

The skull

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Fun Fact

The strength of bone comes from its inorganic components of such durability that they resist decomposition even after death.

The Axial Skeleton

- Eighty bones segregated into three regions
 - Skull
 - Vertebral column
 - Bony thorax

The Skull

The **skull** is the bony framework of the head. It is comprised of the eight **cranial** and fourteen **facial** bones.

- The skull, the body's most complex bony structure, is formed by the cranium and facial bones
- The Skull cranial vault (which encloses the brain) bones are formed by **intramembranous ossification**. While the **bones that form the base of the skull are formed by endochondrial ossification**.
- The bones enclosing the brain have large flexible fibrous joints (sutures) which allow firstly the head to pass through the birth canal and secondly postnatal brain growth.
- Ossification continues postnatally, through puberty until mid 20s. Note that in old age the sutures are in some cases completely ossified.
- In the entire skeleton, early ossification occurs in the jaw and at the ends of long bones
 -
 - Cranium – protects the brain and is the site of attachment for head and neck muscles
 - Facial bones
 - Supply the framework of the face, the sense organs, and the teeth
 - Provide openings for the passage of air and food
 - Anchor the facial muscles of expression

The cranial bones are:

- The frontal forms part of the cranial cavity as well as the forehead, the brow ridges and the nasal cavity.
- The left and right parietal forms much of the superior and lateral portions of the cranium.
- The left and right temporal form the lateral walls of the cranium as well as housing the external ear.
- The occipital forms the posterior and inferior portions of the cranium. Many neck muscles attach here as this is the point of articulation with the neck.

- The sphenoid forms part of the eye orbit and helps to form the floor of the cranium.
- The ethmoid forms the medial portions of the orbits and the roof of the nasal cavity.

- The joints between bones of the skull are immovable and called sutures.
- The parietal bones are joined by the **sagittal** suture.
- Where the parietal bones meet the frontal is referred to as the **coronal** suture.
- The parietals and the occipital meet at the **lambdoidal** suture.
- The suture between the parietals and the temporal bone is referred to as the **squamous** suture.
- These sites are the common location of **fontanelles** or "soft spots" on a baby's head.

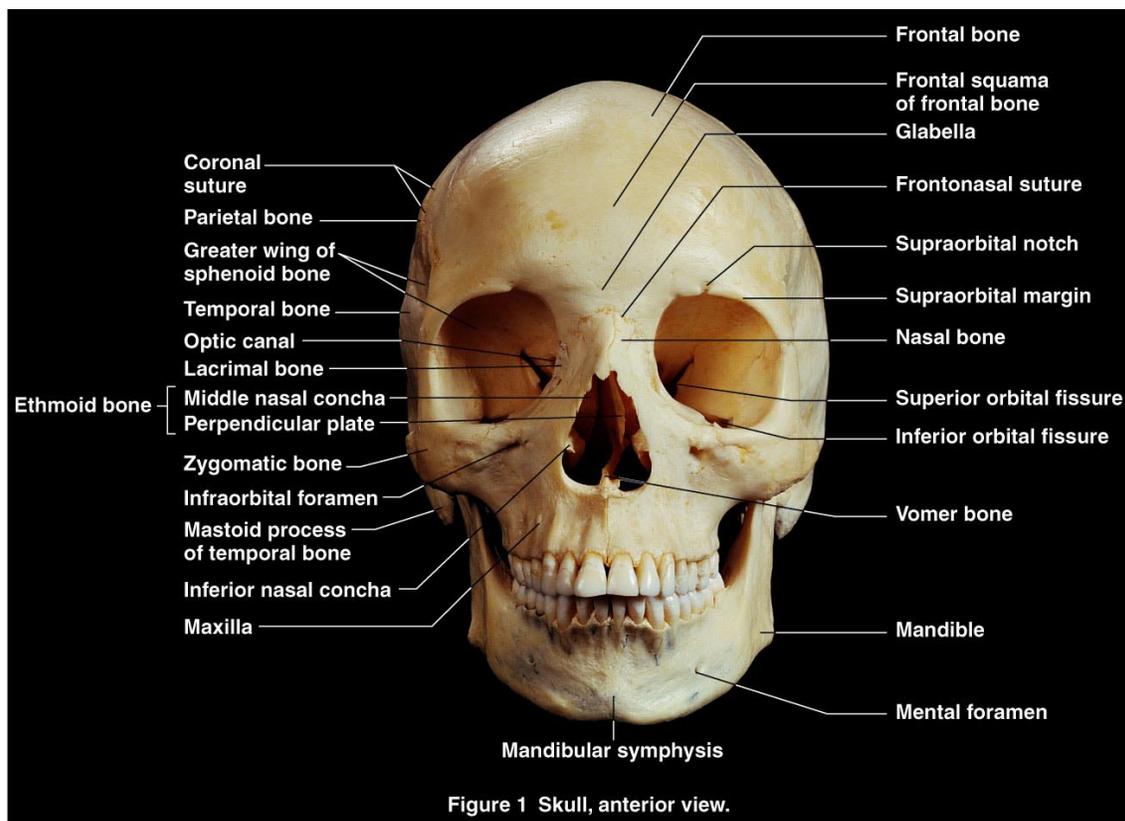
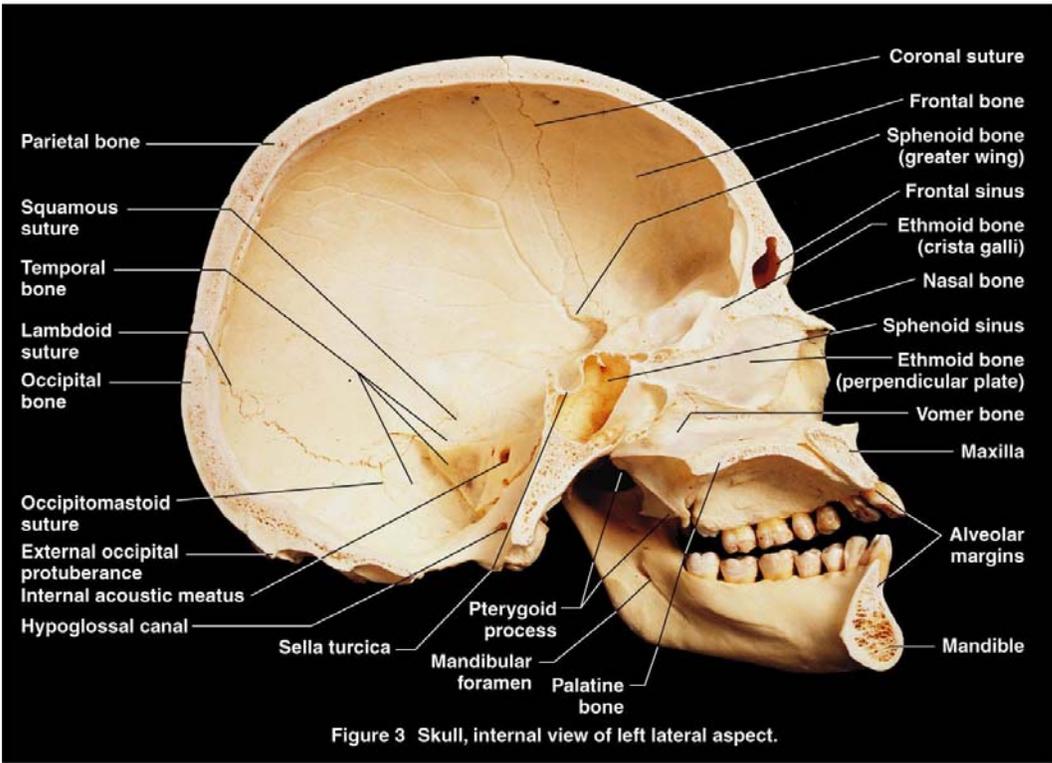
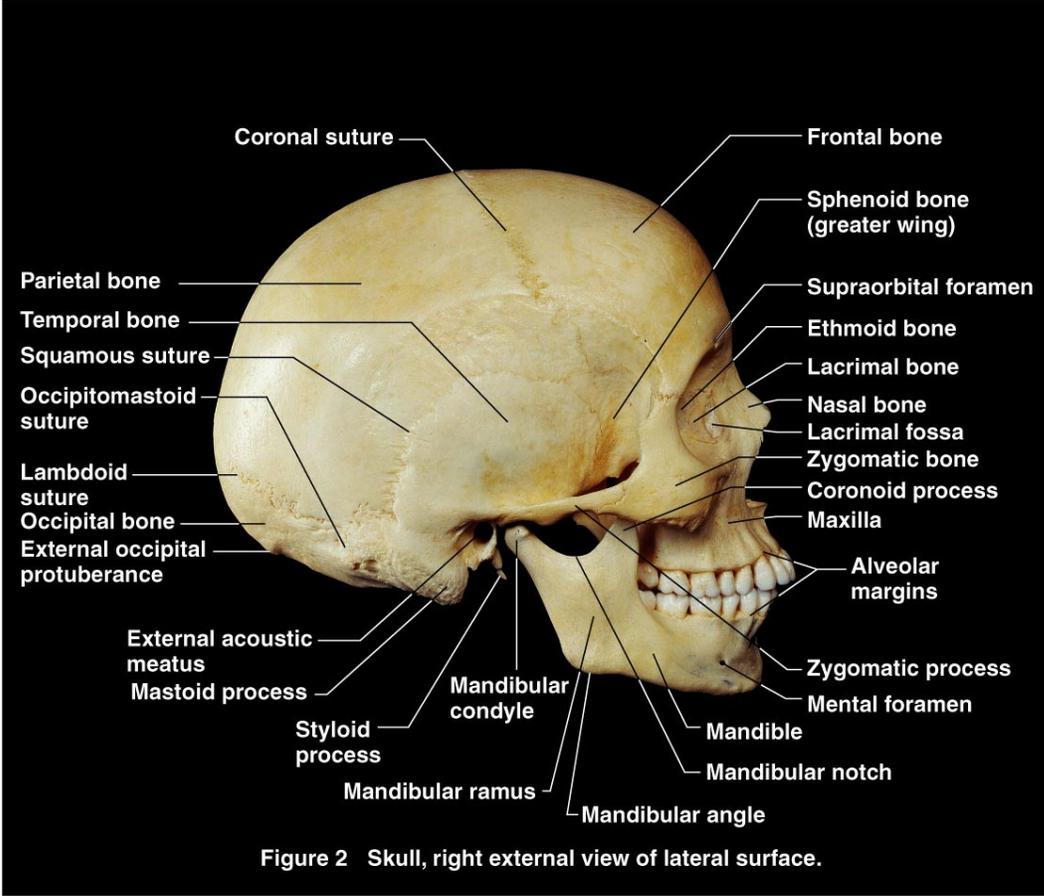


Figure 1 Skull, anterior view.



