

# **Ventricles, CSF & Meninges**

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## Question

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The living brain is about the consistency of butter on a warm day.

Why isn't your soft brain injured by hitting against the hard skull every time you bump your head?

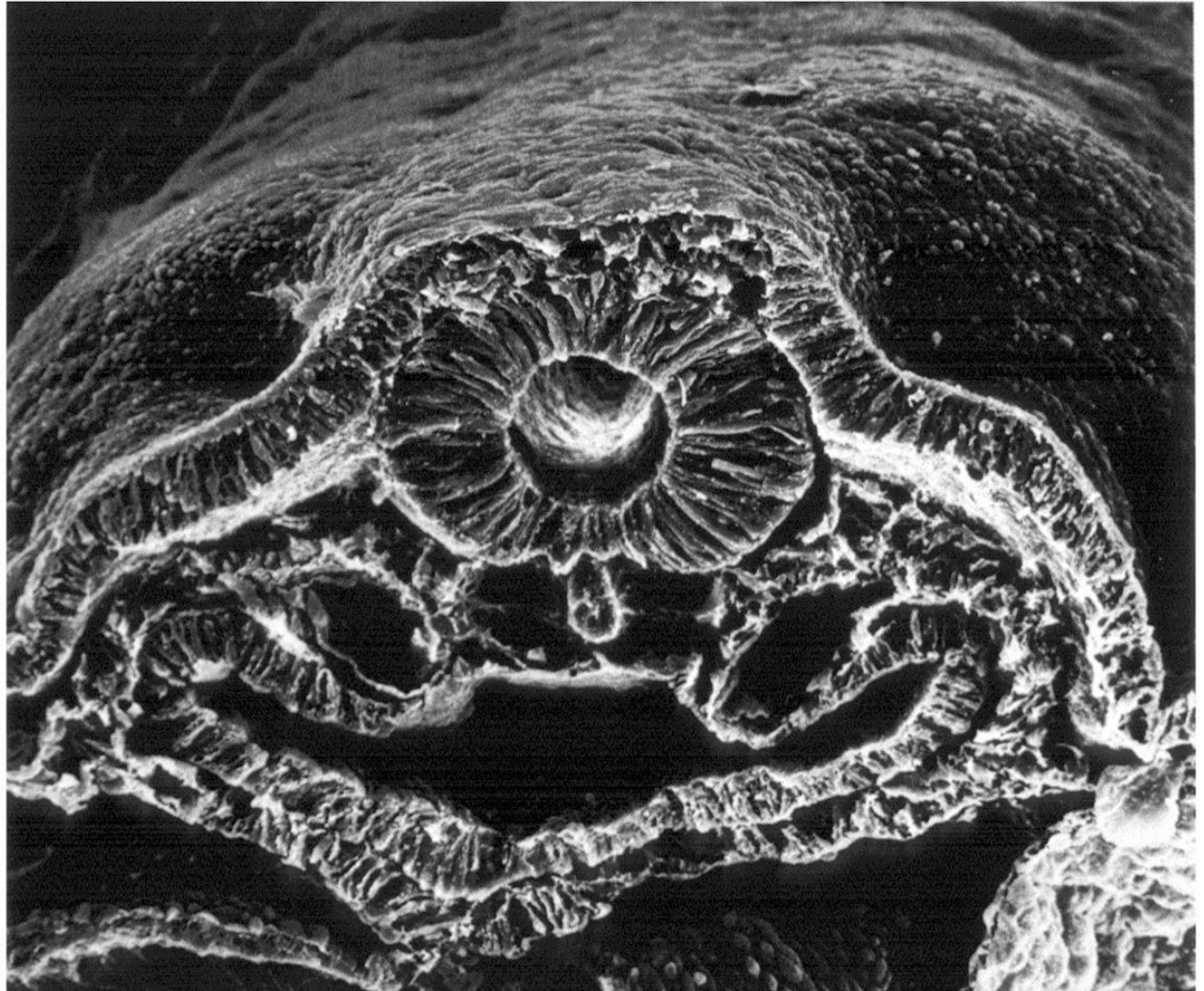
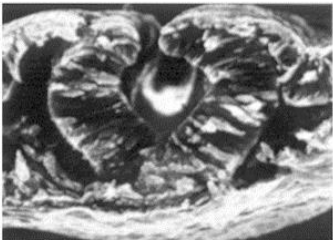
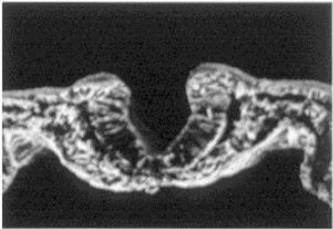
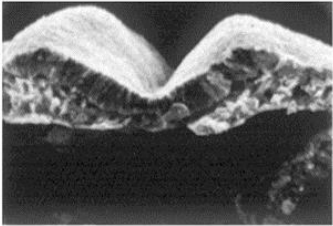
## Answer

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The brain is kept suspended inside the skull and is not allowed to impact the bone by the meninges and CSF. The brain actually floats in CSF.

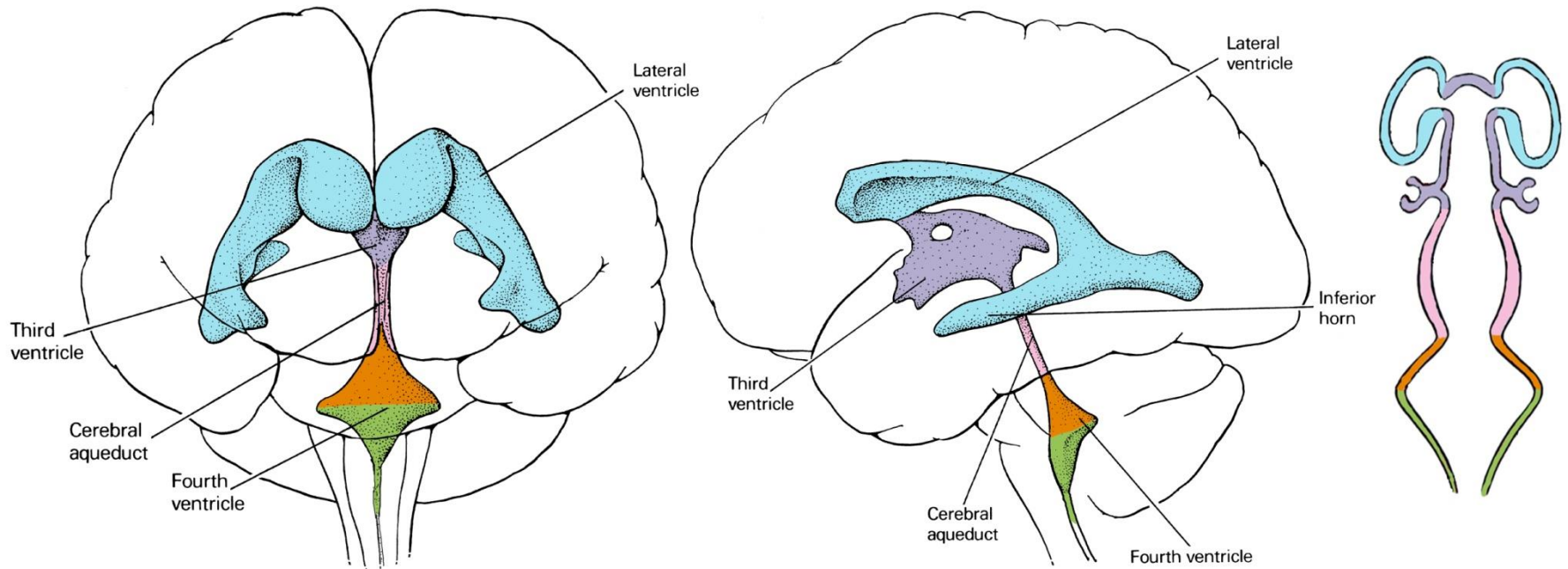
The embryonic neural tube is a tube with a lumen.

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# The lumen of the neural tube persists in the adult brain as the ventricular system.

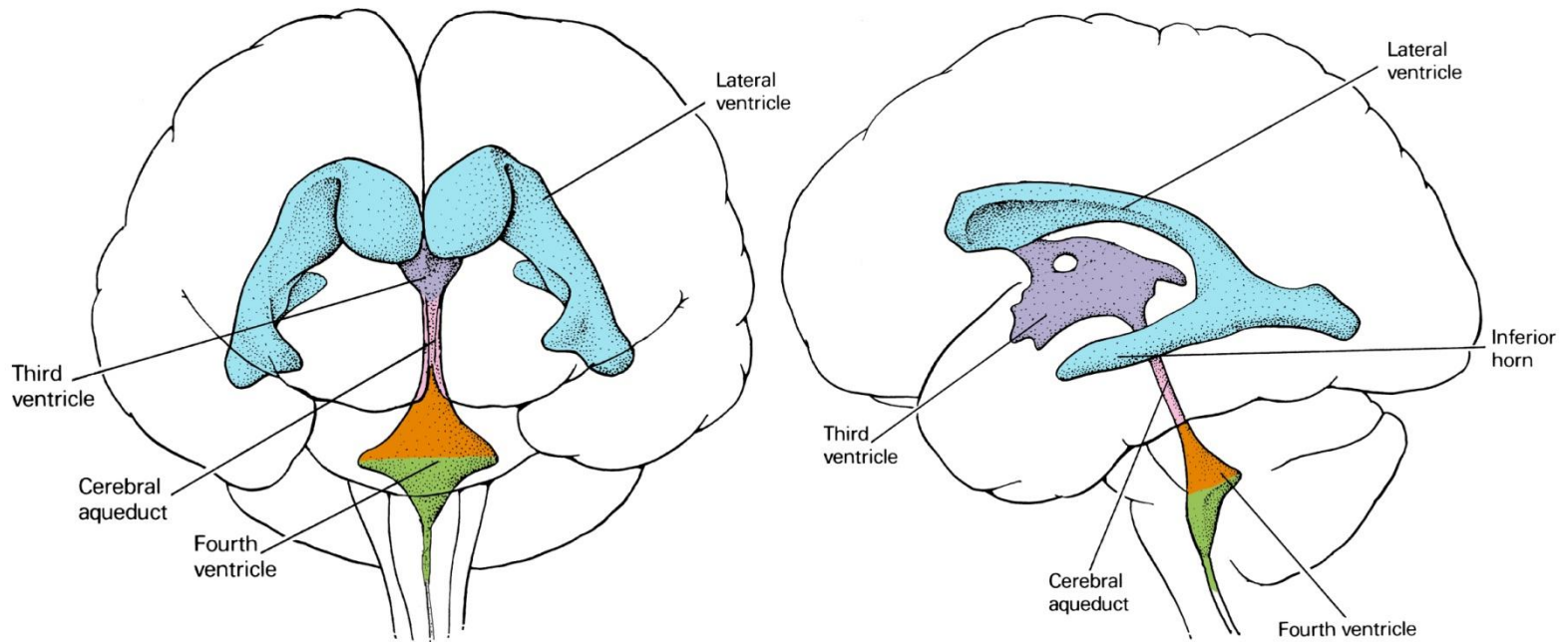
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# Ventricular System

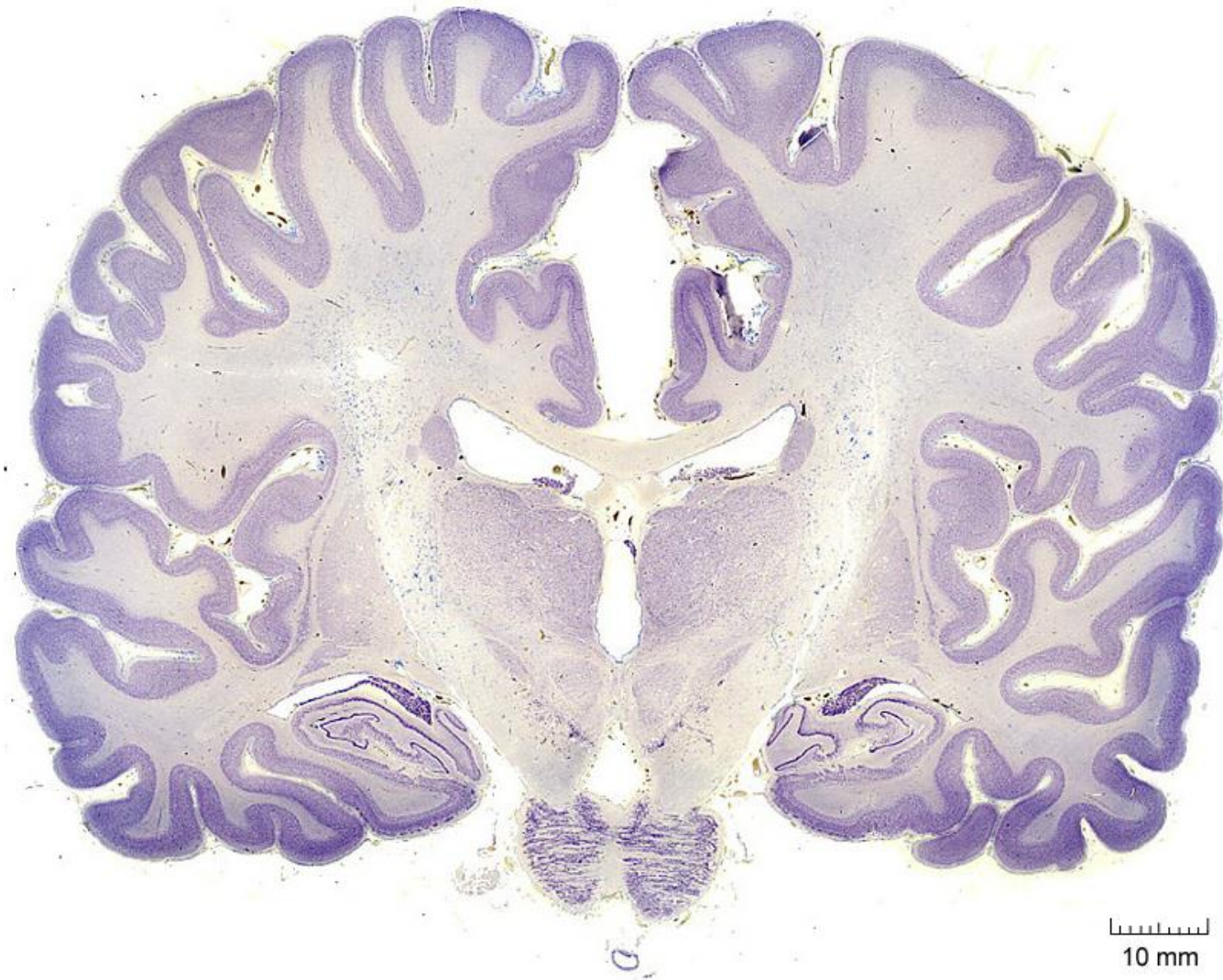
Lateral ventricles (x2):

