كلية المستقبل الجامعة قسم هندسة الطب الحياتي

المرحلة الثانية

ANATOMY

HEAD & NECK

NEUROANATOMY

(L3)

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Bones of the Skull

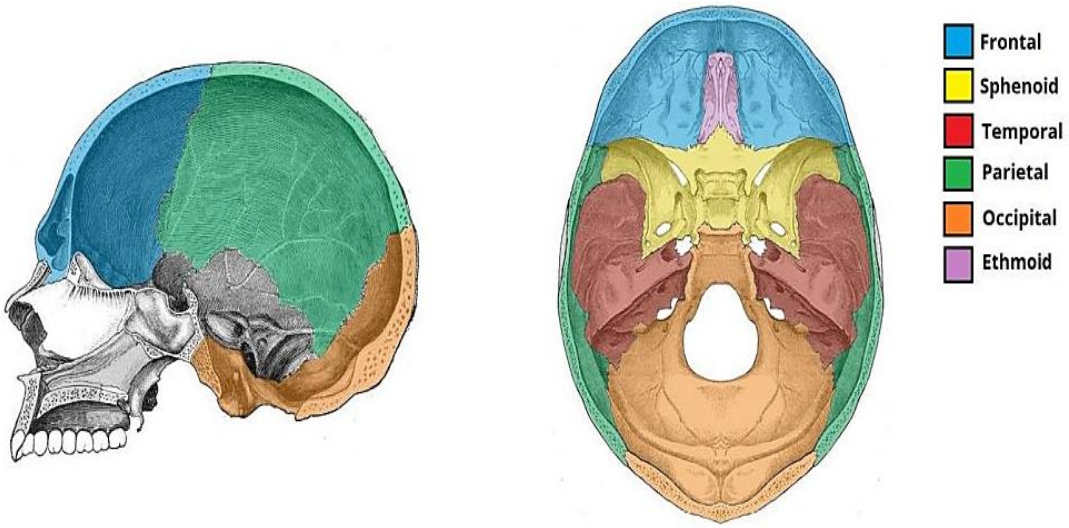
The bones of the skull can be considered as two groups: those of the cranium (which consist of the cranial roof and cranial base) and those of the face.

Cranium

The cranium (also known as the neurocranium) is formed by the superior aspect of the skull. It encloses and protects the brain, meninges, and cerebral vasculature.

Anatomically, the cranium can be subdivided into a roof and a base:

- Cranial roof – comprised of the frontal, occipital and two parietal bones. It is also known as the calvarium.
- Cranial base – comprised of six bones: frontal, sphenoid, ethmoid, occipital, parietal and temporal. These bones articulate with the 1st cervical vertebra (atlas), the facial bones, and the mandible (jaw).



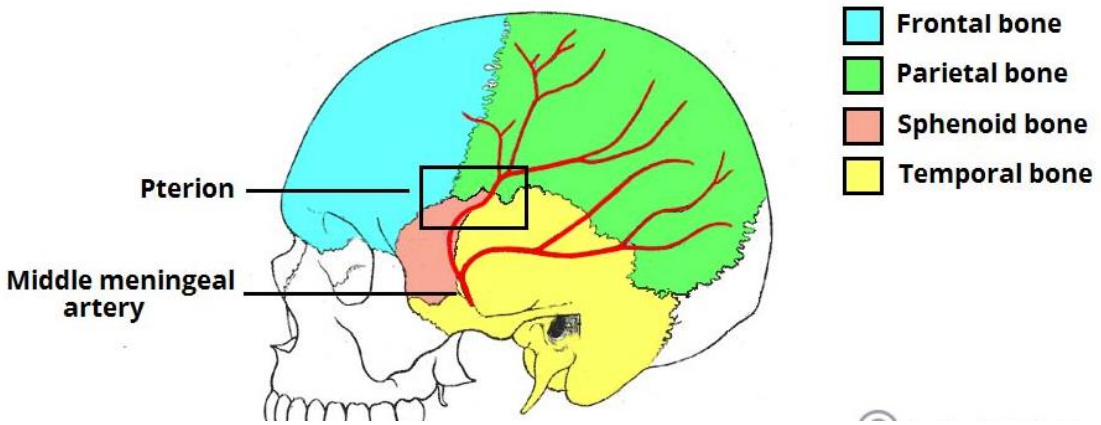
a) Bones of the calvarium **b) Bones of the cranial base**

Clinical Relevance: Cranial Fractures

Fractures of the cranium typically arise from blunt force or penetrating trauma. When considering cranial fractures, one area of clinical

importance is the pterion – a H-shaped junction between the temporal, parietal, frontal, and sphenoid bones.

The pterion overlies the middle meningeal artery, and fractures in this area may injury the vessel. Blood can accumulate between the skull and the dura mater, forming an extradural haematoma.