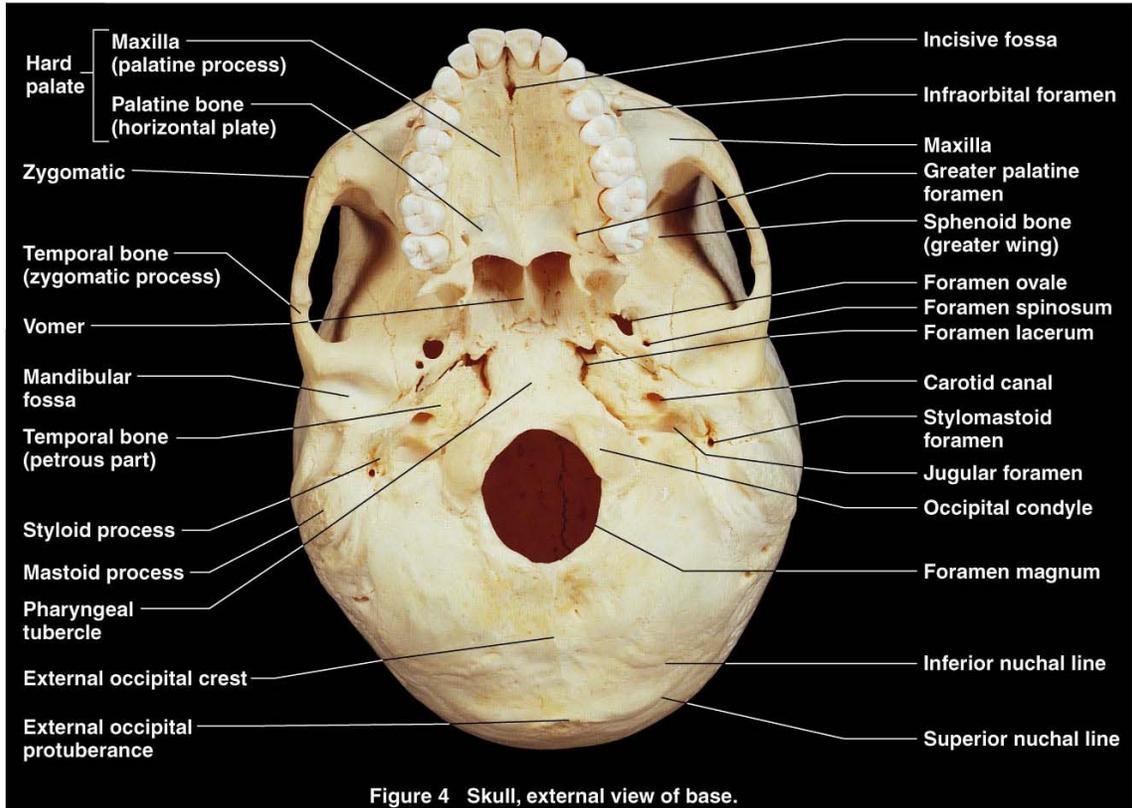


Figure 4 Skull, external view of base.

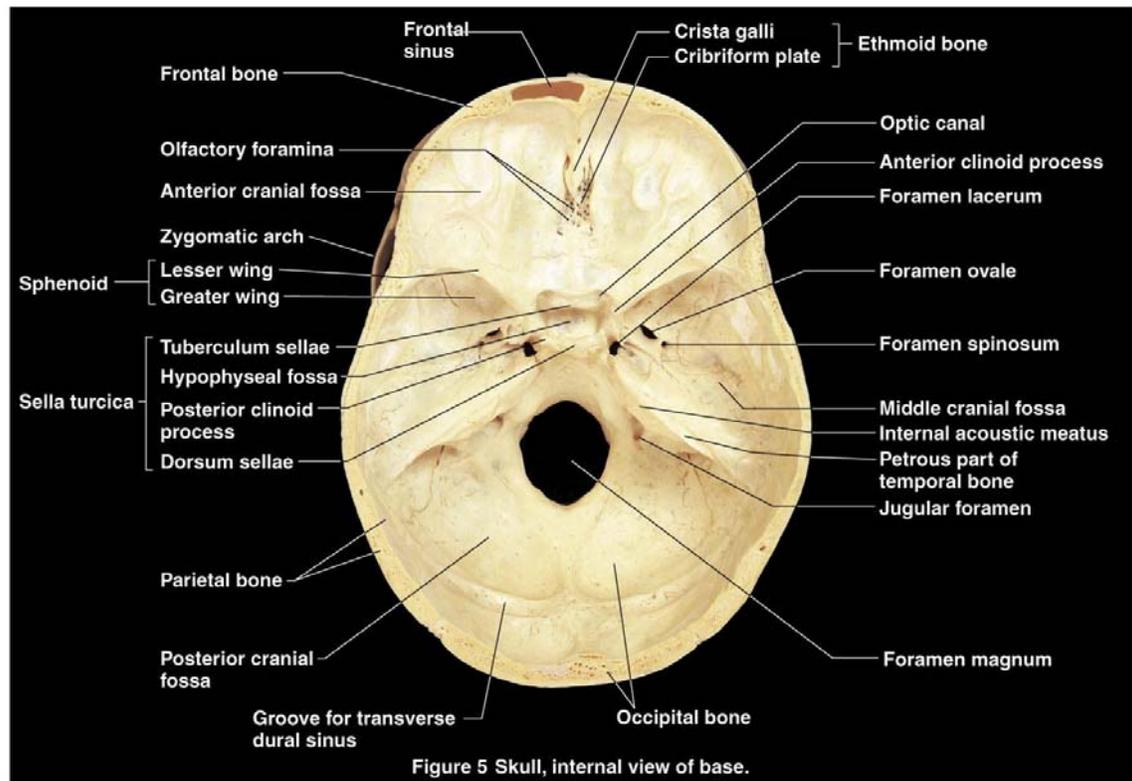


Figure 5 Skull, internal view of base.

1. The skull consists of 22 bones:
 - i. 8 **cranial bones** that form the cranial cavity to enclose and protect the brain
 - ii. 14 **facial bones** that form the face
2. The 8 cranial bones (each having specific **surface markings**) are:
 - i. **frontal bone**
 - a. **frontal squama (vertical plate)**
 - b. **supraorbital margin**
 - c. **supraorbital foramen**
 - d. **frontal sinuses**
 - ii. two **parietal bones**
 - iii. two **temporal bones**, each one having:
 - a. **temporal squama**
 - b. **zygomatic process** (which contributes to the **zygomatic arch**)
 - c. **mandibular (glenoid) fossa**
 - d. **articular tubercle**
 - e. **mastoid portion**
 - f. **external auditory (acoustic) meatus**
 - g. **mastoid “air cells”**
 - h. **mastoid process**
 - i. **internal auditory (acoustic) meatus**
 - j. **styloid process**
 - k. **stylomastoid foramen**
 - l. **petrous portion**
 - m. **carotid foramen**
 - n. **jugular foramen**
 - iv. **occipital bone**
 - a. **foramen magnum**
 - b. **occipital condyles**
 - c. **hypoglossal foramen**
 - d. **external occipital protuberance**
 - e. **superior nuchal lines**
 - f. **inferior nuchal lines**
 - v. **sphenoid bone**
 - a. **body**
 - b. **sphenoidal sinuses**
 - c. **sella turcica**
 - d. **greater wings** (each having a foramen ovale)
 - e. **lesser wings**
 - f. **optic foramen**
 - g. **superior orbital fissure**
 - h. **pterygoid processes**
 - vi. **ethmoid bone**
 - a. **lateral masses**
 - b. **ethmoidal sinuses**
 - c. **perpendicular plate**
 - d. **cribriform plate**
 - e. **olfactory foramina**
 - f. **crista galli**
 - g. **superior nasal conchae (turbinates)**
 - h. **middle nasal conchae (turbinates)**
3. The 14 facial bones (each having specific **surface markings**) are:

- i. two **nasal** bones
- ii. two **maxillae**, each one having:
 - a. **maxillary sinus**
 - b. **alveolar process with alveoli**
 - c. **palatine process**
- iii. two **zygomatic** bones, each one having:
 - a. **temporal process** (which contributes to the **zygomatic arch**)
- iv. two **lacrimal** bones, each one having:
 - a. **lacrimal fossa**
- v. two **palatine** bones, each one having:
 - a. **horizontal plates**
- vi. two **inferior nasal conchae (turbinates)**
- vii. **vomer**
- viii. **mandible**
 - a. **body**
 - b. **rami**
 - c. **angle**
 - d. **condylar process**
 - e. **temporomandibular joint**
 - f. **coronoid process**
 - g. **mandibular notch**
 - h. **alveolar process with alveoli**
 - i. **mental foramen**
 - j. **mandibular foramen**
 - k. **mandibular canal**