- one in each hemisphere of the cerebral cortex
- each has the ram's horn shape of the cortex



# Ventricular System

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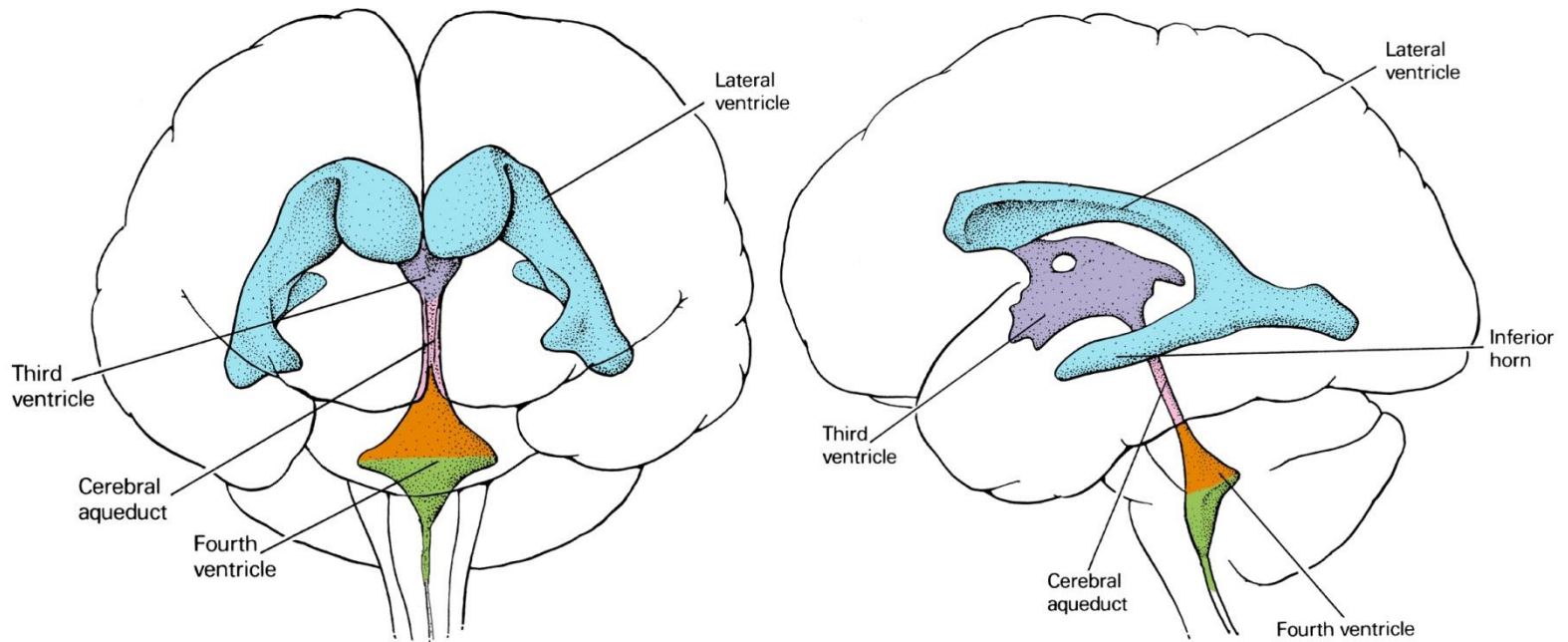


# Ventricular System

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Third ventricle (x1):

- unpaired structure in the midline of the diencephalon



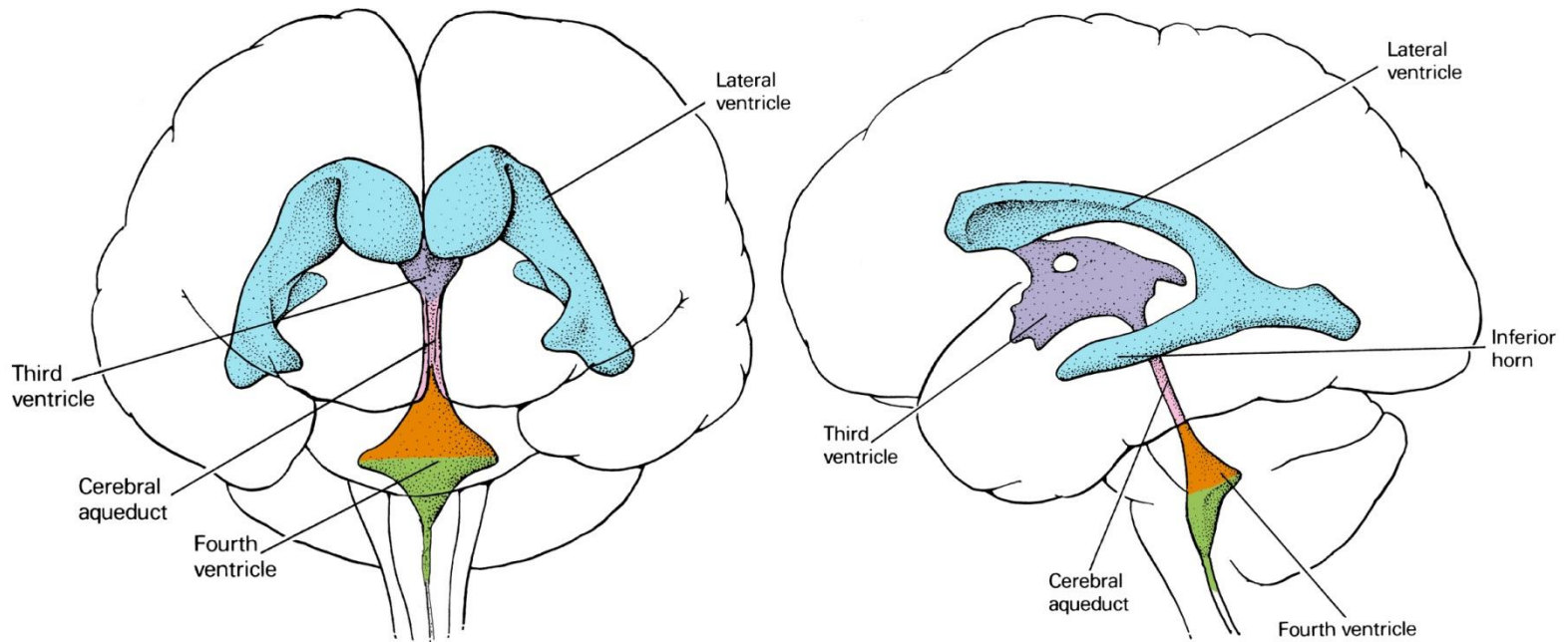


# Ventricular System

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Cerebral aqueduct (x1):

- in the midline of the midbrain
- narrow canal connecting the third and fourth ventricles

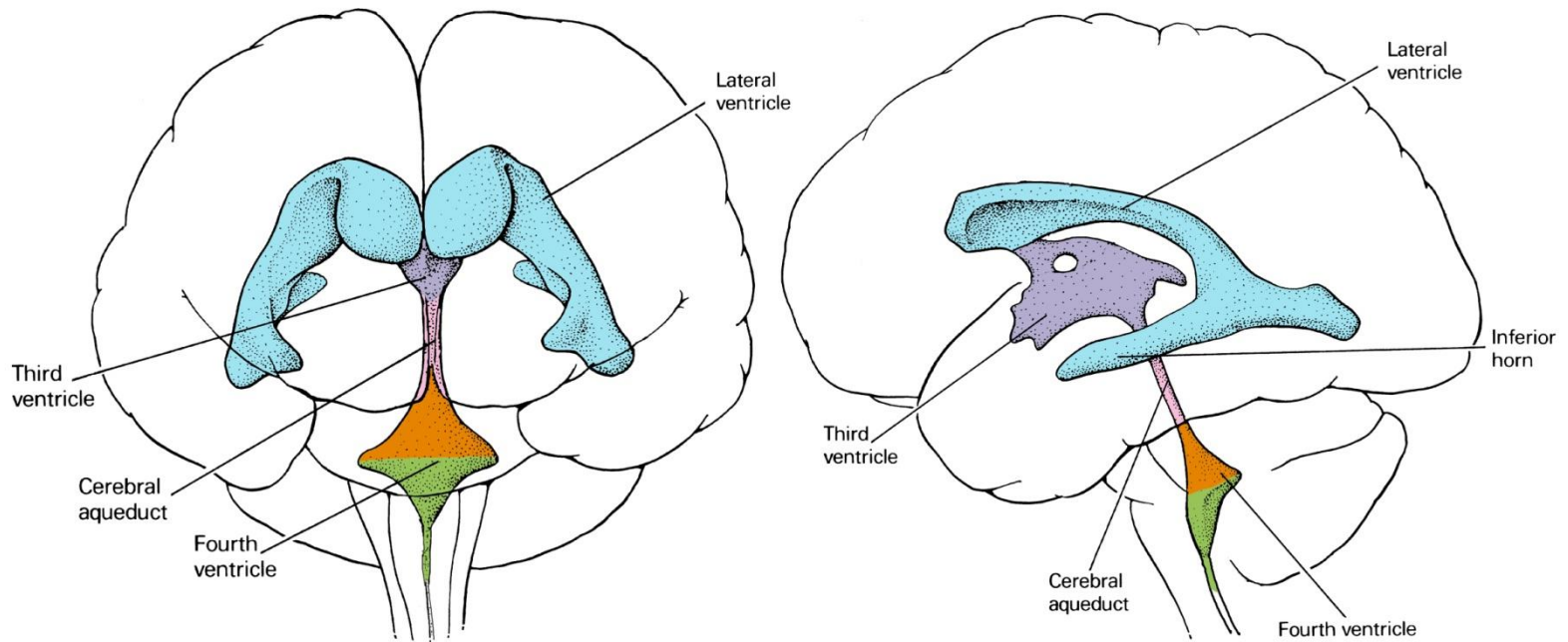


# Ventricular System

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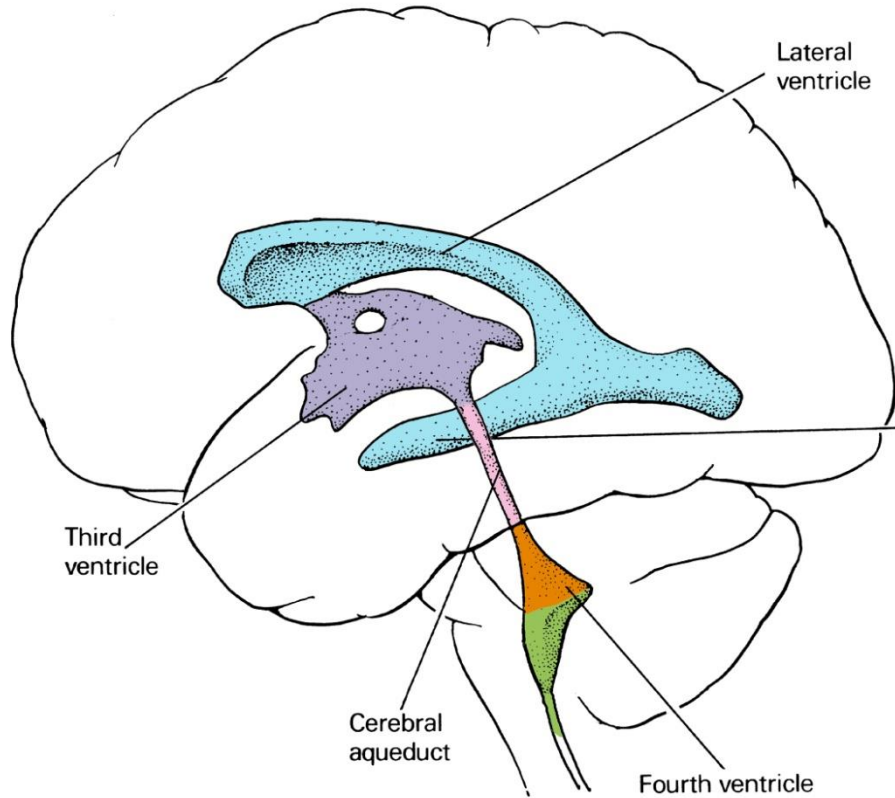
## Fourth ventricle (x1):

- in the midline of the hindbrain (pons/cerebellum and medulla)
- has three openings into the subarachnoid space