Fig– Lateral view of the skull, showing the path of the meningeal arteries. Note the pterion, a weak point of the skull, where the anterior middle meningeal artery is at risk of damage.

Face

The facial skeleton (also known as the viscerocranium) supports the soft tissues of the face.

It consists of 14 bones, which fuse to house the orbits of the eyes, the nasal and oral cavities, and the sinuses. The frontal bone, typically a bone of the calvaria, is sometimes included as part of the facial skeleton.

The facial bones are:

- Zygomatic (2) – forms the cheek bones of the face and articulates with the frontal, sphenoid, temporal and maxilla bones.
- Lacrimal (2) – the smallest bones of the face. They form part of the medial wall of the orbit.
- Nasal (2) – two slender bones that are located at the bridge of the nose.

- Inferior nasal conchae (2) – located within the nasal cavity, these bones increase the surface area of the nasal cavity, thus increasing the amount of inspired air that can come into contact with the cavity walls.
- Palatine (2) – situated at the rear of oral cavity and forms part of the hard palate.
- Maxilla (2) – comprises part of the upper jaw and hard palate.
- Vomer – forms the posterior aspect of the nasal septum.
- Mandible (jaw) – articulates with the base of the cranium at the temporomandibular joint (TMJ).

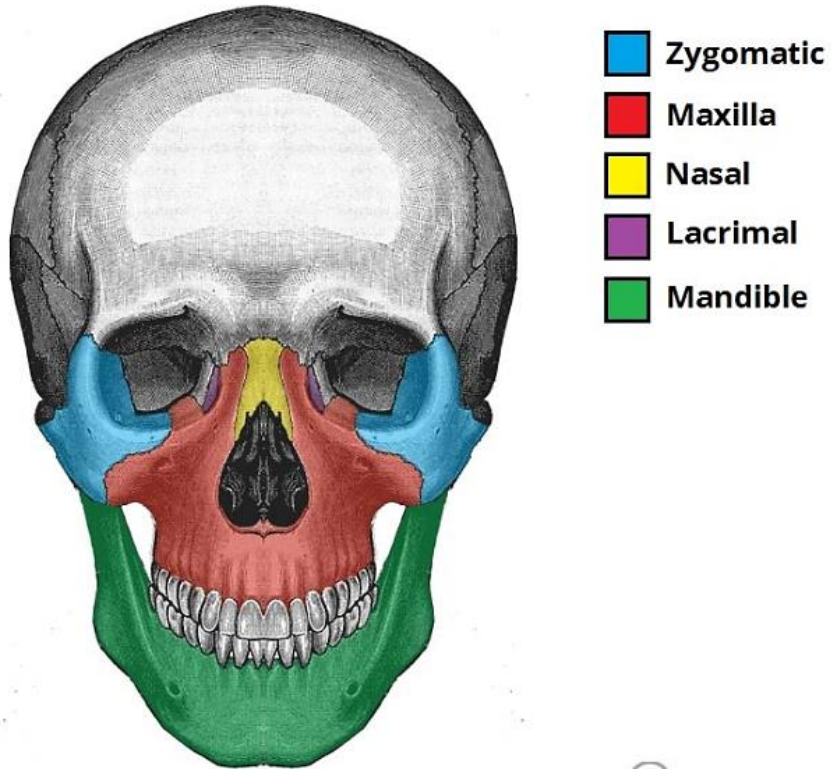


Fig – Anterior view of the face, showing some of the bones of the nasal skeleton. The vomer, palatine and inferior conchae bones lie deep within the face.

Sutures of the Skull

Sutures are a type of fibrous joint that are unique to the skull. They are immovable and fuse completely around the age of 20.

These joints are important in the context of trauma, as they represent points of potential weakness in the skull. The main sutures in the adult skull are:

- Coronal suture – fuses the frontal bone with the two parietal bones.
- Sagittal suture – fuses both parietal bones to each other.
- Lambdoid suture – fuses the occipital bone to the two parietal bones.

In neonates, the incompletely fused suture joints give rise to membranous gaps between the bones, known as fontanelles. The two major fontanelles are:

- Frontal fontanelle – located at the junction of the coronal and sagittal sutures
- Occipital fontanelle – located at the junction of the sagittal and lambdoid sutures