Anatomy of the Cranium

- Eight cranial bones – two parietal, two temporal, frontal, occipital, sphenoid, and ethmoid
- Cranial bones are thin and remarkably strong for their weight

In the skull (22):

Cranial bones:

1. **frontal bone**
2. **parietal bone (2)**
3. **temporal bone (2)**
4. **occipital bone**
- sphenoid bone**
- ethmoid bone**

Facial bones:

5. **zygomatic bone (2)**
6. **superior and inferior maxilla**
9. **nasal bone (2)**
7. **mandible**
- palatine bone (2)**
- lacrimal bone (2)**
- vomer bone**
- inferior nasal conchae (2)**

In the middle ears (6):

- **malleus (2)**
- **incus (2)**
- **stapes (2)**

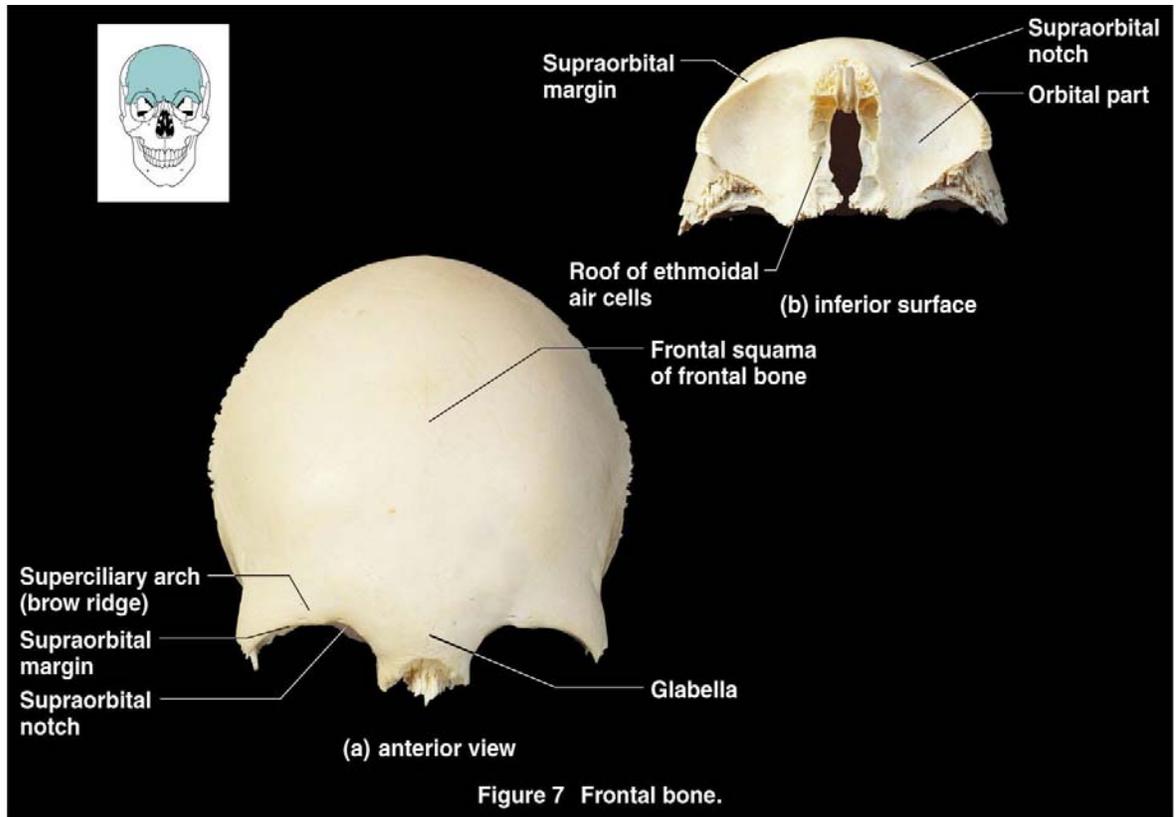
In the throat (1):

- **hyoid bone**

<p>Paired Cranial Bones:</p> <ul style="list-style-type: none"> •Parietals •Temporals <p>Unpaired Cranial Bones:</p> <ul style="list-style-type: none"> •Frontal •Occipital •Sphenoid •Ethmoid 	<p>Paired Facial Bones:</p> <ul style="list-style-type: none"> •Lacrimals •Nasals •Zygomatics •Maxillae •Palatines •Inferior Nasal Conchae 	<p>Unpaired Facial Bones:</p> <ul style="list-style-type: none"> •Vomer •Mandible •Hyoid
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Frontal Bone

- Forms the anterior portion of the cranium
- Articulates posteriorly with the parietal bones via the coronal suture
- Major markings include the supraorbital margins, the anterior cranial fossa, and the frontal sinuses (internal and lateral to the glabella)



Parietal Bones and Major Associated Sutures

- Form most of the superior and lateral aspects of the skull
- Four sutures mark the articulations of the parietal bones
 - Coronal suture – articulation between parietal bones and frontal bone anteriorly
 - Sagittal suture – where right and left parietal bones meet superiorly
 - Lambdoid suture – where parietal bones meet the occipital bone posteriorly
 - Squamosal or squamous suture – where parietal and temporal bones meet

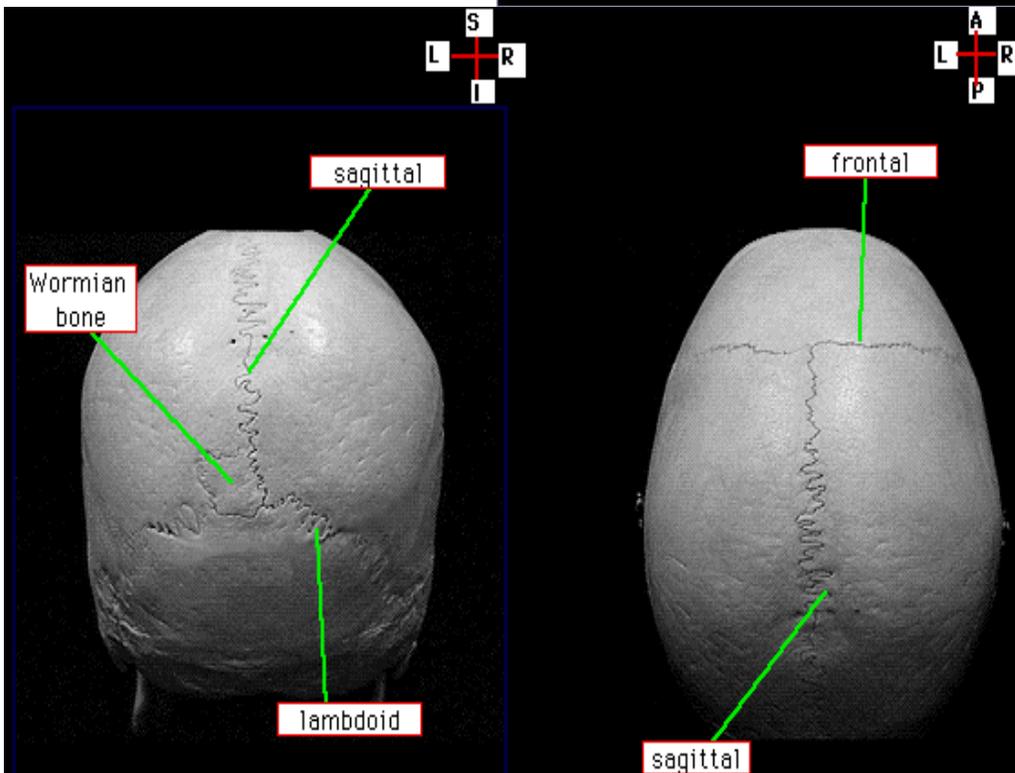
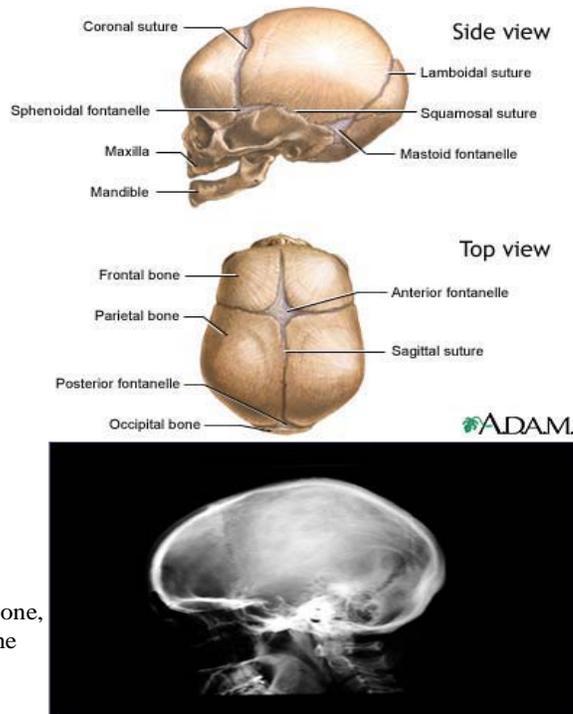
Coronal Suture Articulation between the parietal bones and the frontal bone.

Squamous Suture: Articulation between the temporal bones with the parietal bones.

Lambdoid Suture: Articulation of the parietal bones and the occipital bone.

Occipitomastoid Suture: Articulation between the occipital bone and the mastoid process of the temporal bone.

Sagittal Suture: You can't really see this one, but it is on the very top of the cranium. The articulation between the parietal bones.