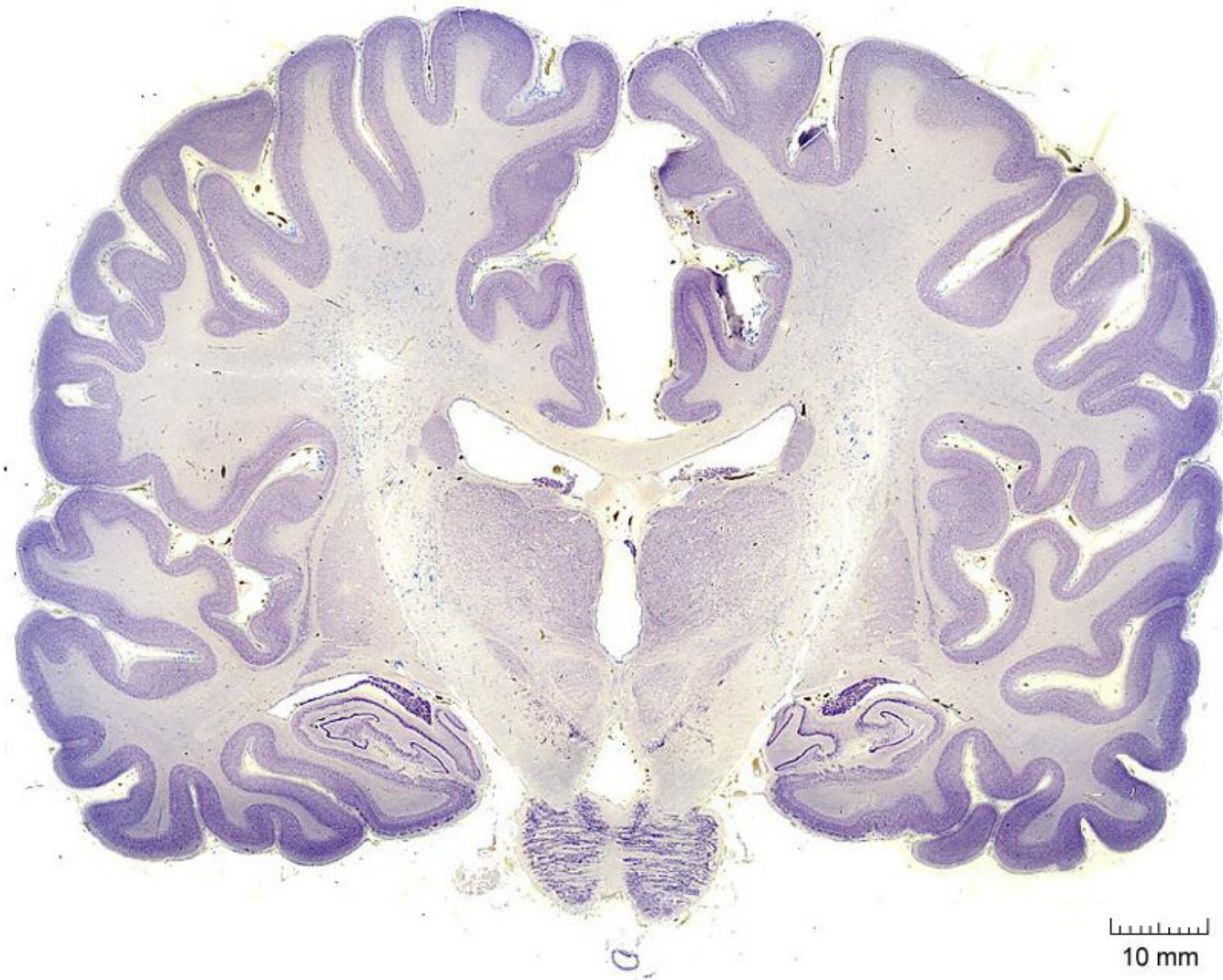
# Ventricular System

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# Ventricular System

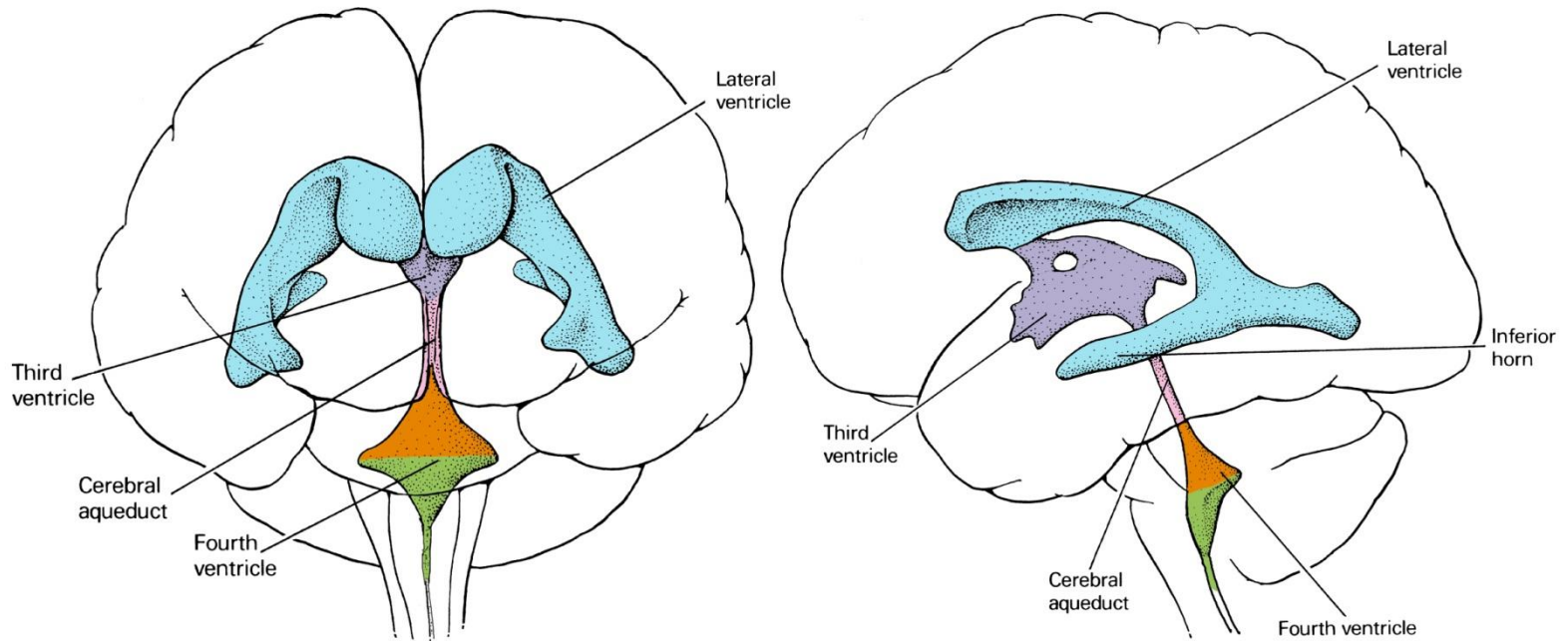
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# Ventricular System

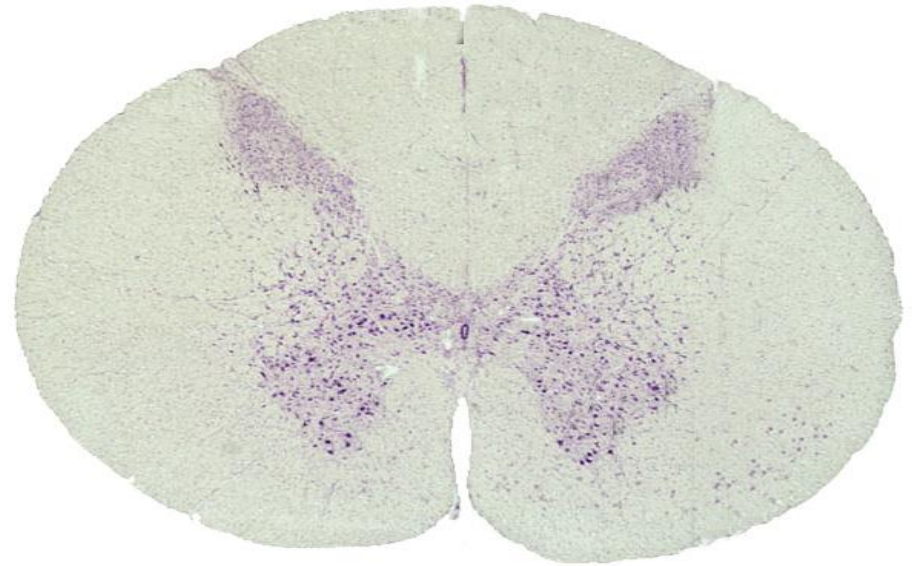
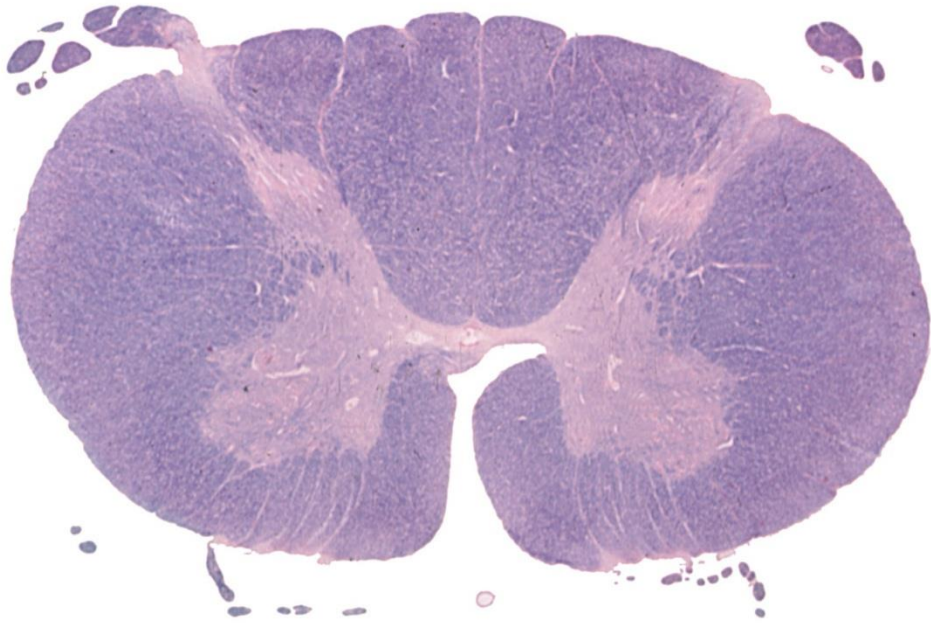
## Central canal:

- in the midline of the lower medulla and spinal cord
- continues from the fourth ventricle
- mostly obliterated in the adult



# Ventricular System

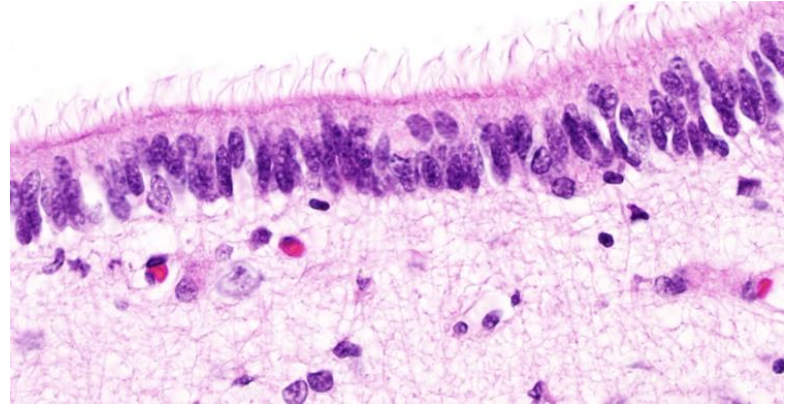
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## Ependymal Cells

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- Ependymal cells, a special type of CNS glia, line the ventricles.
- Ependymal cells are permeable to some molecules, which allows an exchange of molecules between the brain and CSF.



## Cerebrospinal Fluid (CSF)

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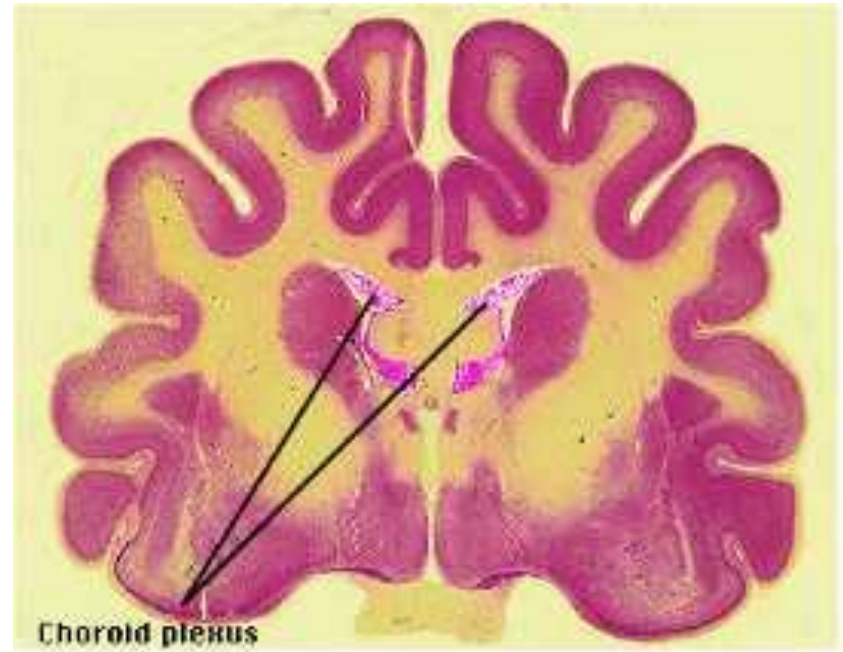
- Ventricular system is filled with CSF.
- CSF is a watery solution.
- It is an ultrafiltrate of blood produced by the choroid plexus in the ventricles.
- CSF contains most of the components of plasma, but not the blood cells.
- CSF also contains some molecules produced by neurons of the brain.



# Choroid Plexus

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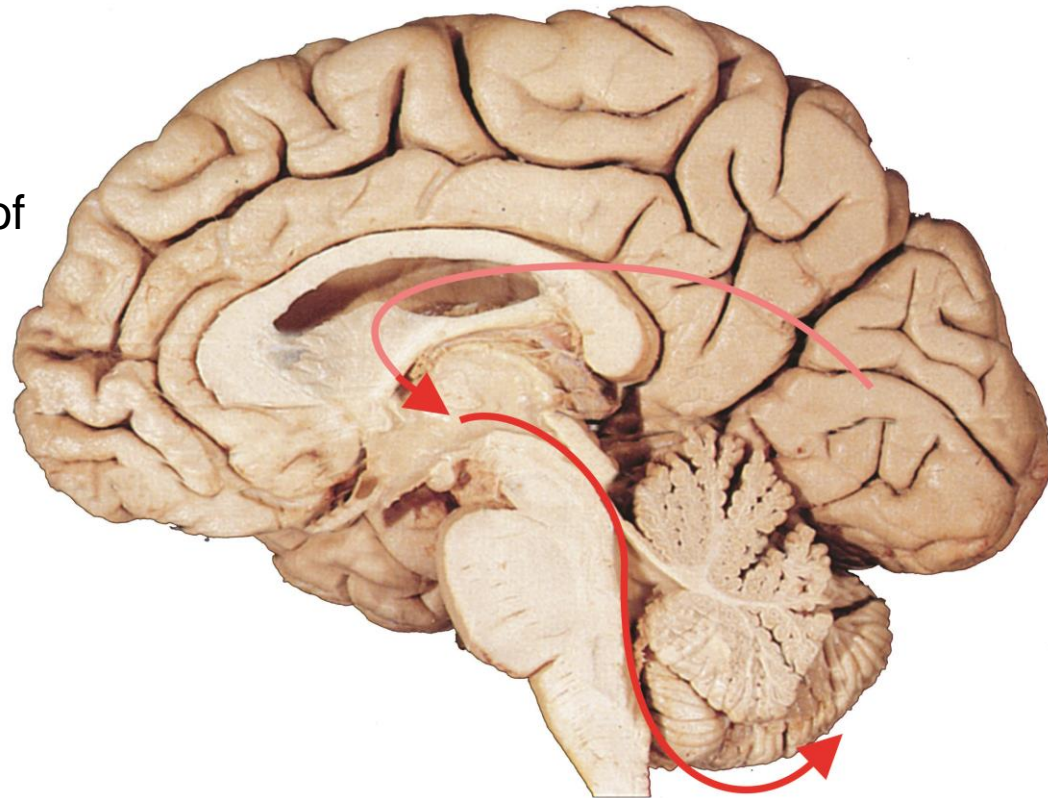
- Choroid plexus is present in the roof of the ventricles.
- Choroid plexus has highly permeable capillaries



## Ventricles to Subarachnoid Space

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- CSF flows from the lateral ventricles towards the IV ventricle in the medulla.
- In the IV ventricle, CSF flows out of the ventricular system via three openings into the subarachnoid space.
- ~25ml of CSF is in the ventricular system and ~150ml is in the subarachnoid space.
- ~500ml (half quart) of CSF is produced per day.

