MEDICAL EDUCATION RESOURCE

Introduction qnd Osteology

Introduction

- **Face**: Anterior aspect of head; contains facial muscles responsible for expression.
- **Scalp**: Covers lateral, posterior, and superior parts of skull.

Compartments of Neck

1. **Posterior/Vertebral compartment** ? 7 cervical vertebrae and associated muscles.
2. **Anterior/Visceral compartment** ? thyroid, parathyroid, thymus, parts of respiratory and digestive tracts.
3. **Two lateral vascular compartments** ? major arteries, veins, lymphatics, and nodes.

Pharynx: Musculofascial tube divided into naso-, oro-, and laryngopharynx.
Larynx: Between hyoid and trachea; made of cartilages and membranes; functions in **phonation and respiration**.

Functions of Head and Neck

1. Protects brain, endocrine glands, and special sense organs.
2. Provides passage for food and air.
3. Enables voice and speech.

Evolutionary adaptations:

- Enlarged cranial cavity ? accommodates evolved brain.
- Retracted mandible, anterior eyes, prominent nose, smaller external ear.
- Tongue specialized for articulation; speech as human hallmark.

Regional Divisions of Head

- **Frontal region** – front of skull.
- **Parietal region** – top of skull.
- **Occipital region** – back of skull.
- **Temporal region** – above ears (hearing & balance center).
- **Ocular region** – around orbit; contains eyeball & accessory structures.
- **Auricular region** – around external ear & meatus.
- **Nasal region** – external nose & cavity (smell).
- **Oral region** – lips, angles of mouth; emotional expression.
- **Oral cavity** – contains tongue (taste & speech).
- **Parotid region** – lateral face, houses parotid gland.

Triangles of Neck

- **Posterior triangle**: Between sternocleidomastoid, trapezius, and clavicle.

    - Contains subclavian vessels, branches, and brachial plexus roots.

- **Anterior triangle**: Between midline and sternocleidomastoid.
    - Contains carotid artery, thyroid isthmus, and related structures.

Bones of Head and Neck

- **Includes:** Skull (cranium + mandible), 7 cervical vertebrae, hyoid, and 6 ear ossicles.
- **Skull cap (calvaria):** Frontal, parietal, squamous temporal, and occipital parts — ossify **intramembranously**.
- **Skull base:** Ossifies **endochondrally** (cartilaginous).

Functions:

- Lodges brain, meninges, teeth, and sense organs (eye, ear, olfactory, taste).
- Brain weight supported by cerebrospinal fluid (CSF).

Skull

- **Definition:** Skeleton of head comprising cranium and mandible.
- **Parts:**
    - **Neurocranium (calvaria):** Brain box – vault + base.
    - **Viscerocranium:** Facial skeleton including mandible.

Bones of Skull

Neurocranium (8 bones)

- *Paired:* Parietal (2), Temporal (2)
- *Unpaired:* Frontal (1), Occipital (1), Sphenoid (1), Ethmoid (1)

Facial skeleton (14 bones)

- *Paired:* Maxilla, Zygomatic, Nasal, Lacrimal, Palatine, Inferior nasal concha (each 2)
- *Unpaired:* Mandible, Vomer

Ear Ossicles (6): Malleus, Incus, Stapes (each pair).

Joints of Skull

- Mostly **sutures** (fibrous joints).
- Some **primary cartilaginous** joints.
- **Synovial joints:**
    - Ossicular joints (malleus–incus–stapes).
    - Temporomandibular joint (mobile).

Types of sutures:
Plane ? internasal
Serrate ? coronal
Denticulate ? lambdoid
Squamous ? parietotemporal

Anatomical Position of Skull

1. **Reid’s baseline:** From infraorbital margin ? center of external acoustic meatus.
2. **Frankfurt’s horizontal plane:** From infraorbital margin ? upper border of external acoustic meatus.

