachnoid villi and returned to the plasma

Function of CSF?

- Support the weight of the brain within the skull
  - weight of brain ± 1400 g in air, is reduced to ± 45 g when it is suspended in CSF
- Mechanical protection
  - dampening the effect of trauma (shock absorbing fluid)
- Chemical protection
  - provides a constant chemical environment for CNS
  - pH of the CSF is important in the control of breathing
- Circulation for the exchange of nutrients and waste products between the blood and nervous tissue

Formation of CSF

- The main source of CSF is from the choroid plexus in the ventricles

- Other minor source of CSF is
  1) Ependymal cells lining ventricles
  2) Extraventricular sites such as cerebral pial surface

- CSF is formed at a rate of 0.35 ml/min
  - 15-20 ml/hr
  - 500 ml/day
  - Total volume of CSF is renewed about 3 times a day

Location of choroid plexus

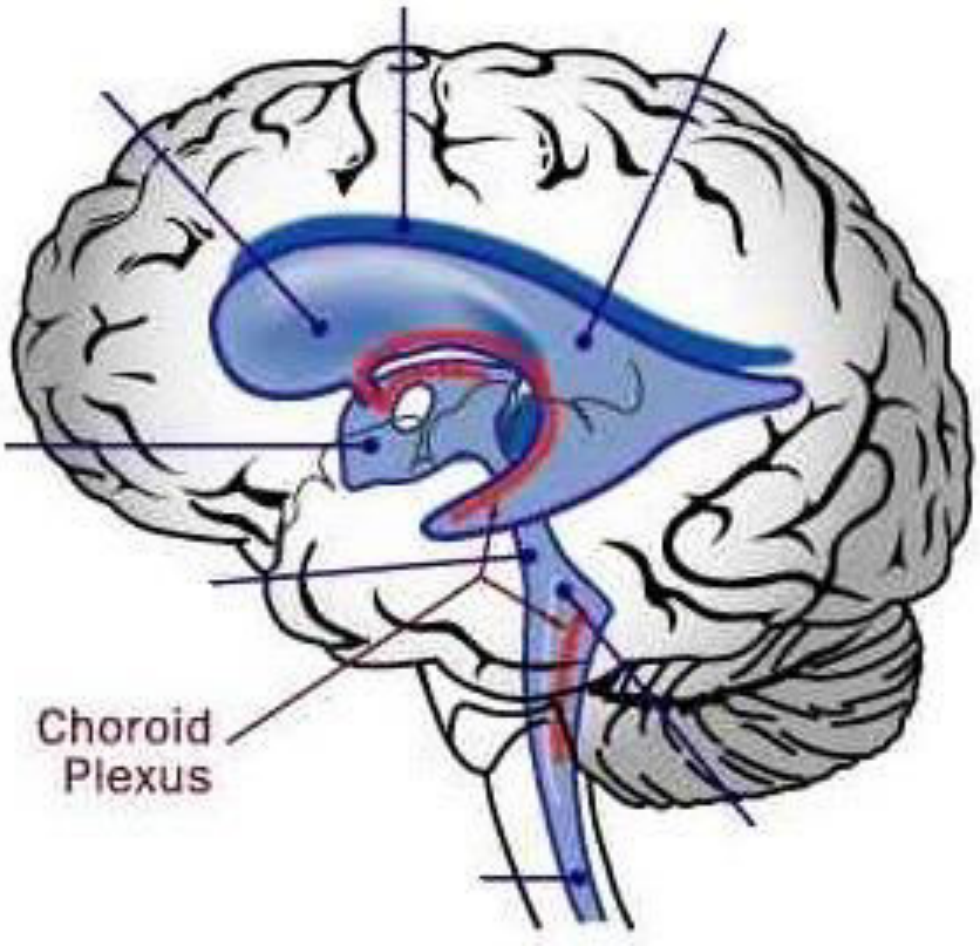
- Body, atrium and inferior horn of lateral ventricle