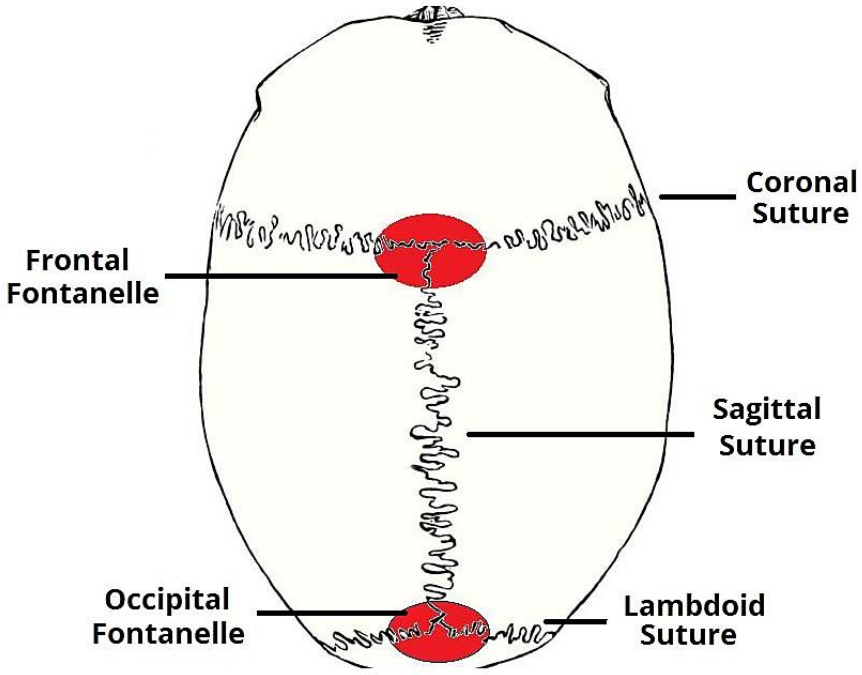


Fig – The major fontanelles and sutures of the skull

The Scalp

The scalp refers to the layers of skin and subcutaneous tissue that cover the bones of cranial vault.

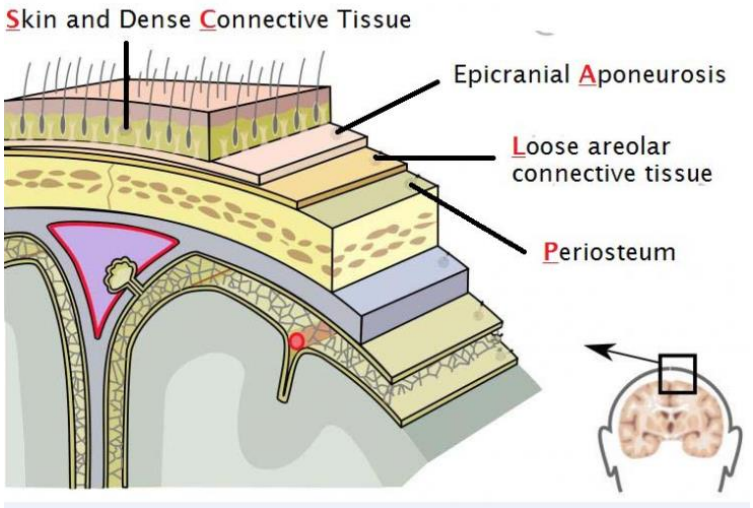
Layers of the Scalp

The scalp consists of five layers. The first three layers are tightly bound together and move as a collective structure.

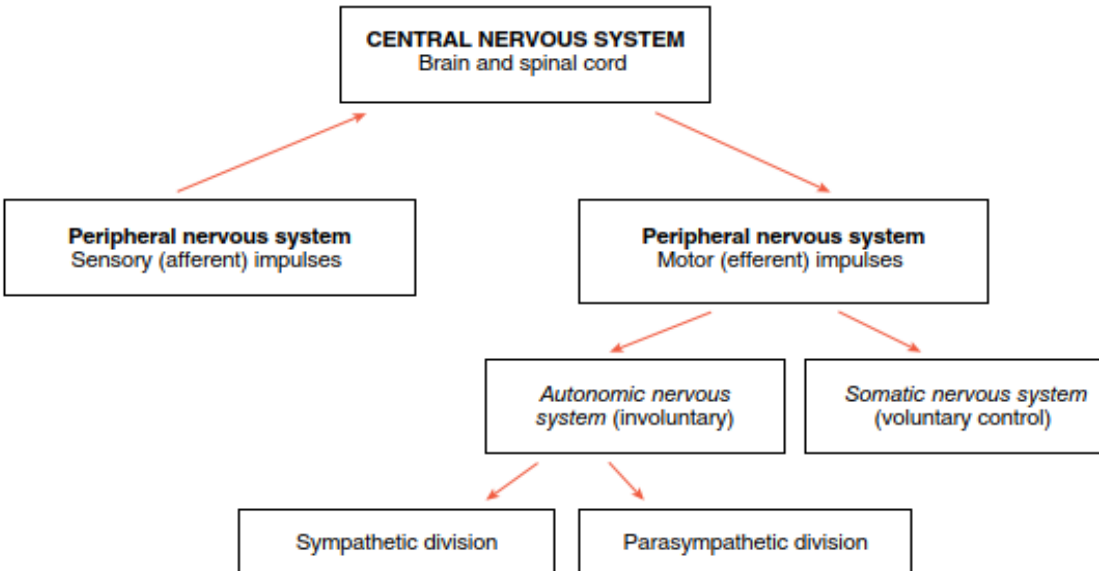
The mnemonic 'SCALP' can be a useful way to remember the layers of the scalp: Skin, Dense Connective Tissue, Epicranial Aponeurosis, Loose Areolar Connective Tissue and Periosteum.