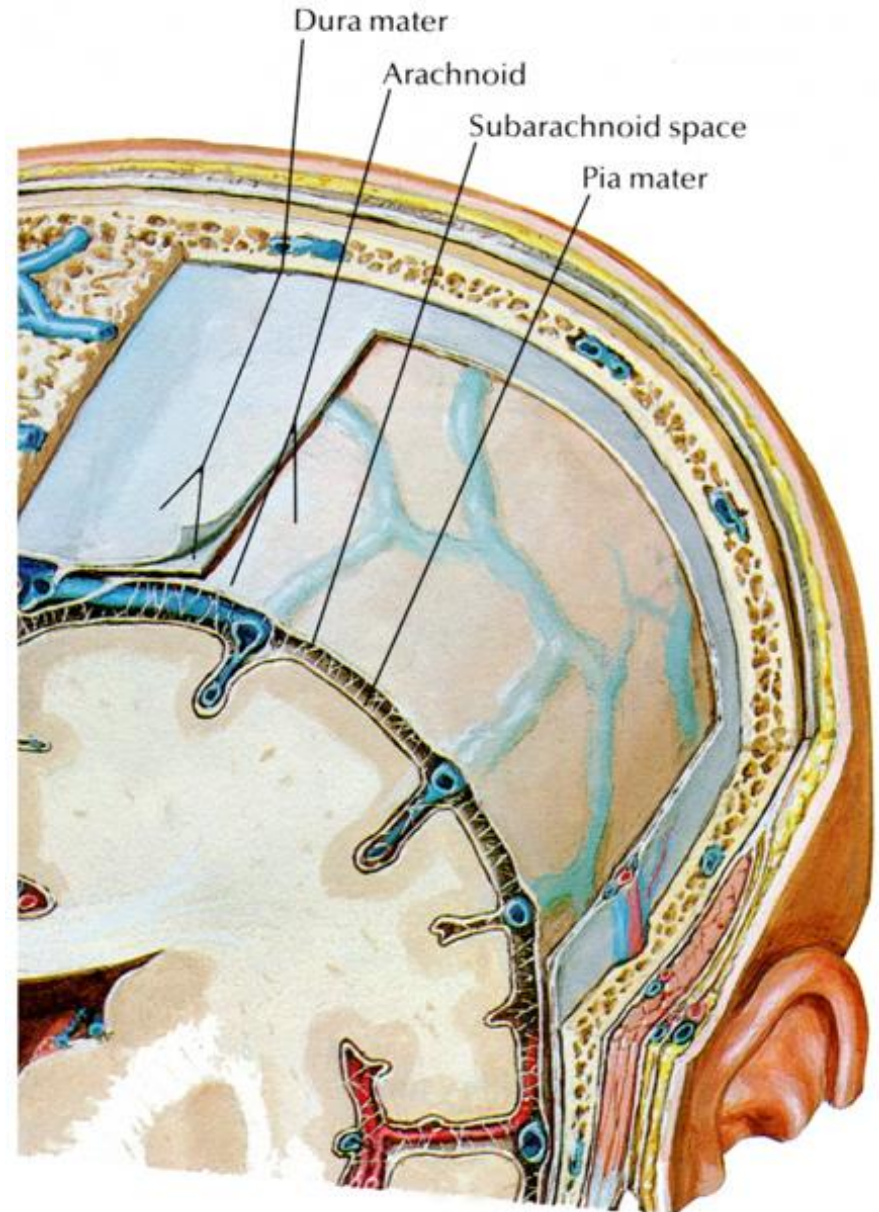


## Layers of the Meninges

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The meninges are three layers of membrane and a fluid-filled space between the skull and brain.

- dura mater
- arachnoid
- subarachnoid space filled with CSF
- pia mater

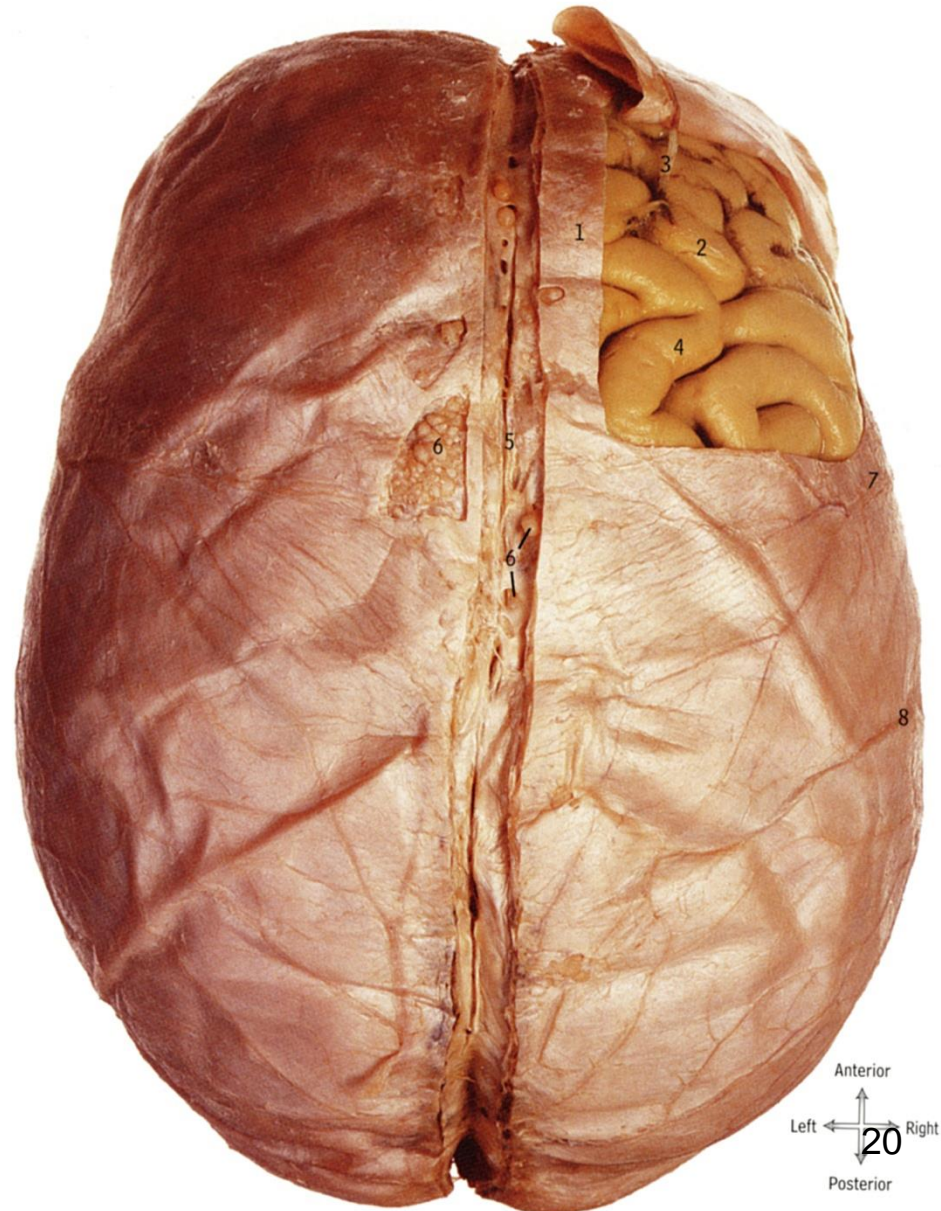


# Layers of the Meninges

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Dura mater (or dura):

- very dense and tough membrane
- tightly anchored to skull and arachnoid
- composed of two layers



# Layers of the Meninges

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## Arachnoid:

- thin clear membrane
- anchored directly to the dura and indirectly to the pia by fine fibers



# Layers of the Meninges

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Pia mater (or pia):

- thin membrane
- tightly anchored to the surface of the brain – it can not be separated from the brain

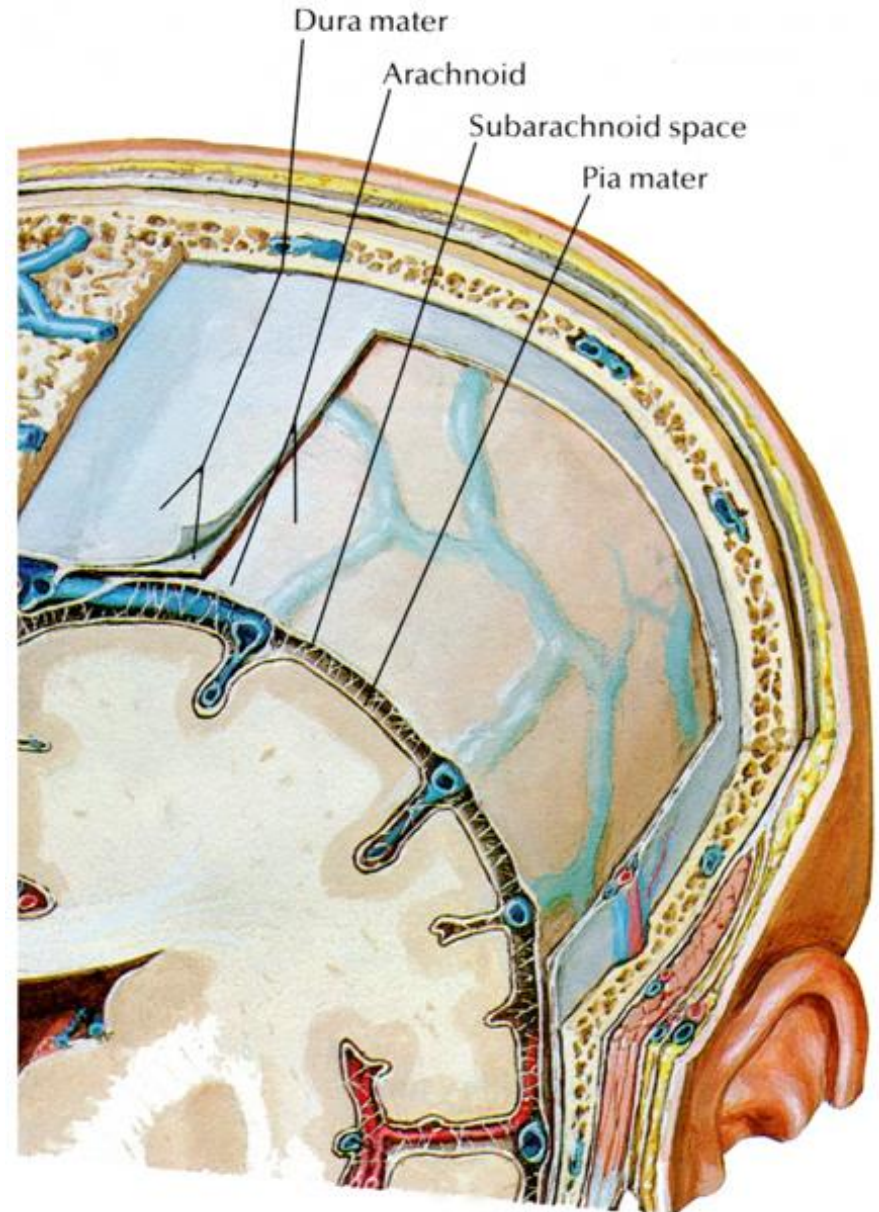


# Layers of the Meninges

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## Subarachnoid space:

- between the arachnoid and pia membranes
- space is filled with cerebrospinal fluid (CSF)
- brain floats in a sea of CSF
- fine fibers, trabecule, run between pia and arachnoid; trabecule suspend brain from dura-arachnoid