  (No choroid plexus in anterior & posterior horns)

- Roof of third ventricle

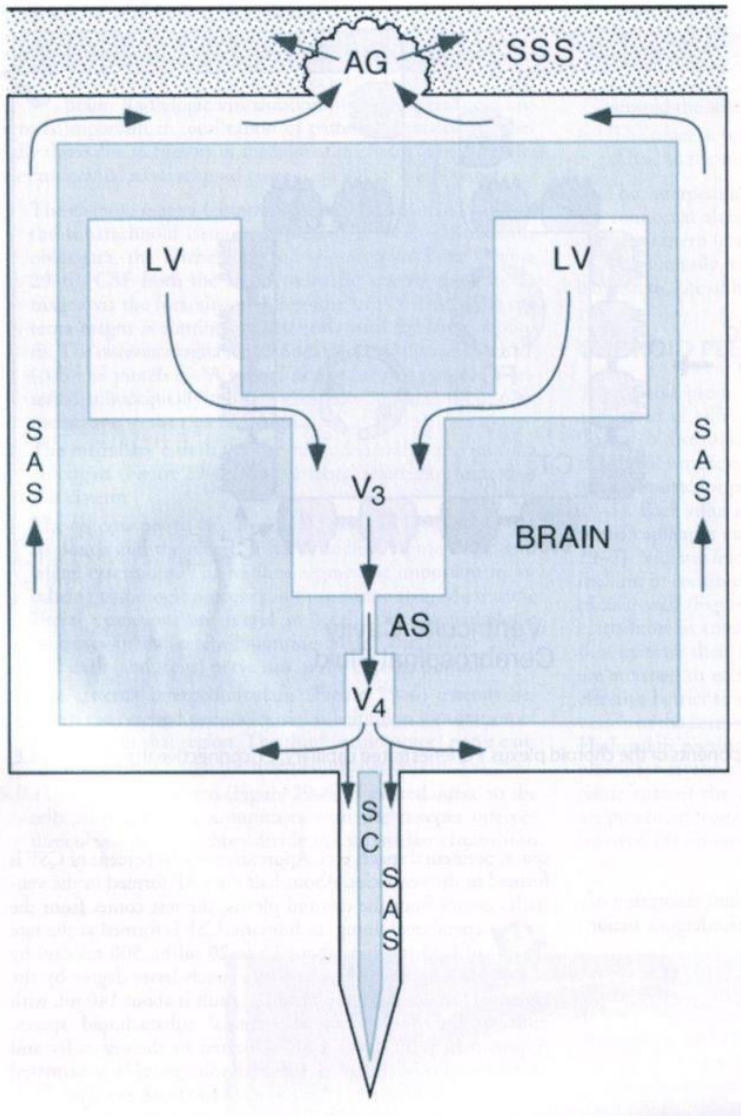
- Posterior part of roof of fourth ventricle