Methods of Study

- **External views (normae):**
  - Superior ? Norma verticalis
  - Posterior ? Norma occipitalis
  - Anterior ? Norma frontalis
  - Lateral ? Norma lateralis
  - Inferior ? Norma basalis
- **Internal views:**
  - Cranial vault (roof)
  - Cranial base (anterior, middle, posterior fossae)

Peculiarities of Skull Bones

1. **Base** ossifies in cartilage; **vault** in membrane.
2. **Diploë** (between outer & inner tables) ? red marrow for hematopoiesis.
3. **Fontanelles** ? membranous gaps at parietal angles for growth and parturition.

4. **Pneumatic bones:** Frontal, Maxilla – lighten skull, humidify air, resonate voice, may get infected (sinusitis).
5. **Sutures** unite most bones.
6. **Emissary veins** connect intracranial sinuses with extracranial veins ? spread of infection possible.
7. **Petrous temporal bone** = densest bone; lodges ear structures.
8. Skull protects brain, meninges, CSF, sinuses, and special sense organs.

Emissary Veins (examples):

- Parietal (to superior sagittal sinus)
- Mastoid (to sigmoid sinus)
- Condylar (to sigmoid sinus)
- Foramen ovale emissary (to cavernous sinus)

Norma Verticalis (Superior View)

- **Shape:** Oval, wider posteriorly.
- **Bones:** Frontal (anterior), Parietals (sides), Occipital (posterior).
- **Sutures:** Coronal, Sagittal, Lambdoid, occasional Metopic.
- **Key landmarks:**

- *Bregma* – coronal + sagittal intersection (anterior fontanelle).
- *Lambda* – sagittal + lambdoid intersection (posterior fontanelle).
- *Vertex* – highest point on sagittal suture.
- *Parietal tuber* – maximal convexity.
- *Temporal lines* – muscular attachments.

Clinical Anatomy:

- Fontanelle tension indicates intracranial pressure.
- Early closure ? microcephaly; delayed closure ? hydrocephalus.
- Caput succedaneum ? birth-related swelling due to venous rupture.

Norma Occipitalis (Posterior View)

- **Bones:** Parietal (upper), Occipital (below), Mastoid part of temporal (sides).
- **Sutures:** Lambdoid, Occipitomastoid, Parietomastoid, posterior Sagittal.
- **Features:**
  - *External occipital protuberance* ? palpable midline bump.
  - *Inion* – tip of protuberance.
  - *Superior & highest nuchal lines* – muscular attachment ridges.

- *Occipital point* – farthest from glabella.
- *Mastoid foramen* – emissary vein & meningeal artery.
- *Interparietal bone* (inca bone) occasionally present.

Attachments:

- *Trapezius*, *ligamentum nuchae*, *sternocleidomastoid*, *splenius capitis*, *occipitalis*.

Norma Frontalis (Anterior View)

- **Bones:** Frontal, Maxilla, Nasal, Zygomatic, Mandible.
- **Regions:**
  - *Frontal region*: Superciliary arches, glabella, nasion, frontal tuber.
  - *Orbital openings*:
    - Margins ? supraorbital (frontal), infraorbital (maxilla + zygomatic).
    - Supraorbital notch ? supraorbital nerves/vessels.
  - *Nasal aperture*: Pear-shaped, bounded by nasal bones & maxillae.
    - Anterior nasal spine at lower border.
  - *Lower face*: Infraorbital foramen (infraorbital nerve), canine & incisive fossae, alveolar process with teeth sockets.
  - *Zygomatic bones*: Cheek prominence, zygomaticofacial foramen.

- *Mandible*: Mental protuberance, tubercles, and foramen.

Attachments: Corrugator supercilii, procerus, orbicularis oculi, levator labii muscles, nasalis, zygomaticus, buccinator, etc.

Clinical Anatomy:

- Nasal bone ? most frequently fractured facial bone.
- Parietal eminence & mandible next in frequency.

