

***Lecture 1 & 2***  
***Radiological anatomy of the skull***  
***(cranium) bones***

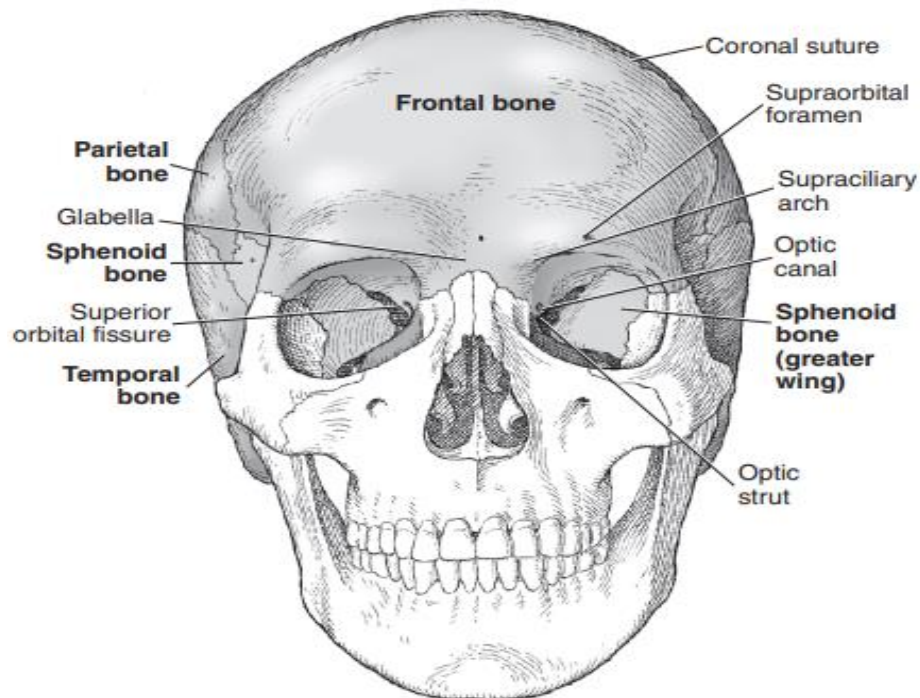
**BY**

**Assistant Lecturer. Hind Moafak Abdul-Jabbar**

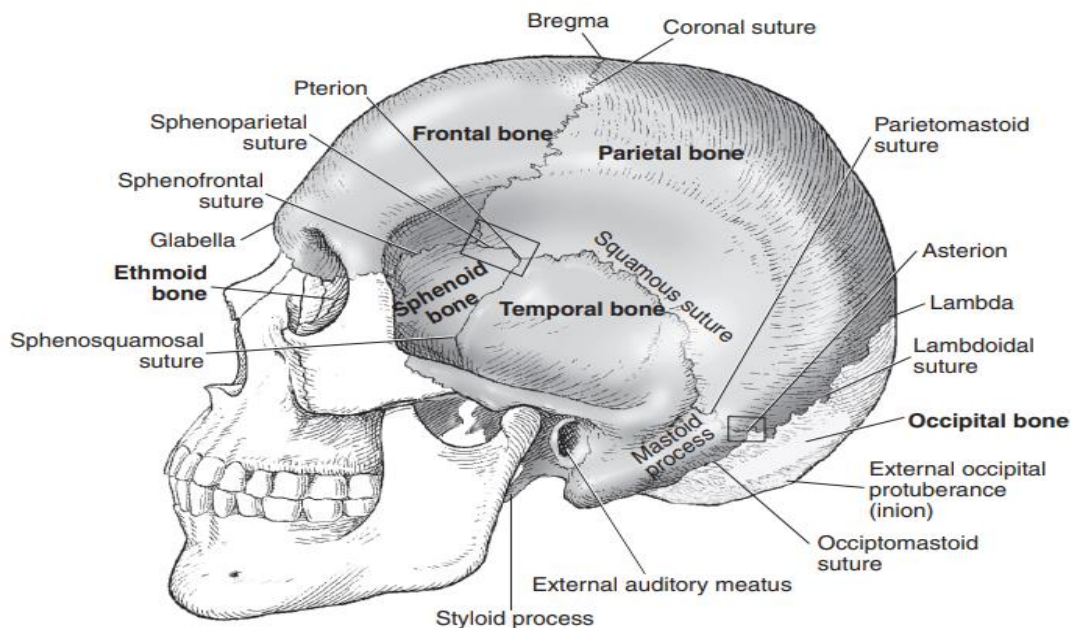
**Third Academic Year**

## Radiological anatomy of the skull (cranium) bones:

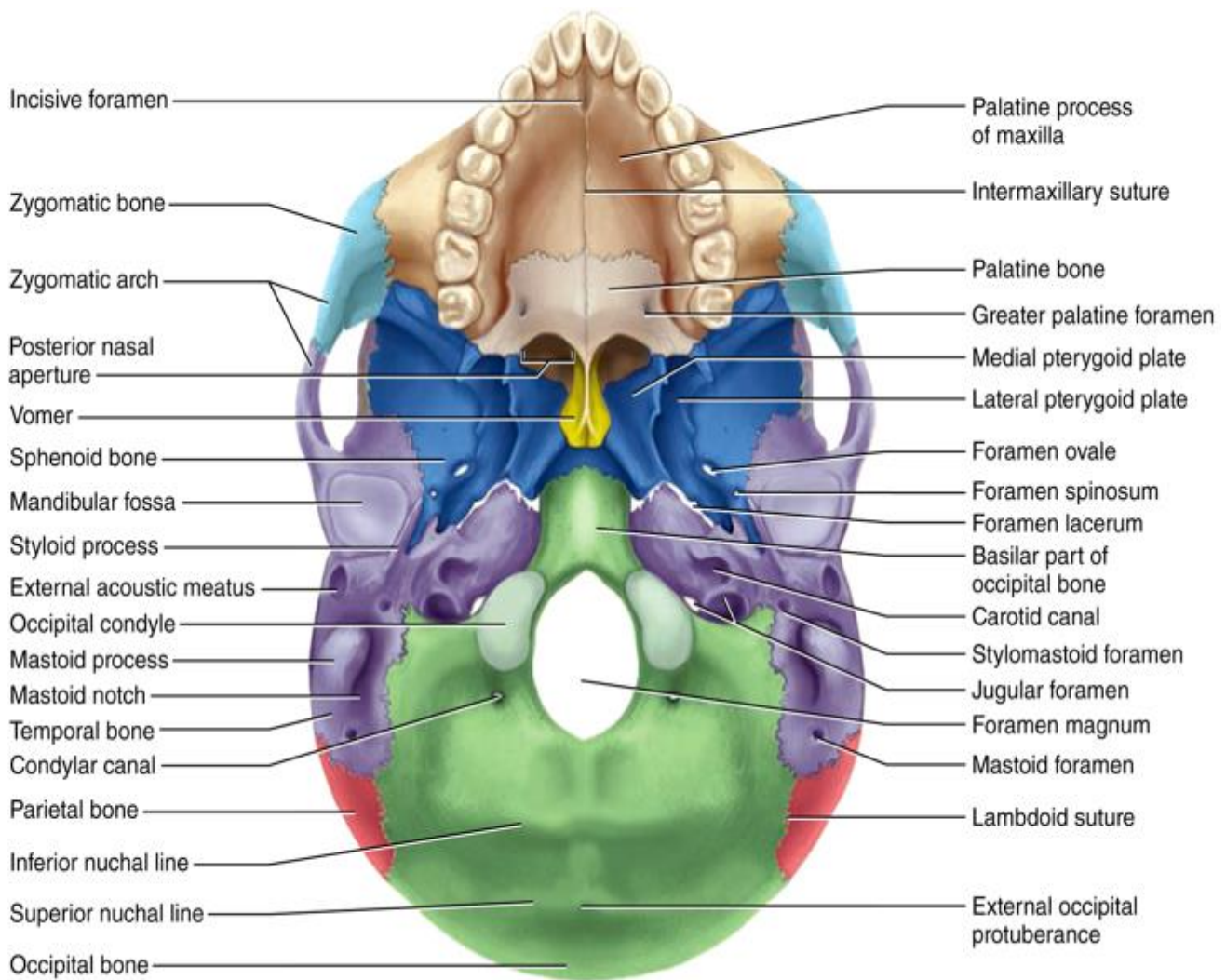
The **cranium** is composed of eight bones that surround and protect the brain. These bones include the **parietal (2)**, **frontal (1)**, **ethmoid (1)**, **sphenoid (1)**, **occipital (1)**, and **temporal (2)**, (Figs. 1, 2a, b & 3).