- Interventricular foramen

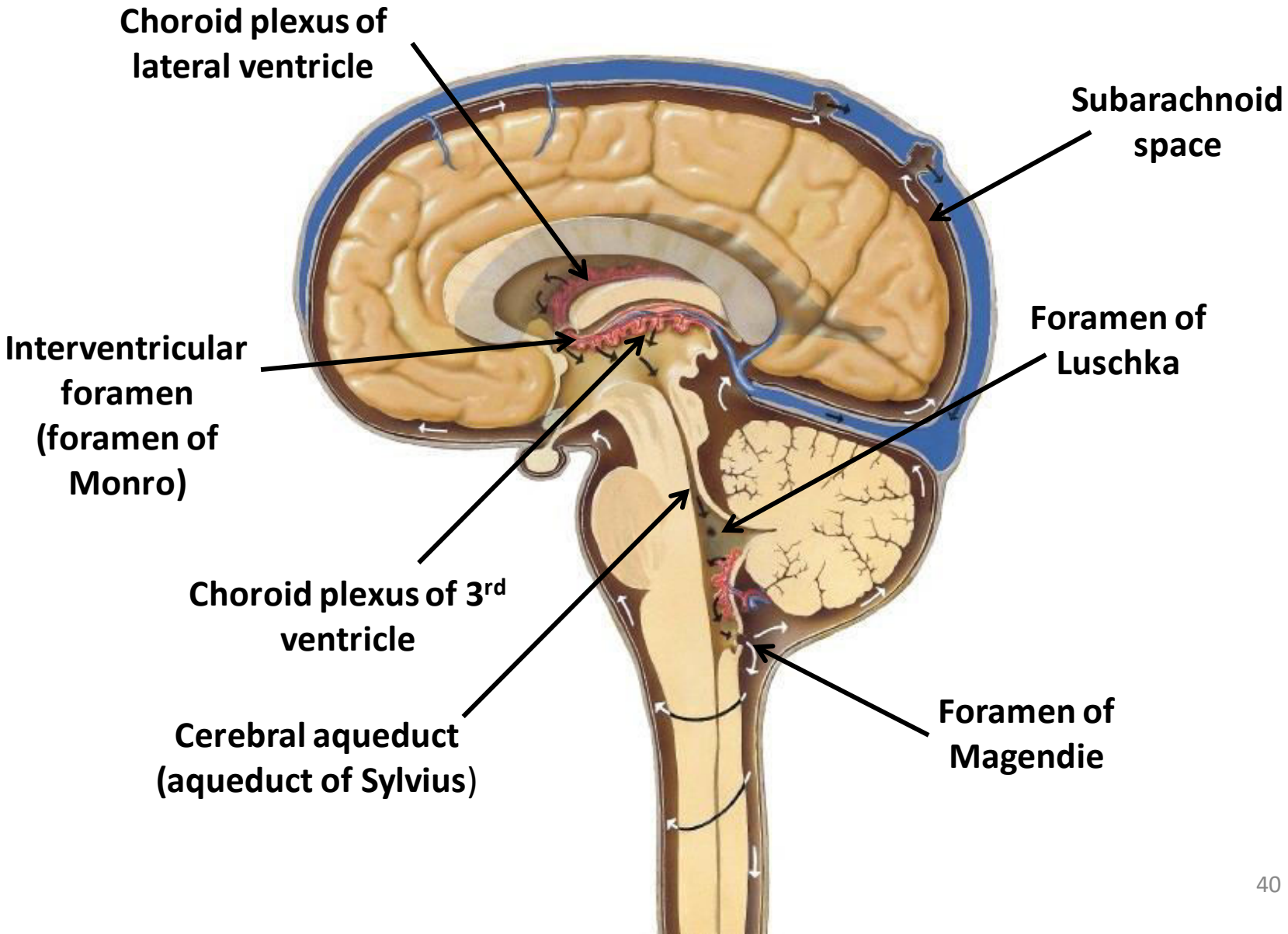


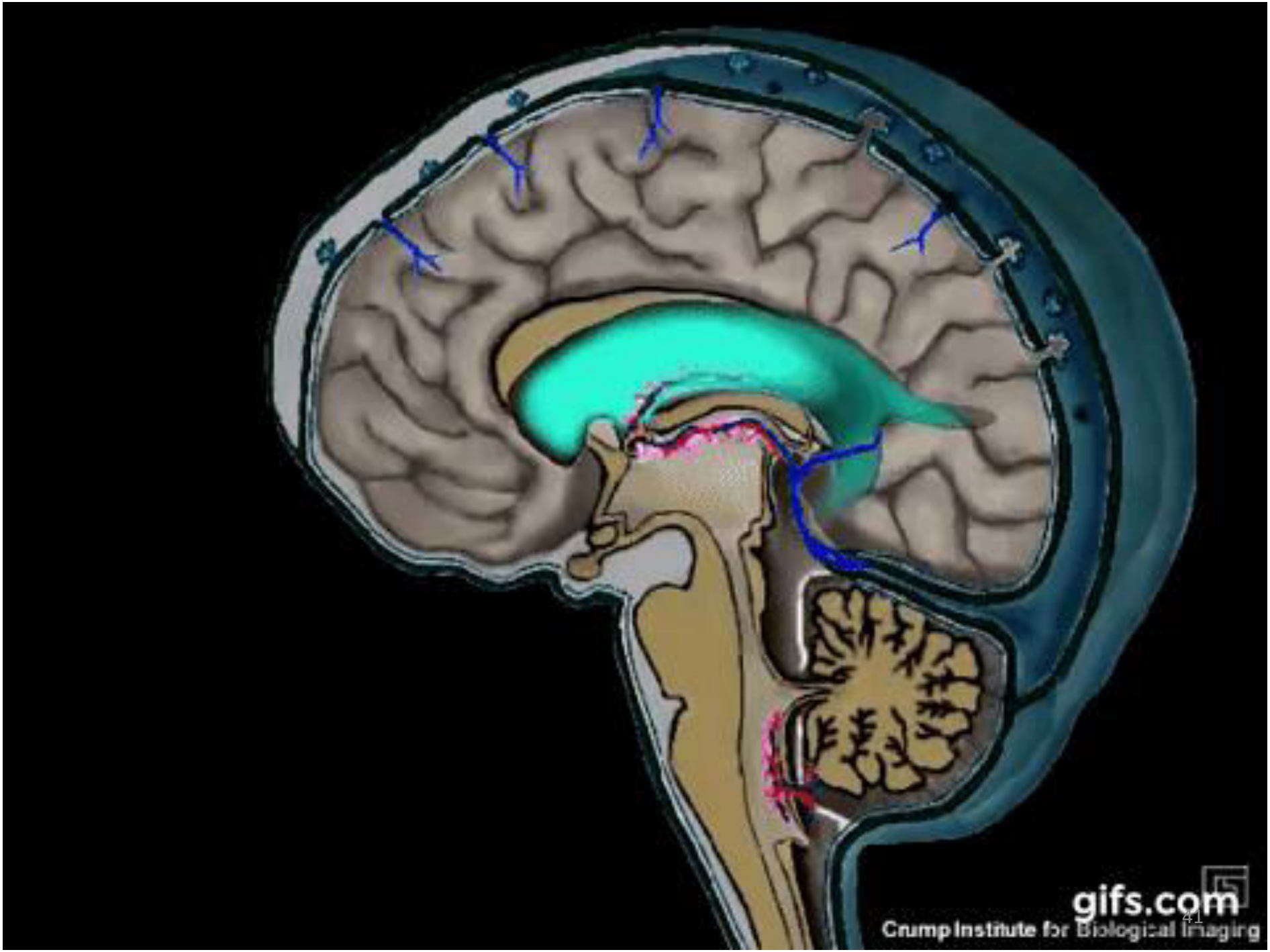
Circulation of CSF

- CSF produced by choroid plexus passes through ventricular system
  - From lateral ventricle to 3rd ventricle (foramen of Monro) and then to 4th ventricle (cerebral aqueduct)
- CSF exit fourth ventricle through foramen of Luschka and Magendie to enter subarachnoid space
- After passing through subarachnoid space, CSF reach arachnoid villi to be reabsorbed into venous system



Circulation of CSF

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Circulation of CSF

- 2 major factors influence the circulation of CSF through ventricles and subarachnoid space

  1**) Subtle pressure gradient differences** between the site of production and site of reabsorption

