The Meninges

The brain in the skull is surrounded by three protective membranes, or meninges: the dura mater, the arachnoid mater, and the pia mater. (The spinal cord in the vertebral column is also surrounded by three meninges)

Dura Mater of the Brain

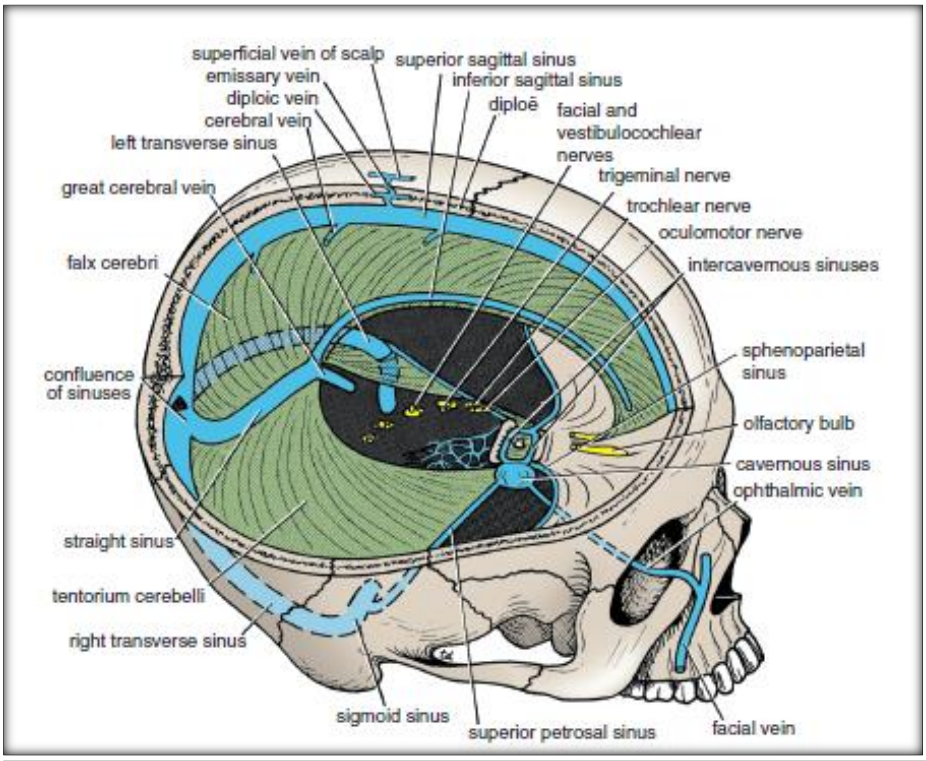
The dura mater is conventionally described as two layers: the endosteal layer and the meningeal layer. These are closely united except along certain lines, where they separate to form venous sinuses. The **endosteal layer** is nothing more than the ordinary periosteum covering the inner surface of the skull bones. **It does not extend** through the foramen magnum to become continuous with the dura mater of the spinal cord. Around the margins of all the foramina in the skull, it becomes continuous with the periosteum on the outside of the skull bones. At the sutures, it is continuous with the sutural ligaments. It is most strongly adherent to the bones over the base of the skull.