- Skin – contains numerous hair follicles and sebaceous glands (thus a common site for sebaceous cysts).
- Dense Connective tissue – connects the skin to the epicranial aponeurosis. It is richly vascularised and innervated.
- Epicranial Aponeurosis – a thin, tendon-like structure that connects the occipitalis and frontalis muscles.
- Loose Areolar Connective Tissue – a thin connective tissue layer that separates the periosteum of the skull from the epicranial aponeurosis.
- Periosteum – the outer layer of the skull bones. It becomes continuous with the endosteum at the suture lines.

(Figure The five layers of the scalp. Note – The three layers below the periosteum are the meninges)



Neuroanatomy



(Organization of Nervous System)

Central nervous system

The central nervous system consists of the brain and spinal cord. The central nervous system processes and integrates sensory information. The received information has to be interpreted, it can be stored to be dealt with later or it can be acted upon immediately with one or more motor responses. For example, the sensation of temperature change would be received and interpreted by the hypothalamus (a structure of the central nervous system) and an appropriate action would be initiated.

THE BRAIN

1.The Cerebrum

The cerebrum is the largest part of the brain, located superiorly and anteriorly in relation to the brainstem. It consists of two **cerebral hemispheres** (left and right), separated by the falx cerebri of the dura mater.

(Fig – Anatomical position of the cerebrum)

Anatomical Position and Structure

The cerebrum is located within the bony cranium. It extends from the frontal bone anteriorly to the occipital bone posteriorly.

Internal Structure

The cerebrum is comprised of two different types of tissue – grey matter and white matter:

- Grey matter forms the surface of each cerebral hemisphere (known as the cerebral cortex), and is associated with processing and cognition.
- White matter forms the bulk of the deeper parts of the brain. It consists of glial cells and myelinated axons that connect the various grey matter areas.

External Structure

Externally, the cerebrum has a highly convoluted appearance, consisting of sulci (grooves or depressions) and gyri (ridges or elevations). It is divided into two anatomically symmetrical hemispheres by the longitudinal fissure – a major sulcus that runs in the median sagittal plane. The falx cerebri (a fold of dura mater) descends vertically to fill this fissure. The two cerebral hemispheres are connected by a white matter structure, called the corpus callosum.

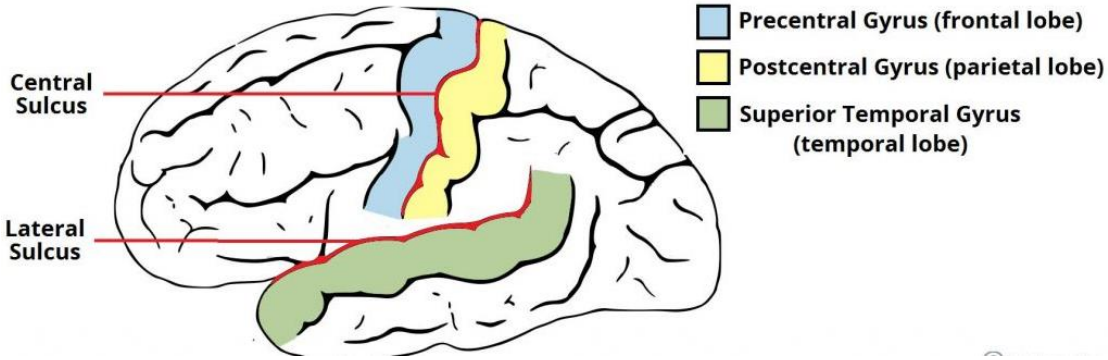
The main sulci are:

- Central sulcus – groove separating the frontal and parietal lobes.
- Lateral sulcus – groove separating the frontal and parietal lobes from the temporal lobe.

- Lunate sulcus – groove located in the occipital cortex.