**Figure 1:** Anterior view of skull.



**Figure 2a:** Lateral view of skull.

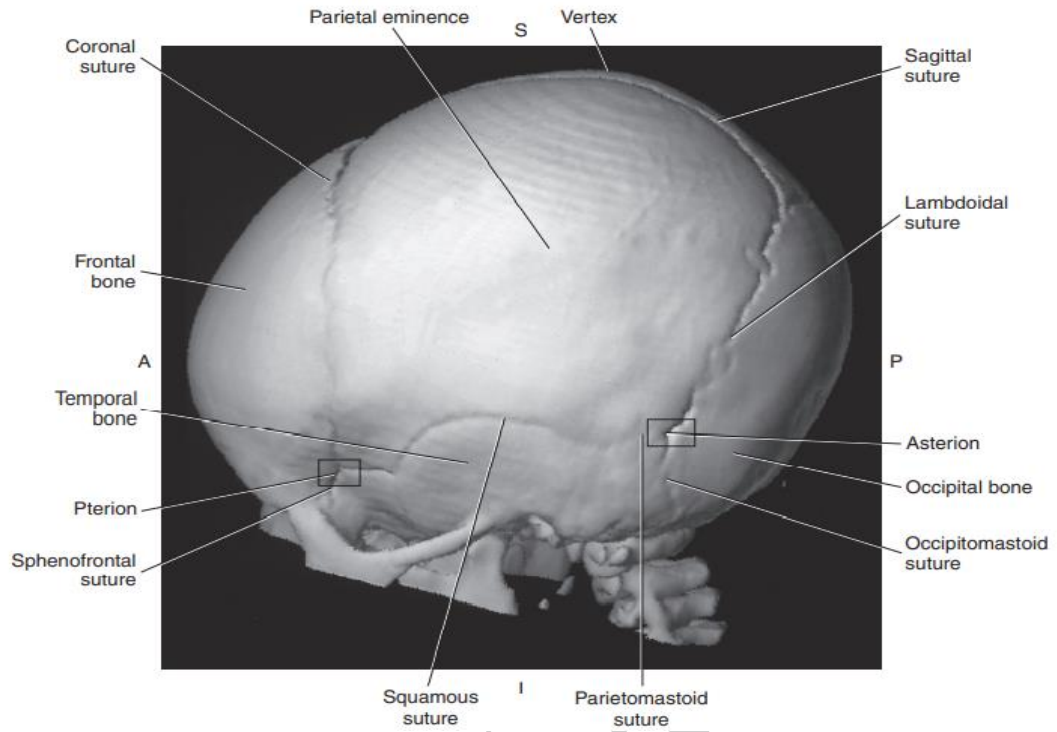


**Figure 2b:** Inferior view of skull.

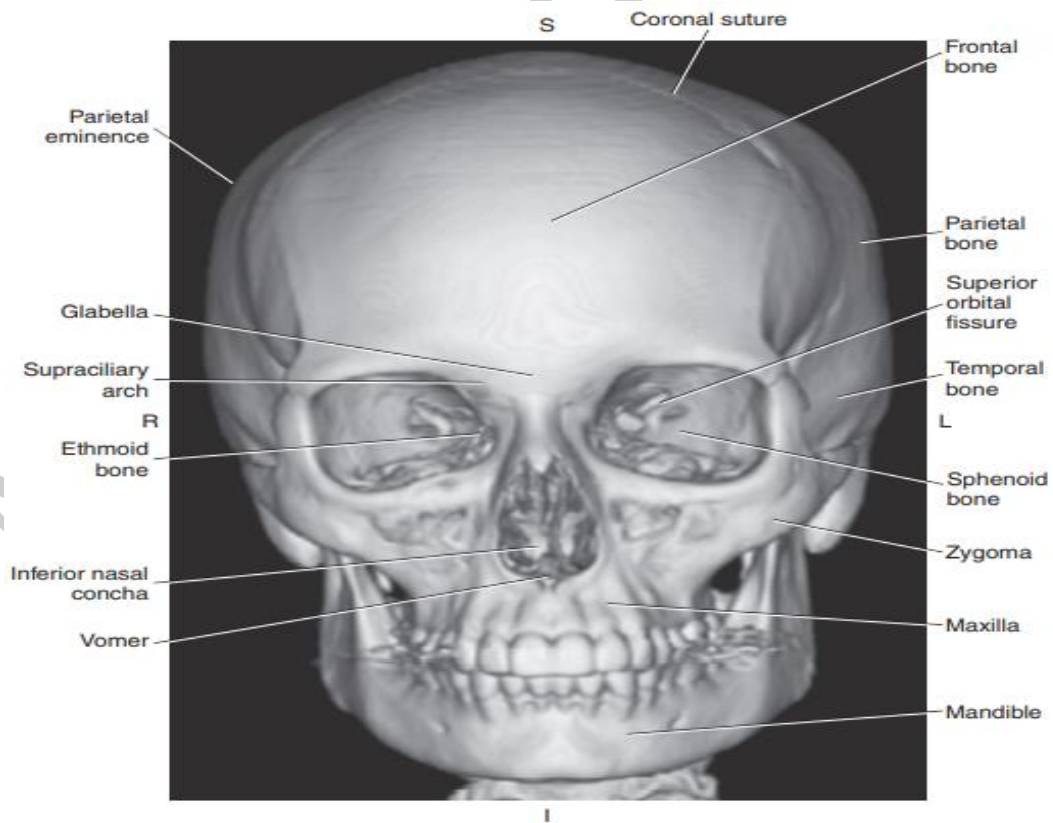
### **Parietal Bones:**

The **two parietal bones** form a large portion of the sides of the cranium. The parietal bones articulate with the **frontal, occipital, temporal, and sphenoid bones**.

The superior point between the parietal bones is the **vertex**, which is the highest point of the cranium, (Fig. 3). Each parietal bone has a central prominent bulge on its outer surface termed the **parietal eminence**, (Fig. 4).



**Figure 3: 3D CT of lateral surface of cranium.**

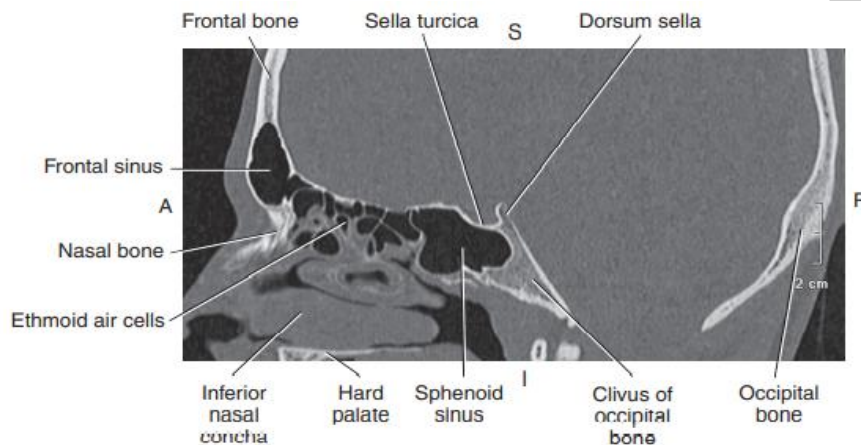


**Figure 4: 3D CT of anterior skull.**

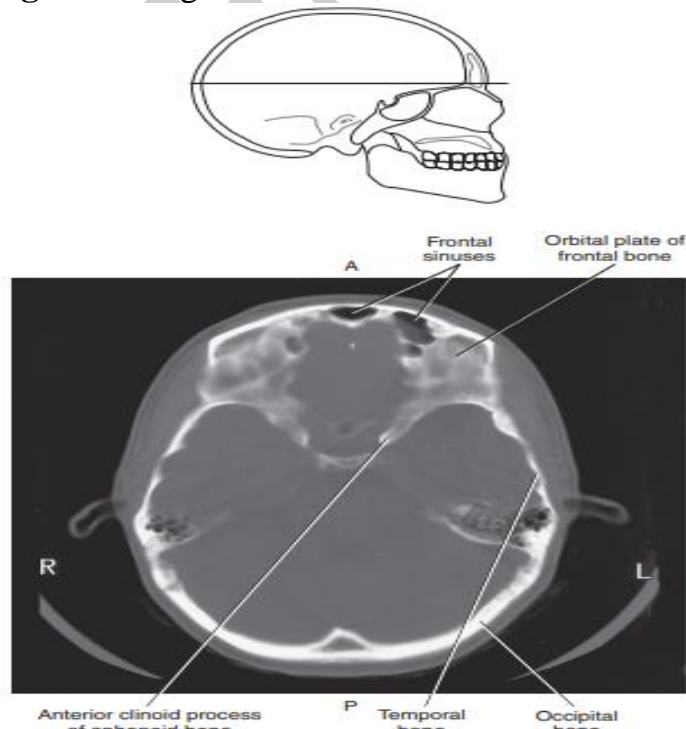
## Frontal Bone:

The **frontal bone** consists of a **vertical** and a **horizontal portion**. The **vertical portion** forms the forehead and anterior vault of the cranium, (Fig. 1). The vertical portion contains the frontal sinuses, (Fig. 5).

The **horizontal portion** forms the roof over each orbit, termed the **orbital plate**, and the majority of the anterior cranial fossa, (Fig. 6). Located in the superior portion of each orbit is the **supraorbital foramen**, which exists for the passage of the supraorbital nerve, (Fig. 1).



**Figure 5:** Sagittal CT reformat of frontal sinus.

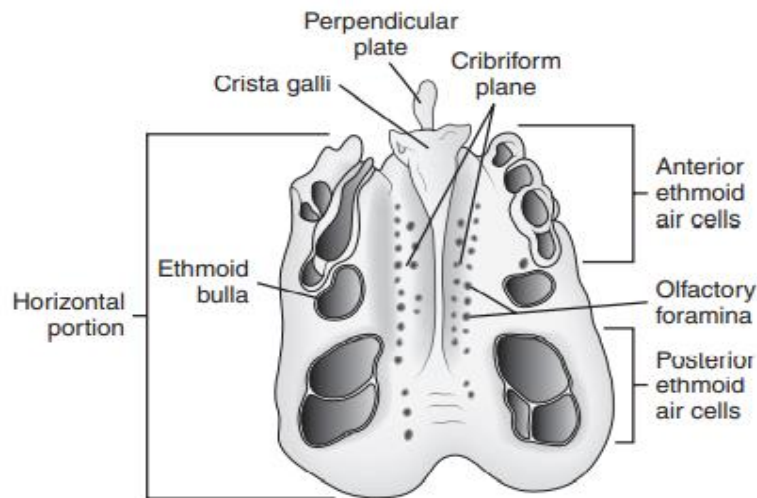


**Figure 6:** Axial CT of orbital plates.

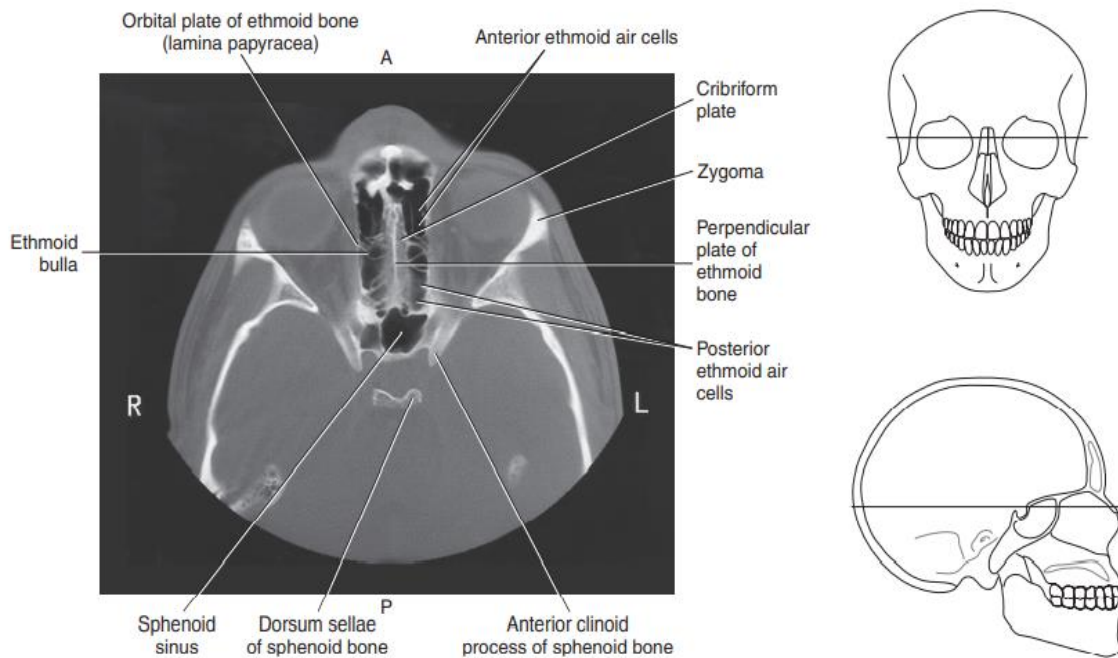
## Ethmoid Bone:

The **ethmoid bone** is the smallest of the cranial bones and is situated in the anterior cranial fossa. This cube shaped bone can be divided into four parts: **horizontal portion**, **vertical portion**, and **two lateral masses (labyrinths)**.

The **horizontal portion**, called the **cribriform plate**. This plate contains many foramina for the passage of olfactory nerve fibers, (Figs. 7 & 8).



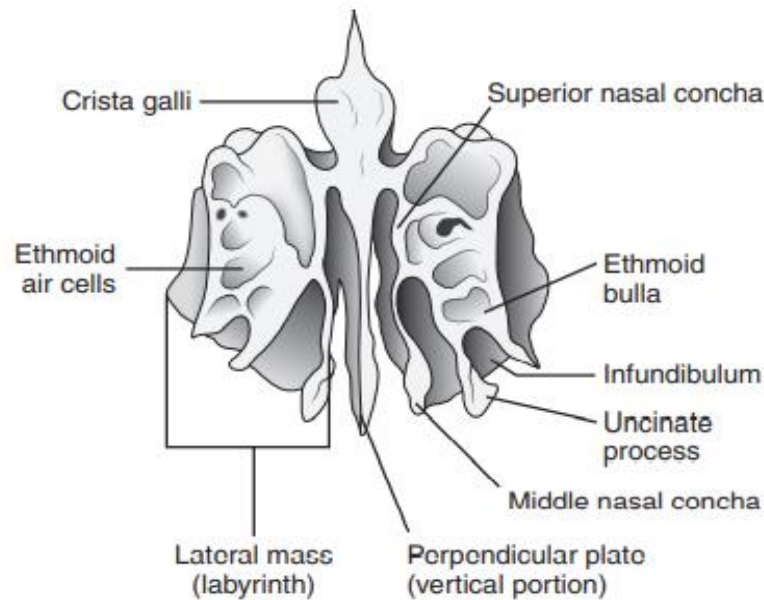
**Figure 7:** Superior view of ethmoid bone.