Norma Lateralis (Side View)

- **Bones:** Frontal, Parietal, Occipital, Temporal, Sphenoid, Zygomatic, Maxilla, Nasal, Mandible.
- **Temporal lines:** Superior & inferior – temporalis attachment.
- **Zygomatic arch:** Temporal + zygomatic bones; attachment for **masseter** (below) and **temporalis** (above).
- **External acoustic meatus:** Bony canal for sound conduction.
- **Temporal fossa:** Above zygoma; **temporalis muscle**.
- **Infratemporal fossa:** Below arch; **pterygoid muscles** and maxillary artery.
- **Pterion:** Junction of frontal, parietal, temporal, sphenoid bones — thin area where middle meningeal artery lies.

Clinical Anatomy:

- Fracture at pterion may rupture **middle meningeal artery**, causing **extradural hematoma** — a neurosurgical emergency.

Norma Basalis

The **base of skull (Norma Basalis)** is studied by dividing it into **three arbitrary parts**: **Anterior**, **Middle**, and **Posterior** parts.

Anterior Part

Formed by **hard palate** and **alveolar arches**.

Alveolar Arch

- Bears sockets (alveoli) for upper teeth.

Hard Palate

- **Formation:**
  - *Anterior 2/3* ? Palatine processes of maxillae.
  - *Posterior 1/3* ? Horizontal plates of palatine bones.
- **Sutures:**
  - Crossed by a cruciform suture (intermaxillary, interpalatine, palatomaxillary).
- **Features:**
  - *Incisive foramen* ? Median pit with right and left incisive canals.

- *Greater palatine foramina* ? Behind palatomaxillary suture, transmits greater palatine nerves and vessels.
- *Lesser palatine foramina* ? Behind greater, in pyramidal process of palatine.
- *Posterior nasal spine* ? Median posterior projection.
- *Palatine crest* ? Curved ridge behind greater palatine foramen.

Middle Part

Extends from **posterior border of hard palate** to **anterior margin of foramen magnum**.

Median Area

- Posterior border of vomer.
- **Sphenoid rostrum** ? Overlaps vomer.
- **Basilar part of occipital bone** anterior to foramen magnum.

Lateral Areas

- *Greater wing of sphenoid* (infratemporal surface).
- *Pterygoid process* ? Medial & lateral plates with pterygoid fossa between them.
- *Foramina:*
  - *Foramen ovale* ? Mandibular nerve.
  - *Foramen spinosum* ? Middle meningeal artery.

- *Foramen lacerum* ? Filled with fibrocartilage, transmits emissary veins and meningeal branch.

Posterior Part

Extends behind the **foramen magnum**.

Key Features:

- **Foramen magnum** ? Spinal cord, meninges, vertebral arteries, and spinal roots of accessory nerves.
- **Occipital condyles** ? Articulate with atlas.
- **Condylar canal** ? Emissary vein connecting sigmoid sinus with suboccipital plexus.
- **Hypoglossal canal** ? Hypoglossal nerve.
- **Jugular foramen** ? Cranial nerves IX, X, XI, and internal jugular vein.
- **Styloid process** ? For muscle and ligament attachment.
- **Mastoid foramen** ? Emissary vein + meningeal branch of occipital artery.
- **Stylomastoid foramen** ? Facial nerve + stylomastoid artery.

Interior of the Skull

General Features

- Lined by **endocranium** (continuous with pericranium).

- **Thickness varies:** Thinner in temporal and occipital areas, and in females/children.
- **Bone structure:**
  - *Outer table* ? Thick and resilient.
  - *Inner table* ? Thin and brittle.
  - *Diploë* ? Spongy bone with red marrow and diploic veins.

Diploic Veins

1. Frontal ? Supraorbital vein.
2. Anterior temporal ? Sphenoparietal sinus.
3. Posterior temporal ? Transverse sinus.
4. Occipital ? Confluence of sinuses.
5. Small unnamed ? Venous lacunae.

Internal Surface of Cranial Vault

- **Inner table:** Thin and fragile.
- **Grooves:** For meningeal vessels and venous sinuses.
- **Sagittal sulcus:** For superior sagittal sinus.
- **Granular foveolae:** For arachnoid granulations.