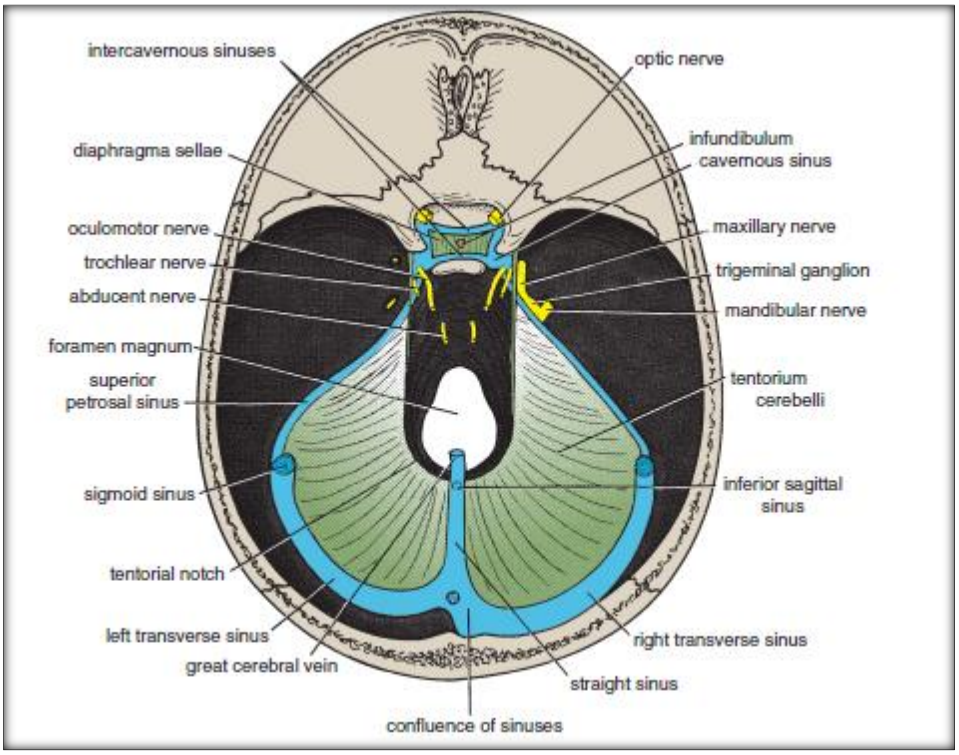
The **meningeal layer** is the dura mater proper. It is a dense, strong, fibrous membrane covering the brain and is continuous through the foramen magnum with the dura mater of the spinal cord. It provides tubular sheaths for the cranial nerves as the latter pass through the foramina in the skull. Outside the skull, the sheaths fuse with the epineurium of the nerves. The meningeal layer sends inward four septa that divide the cranial cavity into freely communicating spaces lodging the subdivisions of the brain. The function of these septa is to restrict the rotatory displacement of the brain.

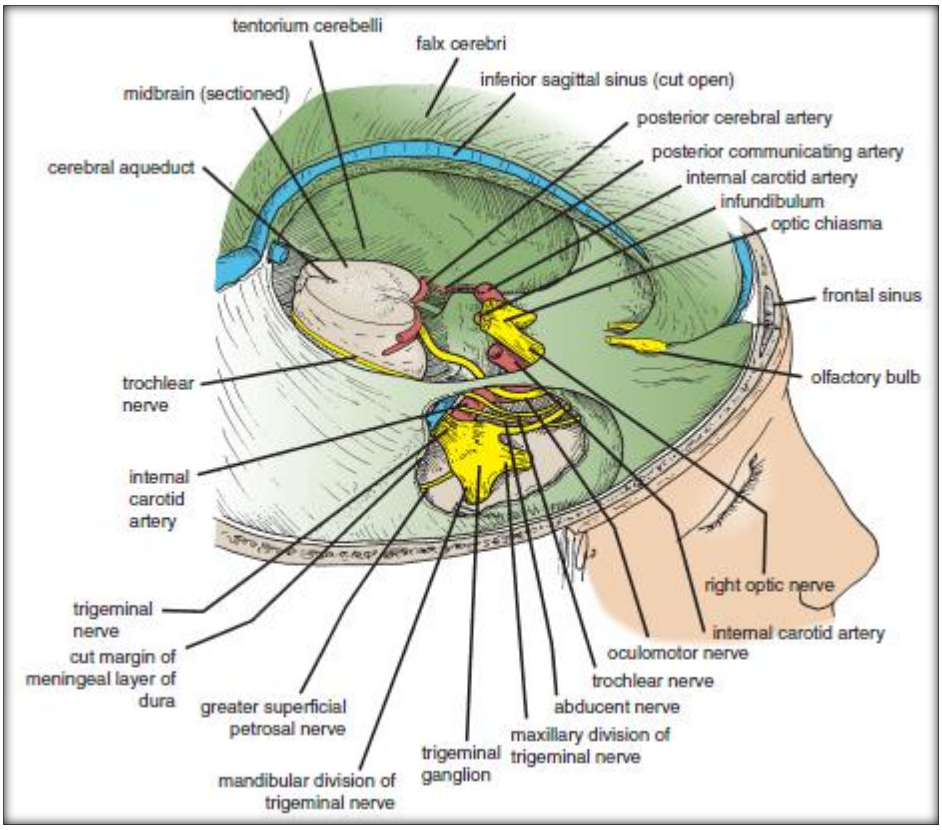
The **falx cerebri** is a sickle-shaped fold of dura mater that lies in the midline between the two cerebral hemispheres. Its narrow end in front is attached to the internal frontal crest and the crista galli. Its broad posterior part blends in the midline with the upper surface of the tentorium cerebelli. The superior sagittal sinus runs in its upper fixed margin, the inferior sagittal sinus runs in its lower concave free margin, and the straight sinus runs along its attachment to the tentorium cerebelli.