▪The bones enclosing the brain have large flexible fibrous joints (sutures) which allow firstly the head to compress and pass through the birth canal and secondly to postnatally expand for brain growth.

▪These sutures gradually fuse at different times postnatally, firstly the metopic suture in infancy and the others much later.

- Abnormal fusion (synostosis) of any of the sutures will lead to a number of different skull defects.
- In old age all these sutures are generally completely fused and ossified.
- coronal suture
- lambdoid suture
- metopic suture begins at nose and runs superiorly to meet sagittal suture and fuses during infancy (fusion beginning at 3 months and completes by 6 to 8 months of age) before all other cranial sutures.
- sagittal suture

Occipital Bone and Its Major Markings

- Forms most of skull's posterior wall and base
- Major markings include the posterior cranial fossa, foramen magnum, occipital condyles, and the hypoglossal canal

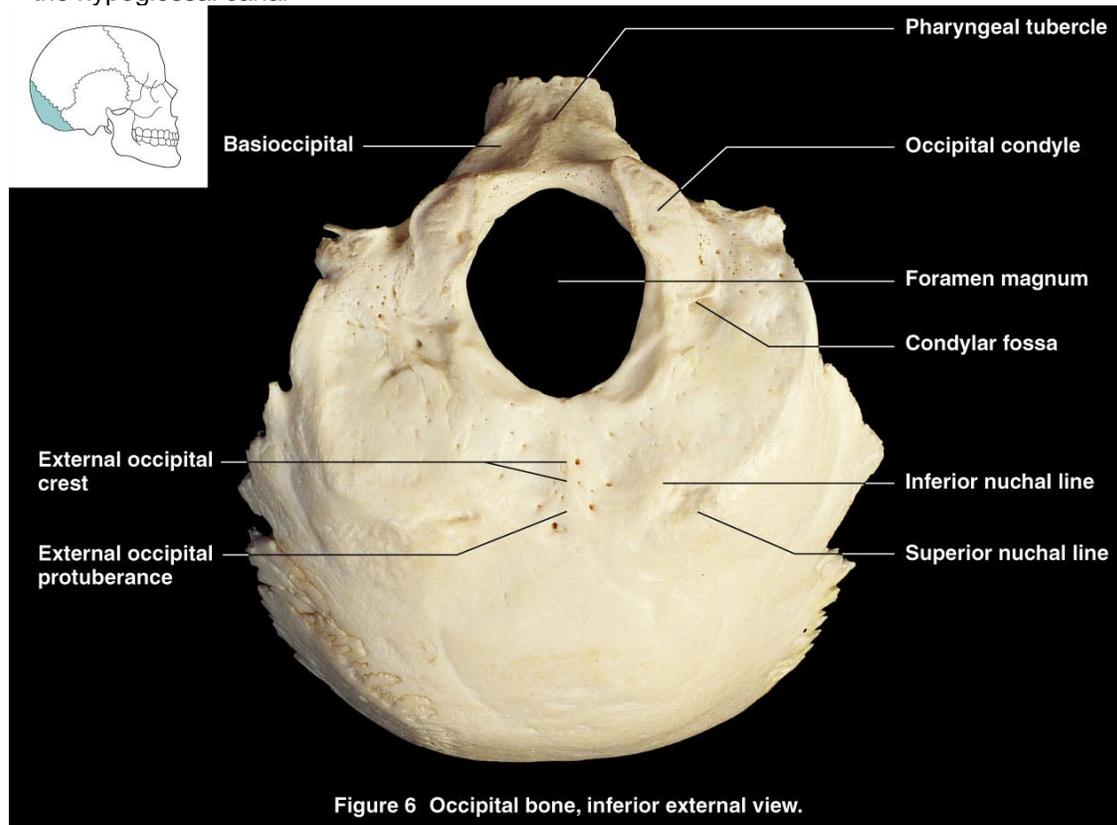
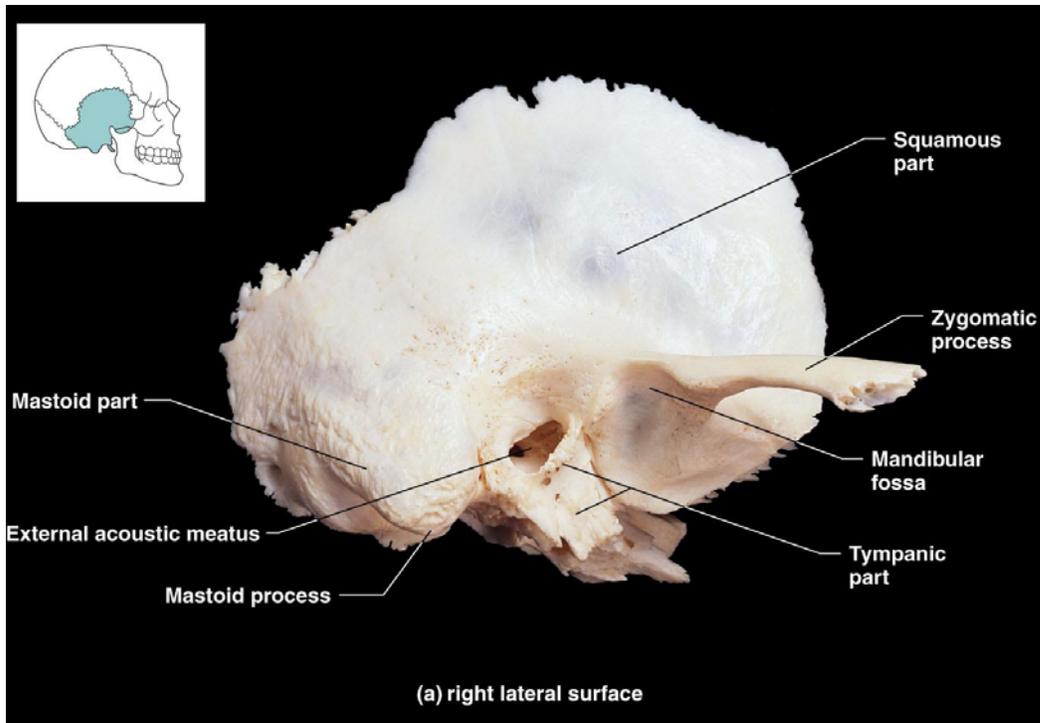


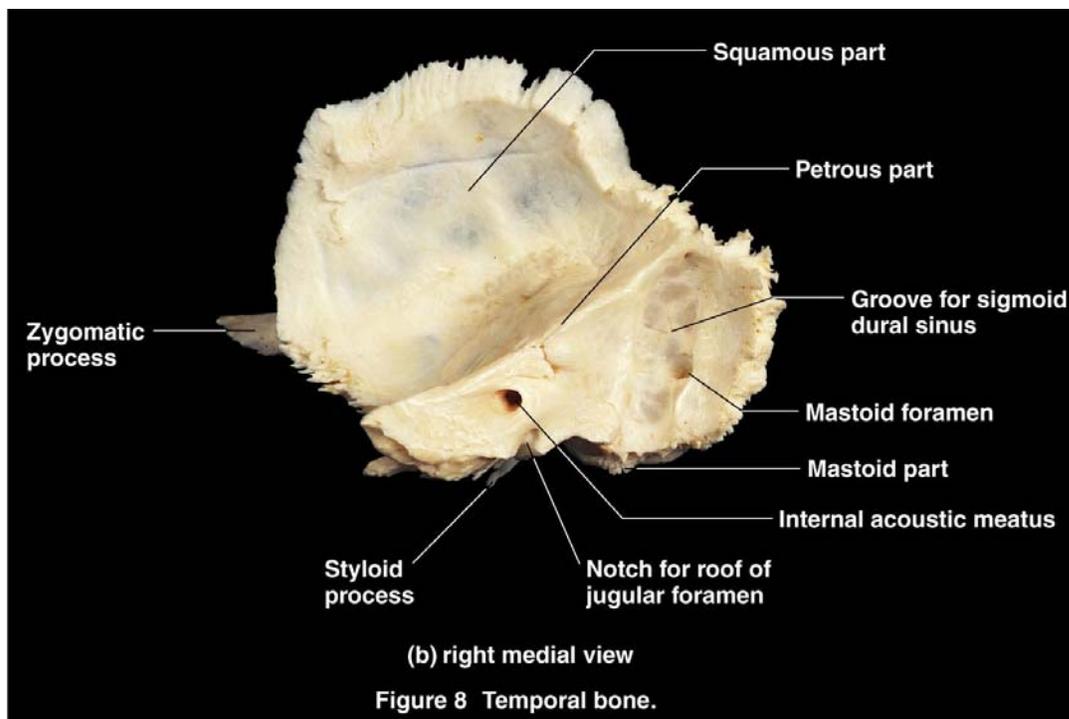
Figure 6 Occipital bone, inferior external view.