- **Parietal foramina:** For emissary veins.
- **Impressions:** From cerebral gyri and meningeal vessels.

Internal Surface of Base of Skull

Divided into **three cranial fossae**:

1. Anterior Cranial Fossa

- Bones: Frontal, ethmoid, lesser wing of sphenoid.
- Holds *frontal lobes*.
- *Foramina*: Cribriform plate (olfactory nerves), foramen cecum (emissary vein).

2. Middle Cranial Fossa

- Bones: Greater wing & body of sphenoid, squamous & petrous temporal.
- Holds *temporal lobes*.
- *Important Foramina:*
    - **Optic canal** – Optic nerve, ophthalmic artery.
    - **Superior orbital fissure** – CN III, IV, V1, VI, ophthalmic veins.
    - **Foramen rotundum** – Maxillary nerve.
    - **Foramen ovale** – Mandibular nerve.
    - **Foramen spinosum** – Middle meningeal artery.

- **Carotid canal** – Internal carotid artery.

3. Posterior Cranial Fossa

- Deepest; lodges *cerebellum, pons, medulla*.
- Bones: Occipital + petrous temporal.
- *Foramina:*
  - **Foramen magnum** – Medulla, vertebral arteries.
  - **Jugular foramen** – CN IX, X, XI.
  - **Hypoglossal canal** – CN XII.
  - **Internal acoustic meatus** – CN VII, VIII.

> **Clinical Anatomy**

- **Fractures at pterion** ? Middle meningeal artery rupture ? Extradural hematoma.
- **Basilar skull fractures** ? CSF leakage (nose/ear), cranial nerve palsies.
- **Depressed fractures** ? May tear dura and cause infection.
- **Infection routes:** Via emissary veins to venous sinuses.
- **Foramen magnum herniation:** Cerebellar tonsils compress medulla ? fatal respiratory arrest.

- **Cranial fossae lesions:**
    - Anterior ? anosmia, rhinorrhea.
    - Middle ? visual/oculomotor deficits.
    - Posterior ? lower cranial nerve palsies.

Attachments and Relations: Interior of the Skull

Anterior Cranial Fossa

- **Lodges:** Frontal lobes of the brain.
- **Attachments:** Falx cerebri along crista galli.
- **Relations:** Cribriform plate transmits olfactory nerves; closely related to nasal cavity — prone to CSF rhinorrhea after fracture.

Middle Cranial Fossa

- **Lodges:** Temporal lobes.
- **Attachments:** Tentorium cerebelli along superior border of petrous temporal bone.
- **Grooves:** For cavernous sinus and internal carotid artery.
- **Relations:**
    - Trigeminal impression on petrous apex ? lodges trigeminal ganglion.

- Cavernous sinus lateral to sella turcica.
- Hypophyseal fossa lodges pituitary gland.

Posterior Cranial Fossa

- **Lodges:** Cerebellum, pons, medulla.
- **Attachments:**
  - Falx cerebelli ? internal occipital crest.
  - Tentorium cerebelli ? superior petrosal sinus groove.
  - Apical ligament, cruciate ligament, and membrana tectoria ? lower clivus.
- **Relations:** Jugular tubercle (IX, X, XI cranial nerves), subarcuate fossa (lodges flocculus of cerebellum).

Principles Governing Fractures of the Skull

1. **Preventive Factors**
   - Elasticity of skull.
   - Rounded shape.
   - Construction from multiple secondary elastic arches (each a bone).
   - Muscles overlying thin areas act as cushions.

2. **Mechanism**
    - The skull behaves like an *elastic sphere filled with semi-fluid brain*.
    - Impact ? splitting effect radiating along *lines of least resistance*.
3. **Sites**
    - **Base of skull** more fragile ? fractures common near foramina.
    - **Vault fractures** ? typically parietal area.
    - **Inner table** more brittle than outer ? sometimes fractured alone.
4. **Common Facial Bone Fractures**
    - Nasal bone.
    - Mandible.
5. **Clinical Notes**
    - Base fracture ? CSF otorrhea/rhinorrhea, cranial nerve palsies.
    - Vault fracture ? intracranial hemorrhage risk.