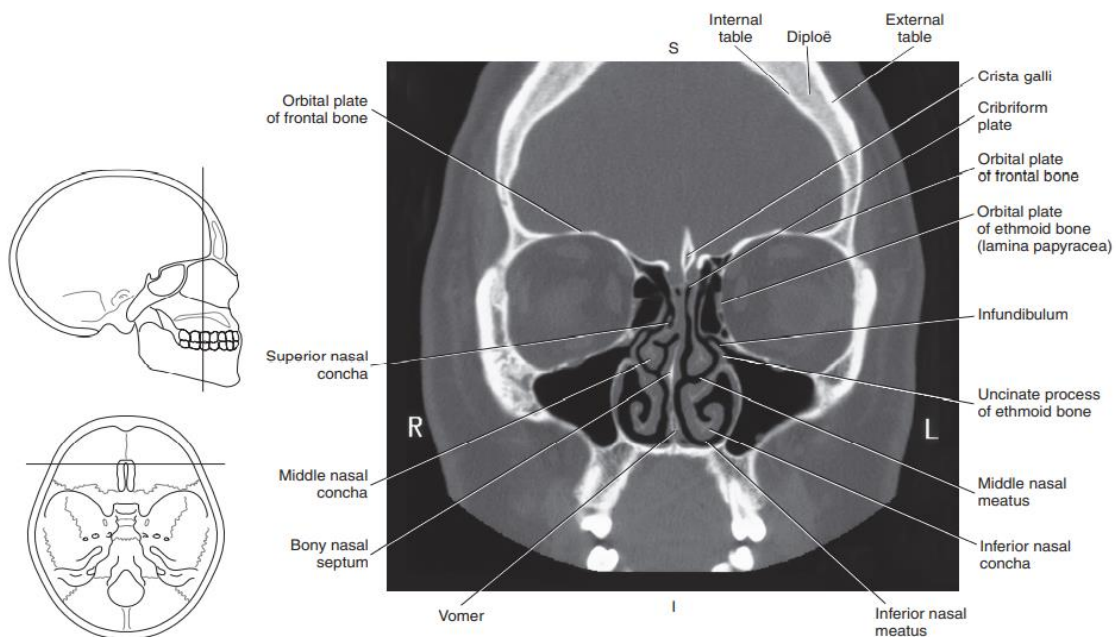
**Figure 8:** Axial CT of ethmoid bone.

The **crista galli**, a bony projection stemming from the midline of the cribriform plate, projects superiorly to act as an attachment for the falx cerebri, which is the connective tissue that anchors the brain to the anterior cranial fossa, (Figs. 9 & 10).

The **vertical portion** of the ethmoid bone, called the **perpendicular plate**, projects inferiorly from the cribriform plate to form a portion of the bony nasal septum, (Fig. 9).



**Figure 9:** Anterior view of ethmoid bone.



**Figure 10:** Coronal CT of ethmoid bone with crista galli.

The **lateral masses (labyrinth)** incorporate thin-walled **orbital plates (lamina papyracea)**, which create a portion of the medial orbit, (Figs. 8 & 10). Contained within the lateral masses are many ethmoid air cells (ethmoid sinuses), (Figs. 7 - 9).

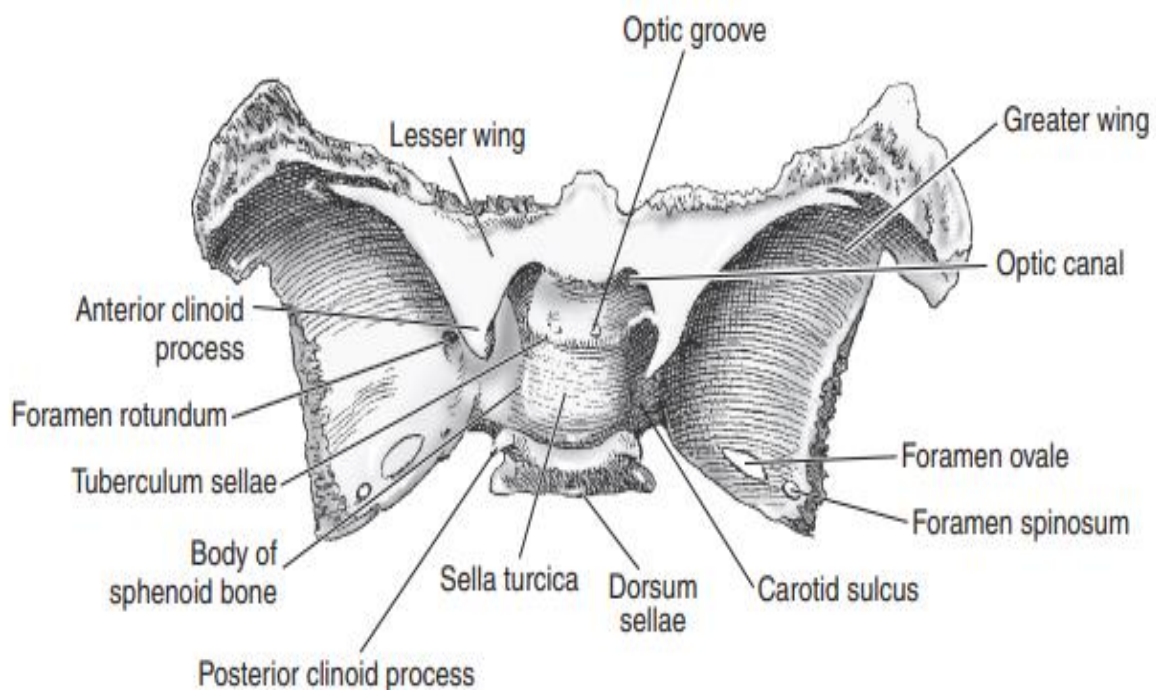
Projecting from the lateral masses are two scroll-shaped processes called the **superior** and **middle nasal conchae (turbinates)**, (Figs. 9 & 10).

### Sphenoid Bone:

The butterfly shaped **sphenoid bone** extends completely across the floor of the middle cranial fossa. This bone forms the majority of the base of the skull and articulates with the **occipital, temporal, parietal, frontal, and ethmoid bones**.

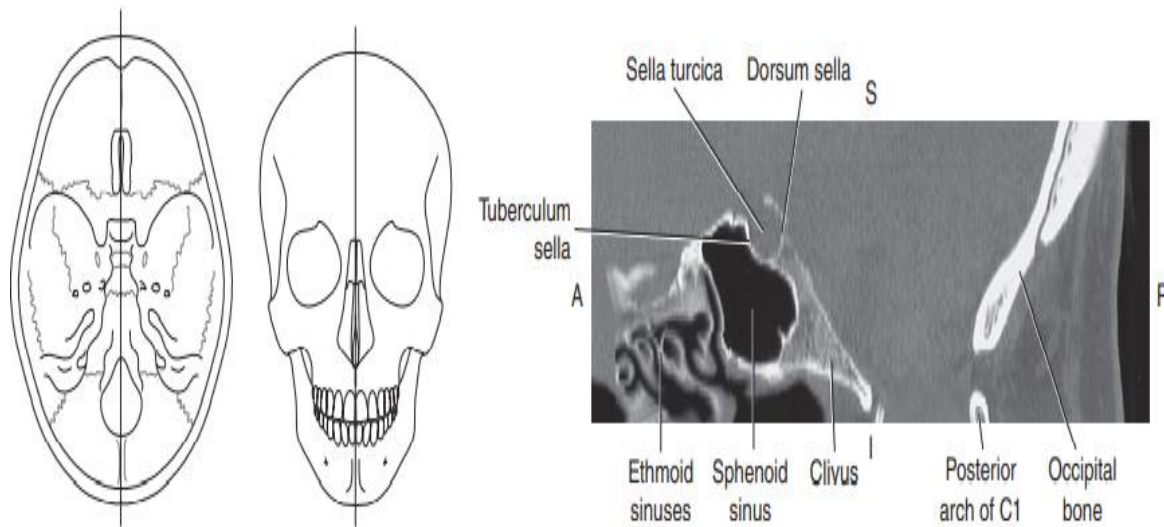
The main parts of the sphenoid bone are the **body, lesser wings (2), and greater wings (2)**, (Fig. 11).

Located within the **body of the sphenoid bone** is a deep depression called the **sella turcica**, which houses the hypophysis (pituitary gland). Directly below the **sella turcica** are two air-filled cavities termed sphenoid sinuses, (Figs. 8 & 12).



**Figure 11:** Superior view of sphenoid bone.

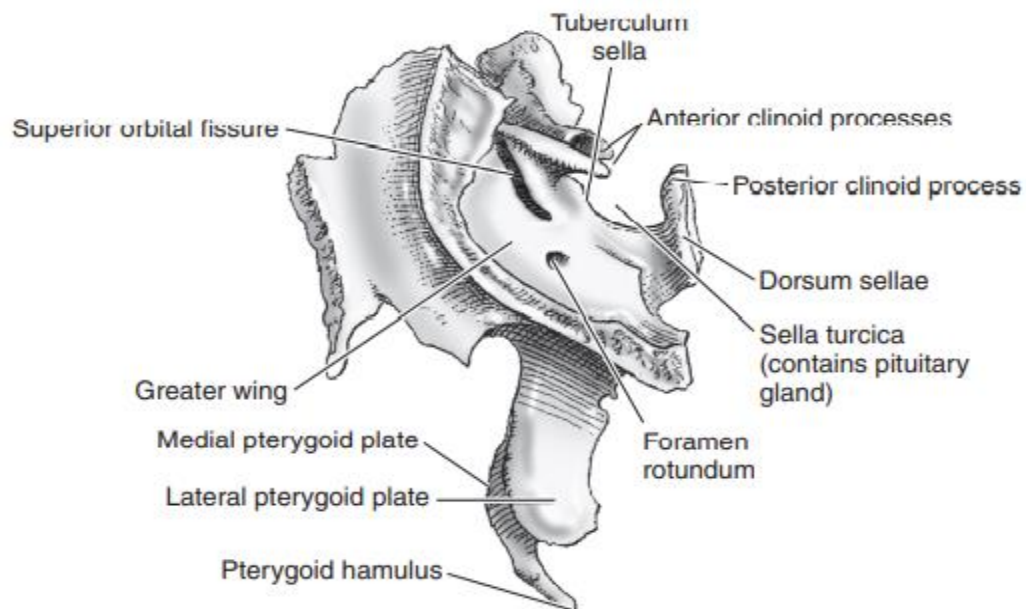




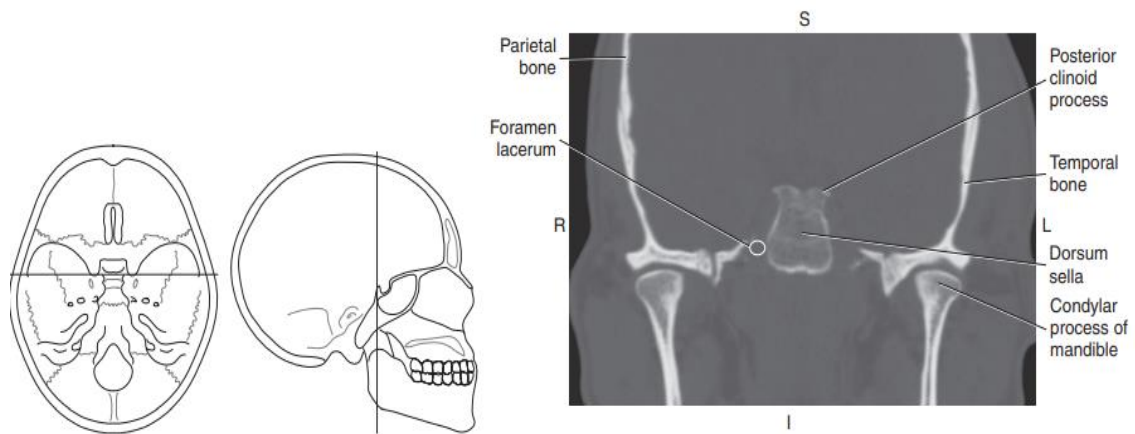
**Figure 12:** Sagittal CT reformat of sella turcica.