Temporal Bones

- Form the inferolateral aspects of the skull and parts of the cranial floor
- Divided into four major regions – squamous, tympanic, mastoid, and petrous
- Major markings include the zygomatic, styloid, and mastoid processes, and the mandibular and middle cranial fossae



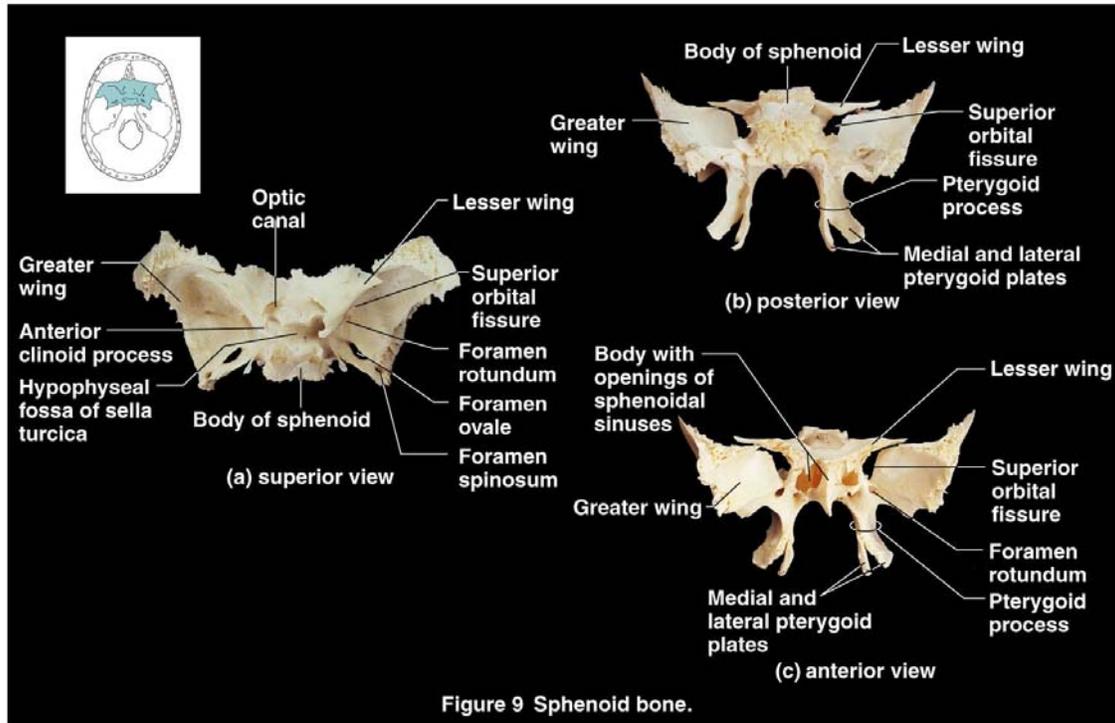
- Major openings include the stylomastoid and jugular foramina, the external and internal auditory meatuses, and the carotid canal



Sphenoid Bone

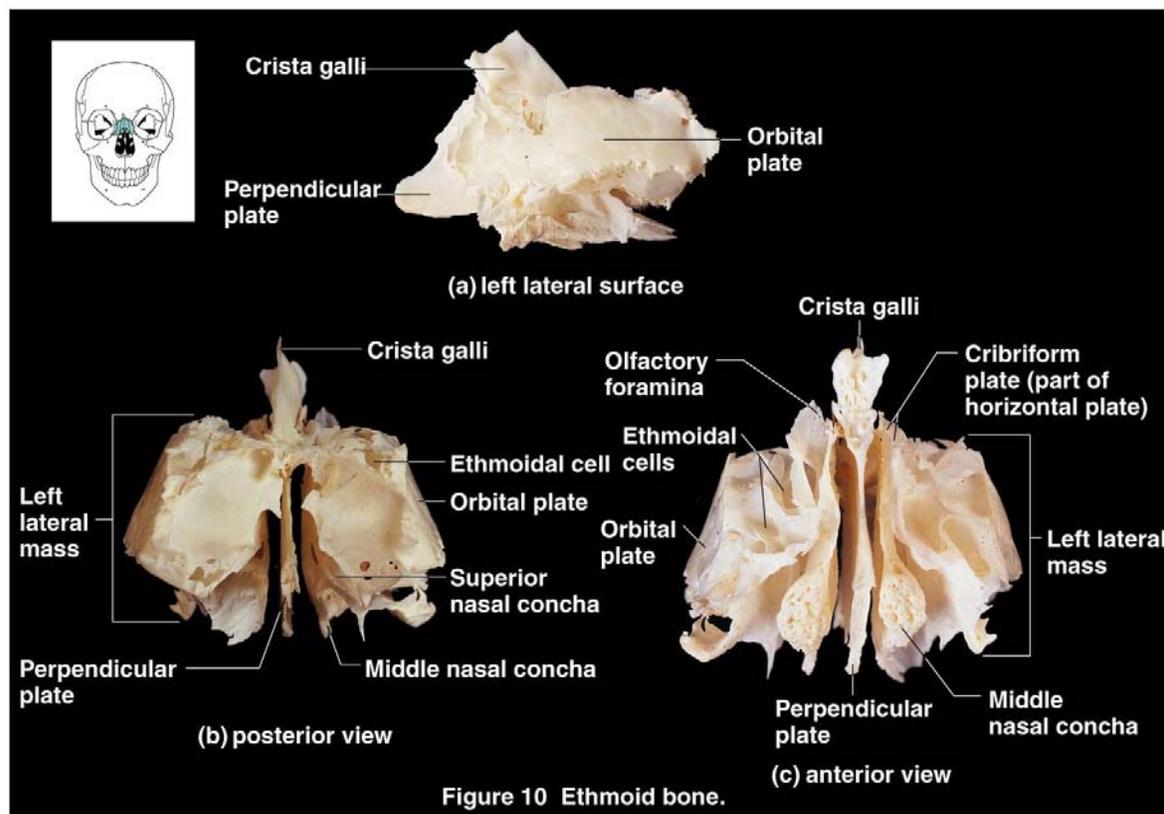
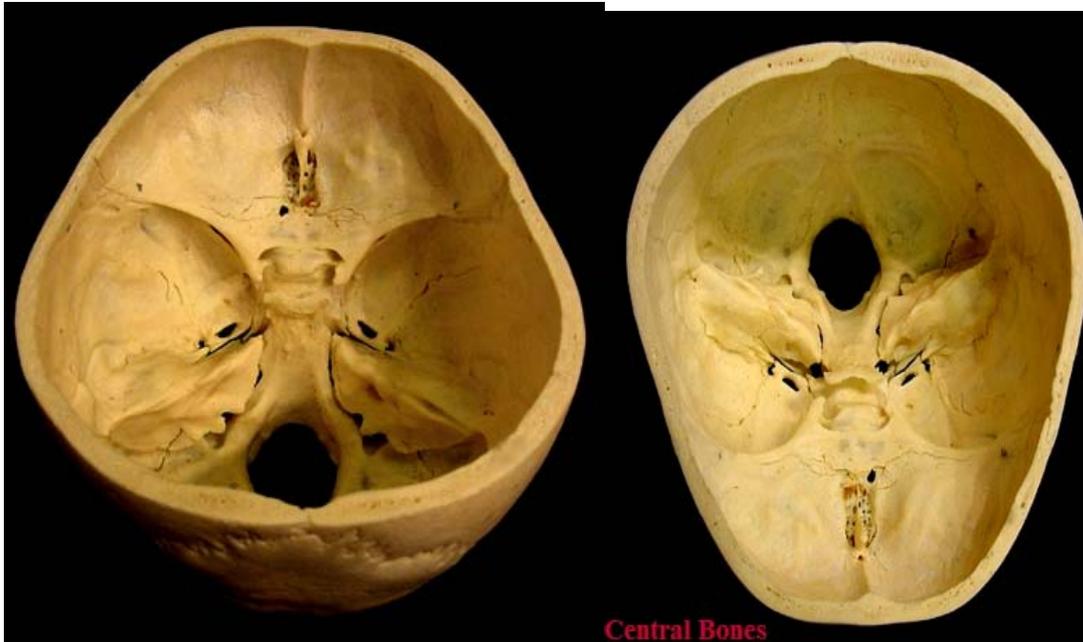
- Butterfly-shaped bone that spans the width of the middle cranial fossa
- Forms the central wedge that articulates with all other cranial bones

- Consists of a central body, greater wings, lesser wings, and pterygoid processes
- Major markings: the sella turcica, hypophyseal fossa, and the pterygoid processes
- Major openings include the foramina rotundum, ovale, and spinosum; the optic canals; and the superior orbital fissure



Ethmoid Bone

- Most deep of the skull bones; lies between the sphenoid and nasal bones
- Forms most of the bony area between the nasal cavity and the orbits
- Major markings include the cribriform plate, crista galli, perpendicular plate, nasal conchae, and the ethmoid sinuses



Wormian Bones

- Tiny irregularly shaped bones that appear within sutures

Facial Bones

- Fourteen bones of which only the mandible and vomer are unpaired
- The paired bones are the maxillae, zygomatics, nasals, lacrimals, palatines, and inferior