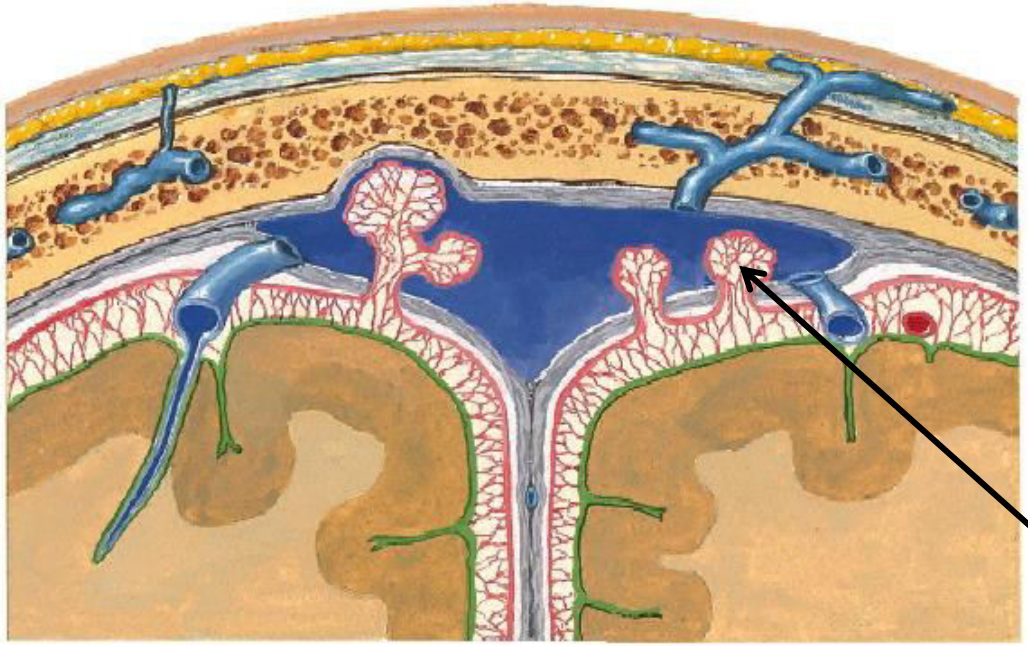
  2) **Mechanical factors** – pulsation of arteries in subarachnoid space and gentle movement of brain during normal activities

- CSF only move only from subarachnoid space into the venous sinus (because of **pressure gradient**)

- If pressure in the venous sinus exceeds that of subarachnoid space, the flow of CSF will slow or stop
  - But blood never flows from venous sinus into subarachnoid space

CSF Resorption

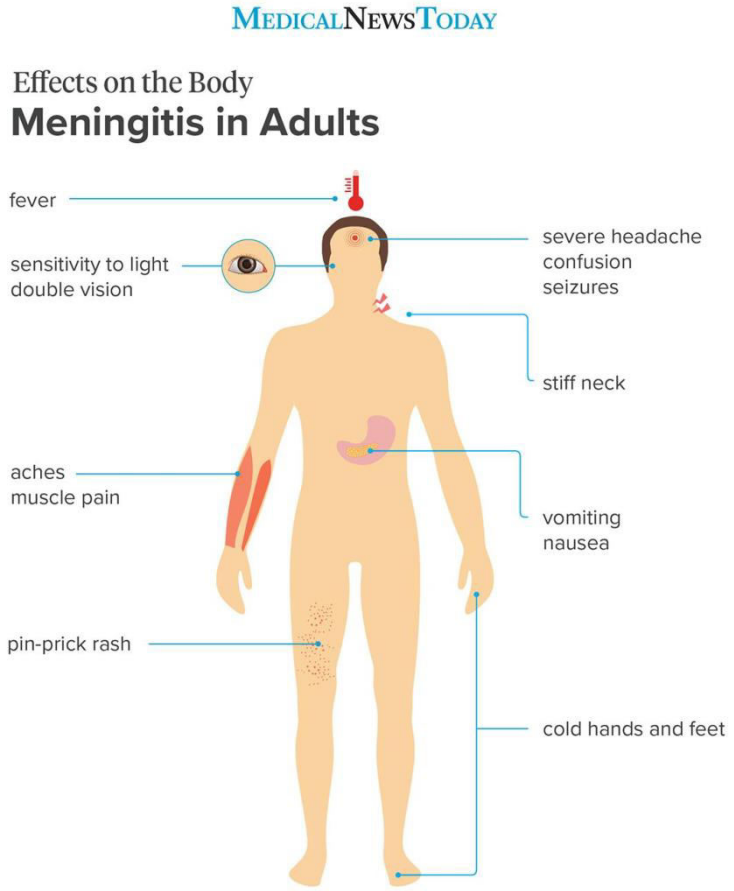
- Most CSF is reabsorbed through arachnoid villi
- Minor sites of reabsorption – ependyma of ventricle, arachnoid membrane, perineurial sheath of nerves