The anterior portion of the **sella turcica** is formed by the **tuberculum sellae**, and the posterior portion by the **dorsum sellae**. The dorsum sellae give rise to the **posterior clinoid processes**, (Figs. 11 & 13-15).

The triangular shaped **lesser wings** attach to the superior aspect of the body and form two sharp points called **anterior clinoid processes**, which, along with the posterior clinoid processes, serve as attachment sites for the tentorium cerebelli, (Figs. 11, 13 & 15).

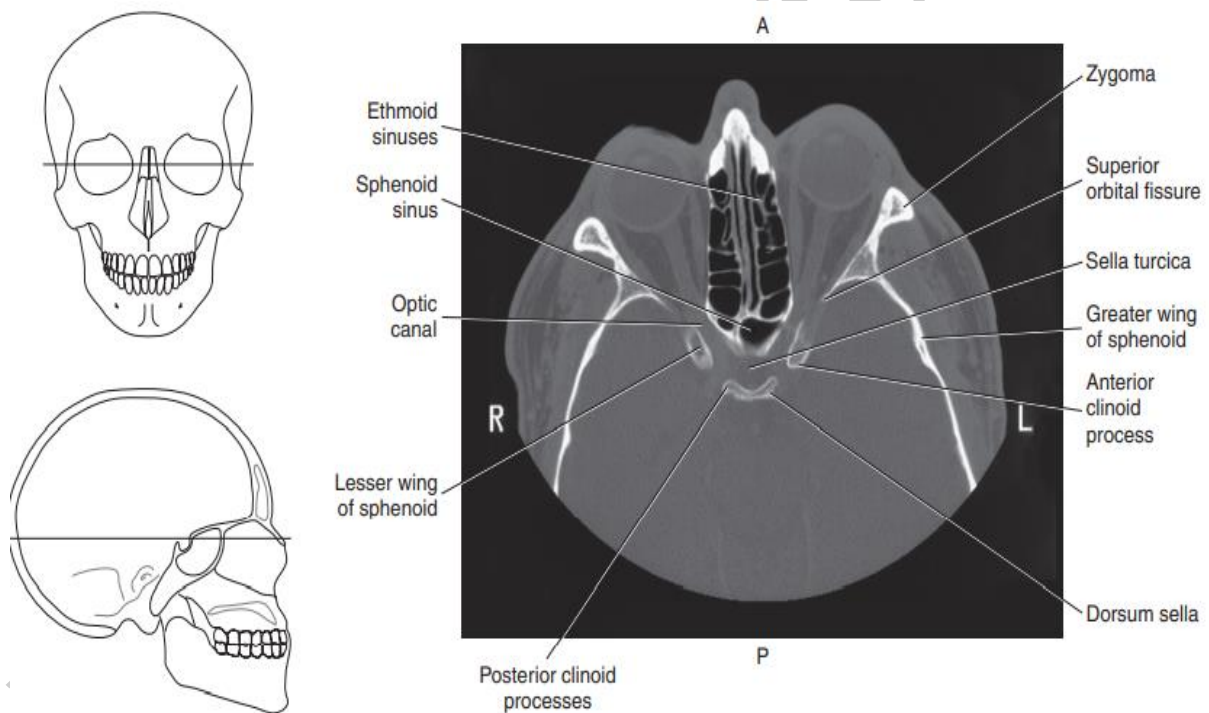


**Figure 13:** Lateral view of sphenoid bone.



**Figure 14:** Coronal CT of dorsum sellae.

The **optic canal** is completely contained within the lesser wing and provides passage of the optic nerve and ophthalmic artery, (Fig. 15).

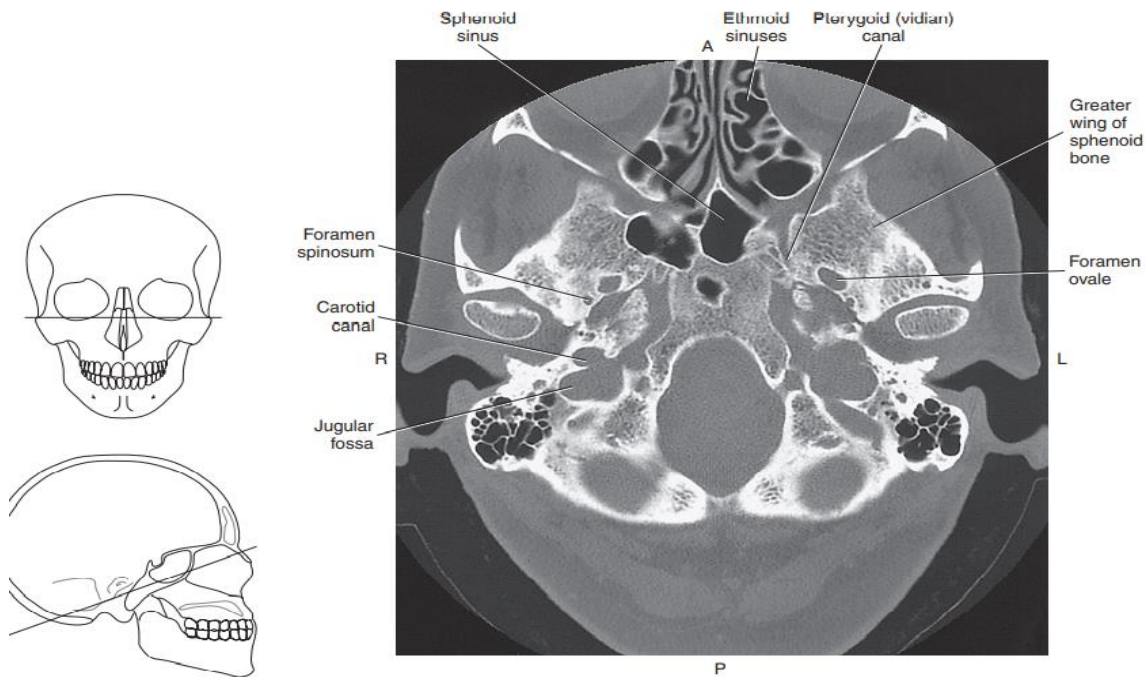


**Figure 15:** Axial CT of anterior clinoid processes and sphenoid bone.

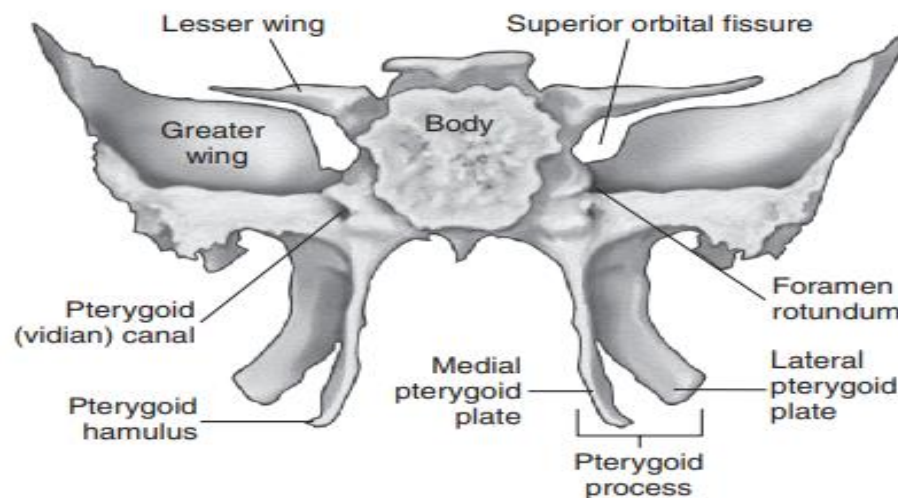
The **superior orbital fissure** is a triangular-shaped opening located between the lesser and greater wings that allows for the transmission of the oculomotor, trochlear, abducens, & ophthalmic division of the trigeminal nerves, as well as the superior ophthalmic vein, (Figs. 1, 15 & 17).

The **greater wings** extend laterally from the sides of the body and contain three paired foramina: rotundum, ovale, & spinosum, through which nerves and blood vessels course, (Figs. 11, & 16 -18).

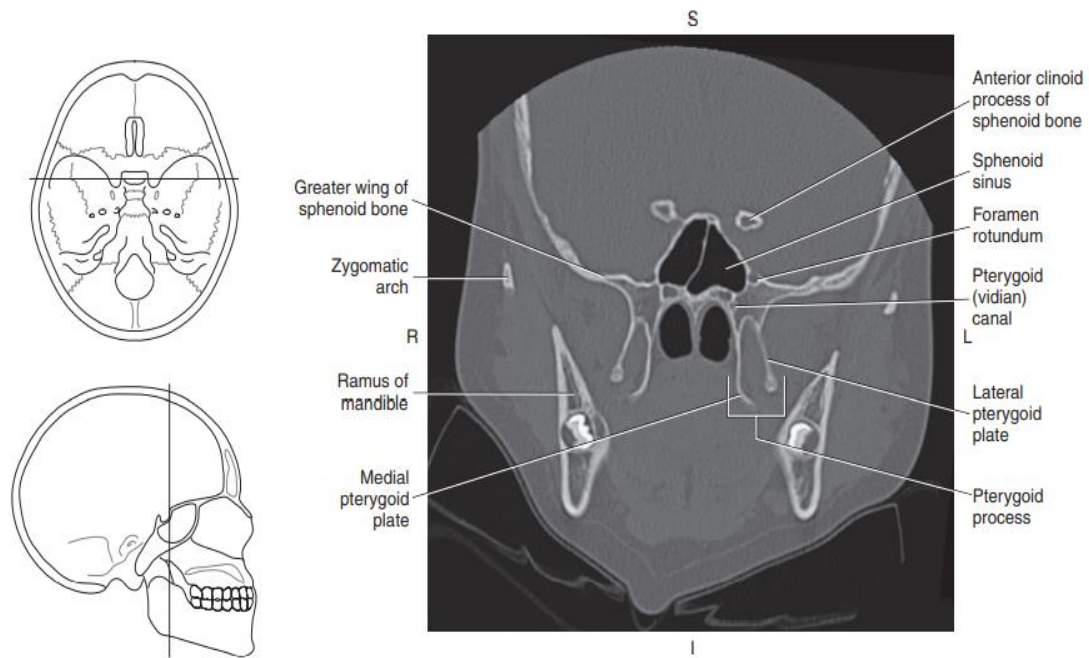
Extending from the inferior surface of each greater wing is a **pterygoid process**, which is divided into **medial** and **lateral pterygoid plates**. The pterygoid plates serve as attachment sites for the pterygoid muscles used in movements of the lower jaw, (figs. 17 & 18).