The main gyri are:

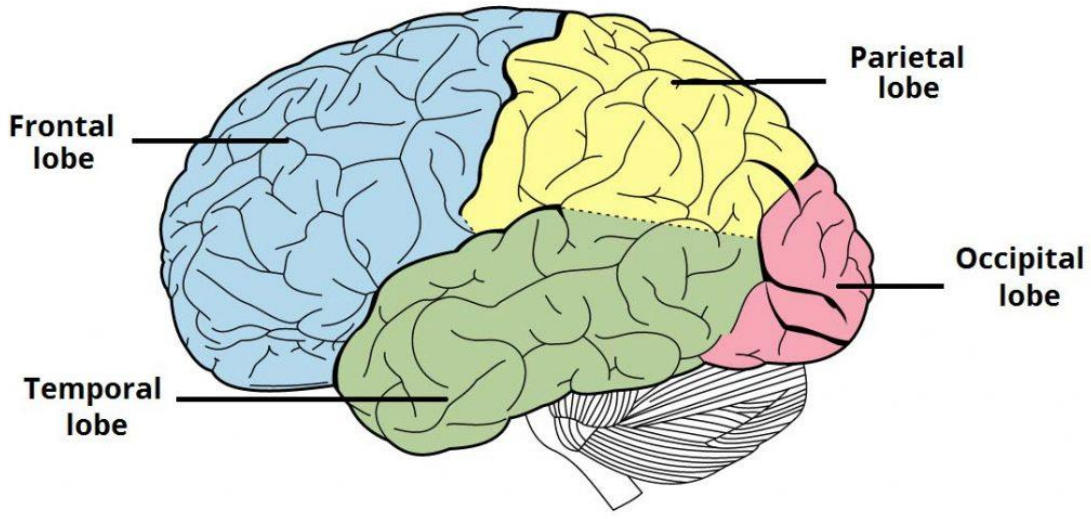
- Precentral gyrus – ridge directly anterior to central sulcus, location of primary motor cortex.
- Postcentral gyrus – ridge directly posterior to central sulcus, location of primary somatosensory cortex.
- Superior temporal gyrus – ridge located inferior to lateral sulcus, responsible for the reception and processing of sound.



(The notable sulci and gyri of the cerebrum)

Lobes of the Cerebrum

The cerebral cortex is classified into four lobes, according to the name of the corresponding cranial bone that approximately overlies each part, Frontal, parietal, temporal, and occipital lobes.



2. Diencephalon

This part of the brain is surrounded by the cerebrum and contains three paired structures:

• Thalamus – acts as a relay station for sensory impulses going to the cerebral cortex for integration and motor impulses entering and leaving the cerebral hemispheres. It also has a role in memory.

• Hypothalamus – is closely associated with the pituitary gland and produces two hormones: antidiuretic hormone (ADH) and oxytocin. The hypothalamus has many functions and these include:

◦ control of body temperature

◦ control of the autonomic nervous system

◦ control of fluid balance and thirst

◦ control of appetite

◦ associated with the limbic system dealing with emotional reactions

◦ control of sexual behaviours.

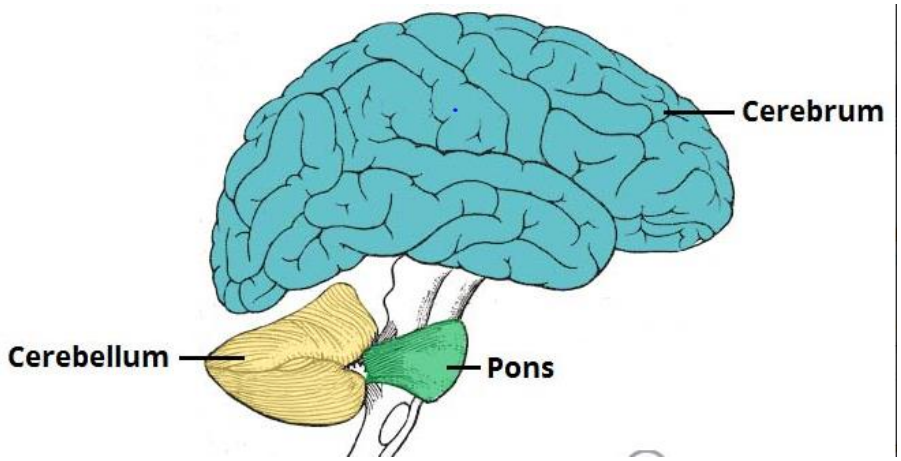
• Epithalamus – this structure is linked to the pineal gland, which secretes the hormone melatonin responsible for sleep–wake cycles.

3. The Cerebellum

The cerebellum, which stands for “little brain”, is a structure of the central nervous system. This portion of the brain is primarily responsible for aiding motor function. The cerebellum does this by coordinating rapid alternating movements, balance, and position sense. Disease of the cerebellum may present with dysfunction of speech, tremor, or ocular findings, such as nystagmus. Cerebellar disease may also be found with examination findings of abnormal gait, or abnormal findings on finger-to-nose testing

Anatomical Location

The cerebellum is located at the back of the brain, immediately inferior to the **occipital** and **temporal lobes**, and within the posterior cranial fossa.