The **tentorium cerebelli** is a crescent-shaped fold of dura mater that roofs over the posterior cranial fossa. It covers the upper surface of the cerebellum and supports the occipital lobes of the cerebral hemispheres. In front is a gap, the **tentorial notch,** for the passage of the midbrain, thus producing an inner free border and an outer attached or fixed border. The fixed border is attached to the posterior clinoid processes, the superior borders of the petrous bones, and the margins of the grooves for the transverse sinuses on the occipital bone. The free

border runs forward at its two ends, crosses the attached border, and is affixed to the anterior clinoid process on each side. At the point where the two borders cross, the third and fourth cranial nerves pass forward to enter the lateral wall of the cavernous sinus







Close to the apex of the petrous part of the temporal bone, the lower layer of the tentorium is pouched forward beneath the superior petrosal sinus to form a recess for the trigeminal nerve and the trigeminal ganglion.

The falx cerebri and the falx cerebelli are attached to the upper and lower surfaces of the tentorium, respectively. The straight sinus runs along its attachment to the falx cerebri, the superior petrosal sinus along its attachment to the petrous bone, and the transverse sinus along its attachment to the occipital bone.

The **falx cerebelli** is a small, sickle-shaped fold of dura mater that is attached to the internal occipital crest and projects forward between the two cerebellar hemispheres. Its posterior fixed margin contains the occipital sinus.

The **diaphragma sellae** is 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.

Dural Nerve Supply

Branches of the trigeminal, vagus, and first three cervical nerves and branches from the sympathetic system pass to the dura. Numerous sensory endings are in the dura. The dura is sensitive to stretching, which produces the sensation of headache. Stimulation of the sensory endings of the trigeminal nerve above the level of the tentorium cerebelli produces referred pain to an area of skin on the same side of the

head. Stimulation of the dural endings below the level of the tentorium produces referred pain to the back of the neck and back of the scalp along the distribution of the greater occipital nerve.

Dural Arterial Supply

Numerous arteries supply the dura mater from the internal carotid, maxillary, ascending pharyngeal, occipital, and vertebral arteries. From a clinical standpoint, the most important is the middle meningeal artery, which is commonly damaged in head injuries.

The **middle meningeal artery** arises from the maxillary artery in the infratemporal fossa. It enters the cranial cavity and runs forward and laterally in a groove on the upper surface of the squamous part of the temporal bone. To enter the cranial cavity, it passes through the foramen spinosum to **lie between the meningeal and endosteal layers of dura.** The anterior (frontal) branch deeply grooves or tunnels the anteroinferior angle of the parietal bone, and its course corresponds roughly to the line of the underlying precentral gyrus of the brain. The posterior (parietal) branch curves backward and supplies the posterior part of the dura mater.

Dural Venous Drainage

The **meningeal veins** lie in the endosteal layer of dura. The middle meningeal vein follows the branches of the middle meningeal artery and drains into the pterygoid venous plexus or the sphenoparietal sinus. The veins lie lateral to the arteries.

Arachnoid Mater of the Brain

The arachnoid mater is a delicate, impermeable membrane covering the brain and lying between the pia mater internally and the dura mater externally. It is separated from the dura by a potential space, the **subdural space,** and from the pia by the **subarachnoid space,** which is filled with **cerebrospinal fluid.**

The arachnoid bridges over the sulci on the surface of the brain, and in certain situations the arachnoid and pia are widely separated to form the **subarachnoid cisternae.**

In certain areas, the arachnoid projects into the venous sinuses to form **arachnoid villi.** The arachnoid villi are most numerous along the superior sagittal sinus. Aggregations of arachnoid villi are referred to as **arachnoid granulations**. Arachnoid villi serve as sites where the cerebrospinal fluid diffuses into the bloodstream.