**Figure 16:** Axial CT of sphenoid bone with foramina ovale and spinosum.



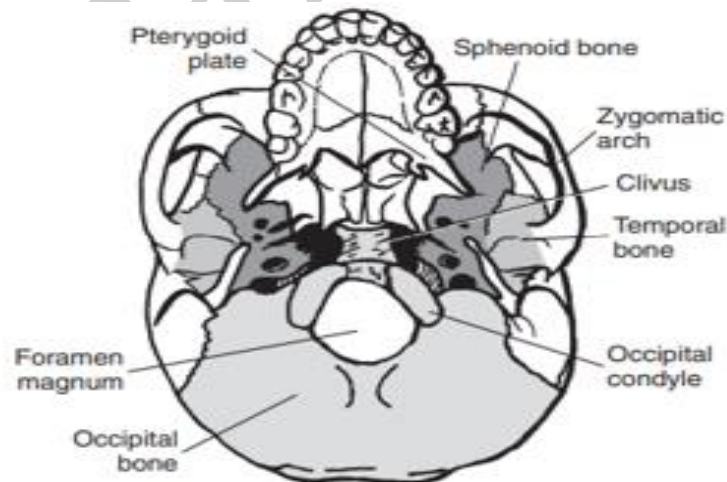
**Figure 17:** Anterior view of sphenoid bone.



**Figure 18:** Coronal CT of sphenoid bone.

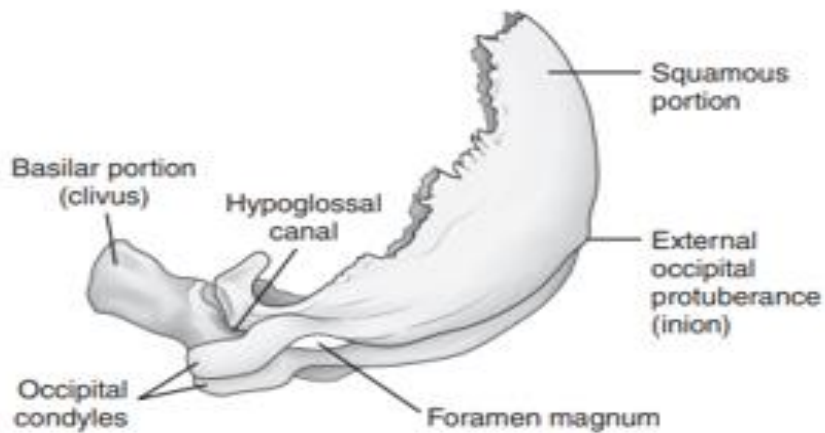
### **Occipital Bone:**

The **occipital bone** forms the posterior cranial fossa and the inferoposterior portion of the cranium. On the inferior portion of the occipital bone is a large oval aperture called the **foramen magnum** located at the junction of the brainstem and spinal cord, (Fig. 19).



**Figure 19:** Inferior surface of occipital bone and cranium.

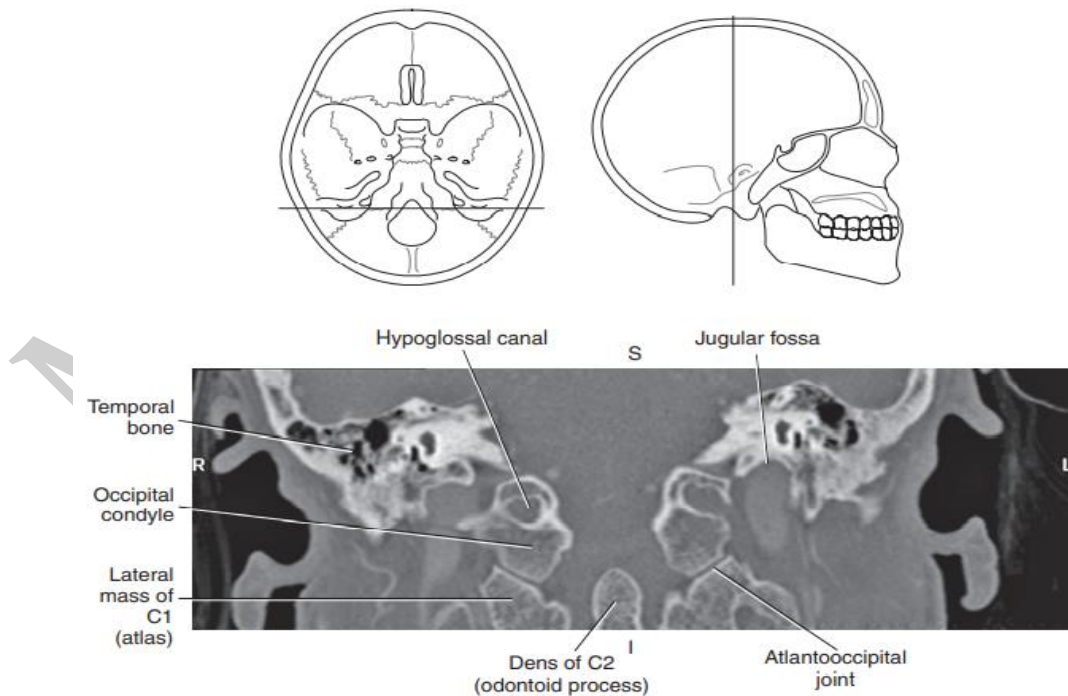
The occipital bone can be divided into four portions: **occipital condyles (2)**, **basilar portion (1)**, and **squamous portion (1)**, (Fig. 20).



**Figure 20:** Lateroinferior aspect of occipital bone.

The **occipital condyles** project inferiorly to articulate with the first cervical vertebra (atlas), forming the atlantooccipital joint, (Fig. 21).

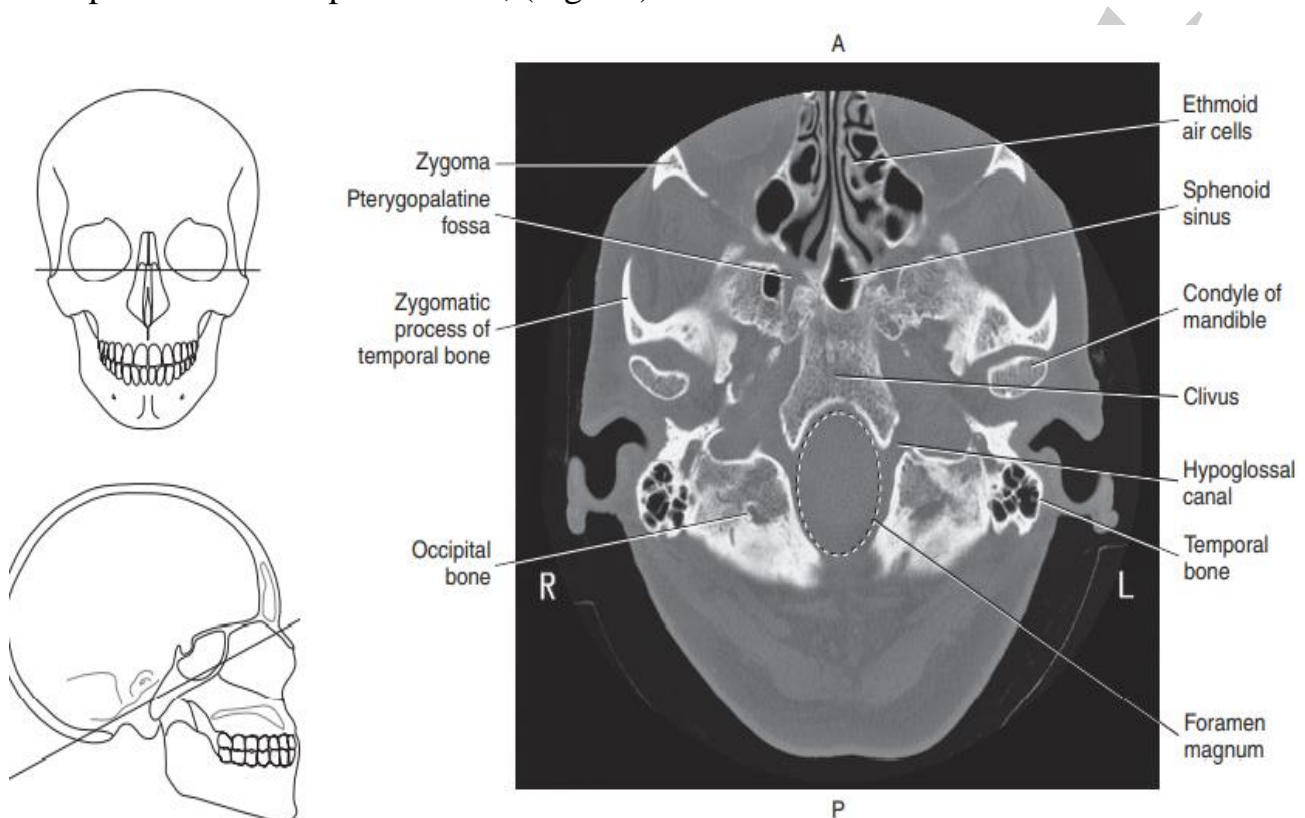
The **hypoglossal canal** is a small opening in the occipital bone. There are two hypoglossal canals (left and right) located in the anterolateral margins of the foramen magnum, deep to the occipital condyles. It transmits the hypoglossal nerve, (figure 21).



**Figure 21:** Coronal CT reformat of occipital condyles.

The **basilar portion** forms the anterior margin of the foramen magnum and slopes superiorly and anteriorly to meet with the dorsum sellae of the sphenoid bone to form the **clivus**, (Figs. 20 & 22).