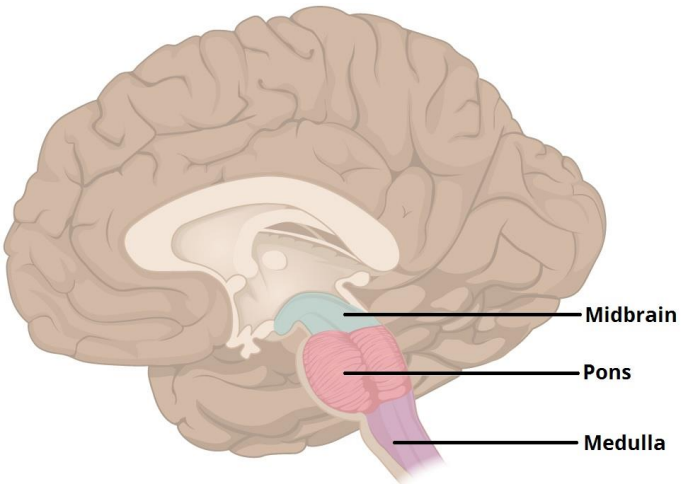


(Fig – Anatomical position of the cerebellum. It is inferior to the cerebrum, and posterior to the pons)

4. Brainstem

The Midbrain

The **midbrain** (also known as the mesencephalon) is the most superior of the three regions of the brainstem. It acts as a conduit between the forebrain above and the pons and cerebellum below.



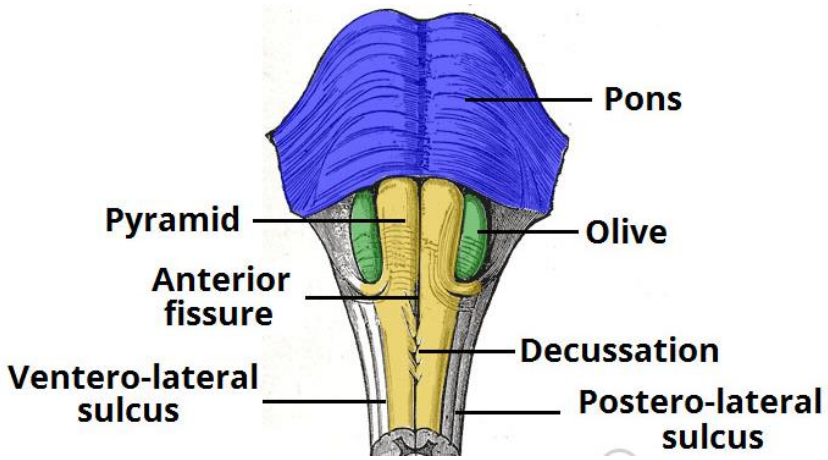
(Figure – The three major parts of the brainstem)

The Pons

The **pons** is the largest part of the brainstem, located above the medulla and below the midbrain. It is a group of nerves that function as a connection between the cerebrum and cerebellum (*pons is Latin for bridge*).

The Medulla Oblongata

It is the most inferior of the three and is continuous above with the pons and below with the spinal cord. The medulla is conical in shape, decreasing in width as it extends inferiorly. The medulla houses essential ascending and descending nerve tracts as well as brainstem nuclei. The pyramids are a ventral structure of the medulla where the corticospinal tracts traverse the midline, decussate, and then transmit impulses to the opposite side of the body. It is the process of decussating, or crossing the midline, that results in the right or left side of the brain being responsible for sensation or movement on the opposite side of the body.

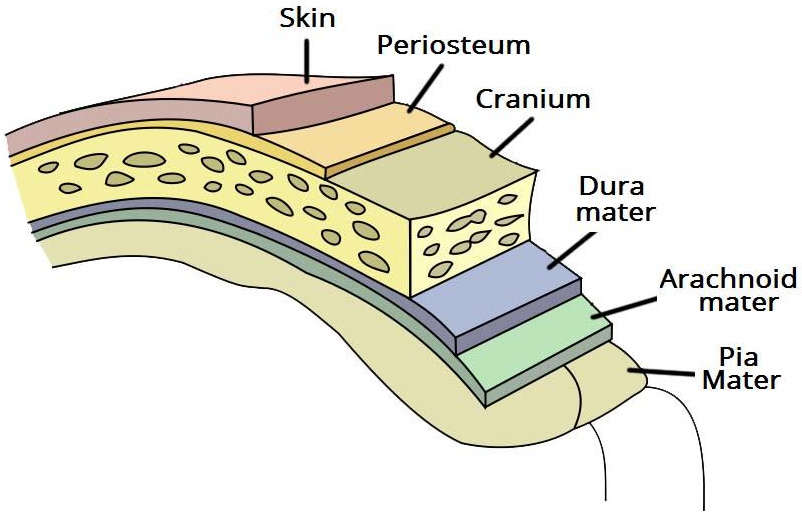


The Meninges

The meninges refer to the **membranous** coverings of the brain and spinal cord. There are three layers of meninges, known as the **dura** mater, **arachnoid** mater and **pia** mater.