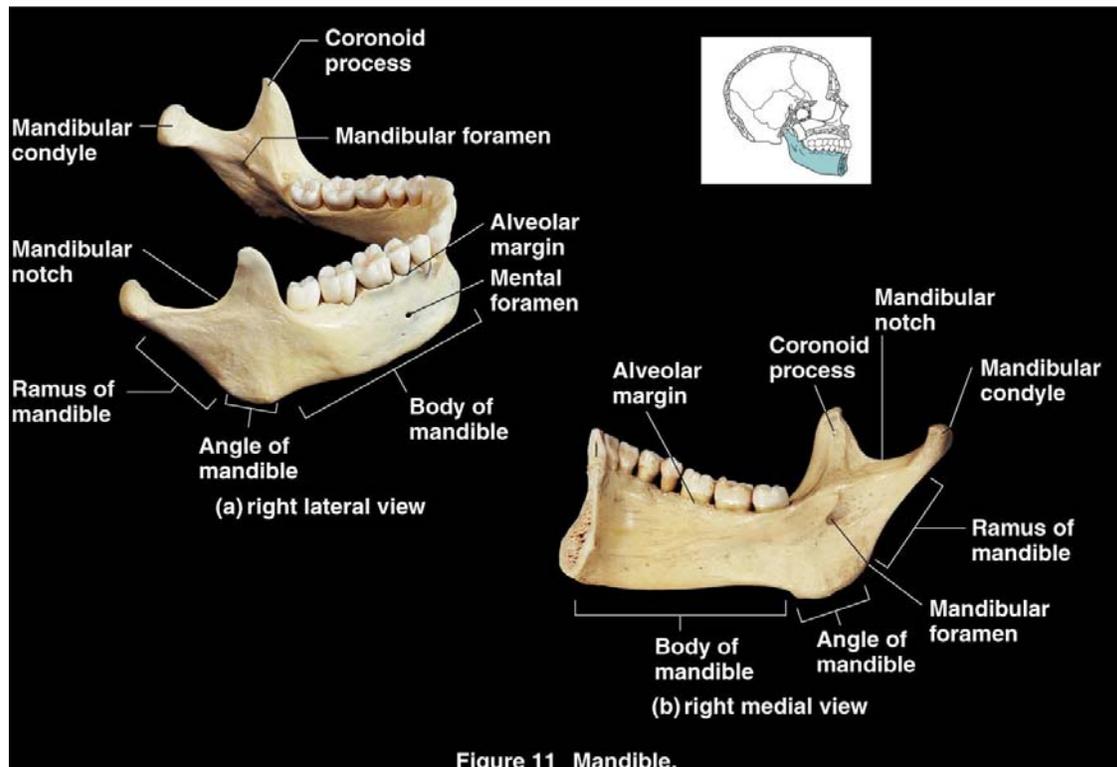
conchae

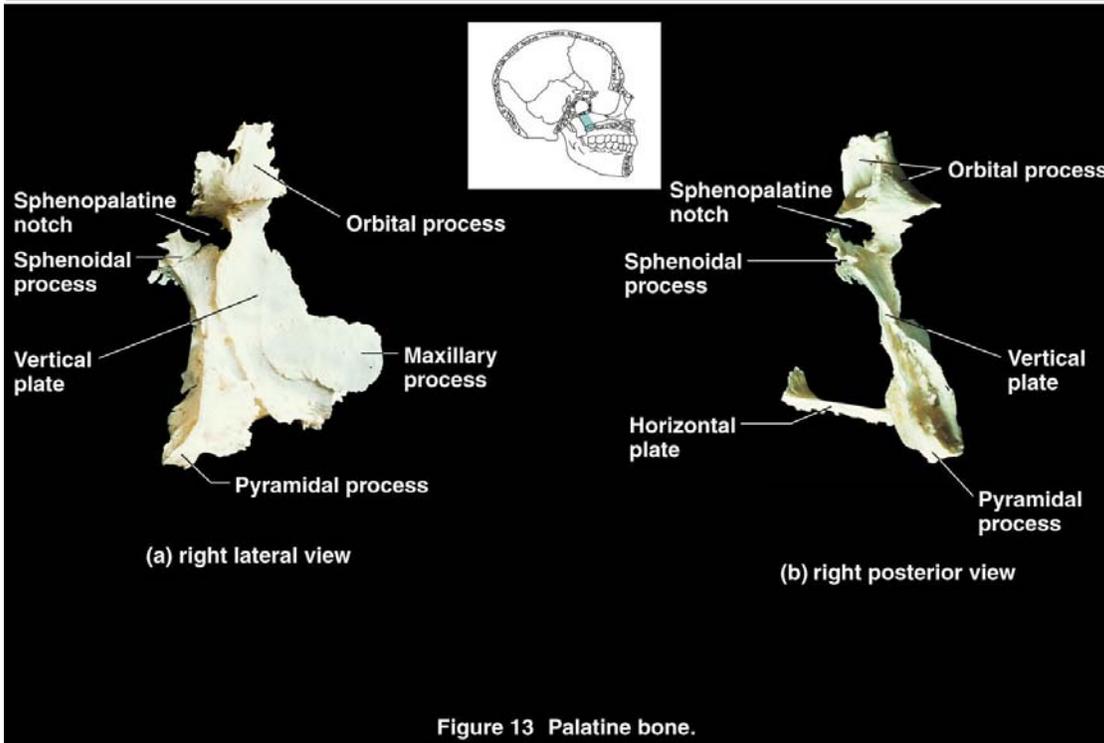
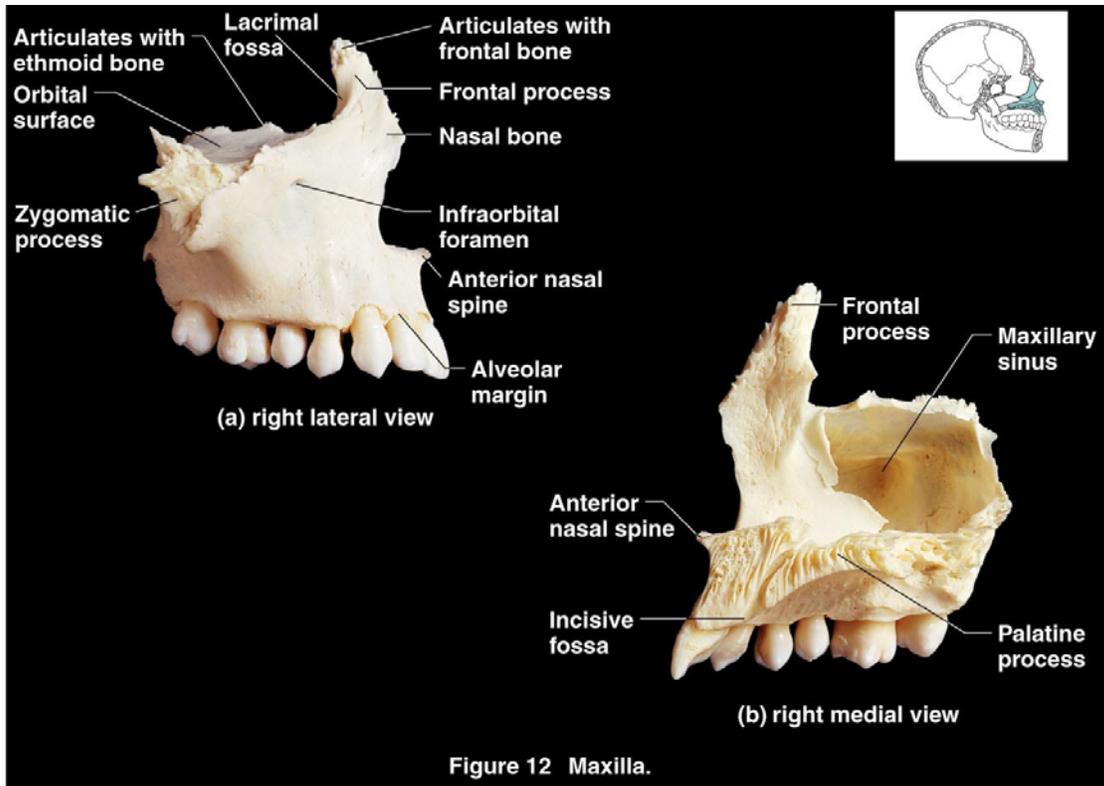
Mandible and Its Markings

- The mandible (lower jawbone) is the largest, strongest bone of the face
- Its major markings include the coronoid process, mandibular condyle, the alveolar margin, and the mandibular and mental foramina

Maxillary Bones

- Medially fused bones that make up the upper jaw and the central portion of the facial skeleton
- Facial keystone bones that articulate with all other facial bones except the mandible
- Their major markings include palatine, frontal, and zygomatic processes, the alveolar margins, inferior orbital fissure, and the maxillary sinuses





Hard Palate

1. Maxillae (palatine processes)
2. Palatines

3. Transverse palatine suture
4. Anterior Palatine Foramen (incisive fossa)



Zygomatic Bones

- Irregularly shaped bones (cheekbones) that form the prominences of the cheeks and the inferolateral margins of the orbits

Other Facial Bones

- Nasal bones – thin medially fused bones that form the bridge of the nose
- Lacrimal bones – contribute to the medial walls of the orbit and contain a deep groove called the lacrimal fossa that houses the lacrimal sac
- Palatine bones – two bone plates that form portions of the hard palate, the posterolateral walls of the nasal cavity, and a small part of the orbits
- Vomer – plow-shaped bone that forms part of the nasal septum
- Inferior nasal conchae – paired, curved bones in the nasal cavity that form part of the lateral walls of the nasal cavity

Cranial Bones:

Temporal bone (2)–

External auditory meatus

Mastoid process

Mandibular fossa

Occipital bone (1)–

Foramen magnum

Occipital condyles

Ethmoid bone (1)–

Cribiform plates

Crista galli

Olfactory foramina

Perpendicular plate

Sphenoid bone (1)–

Optic foramina

Greater and lesser wings

Sella turcica

Pterygoid processes

Parietal bones (2)

Frontal bone (1)

Squamosal Suture

Lambdoidal suture

Sagittal suture

Facial Bones):

Maxillae (2) -

Alveoli

Mandible (1) -

Mental foramina

Condylar processes (mandibular condyles)