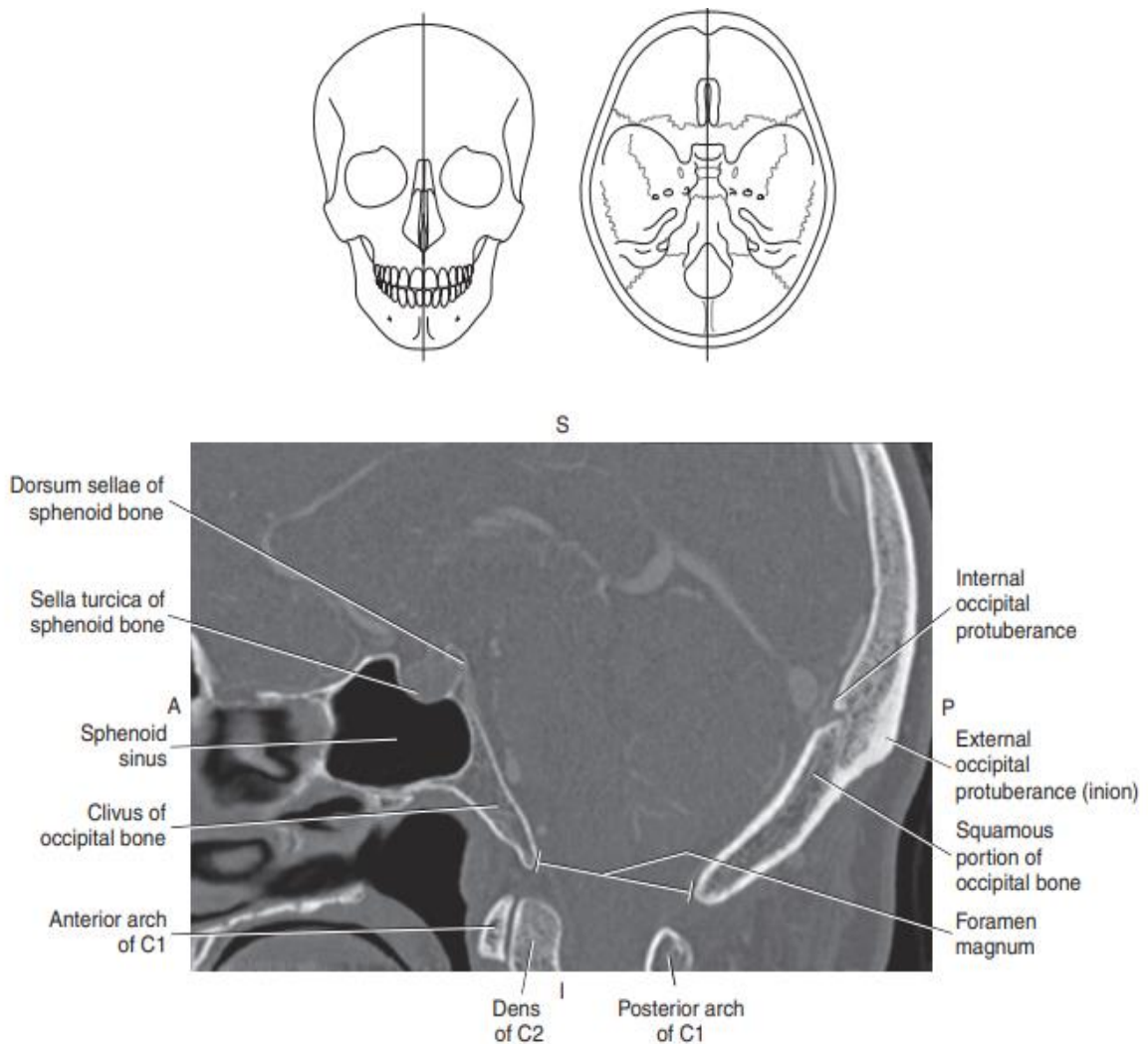
The **squamous portion** curves posterosuperiorly from the foramen magnum to articulate with the parietal and temporal bones, (Fig. 20).



**Figure 22:** Axial CT of occipital bone at level of clivus.

Located on the inner surface of the squama is a bony projection termed the **internal occipital protuberance**, which marks the site where the dural venous sinuses converge, (Fig. 23).

The **external occipital protuberance** is a midline projection on the external surface of the squamous part of the occipital bone. The highest point of the external occipital protuberance is termed the **inion**, (Figs. 20 & 23).

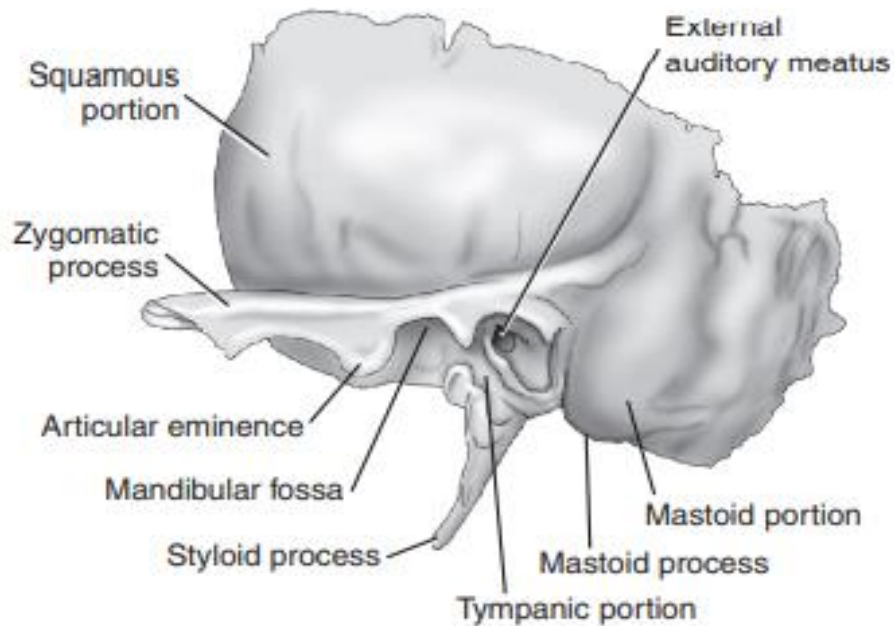


**Figure 23:** Sagittal CT reformat of occipital bone.

### **Temporal Bones:**

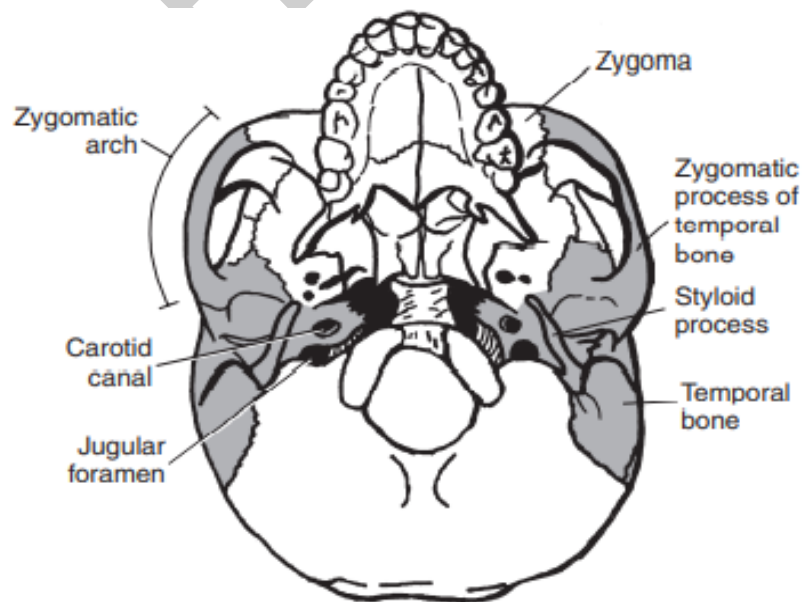
The **two temporal bones** contain many complex and important structures. They form part of the sides and base of the cranium, and together with the sphenoid bone, they create the middle cranial fossa.

The temporal bone can be divided into four portions: **squamous**, **tympanic**, **mastoid**, and **petrous**, (Fig. 24).



**Figure 24:** Lateral view of temporal bone.

The thin **squamous portion** projects upward to form part of the sidewalls of the cranium, (Fig. 2). Extending from the squamous portion is the **zygomatic process**, which projects anteriorly to the zygoma of the face to form the zygomatic arch, (Figs. 16, 18, 22, 24, & 25).



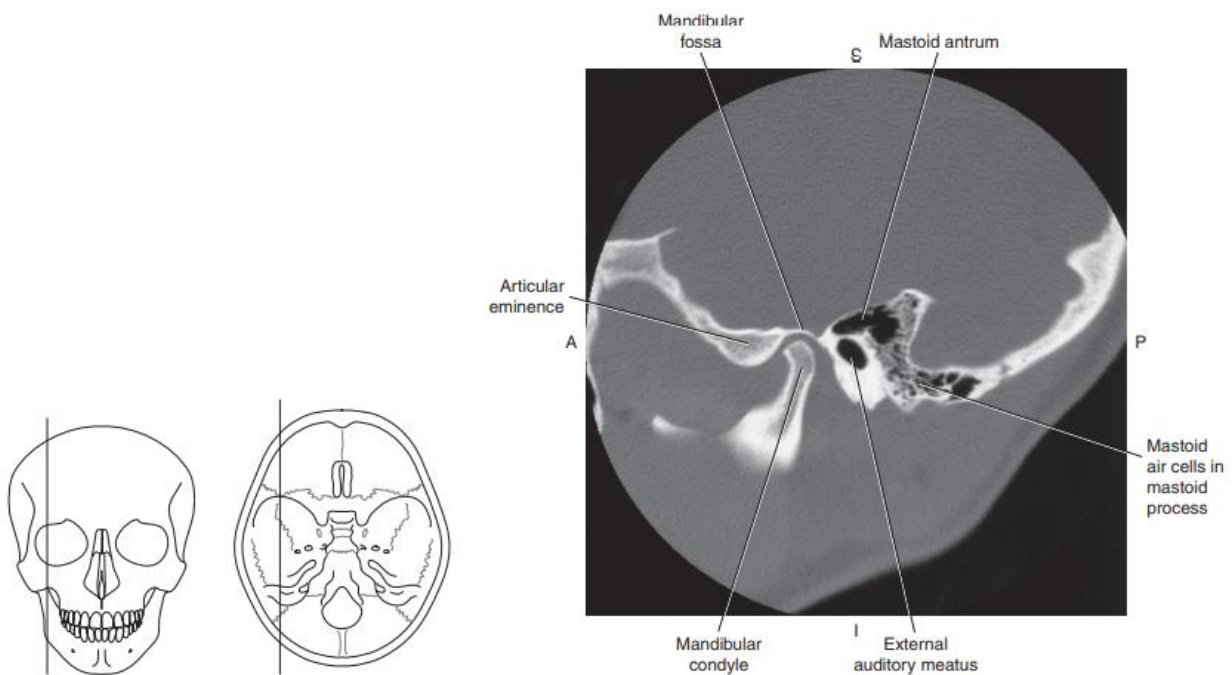
**Figure 25:** Inferior surface of temporal bone and cranium.



At the base of the **zygomatic process** is the **articular eminence** that forms the anterior boundary of the mandibular fossa. The **mandibular fossa** is the depression that articulates with the condylar process of the mandible, creating the **temporomandibular joint (TMJ)**, (Figs. 24 & 26a).

The **tympanic portion** lies below the squama and forms the majority of the external auditory meatus, (Fig. 26a).