These coverings have two major functions:

- Provide a **supportive framework** for the cerebral and cranial vasculature.
- Acting with cerebrospinal fluid to **protect** the CNS from mechanical damage.



(Fig – Overview of the meninges, and their relationship to the skull and brain)

Dura Mater

The dura mater is the **outermost** layer of the meninges and is located directly underneath the bones of the skull and vertebral column. It is thick, tough, and inextensible.

The dura mater consists of two **layered** sheets of connective tissue:

Periosteal layer and **Meningeal layer.** The **dural venous sinuses** are located between the two layers of dura mater. They are responsible for the venous drainage of the cranium and empty into the **internal jugular** veins.

Arachnoid Mater

The arachnoid mater is the middle layer of the meninges, lying directly underneath the dura mater. It consists of layers of connective tissue, is **avascular**, and does not receive any innervation. Underneath the arachnoid is a space known as the **sub-arachnoid space**. It contains cerebrospinal fluid, which acts to cushion the brain.

Pia Mater

The pia mater is located underneath the sub-arachnoid space. It is very thin, and **tightly adhered** to the surface of the brain and spinal cord. It is the only covering to follow the contours of the brain (the gyri and fissures). Like the dura mater, it is **highly vascularized**.

Summary of the Cranial Nerves

The cranial nerves are a set of **12** paired nerves that arise directly from the brain. The first two nerves (**olfactory** and **optic**) arise from the cerebrum, whereas the remaining ten emerge from the brain stem.

The names of the cranial nerves relate to their function and they are also numerically identified in roman numerals (I - XII).

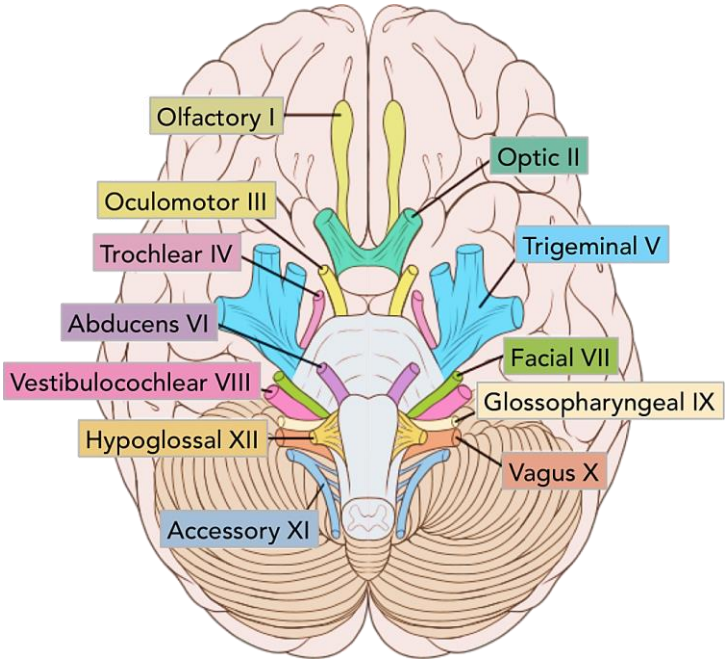
Origin of the Cranial Nerves

There are twelve cranial nerves in total. The olfactory nerve (CN I) and optic nerve (CN II) originate from the **cerebrum**.