Lacrimals

Nasals

Zygomatics

Vomer

Palatines

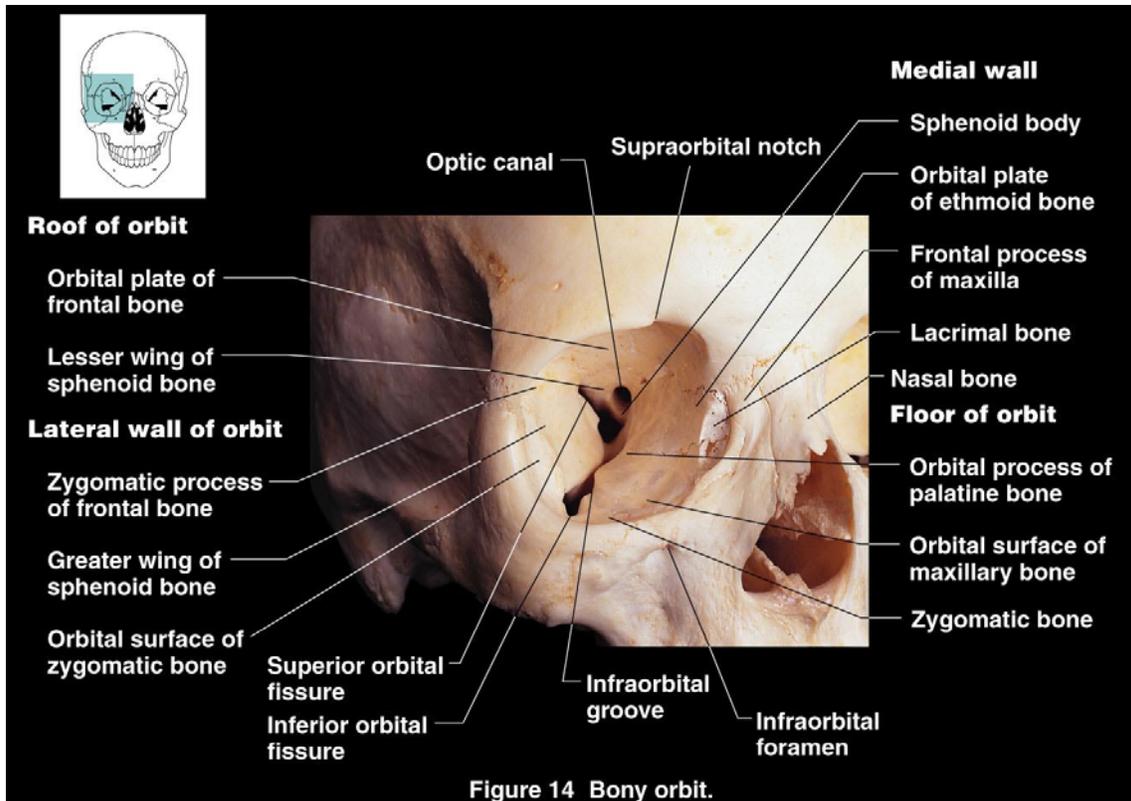
Inferior Nasal Conchae

Unique Features of the Skull

1. The **nasal septum**, formed by the vomer, septal cartilage, and perpendicular plate of the ethmoid bone, divides the nasal cavity into right and left compartments.
2. The **orbits** are deep sockets (each having a roof, lateral wall, floor, and medial wall), formed by several bones, that house the eyeballs and associated structures.
3. The skull bones contain numerous **foramina** that are passageways for blood vessels and nerves.
4. **Sutures** are immovable joints located between skull bones; four notable sutures are:
 - i. **coronal suture**
 - ii. **sagittal suture**
 - iii. **lambdoid suture**
 - iv. (two) **squamous sutures**
5. **Paranasal sinuses** are paired cavities located in certain skull bones;
 - i. they are lined with mucous membranes that are continuous with the lining of the nasal cavity
 - ii. they produce mucus and serve as resonating chambers for sound
 - iii. they are located in the maxillae, frontal, sphenoid, and ethmoid bones.
6. **Fontanels** are fibrous connective tissue membrane-filled spaces located between the cranial bones of infants; their function is to:
 - i. enable the fetal skull to modify its shape as it passes through the birth canal
 - ii. permit rapid growth of the brain during infancy.Major fontanels are:
 - a. **anterior (frontal) fontanel**
 - b. **posterior (occipital) fontanel**
 - c. two **anterolateral (sphenoid) fontanels**
 - d. two **posterolateral (mastoid) fontanels**Fontanels become ossified during the first two years of childhood.
7. The **cranial fossae** are three levels on the floor of the cranial cavity:
 - i. **anterior cranial fossa**
 - ii. **middle cranial fossa**
 - iii. **posterior cranial fossa**

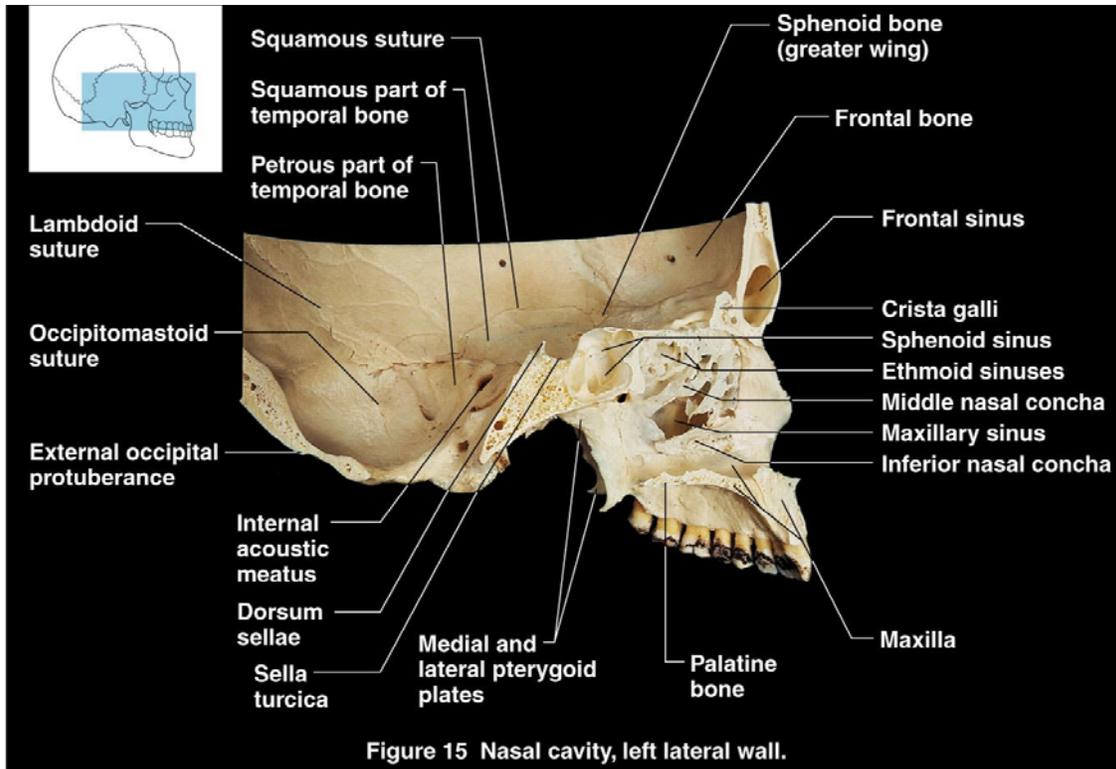
Orbits

- Bony cavities in which the eyes are firmly encased and cushioned by fatty tissue
- Formed by parts of seven bones – frontal, sphenoid, zygomatic, maxilla, palatine, lacrimal, and ethmoid



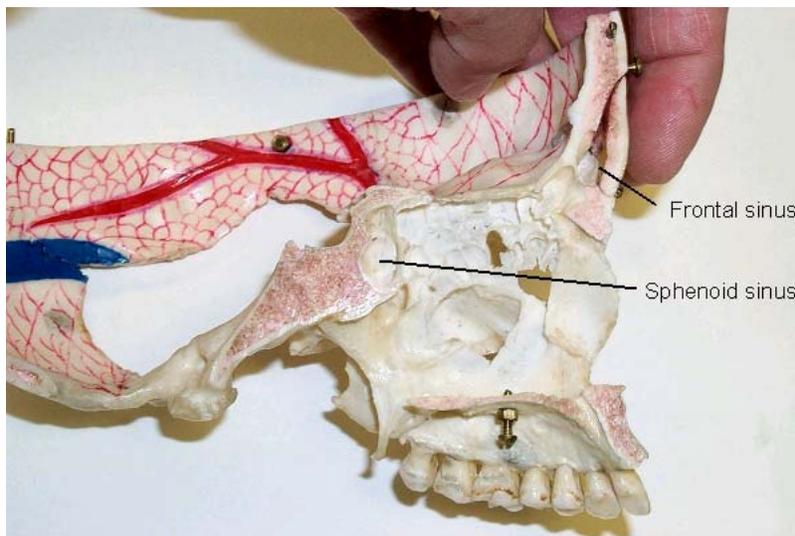
Nasal Cavity

- Constructed of bone and hyaline cartilage
- Roof – formed by the cribriform plate of the ethmoid
- Lateral walls – formed by the superior and middle conchae of the ethmoid, the perpendicular plate of the palatine, and the inferior nasal conchae
- Floor – formed by palatine process of the maxillae and palatine bone



Paranasal Sinuses

- Mucosa-lined, air-filled sacs found in five skull bones – the frontal, sphenoid, ethmoid, and paired maxillary bones
- Air enters the paranasal sinuses from the nasal cavity and mucus drains into the nasal cavity from the sinuses
- Lighten the skull and enhance the resonance of the voice



The facial bones make up the upper and lower jaw and other facial structures.
The facial bones are:

- The mandible is the lower jawbone. It articulates with the temporal bones at the **temporomandibular** joints. This forms the only freely moveable joint in the head. It provides the chewing motion.
- The left and right maxilla are the upper jaw bones. They form part of the nose, orbits, and roof of the mouth.
- The left and right palatine form a portion of the nasal cavity and the posterior portion of the roof of the mouth.
- The left and right zygomatic are the cheek bones. They form portions of the orbits as well.
- The left and right nasal form the superior portion of the bridge of the nose.
- The left and right lacrimal help to form the orbits.
- The vomer forms part of the nasal septum (the divider between the nostrils).