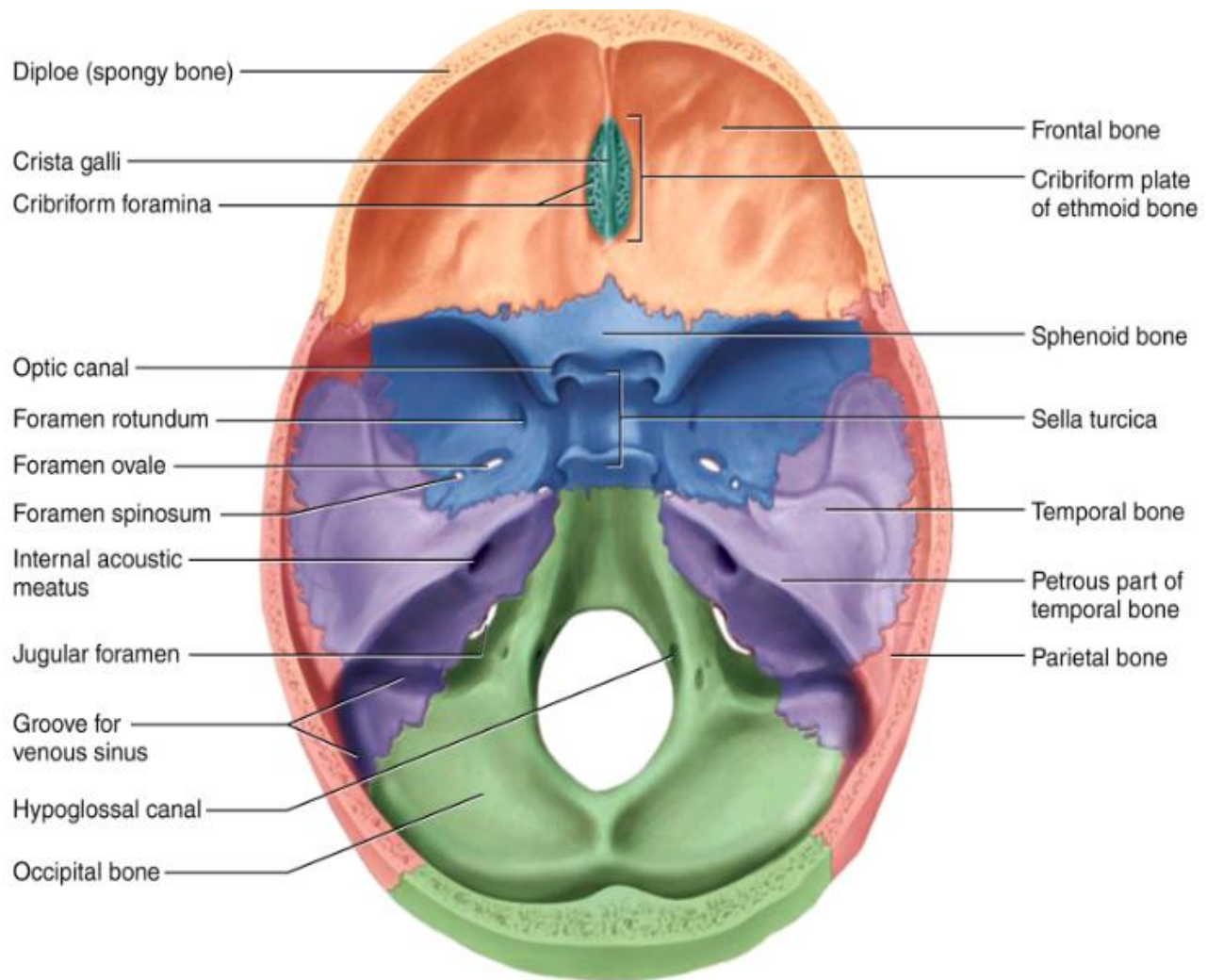
Just posterior to the tympanic portion is the **mastoid portion**, which has a prominent conical region termed the **mastoid process**, (Figs. 24 & 26a). The **mastoid process** encloses the mastoid air cells, (Fig. 26a).



**Figure 26a:** Sagittal CT reformat of temporal bone.

The **petrous portion** of the temporal bone, (figure 26b) is pyramidal in shape. its separates the middle from the posterior cranial fossa.

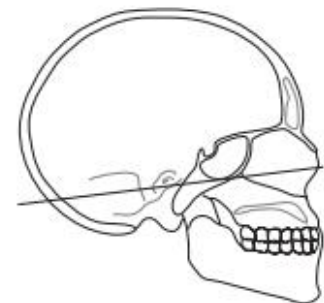
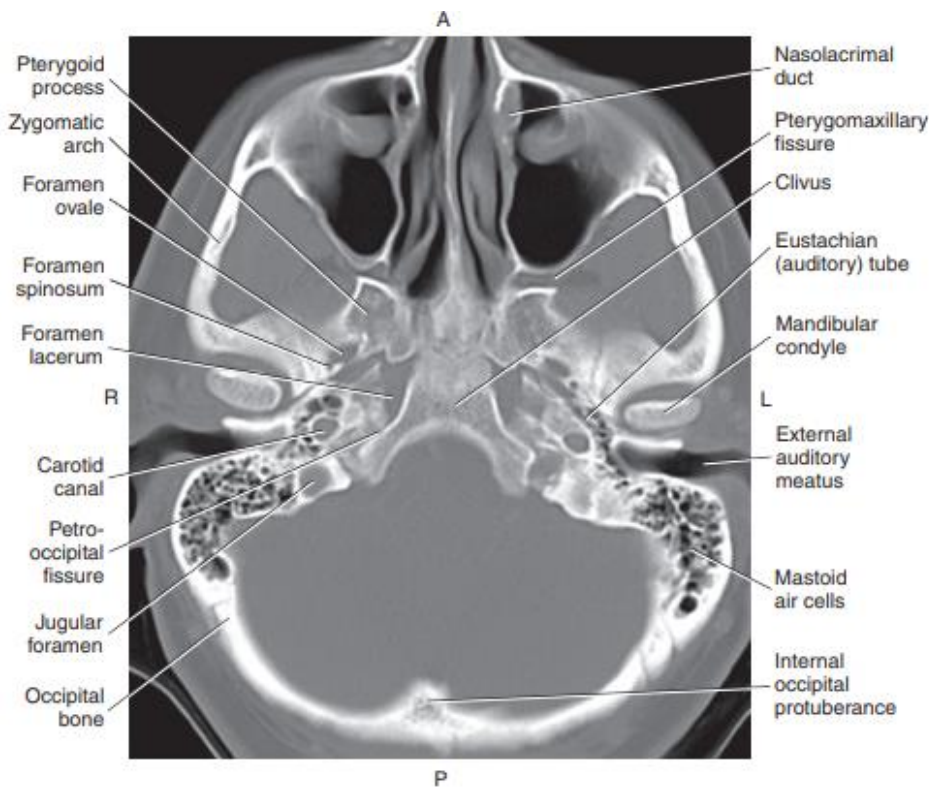
Near the center of this surface is the opening to the **internal auditory canal**, which transmits the seventh and eighth cranial nerves.



**Figure 26b:** Superior view of the cranial floor.

Other openings associated with the posterior surface of the petrous pyramid are the **jugular foramen** and the **carotid canal**, which provide passage for the internal jugular vein and the internal carotid artery, (Figs. 25 & 27).

Between the apex of the petrous pyramid, the body of the sphenoid bone, and the basilar portion of the occipital bone is a jagged slit termed the **foramen lacerum**, which contains cartilage and allows the internal carotid artery to enter the cranium, (figure 27).



**Figure 27:** Axial CT of temporal with foramen lacerum, jugular foramen & carotid canal.

The inferior surface of the petrous pyramid gives rise to the long slender **styloid process** that is attached to several muscles of the tongue and ligaments of the hyoid bone (Fig. 24).

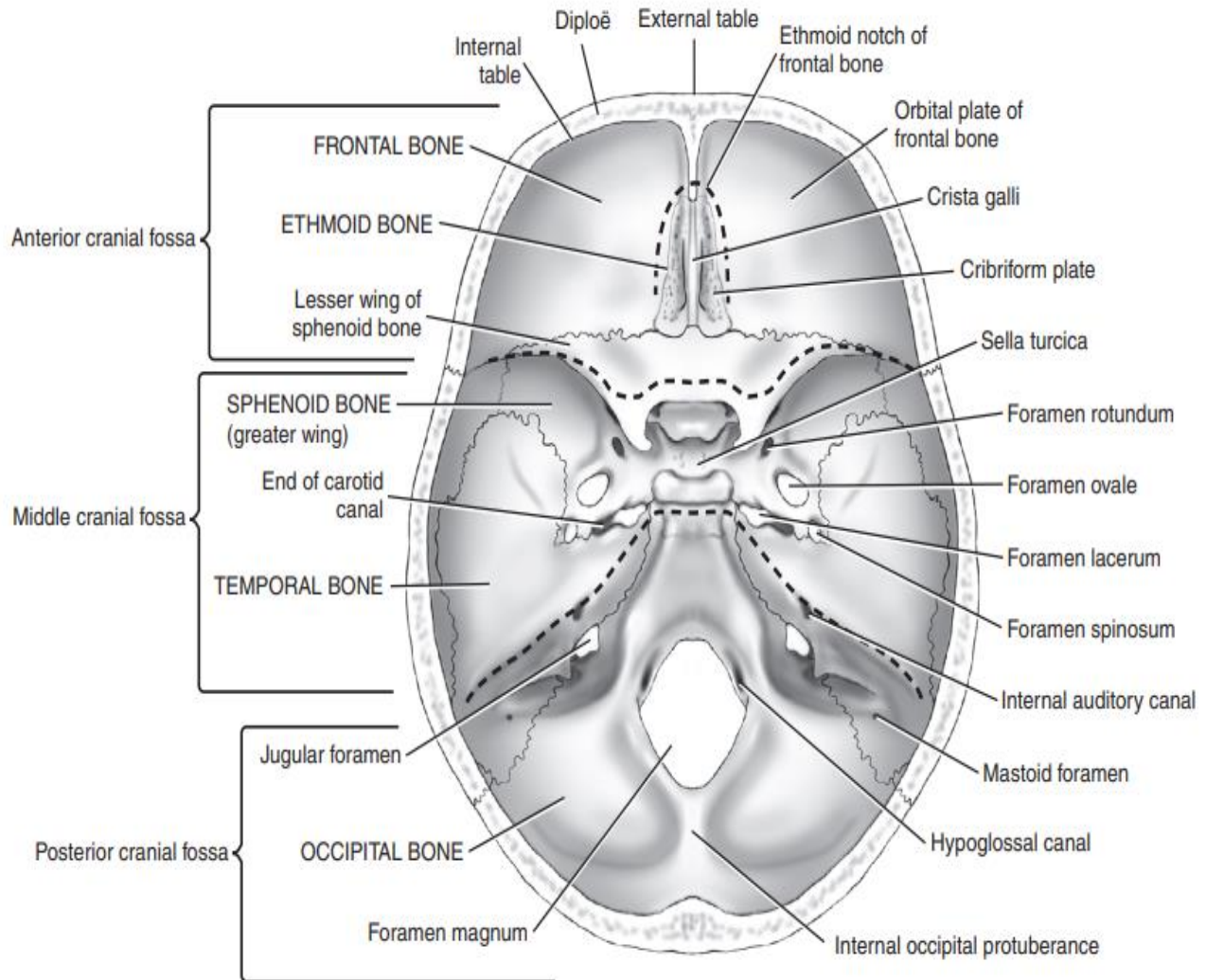
The **stylomastoid foramen** is situated between the mastoid process and the styloid process. This foramen constitutes the end of the facial nerve canal. The interior of the petrous pyramid houses the delicate middle and inner ear structures.

### Cranial fossae

The base of the cranium houses three fossae called the **anterior**, **middle**, and **posterior cranial fossae**. The **anterior cranial fossa**: is composed primarily of the frontal bone, ethmoid bone, and lesser wing of the sphenoid bone.

The **middle cranial fossa**: is formed primarily by the body of the sphenoid and temporal bones.

The **posterior cranial fossa** (largest and deepest of the 3 fossae): is formed by the occipital and temporal bones, (Fig. 28).



**Figure 28:** Superior view of cranial fossae.

For additional details of the contents found within the cranial fossa, see **Table 1**.

**Table 1:** Contents of the cranial fossae

Fossa	Contents
Anterior cranial fossa	Frontal lobes of cerebrum; olfactory nerve (I)
Middle cranial fossa	Temporal lobes of cerebrum, pituitary gland, cavernous sinus, trigeminal ganglion, internal carotid artery, hypothalamus, and the following cranial nerves: optic nerves (II) and chiasm, oculomotor (III), trochlear (IV), trigeminal (V), abducens (VI)
Posterior cranial fossa	Cerebellum, pons, medulla oblongata, mid-brain, and the following cranial nerves: facial (VII), vestibulocochlear (VIII), glossopharyngeal (IX), vagus (X), accessory (XI), hypoglossal (XII)

## Sutures

The cranial bones are joined by **four main articulations** termed **sutures**.

- **Squamous suture:** which is located on the side of the cranium, joins the squamous portion of the temporal bone to the parietal bone.
- **Coronal suture:** runs across the top of the cranium and is the articulation between the frontal and parietal bones.
- **Sagittal suture:** provides the articulation between the parietal bones along the midsagittal plane.
- **Lambdoid suture:** is located posterior in the cranium and joins the occipital and parietal bones, (Figs. 2 & 29).