# Layers of the Meninges



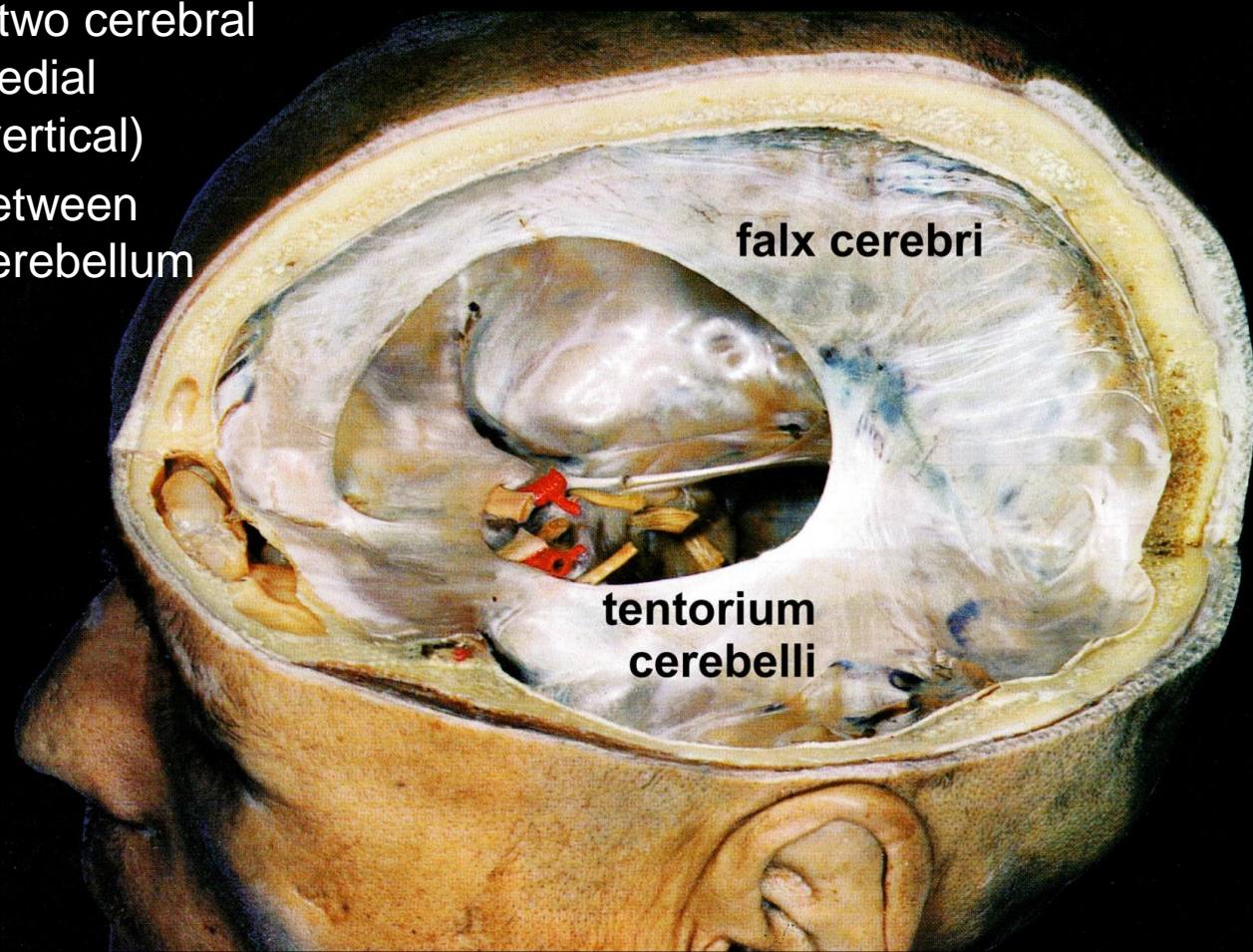


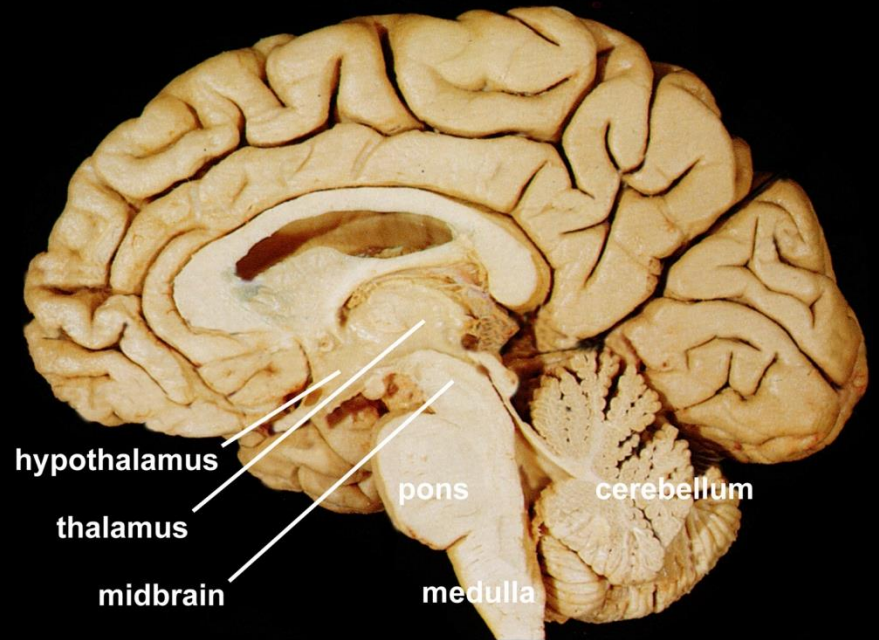
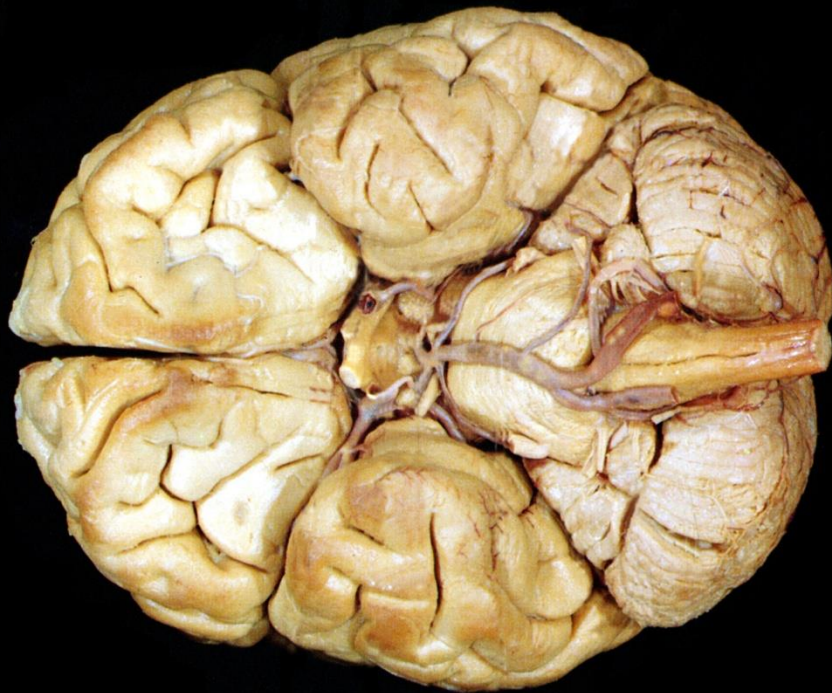
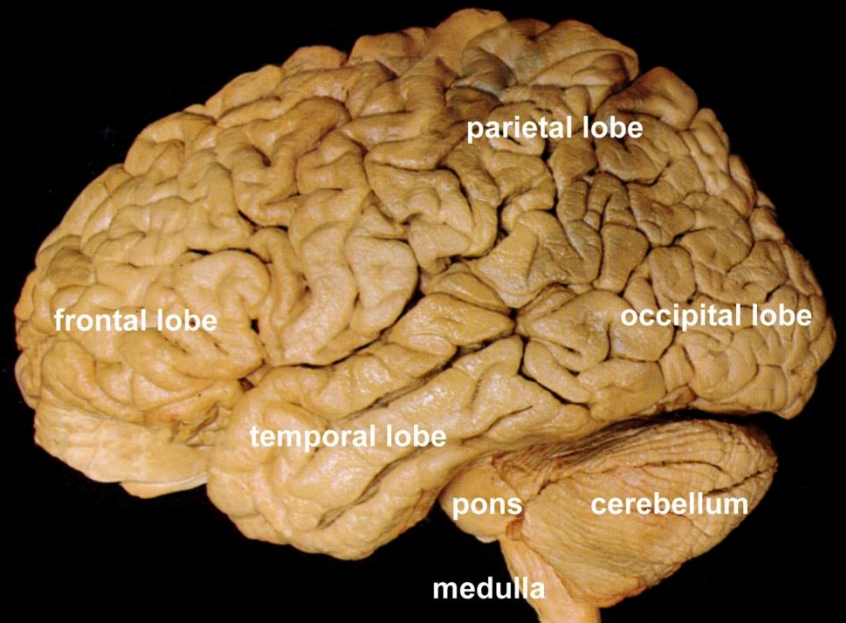
## Dural septa further support the brain.

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Dural septa are sheets of dura suspended from the skull that separate certain brain regions:

- Falx cerebri between two cerebral hemispheres in the medial longitudinal fissure (vertical)
- Tentorium cerebelli between cerebral cortex and cerebellum (horizontal)





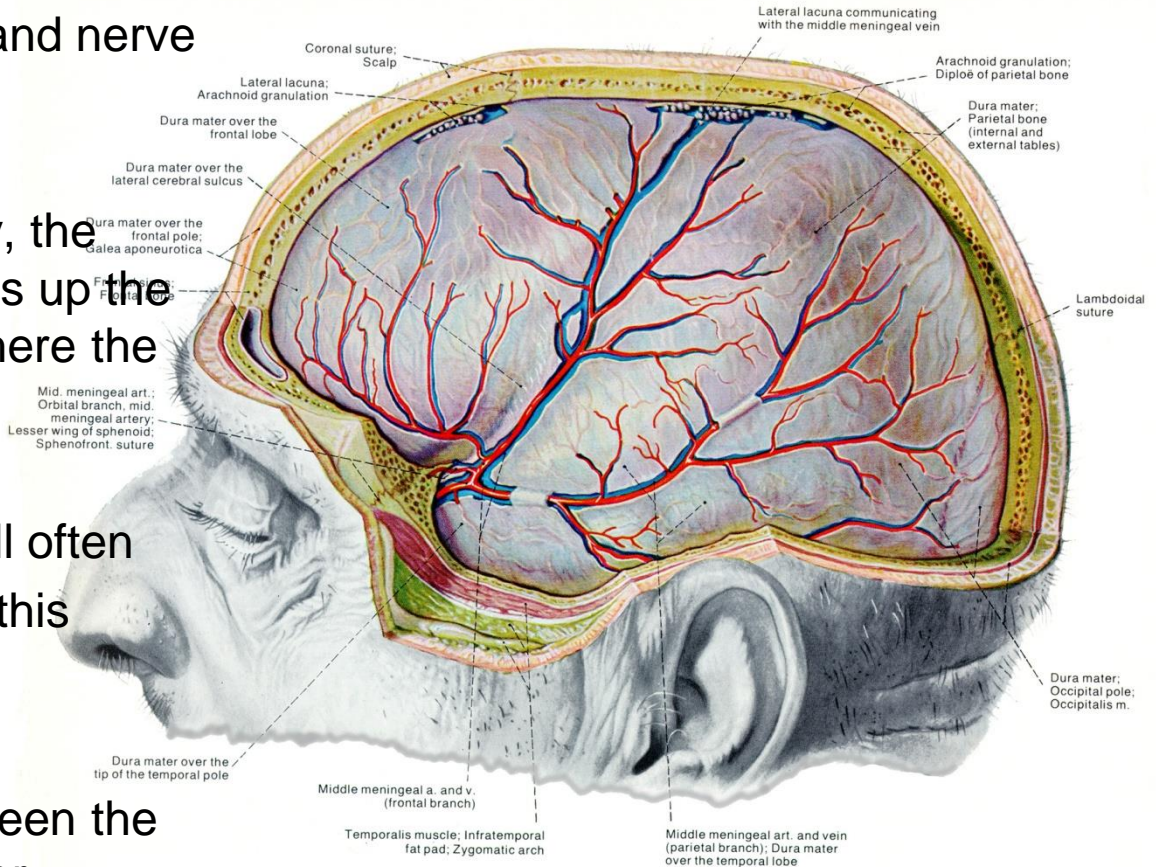
# Meningeal Vasculature & Nerves

The dura has its own blood and nerve supply.

The largest meningeal artery, the middle meningeal artery, runs up the temporal side of the head where the skull is thinnest.

Impact to the side of the skull often fractures the skull and tears this artery.

This results in bleeding between the skull and dura, an epidural (or extradural) hematoma.



## Meningeal Vasculature & Nerves

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Blood between the skull and dura has no route for clearance.

Pressure builds on the brain.

20% of epidural hematomas are lethal.

Head injuries often appear inconsequential for several hours after the injury, and then lead rapidly to death.

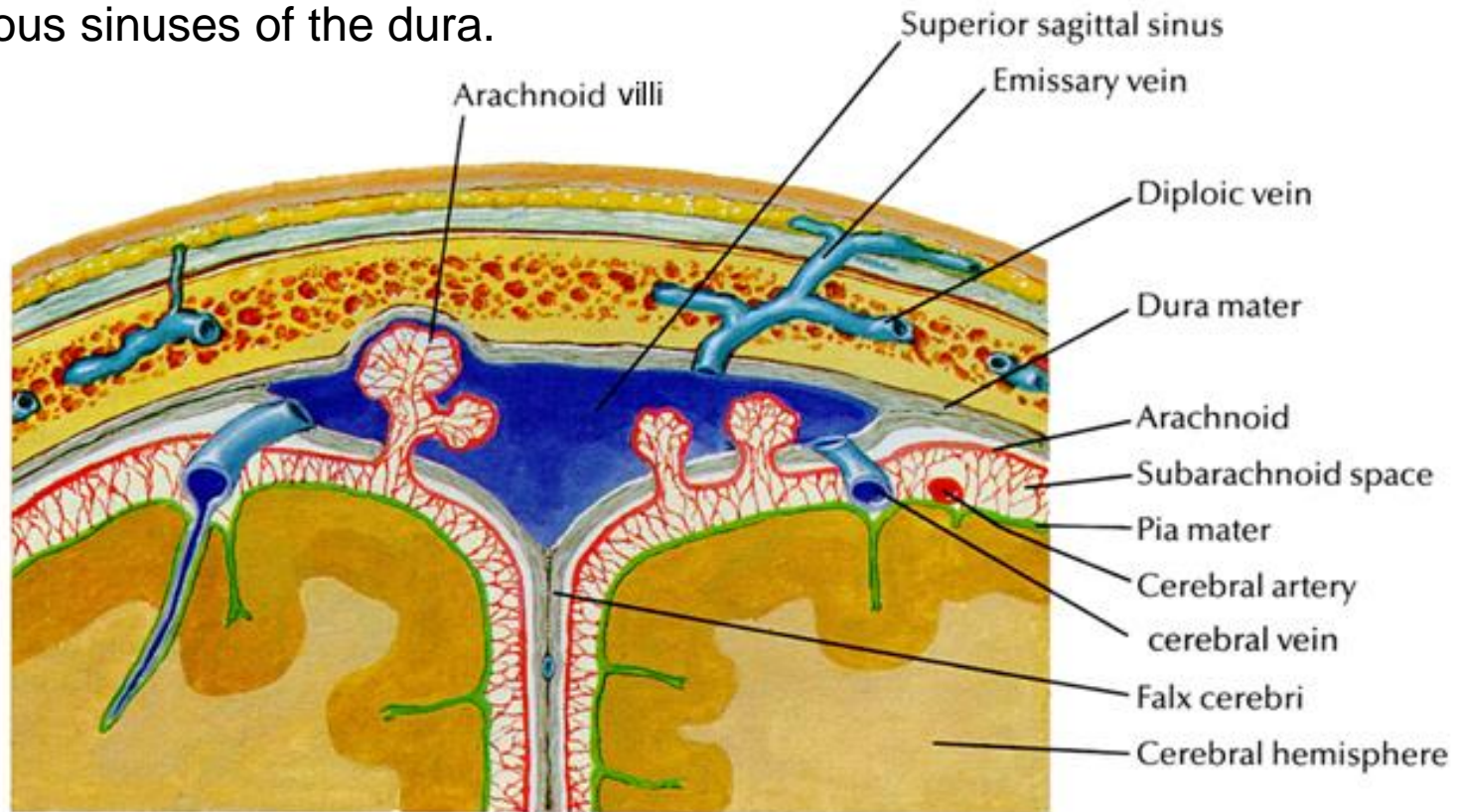
Wear a seat belt in the car, and use a helmet when you bike or skate!