It is important to remember that structures passing to and from the brain to the skull or its foramina must pass

through the subarachnoid space. All the cerebral arteries and veins lie in the space, as do the cranial nerves. The arachnoid fuses with the epineurium of the nerves at

their point of exit from the skull. In the case of the optic nerve, the arachnoid forms a sheath for the nerve that extends into the orbital cavity through the optic canal and fuses with the sclera of the eyeball. Thus, the subarachnoid space extends around the optic nerve as far as the eyeball.

The **cerebrospinal fluid** is produced by the **choroid plexuses** within the lateral, third, and fourth ventricles of the brain. It escapes from the ventricular system of the brain through the three foramina in the roof of the fourth ventricle and so enters the subarachnoid space. It now circulates both upward over the surfaces of the cerebral hemispheres and downward around the spinal cord. The spinal subarachnoid space extends down as far as the **second sacral vertebra**. Eventually, the fluid enters the bloodstream by passing into the arachnoid villi and diffusing through their walls.

In addition to removing waste products associated with neuronal activity, the cerebrospinal fluid provides a fluid medium in which the brain floats. This mechanism effectively protects the brain from trauma.

Pia Mater of the Brain

The pia mater is a vascular membrane that closely invests the brain, covering the gyri and descending into the deepest sulci. It extends over the cranial nerves and fuses with their epineurium. The cerebral arteries entering the substance of the brain carry a sheath of pia with them.

The Venous Blood Sinuses

The venous sinuses of the cranial cavity are blood-filled spaces situated between the layers of the dura mater; they are lined by endothelium. Their walls are thick and composed of fibrous tissue; they have no muscular tissue. The sinuses have no valves. They receive tributaries from the brain, the diploë of the skull, the orbit, and the internal ear.

The **superior sagittal sinus** lies in the upper fixed border of the falx cerebri. It runs backward and becomes continuous with the right transverse sinus. The sinus communicates on each side with the **venous lacunae.** Numerous arachnoid villi and granulations project into the lacunae. The superior sagittal sinus receives the **superior cerebral veins.**

The **inferior sagittal sinus** lies in the free lower margin of the falx cerebri. It runs backward and joins the great cerebral vein to form the straight sinus. It receives cerebral veins from the medial surface of the cerebral hemisphere.

The **straight sinus** lies at the junction of the falx cerebri with the tentorium cerebelli. Formed by the union of the inferior sagittal sinus with the great cerebral vein, it drains into the left transverse sinus.

The **right transverse sinus** begins as a continuation of the superior sagittal sinus; the **left transverse sinus** is usually a continuation of the straight sinus. Each sinus lies in the lateral attached margin of the tentorium cerebelli, and they end on each side by becoming the sigmoid sinus.
The **sigmoid sinuses** are a direct continuation of the transverse sinuses. Each sinus turns downward behind the mastoid antrum of the temporal bone and then leaves the skull through the jugular foramen to become the internal jugular vein.
The **occipital sinus** lies in the attached margin of the falx cerebelli. It communicates with the vertebral veins through the foramen magnum and the transverse sinuses.
Each **cavernous sinus** lies on the lateral side of the body of the sphenoid bone. Anteriorly, the sinus receives the inferior ophthalmic vein and the central vein of the retina. The sinus drains posteriorly into the transverse sinus through the superior petrosal sinus. Intercavernous sinuses connect the two cavernous sinuses through the sella turcica.(see figures above)

Important Structures Associated with the Cavernous Sinuses

- The internal carotid artery and the 6th cranial nerve, which travel through it
- In the lateral wall, the 3rd and 4th cranial nerves, and the ophthalmic and maxillary divisions of the 5th cranial nerve.
- The pituitary gland, which lies medially in the sella turcica
- The veins of the face, which are connected with the cavernous sinus via the facial vein and inferior ophthalmic vein, are an important route for the spread of infection from the face
- The **superior** and **inferior petrosal sinuses,** which run along the upper and lower borders of the petrous part of the temporal bone

Pituitary Gland (Hypophysis Cerebri)

The pituitary gland is a small, oval structure attached to the undersurface of the brain by the **infundibulum**. The gland is well protected by virtue of its location in the sella turcica of the sphenoid bone. The pituitary gland is vital to life and well described later.

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