### Sutures corresponding to the mastoid portion of the temporal bone include:

- **Occipitomastoid suture:** between the occipital bone and mastoid portion of the temporal bone, (fig. 30).
- **Parietomastoid suture:** between the parietal bone and mastoid portion of the temporal bone.

\*\* The **asterion:** is a point on the skull corresponding to the posterior end of the **parietomastoid suture**, (Figs. 2 & 29).

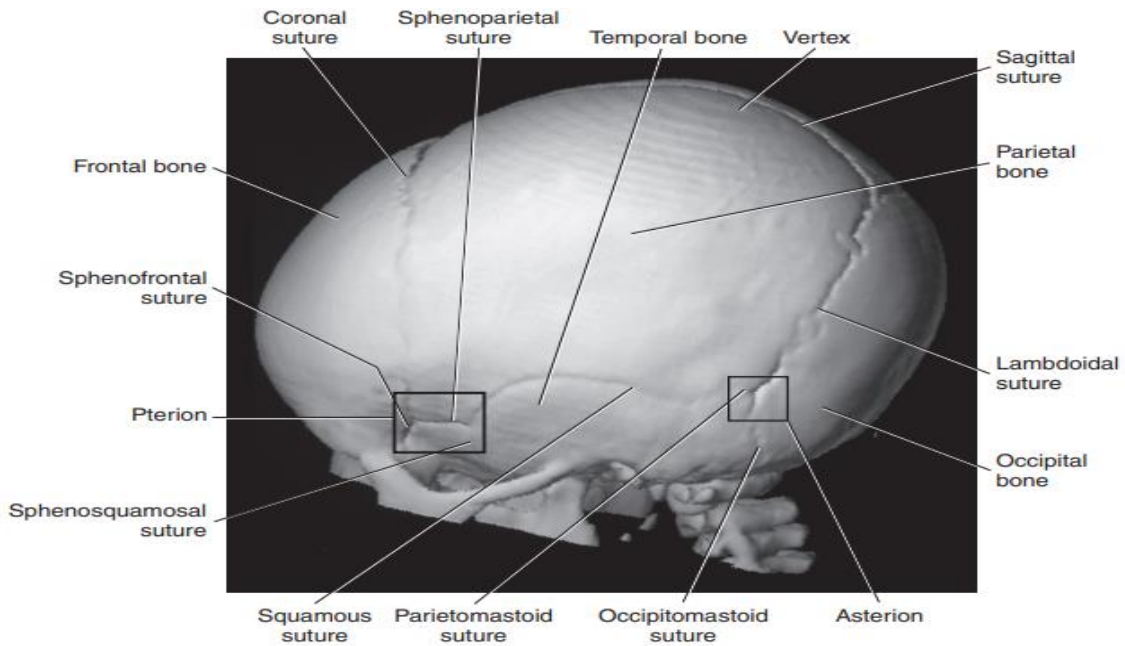
### Sutures corresponding to the sphenoid bone include:

- **Sphenosquamosal suture:** between the sphenoid bone and squamous portion of the temporal bone, (fig. 30).
- **Sphenofrontal suture:** between the greater wing of the sphenoid bone and the frontal bone.
- **Sphenoparietal suture:** located between the greater wing of the sphenoid bone and the parietal bone.

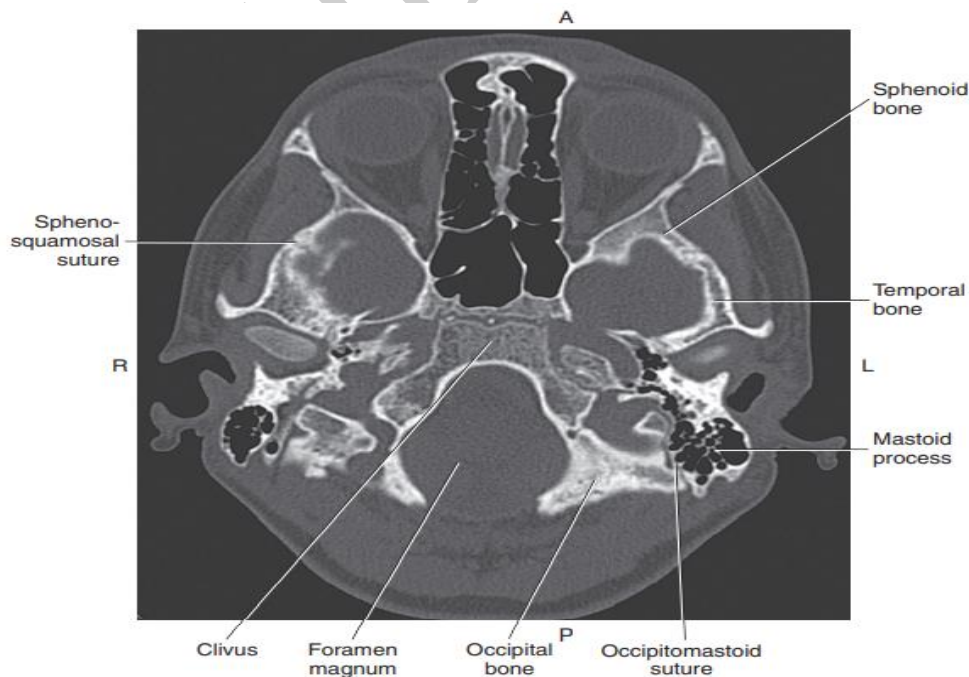
\*\* The region surrounding the **sphenoparietal suture** where the parietal, sphenoid, temporal, and frontal bones meet is termed the **pterion**, an important landmark because it

is considered the weakest part of the skull and is also the site of the anterolateral (sphenoid) fontanel in neonates, (Figs. 2 & 29).

- **Frontal (metopic) suture:** divides the frontal bone into halves as it extends from the sagittal suture to the nasion in infants and children and typically disappears by the age of 6.



**Figure 29:** 3D CT of lateral surface of cranium.



**Figure 30:** Axial CT of occipitomastoid suture.

## Radiological features of the skull:

### Plain films:

- Several projections are required for a full assessment of the skull vault. The standard projections are **lateral**, **OF20** and **Towne's** projections.
- The **submentovertex (SMV)** view is used to assess the skull base and demonstrates most of the foramina.
- The pituitary fossa is visible on **OF20** (occipitofrontal view with 20° caudal angulation), **FO30** (fronto-occipital projection with 30° caudal angulation) and **SMV** views, but the **lateral view** is the most frequently used for its assessment.



1. Sagittal suture
2. Frontal sinus
3. Planum sphenoidale
4. Crista galli
5. Perpendicular plate of ethmoid
6. Floor of pituitary fossa
7. Nasal septum
8. Ethmoid air cells
9. Superior orbital fissure
10. Lesser wing of sphenoid
11. Innominate line
12. Zygomatic process of frontal bone
13. Zygomaticofrontal suture
14. Frontal process of zygomatic bone
15. Foramen rotundum
16. Petrous ridge
17. Maxillary sinus
18. Inferior nasal turbinate
19. Mastoid process
20. Occipital bone
21. Dens of atlas

**Figure 31:** OF20 skull radiograph.



- Bony landmarks:** 1. Bregma 2. Coronal suture  
3. Lambda 4. Lambdoid suture 5. Vertex  
6. Inner skull table 7. Outer skull table  
8. Internal occipital protuberance  
9. External occipital protuberance  
10. External auditory meatus  
11. Styloid process 12. Clivus 13. Dorsum sellae  
14. Posterior clinoid process  
15. Anterior clinoid process 16. Pituitary fossa (sella turcica) 17. Tuberculum sellae  
18. Planum sphenoidale 19. Greater wings of sphenoid  
20. Undulating floor of anterior cranial fossa (roof of orbit)  
21. Anterior limit of foramen magnum  
22. Posterior limit of foramen magnum  
23. Posterior wall of maxillary sinus  
24. Floor of orbit  
25. Hard palate  
26. Neck of mandible  
27. Temporomandibular joint  
28. Condylar (mandibular) canal

**Sinuses/air cells:**

34. Frontal sinus 35. Sphenoid sinus 36. Posterior ethmoidal cells 37. Maxillary sinus 38. Mastoid air cells

**Soft tissues:**

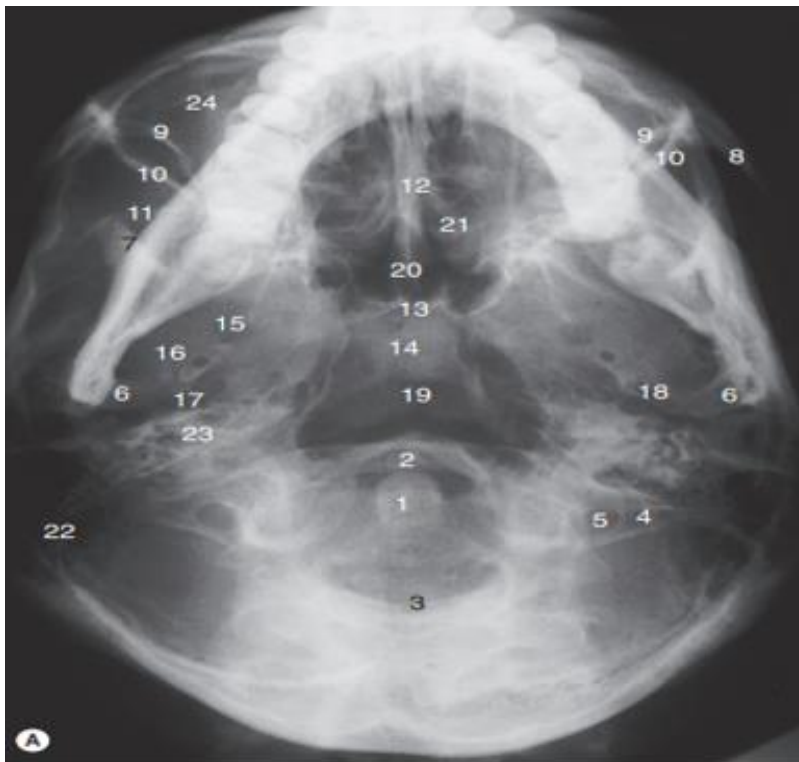
39. Soft palate 40. Base of tongue

**Vascular markings:**

29. Middle meningeal vessels: anterior branches 30. Middle meningeal vessels: posterior branches 31. Transverse sinus  
32. Diploic vein 33. Diploic venous confluence: parietal star

**Figure 32:** Lateral skull radiograph.





#### Air space and sinuses

19. Air in nasopharynx
20. Sphenoid sinus
21. Ethmoid air cells
22. Mastoid air cells
23. Pneumatization in petrous bone
24. Maxillary sinus

#### Bony landmarks

1. Odontoid process of C 2
2. Anterior arch of C1
3. Posterior limit of foramen magnum
4. Transverse process of C 1
5. Foramen transversarium of C1
6. Condylar process of mandible
7. Coronoid process of mandible
8. Zygomatic arch
9. Posterior wall of maxillary sinus
10. Lateral boundary of orbit
11. Lesser wing of sphenoid: anterior limit of middle cranial fossa
12. Nasal septum
13. Posterior limit of hard palate
14. Clivus

#### Foramina and canals

15. Foramen ovale
16. Foramen spinosum
17. Carotid canal
18. Bony part of eustachian tube

Figure 33: Submentovertex (SMV) view of skull.

### Cross sectional imaging:

- **Computed tomography (CT)**, provides excellent visualization of the skull base and foramina.
- **Magnetic resonance imaging (MRI)**, is excellent for demonstration of the soft tissue contents of the foramina.