The left and right inferior **turbinate** forms the lateral walls of the nose and increase the surface area of the nasal cavity.

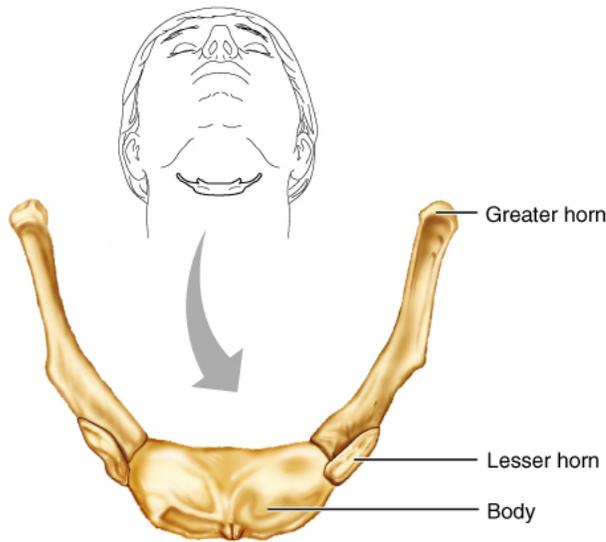
Hyoid Bone

- Not actually part of the skull, but lies just inferior to the mandible in the anterior neck
- Only bone of the body that does not articulate directly with another bone
- Attachment point for neck muscles that raise and lower the larynx during swallowing and speech

Hyoid Bone

1. The hyoid bone is a U-shaped bone, located in the upper neck, that does not articulate with any other bone.
2. It supports the tongue and is an attachment site for several tongue, neck, and pharynx muscles.
3. Its major surface markings are:
 - i. **body**
 - ii. **lesser horns**
 - iii. **greater horns**

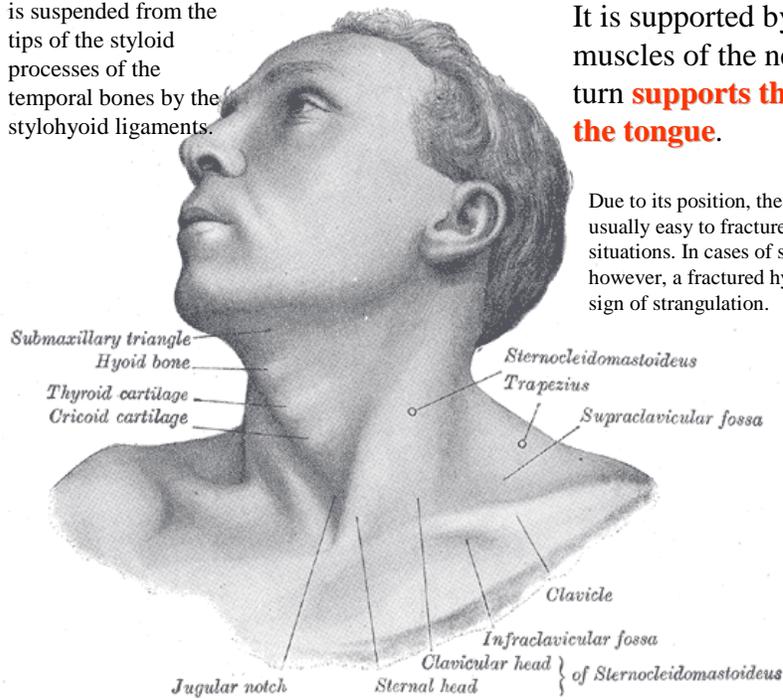
HYOID BONE



is suspended from the tips of the styloid processes of the temporal bones by the stylohyoid ligaments.

It is supported by the muscles of the neck and in turn **supports the root of the tongue.**

Due to its position, the hyoid bone is not usually easy to fracture in most situations. In cases of suspicious death, however, a fractured hyoid is a strong sign of strangulation.



Developmental Aspects: Fetal Skull

- Infant skull has more bones than the adult skull
- At birth, fetal skull bones are incomplete and connected by fontanel
- Fontanel
 - Unossified remnants of fibrous membranes between fetal skull bones
 - The four fontanel are anterior, posterior, mastoid, and sphenoid

- Skull bones such as the mandible and maxilla are unfused

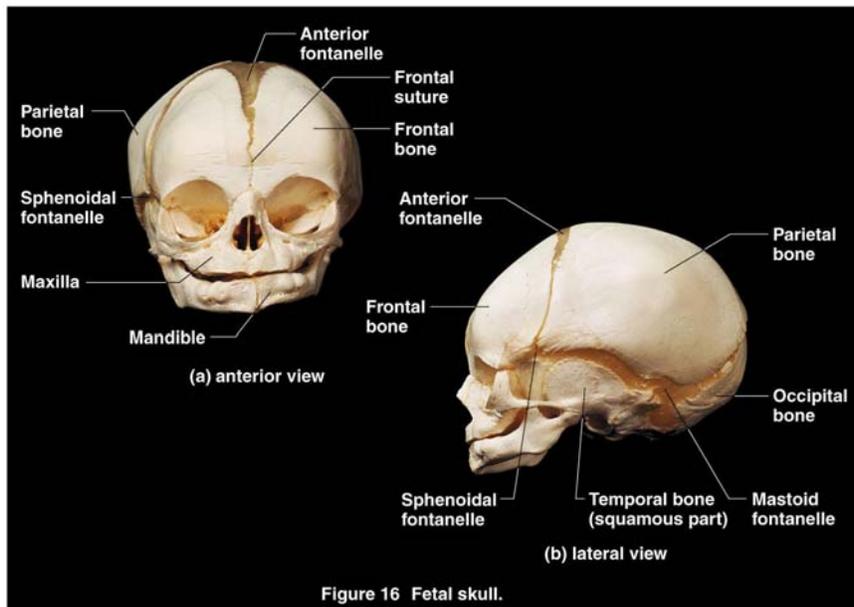
Developmental Aspects: Growth Rates

- At birth, the cranium is huge relative to the face
- Mandible and maxilla are foreshortened but lengthen with age
- The arms and legs grow at a faster rate than the head and trunk, leading to adult proportions

Fetal Skull

1. anterior fontanel (frontal)
2. anterolateral (sphenoidal)
3. posterolateral (mastoid)
4. posterior (occipital)
5. ossification centers

During skull development, the cranial connective tissue framework undergoes intramembranous ossification to form skull bones (calvaria). As the calvarial bones advance to envelop the brain, fibrous sutures form between the calvarial plates. Expansion of the brain is coupled with calvarial growth through a series of tissue interactions within the cranial suture complex. Craniosynostosis, or premature cranial suture fusion, results in an abnormal skull shape, blindness and mental retardation. Recent studies have demonstrated that gain-of-function mutations in fibroblast growth factor receptors (fgfr) are associated with syndromic forms of craniosynostosis. Noggin, an antagonist of bone morphogenetic proteins (BMPs), is required for embryonic neural tube, somites and skeleton patterning. Here we show that noggin is expressed postnatally in the suture mesenchyme of patent, but not fusing, cranial sutures, and that noggin expression is suppressed by FGF2 and syndromic fgfr signalling. Since noggin misexpression prevents cranial suture fusion in vitro and in vivo , we suggest that syndromic fgfr -mediated craniosynostoses may be the result of inappropriate downregulation of noggin expression.



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Abnormal Synostosis

There are several skull deformities caused by premature fusion (synostosis) of different developing skull sutures. Suture abnormalities are classified as either "simple" (only one suture involved) or "compound" (two or more sutures involved).



Oxycephalus (historic image from Hess, 1922)

craniosynostosis premature cranial suture fusion, results in an abnormal skull shape, blindness and mental retardation.

oxycephaly (tower skull) results from premature coronal suture synostosis.

plagiocephaly results from asymmetric coronal suture synostosis, incidence is approximately 1 in 300 live births.

lambdoid synostosis results from premature lambdoid suture synostosis, a rare abnormality (incidence is approximately 3 in 100,000 live births) which displaces ear posteriorly towards the fused suture.

capocephaly results from premature sagittal suture synostosis.

trigonocephaly (wedge skull) results from metopic suture synostosis.

Basal Foramen	Location	Transmits
Olfactory foramen	Anterior crainial fossa	CN I - Olfactory
Optic foramen	Middle Crainial fossa, inferior aspect of lesser	CN II - Optic
Superior Orital fussure	B/w greater and lesser wing	CN III, IV, V1, VI - Occularmor, Trochlear, Trigeninal Ophthalmic, Abdeuces
Foramen Rotundum	Middle Crainial Fossa, greater wing of sphenoid	CN V2 - Trigeminal Maxillary
Foramen Ovale	Middle Crainial fossa, postero-lateral to foramen rotundum	CN V3 - Trigeminal Mandibular
Foramen Spinosum	Middle Crainial fossa, postero-lateral to foramen ovale	Middle meningeal artery
Foramen Lacerum	Middle crainial fossa, lateral to dorsum sallae	Carotid artery
Carotid Foramen	Middle crainial fossa, petrous bone	Leads to foramen lacerum, carotid artery
Foramen Magnum	Posterior crainial fossa	spinal cord and vertebral arteries
Jugular Foramen	Posterior crainial fossa, b/w petrous ridges and occipital bone, antero-lateral to foramen magnum	Jugular vein, CN IX, X, XI - Glossopharengeal, vagus, accessory
Internal Auditory Foramen	Posterior crainial fossa, postero-lateral aspect of petrous ridegs	
Hypoglossal Foramen	Posterior crainial fossa, lateral aspect of foramen magnum	CN XII - hypoglossal