Clinical correlation

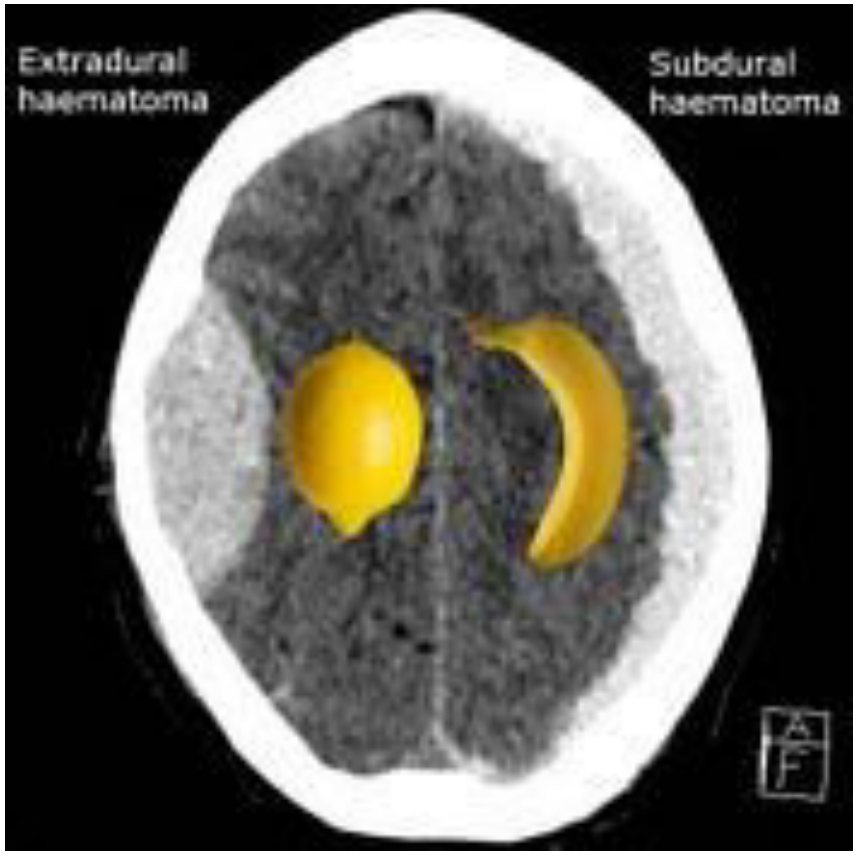
Meningitis

- A bacterial or viral inflammation of the meninges
- The symptoms include high fever and chills, severe painful and stiff neck, nausea and/or vomiting, and in later stages, sleepiness, confusion, and difficulty in waking up
- Meningitis has a high degree of morbidity and mortality, especially if not diagnosed properly.