CT scan of epidural hematoma

# Dural Venous Sinuses

In some regions, the dura is split forming a chamber filled with venous blood, the venous sinuses of the dura.

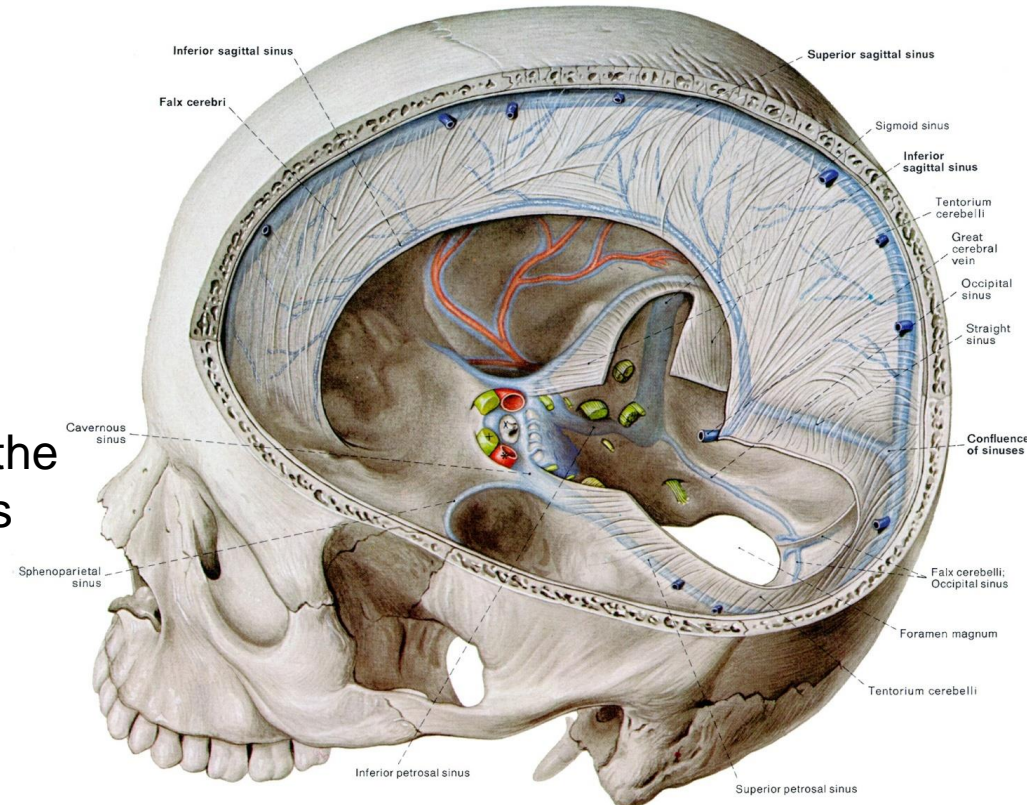


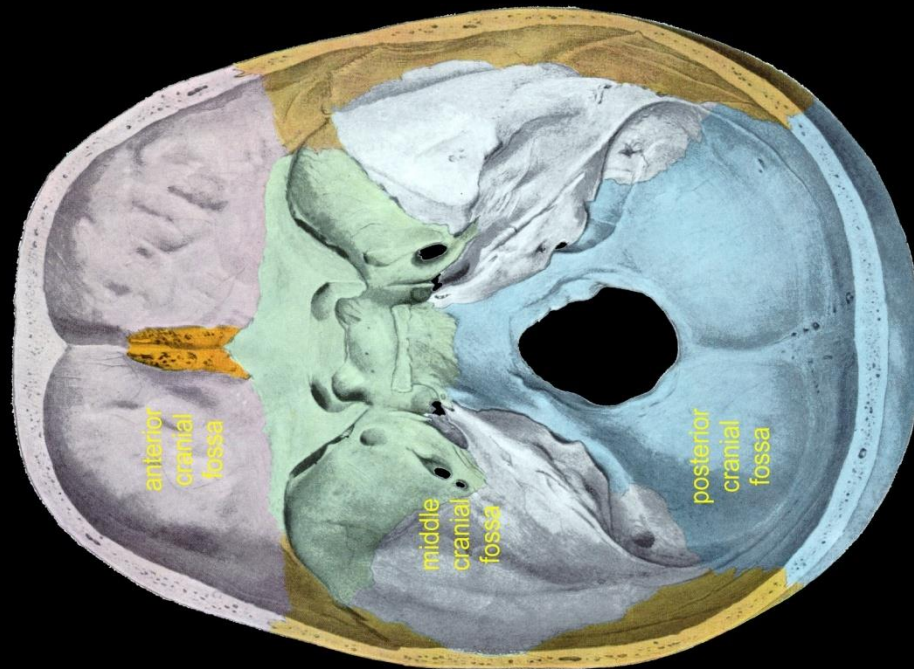
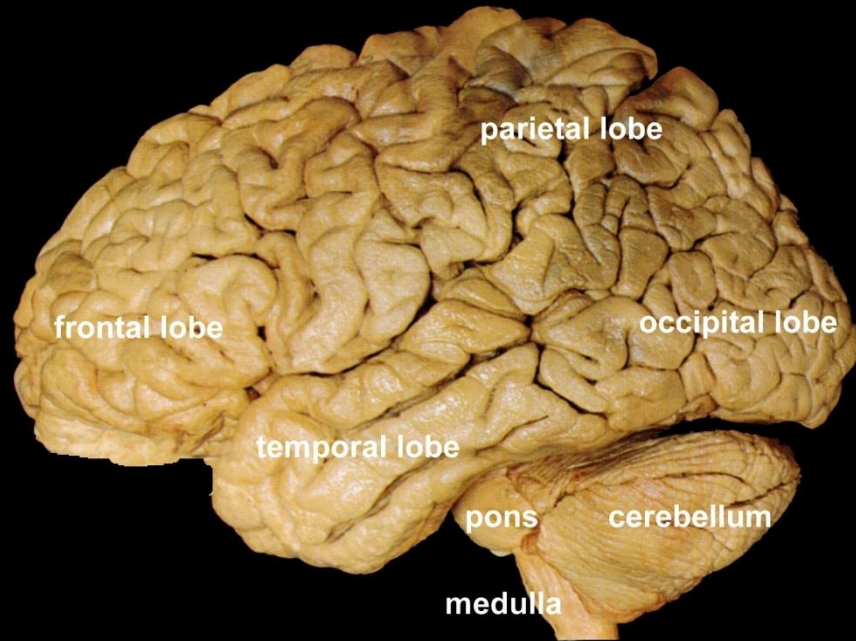
# Dural Venous Sinuses

Blood veins from the brain drain into the dural venous sinuses.

A network of these venous sinuses collects most of the blood from the brain.

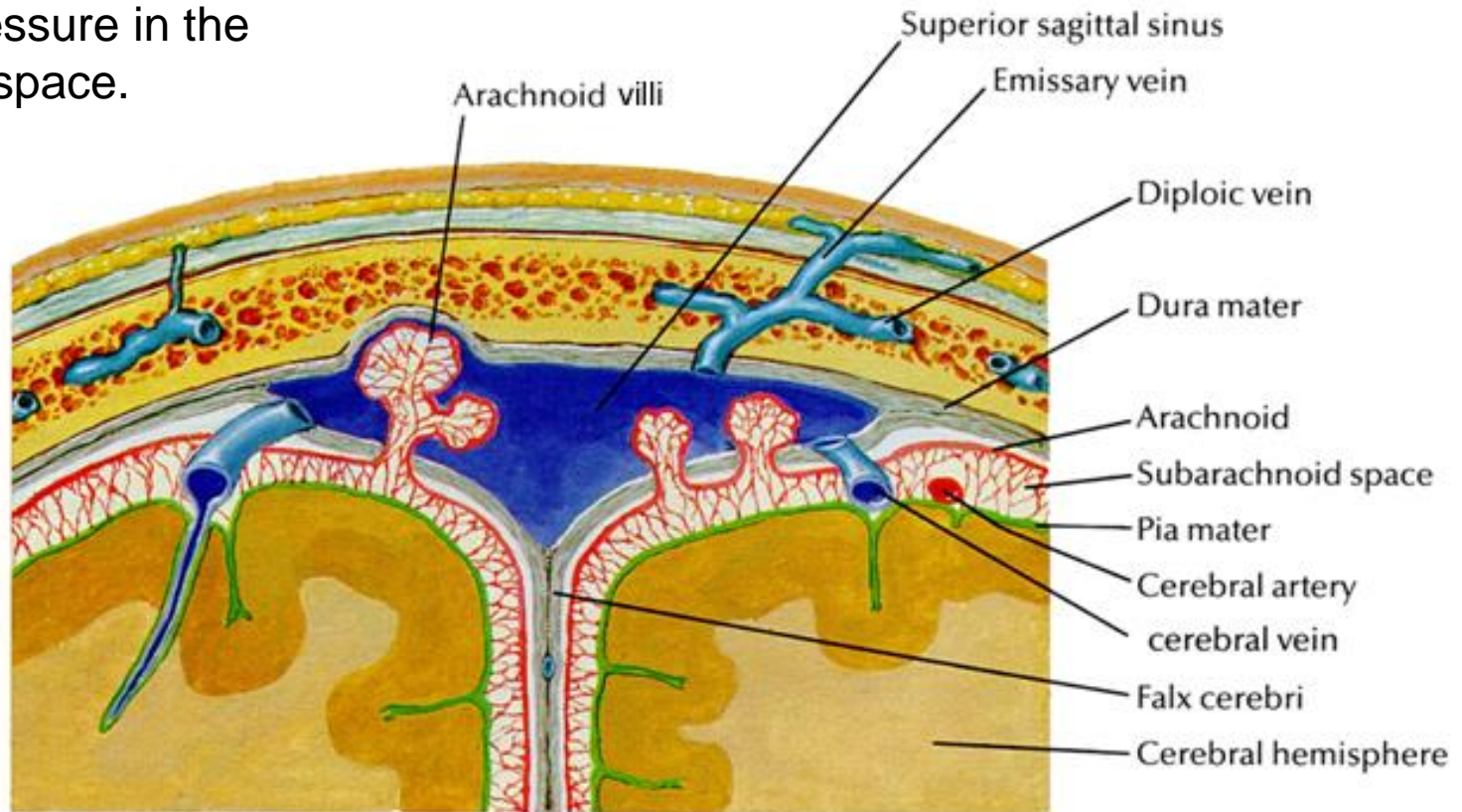
The dural venous sinuses collect in the base of the skull and exit the skull as the internal jugular veins.





## Dural Venous Sinuses

CSF in the subarachnoid space drains into the dural venous sinuses due to hydrostatic pressure in the subarachnoid space.





## Flow of CSF – The Movie

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<http://www.youtube.com/watch?v=JCf273U0ktc>

# Headaches

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Brain has no pain receptors.

Headaches are not due to a pain in the brain.

Dehydration headaches:

- The body is normally 60% water. You can lose 1-2% of your body's water with normal activity during a day.
- Loss of brain volume due to dehydration pulls on the dura and large blood vessels and results in pain.



# Headaches

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Tension headaches:

- result from prolonged contraction of head muscles, especially the muscles of the neck and jaw

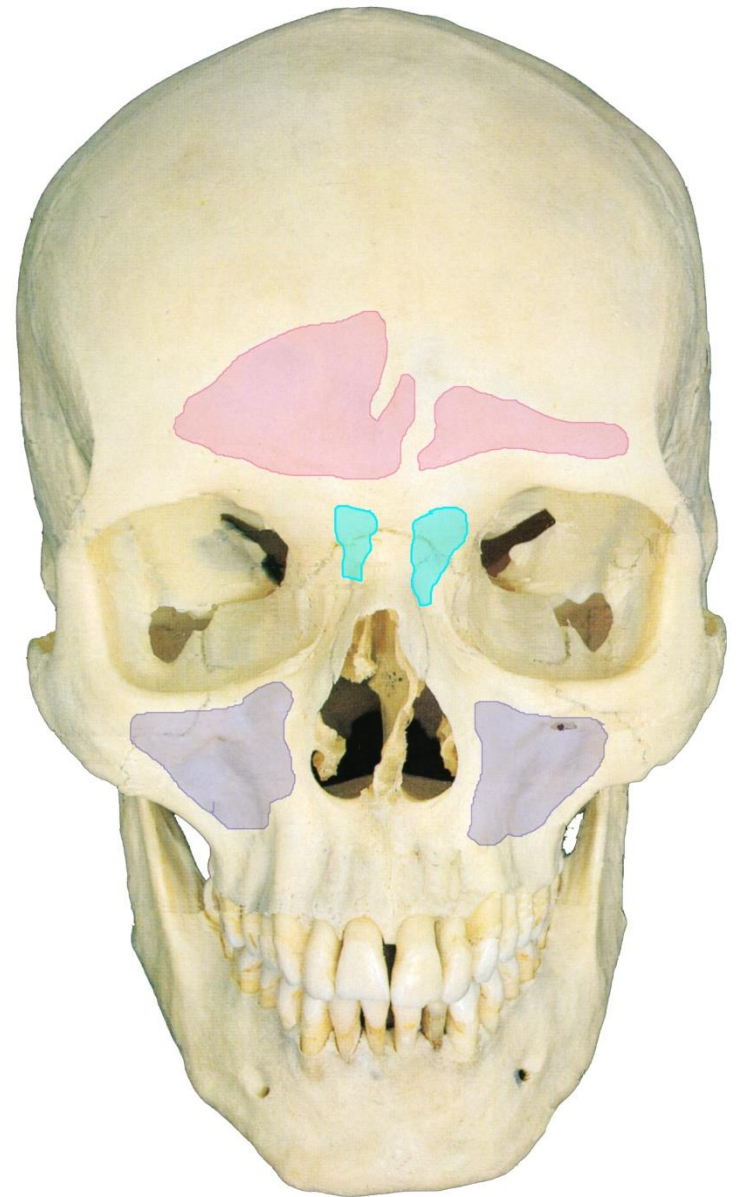


# Headaches

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## Sinus headaches:

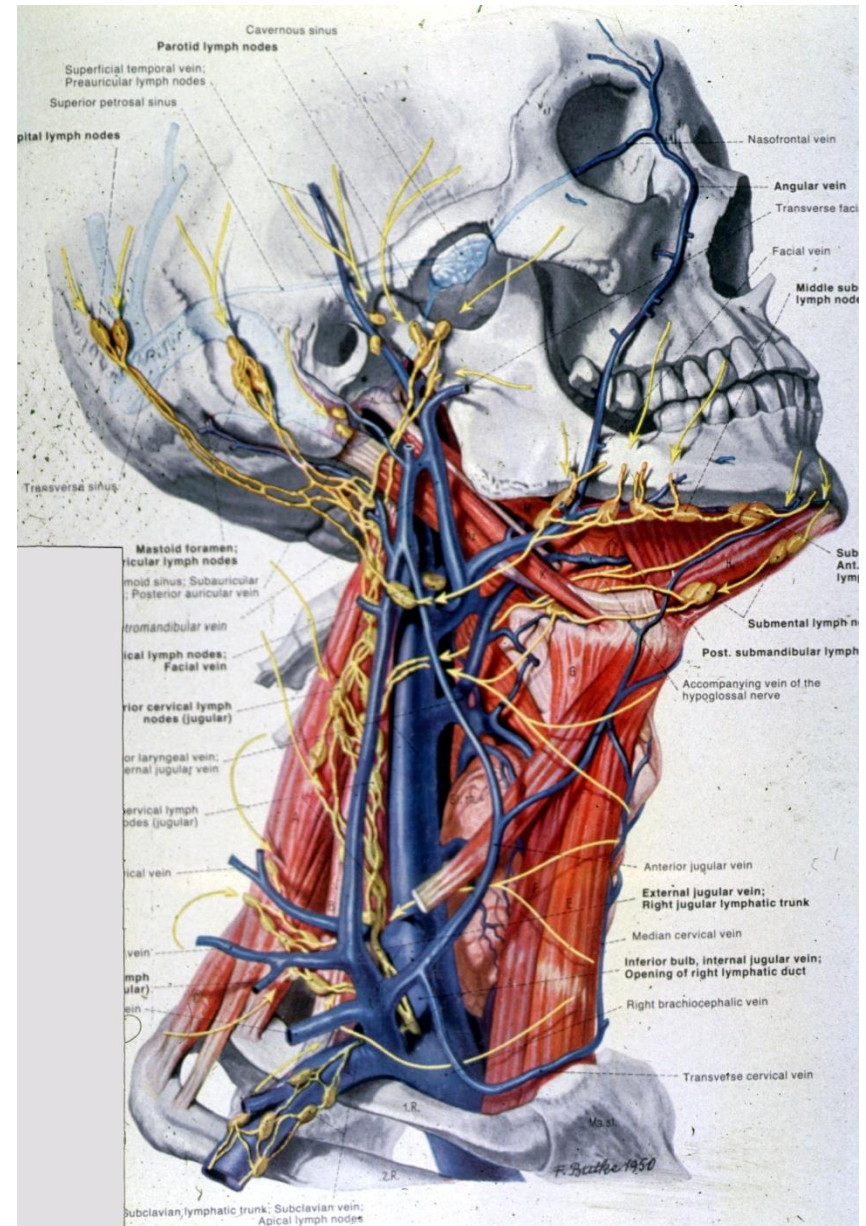
- Paranasal sinuses (a.k.a. the sinuses) are air-filled chambers incased in the skull bone.
- Each sinus has a small opening into the nasal cavity. These openings are easily occluded.
- Increased pressure in a sinus with a blocked passage results in pain.



# Meningitis

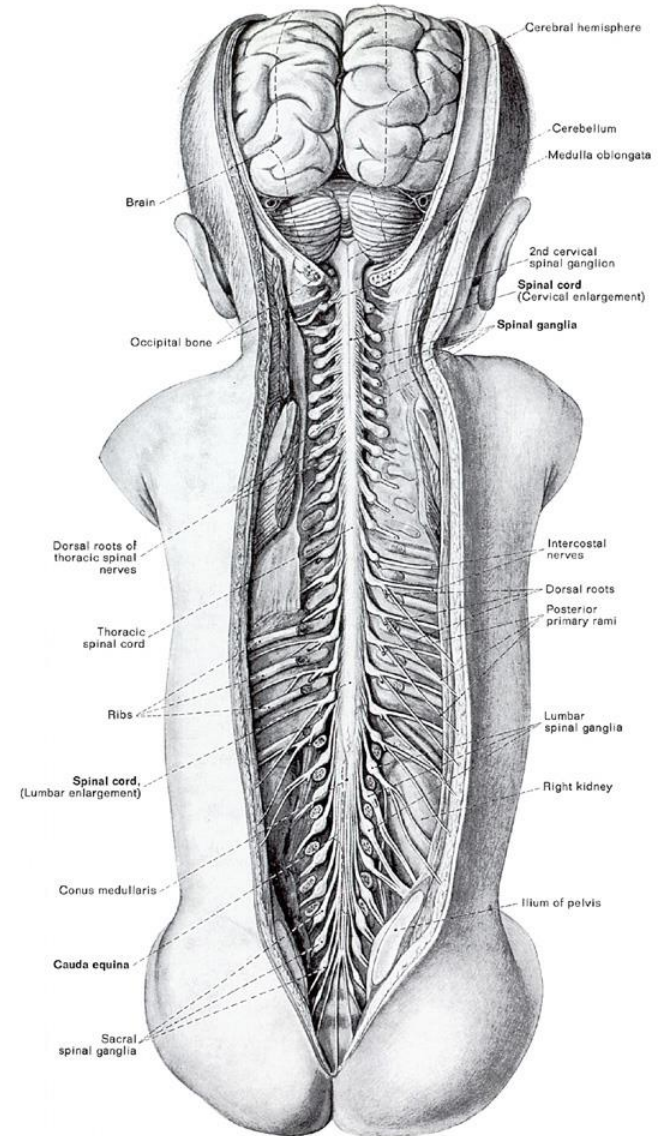
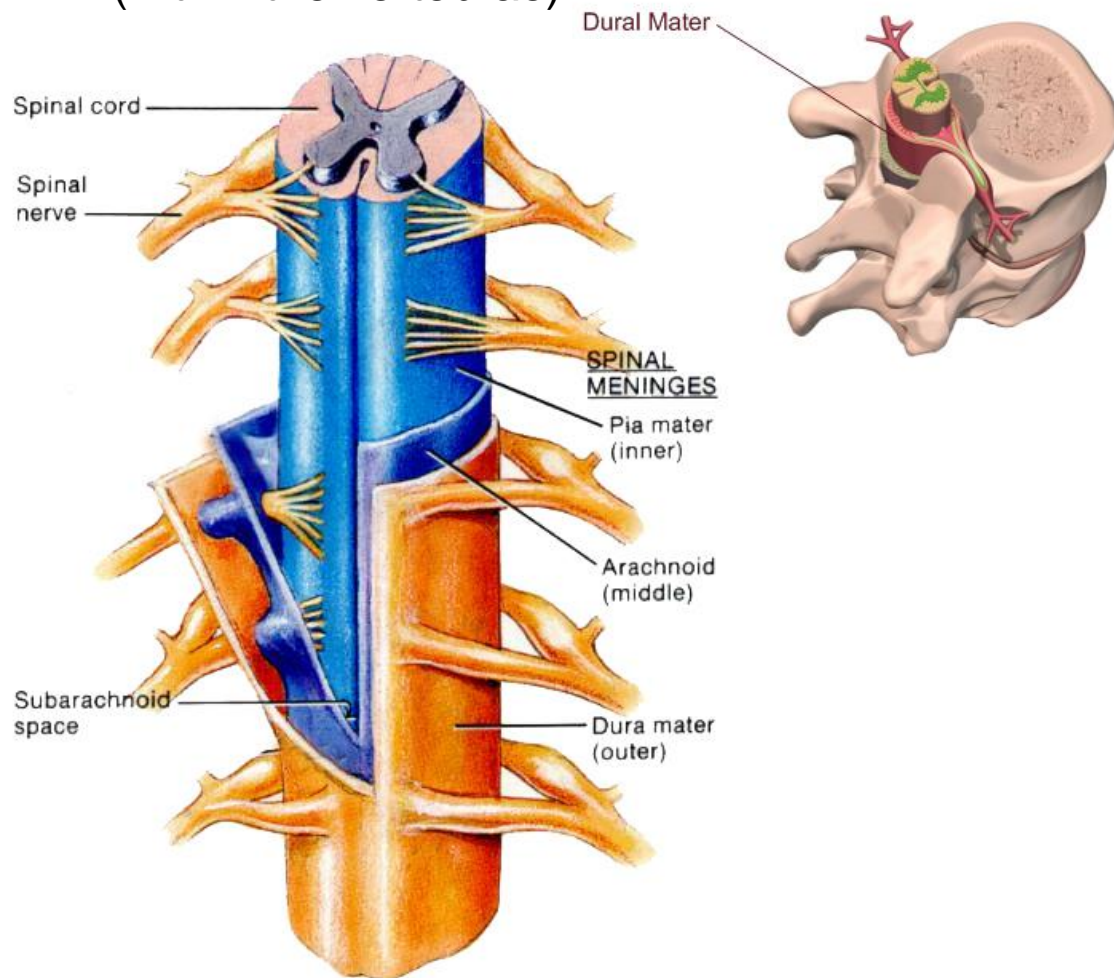
Infection of the meninges, either viral or bacterial, is called meningitis:

- Veins of the face interconnect with veins in the cranium, and blood can flow in either direction.
- Infection can be transmitted via the veins from the face to the meninges resulting in meningitis.
- Bacterial meningitis can be particularly life threatening.
- Certain chemicals and allergic reactions also can result in inflammation of the meninges.



# Spinal Column Meninges

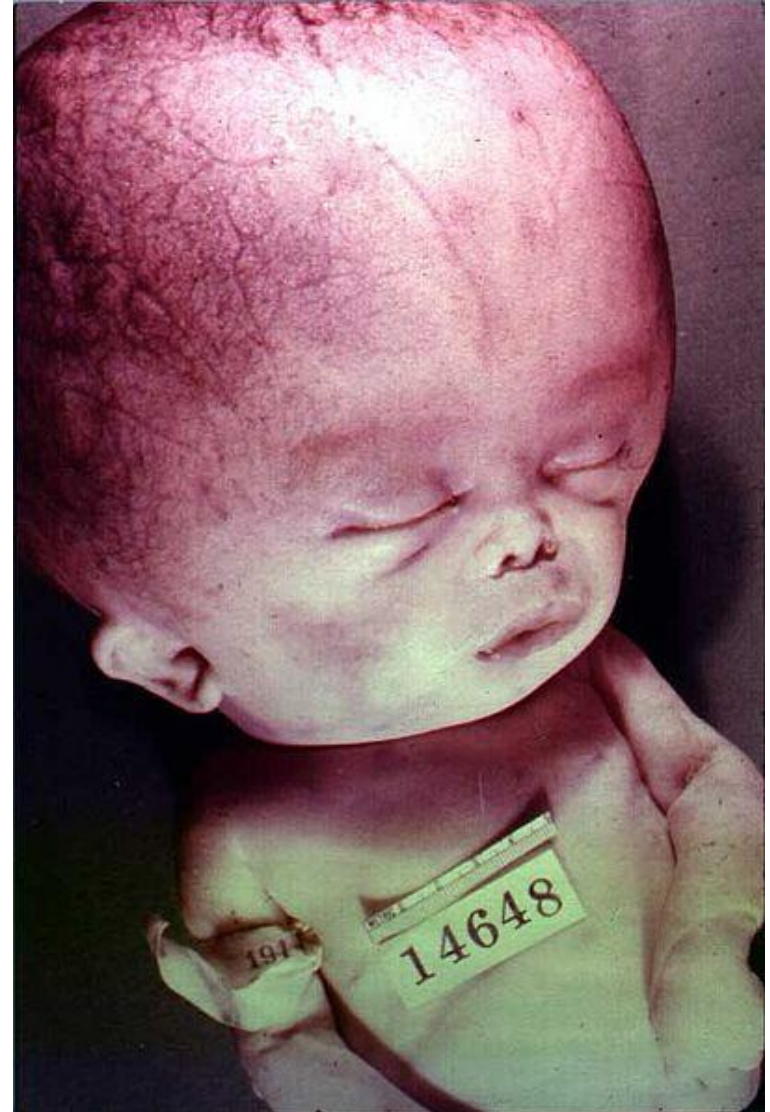
All layers of the cranial meninges are continuous down the spinal canal (within the vertebrae).



# Hydrocephalus

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- Obstruction in the ventricular system can block the flow of CSF and result in increased pressure in the ventricles.
- During development, hydrocephalus can result in an enlarged, deformed head, a thin cortex, mental retardation and death



# Hydrocephalus

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- In the adult, hydrocephalus can result in numerous problems including seizures and can lead to death.
- Hydrocephalus is called colloquially 'water on the brain'.
- A shunt can be inserted surgically to drain CSF from above the obstruction into the subarachnoid space.