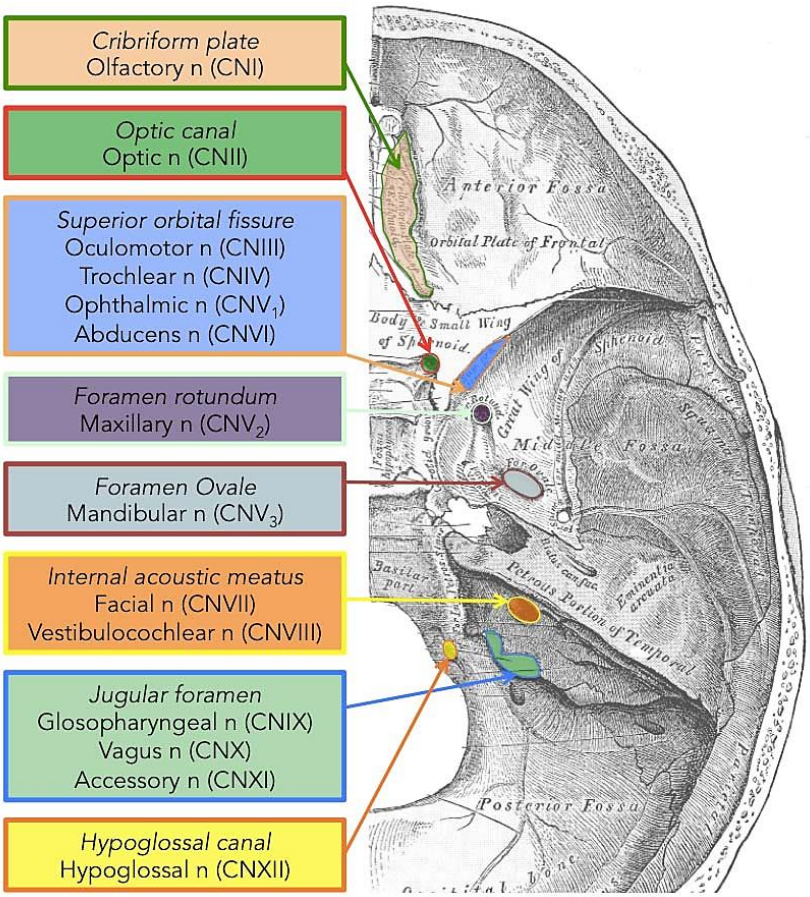
Cranial nerves III – XII arise from the **brain stem** (Figure 1). They can arise from a specific part of the brain stem (midbrain, pons or medulla), or from a junction between two parts:

- **Midbrain** – the trochlear nerve (IV) comes from the posterior side of the midbrain. It has the longest intracranial length of all the cranial nerves.
- **Midbrain-pontine junction** – oculomotor (III).
- **Pons** – trigeminal (V).
- **Pontine-medulla junction** – abducens, facial, vestibulocochlear (VI-VIII).
- **Medulla oblongata** – glossopharyngeal, vagus, accessory (IX-XI). and hypoglossal (XII).

The cranial nerves are numbered by their location on the brain stem (superior to inferior, then medial to lateral) and the order of their exit from the cranium (anterior to posterior) (Figures 1 & 2).



(Figure 1 – The location of the cranial nerves on the cerebrum and brainstem.)



(Figure 2 – Superior view of the skull base showing the foramina and which cranial nerves pass through them)

The Ventricles of the Brain

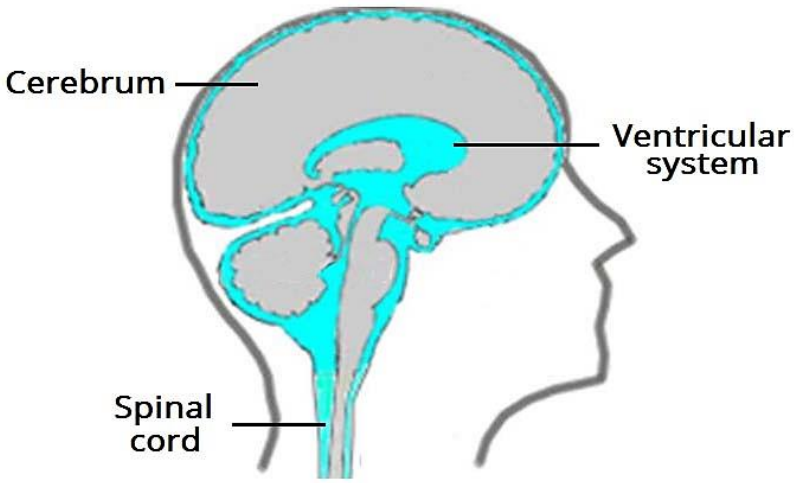
The ventricles of the brain are a communicating network of cavities filled with cerebrospinal fluid (CSF) and located within the brain parenchyma. The ventricular system is composed of two lateral ventricles, the third ventricle, the cerebral aqueduct, and the fourth ventricle. The choroid plexuses located in the ventricles produce CSF, which fills the ventricles and subarachnoid space, following a cycle of constant production and reabsorption.

***Tip**: Cranial nerves with the number 2 in them (e.g. 2-optic and 12-hypoglossal) exit through a **canal** of the same name. They are the only cranial nerves to pass through canals*.

Cerebrospinal fluid

The ventricles are filled with cerebrospinal fluid (CSF) which bathes and cushions the brain and spinal cord within their bony confines. Cerebrospinal fluid is produced by the choroid plexus found in all components of the ventricular system.

There is approximately 150 ml of CSF circulating around the brain, in the ventricles and around the spinal cord. The CSF is replaced every 8 hours.



(Overview of the cerebrospinal fluid distribution in the brain)