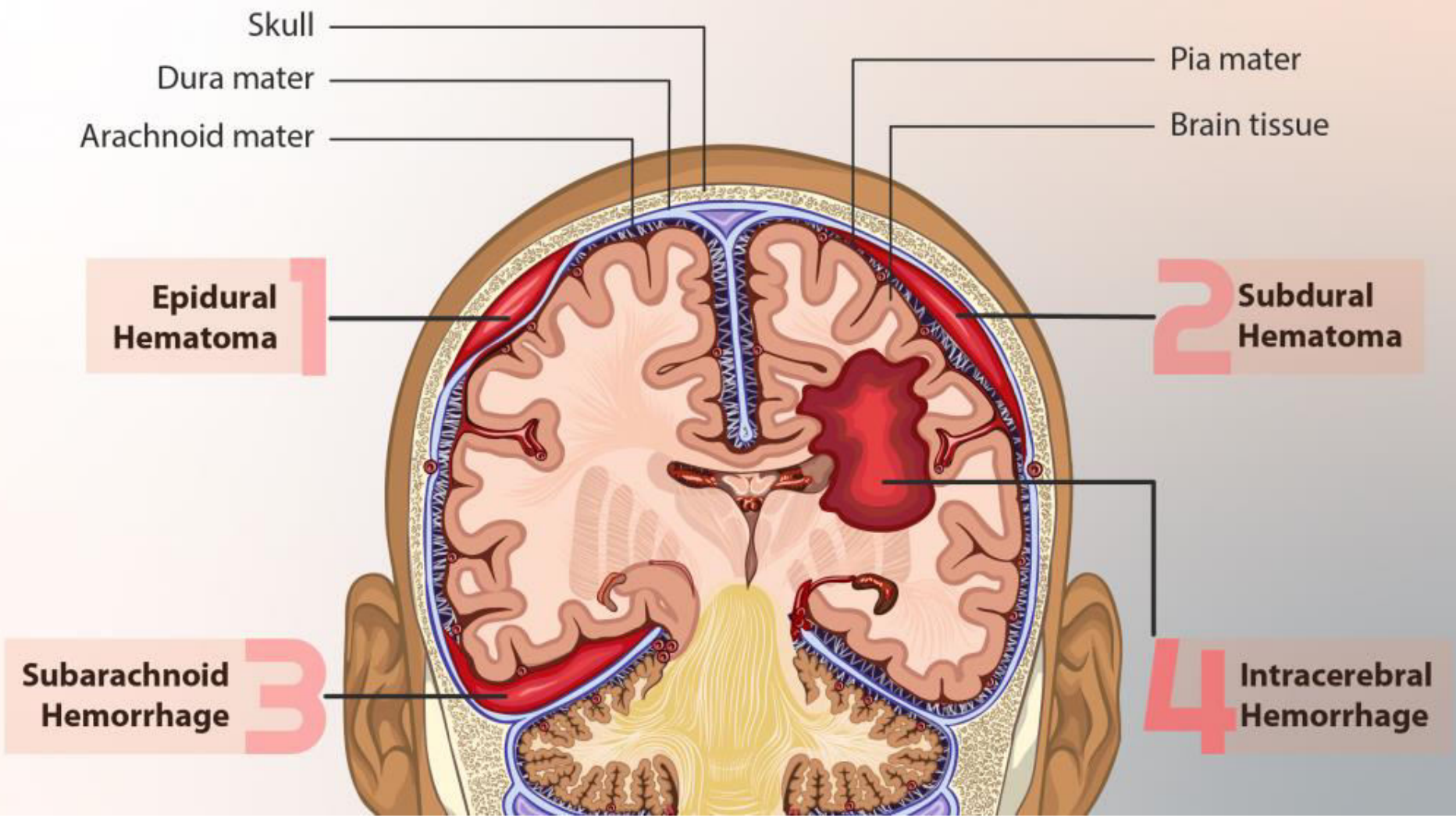


Clinical correlation

Extradural, subdural & subarachnoid hemorrhage



Types of brain hemorrhage



Clinical correlation

Hydrocephalus

- The constant production of CSF by the choroid plexus must be mirrored by its constant resorption by the arachnoid villi
- If too little CSF is resorbed or if there is a blockage of CSF flow within the ventricular system of the brain leads to **hydrocephalus**
- A condition in which excess cerebrospinal fluid (CSF) builds up within the ventricles (fluid-containing cavities) of the brain and may increase pressure within the head.

REFERENCES

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thank you