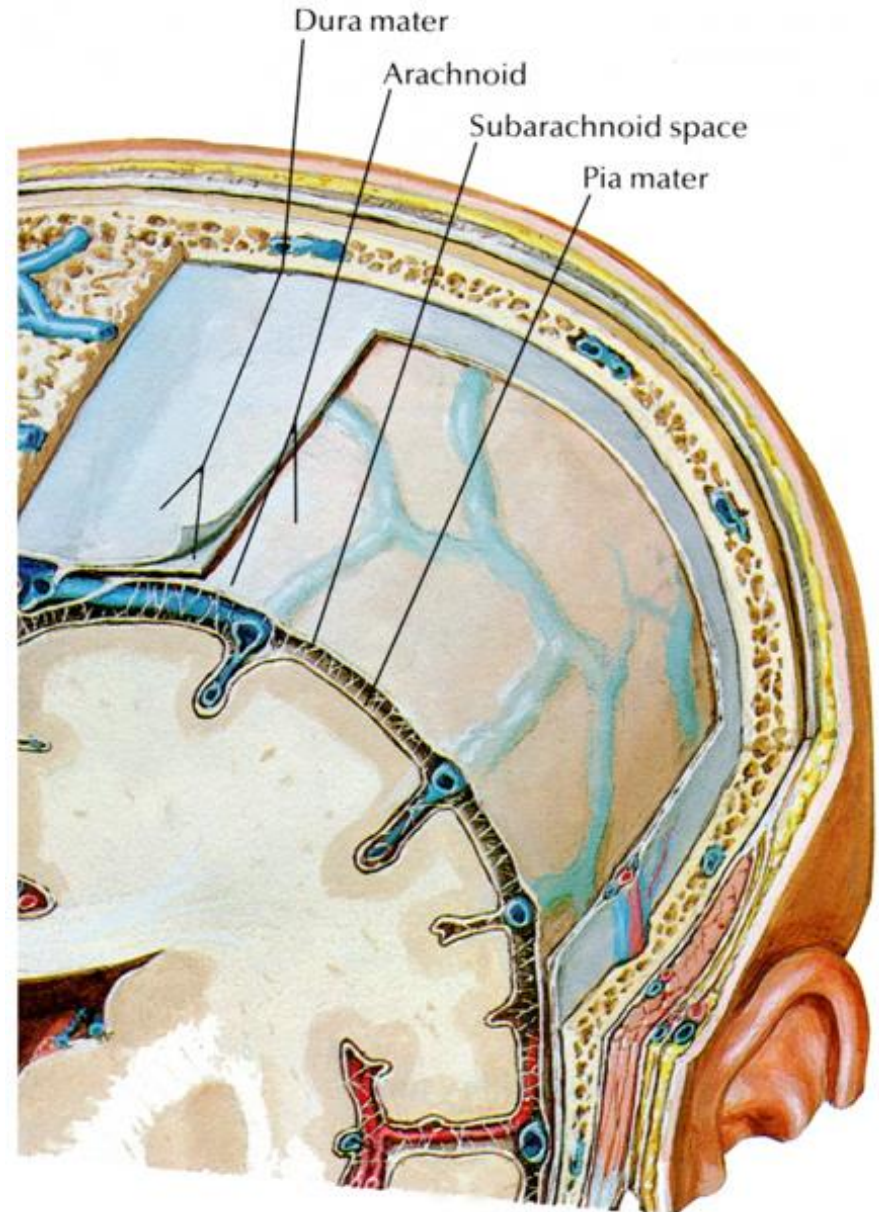
# Hydrocephalus

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<http://www.youtube.com/watch?v=Qmym2iFVNw8>

## Functions of CSF

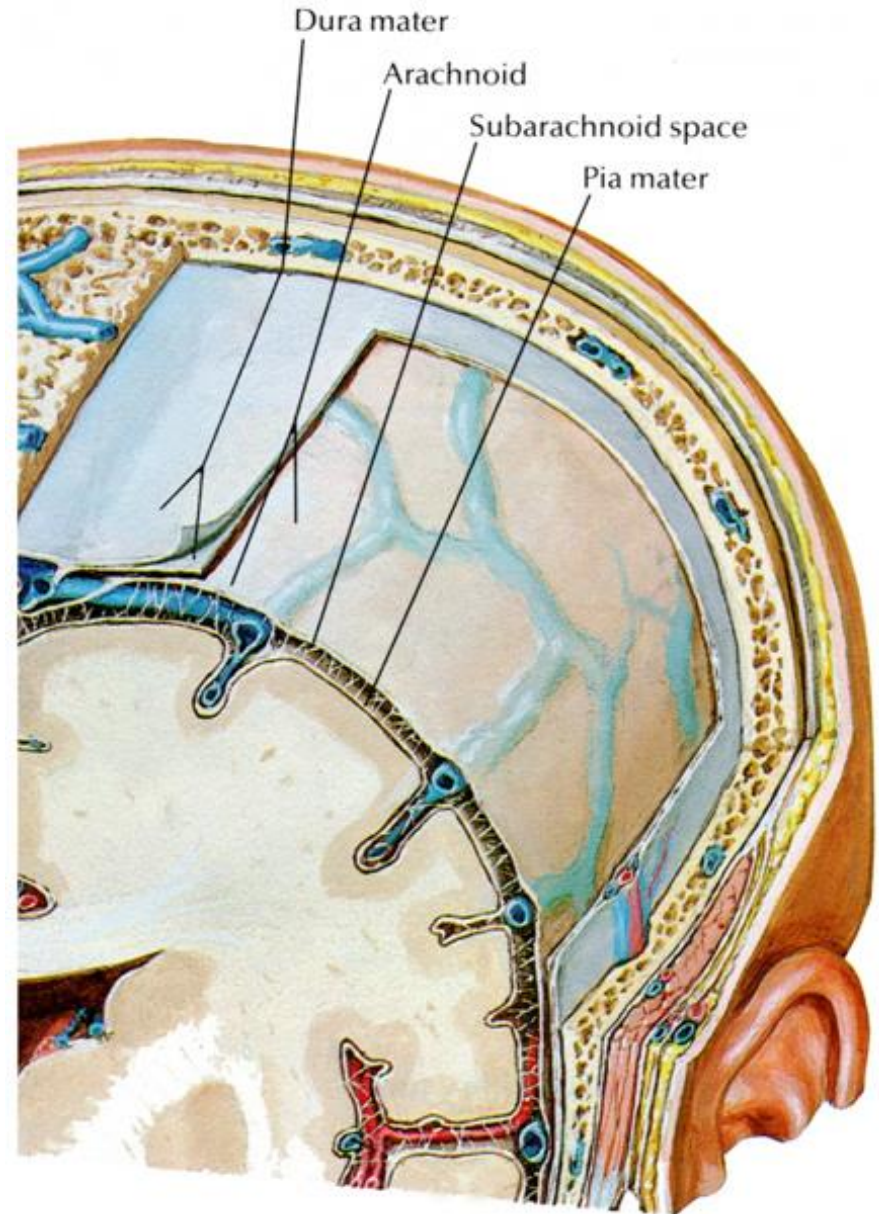
- regulates the chemical environment of the brain (i.e. some water soluble metabolites pass from brain to CSF)
- carries some neuro active molecules
- supports the brain & cushions the brain from physical shock
- allows changes in the brain size, particularly with changes in its hydration state



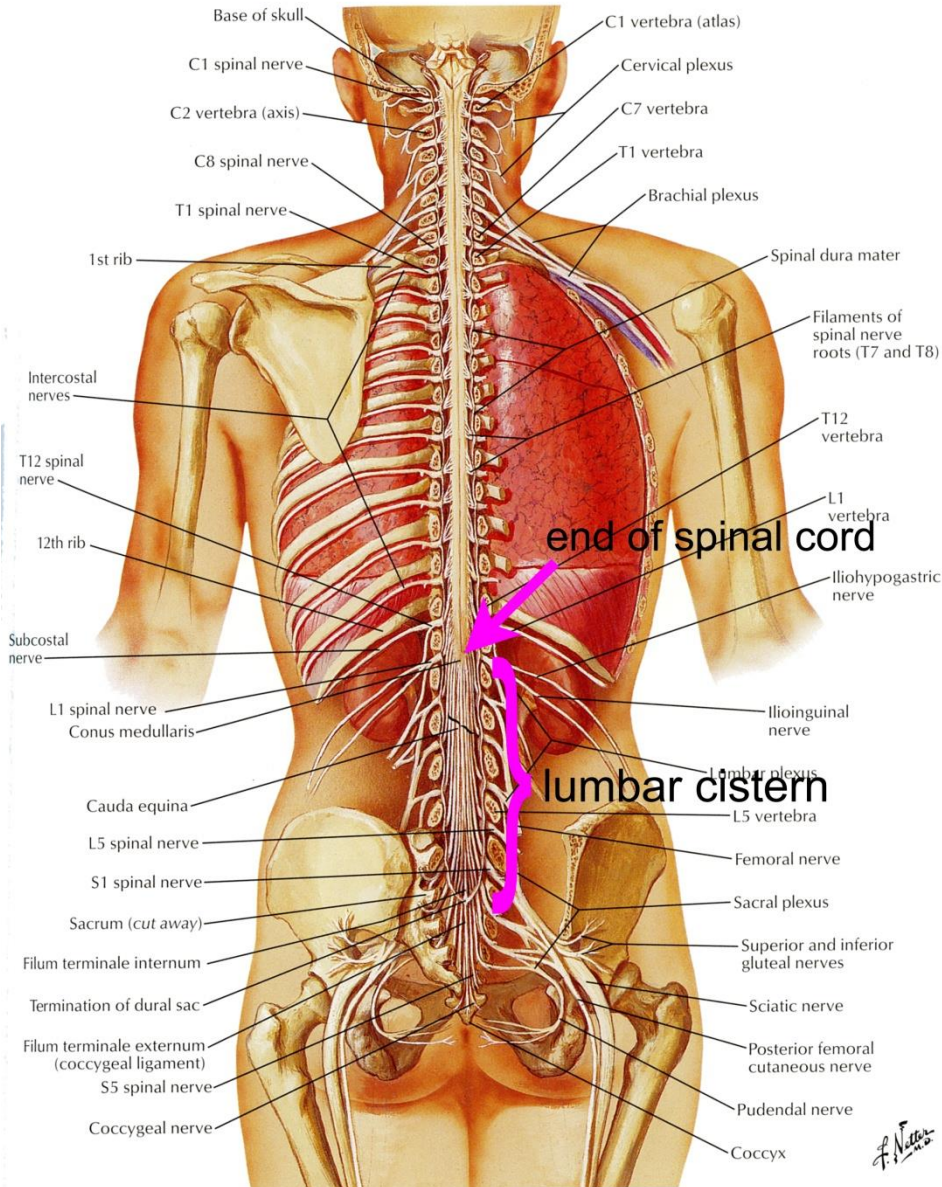
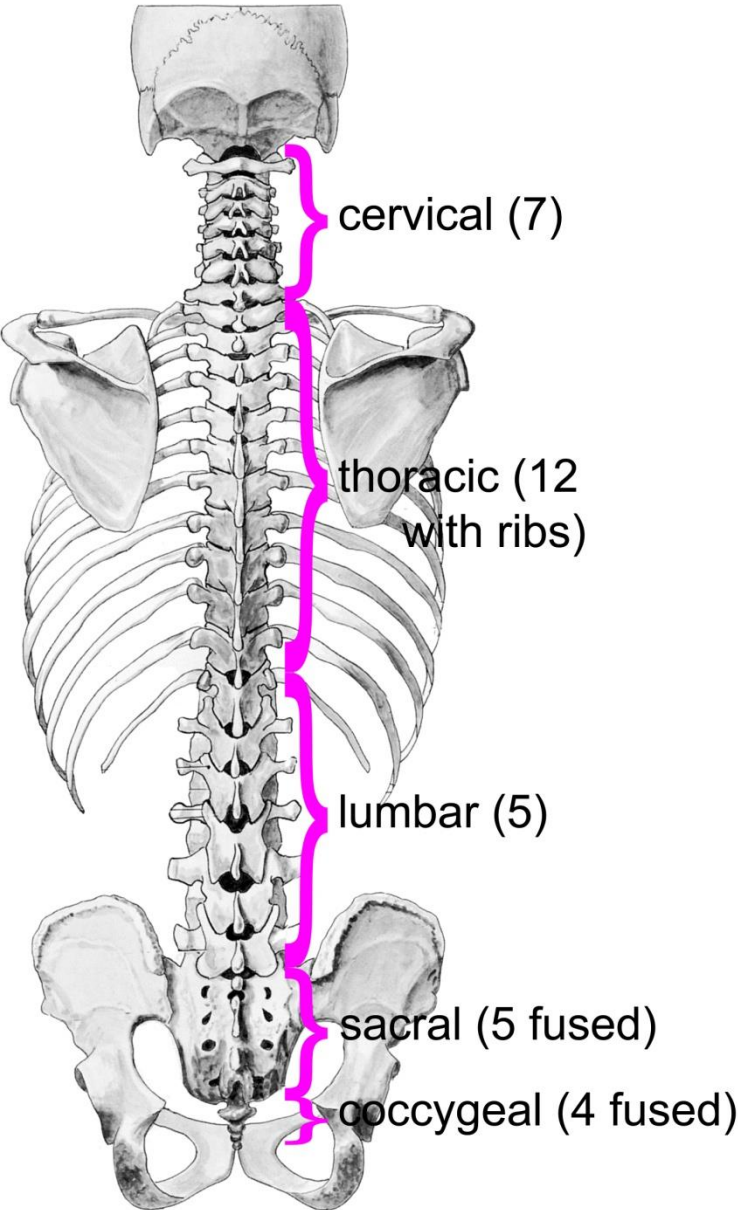
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How would you get a sample of CSF?

Would you take it from a brain ventricle or the subarachnoid space?



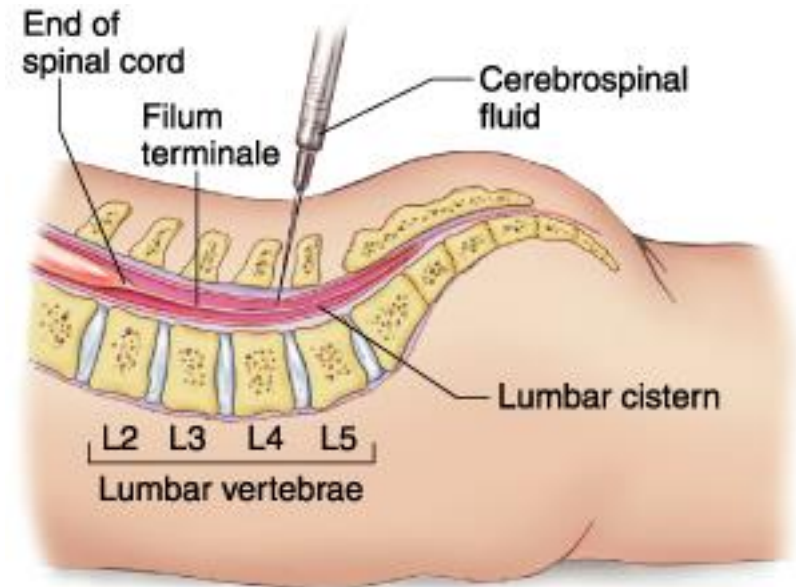
# Sampling CSF



F. Netter

# Sampling CSF

- CSF can be sampled by lumbar puncture (spinal tap).
- This is often done to test for and classify meningitis.



## CSF Leakage

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Trauma to the face can result in leakage of CSF from the subarachnoid space into the nasal cavity.