The Orbit

Overview

- **Pyramidal cavity** on each side of nasal root — protects and allows movement of eyeball.

- **Shape:** Four-sided pyramid with apex posteriorly at superior orbital fissure and base anteriorly on face.

Walls

1. **Roof**
    - *Formed by:* Orbital plate of frontal bone + lesser wing of sphenoid.
    - *Relations:* Separates orbit from anterior cranial fossa; may contain frontal sinus.
    - *Landmarks:*
        - Lacrimal fossa (anterolateral) ? lacrimal gland.
        - Trochlear fossa (anteromedial) ? pulley of superior oblique.
        - Optic canal (posteriorly) ? optic nerve + ophthalmic artery.
2. **Lateral Wall**
    - *Formed by:* Greater wing of sphenoid + frontal process of zygomatic bone.
    - *Strongest wall;* separates orbit from middle cranial and temporal fossae.
    - *Features:* Superior orbital fissure posteriorly, zygomatic foramen, Whitnall's tubercle (lateral check ligament).
3. **Floor**
    - *Formed by:* Maxilla (mainly), zygomatic, and palatine bones.
    - *Inclined upward medially*; separates orbit from maxillary sinus.

- *Contains:* Infraorbital groove and canal ? infraorbital nerve and vessels.

4. **Medial Wall**
    - *Formed by:* Ethmoid, lacrimal, body of sphenoid, frontal process of maxilla.
    - *Thinnest wall (“lamina papyracea”)*; separates orbit from ethmoidal air cells.
    - *Contains:* Anterior and posterior ethmoidal canals.

Foetal / Neonatal Skull

General Features

- Large cranial vault, small face.
- Bones soft and incomplete ossification.
- Sutures wide; fontanelles prominent.

Fontanelles

1. **Anterior fontanelle (bregma):** Diamond-shaped; closes by 18 months.
2. **Posterior fontanelle (lambda):** Triangular; closes by 3 months.
3. **Anterolateral (pterion) & posterolateral (asterion):** Close by 1 year.

Dimensions

- Vault proportionally large (cranial part > facial part).

- Head length ? 1/4 of total body length at birth.

Structure of Bones

- Thin and pliable; diploë absent.
- Separated by membrane at sutures allowing skull molding during birth.

Ossification

- **Membranous ossification:** Vault bones (frontal, parietal, squamous temporal, occipital).
- **Cartilaginous ossification:** Base bones (sphenoid, ethmoid, petrous temporal).

Postnatal Growth

- Rapid in first 2 years (brain growth).
- Sutures allow expansion till late adolescence.
- Face grows after tooth eruption and sinus development.

Clinical Anatomy

- **Delayed closure** ? hydrocephalus, rickets.
- **Early closure** ? microcephaly.
- **Moulding** during birth allows passage through birth canal.
- **Depressed fractures** in infants ? “ping-pong ball” fracture (elastic rebound).

Sex Differences in the Skull

- **Before puberty:** No sexual difference.
- **After puberty:** Distinct male and female characteristics develop.

FEATURE	MALE SKULL	FEMALE SKULL
Weight	Heavier	Lighter
Size	Larger	Smaller
Cranial capacity	Greater	~10% less
Bone walls	Thicker	Thinner
Muscular ridges	Prominent	Less marked
Superciliary arches	More prominent	Slight
Forehead	Sloping	More vertical
Mastoid process	Large, projecting	Small, flat
Occipital region	More curved	Less curved
Frontal & parietal eminences	Less prominent	More prominent
Face	Longer and narrower	Shorter and wider
Orbit	Squarer	Rounder
Chin	Square	Rounded and smaller

FEATURE	MALE SKULL	FEMALE SKULL
Angle of mandible	Everted, 110°	Less everted, ~120°–125°

Craniometry

Cephalic Index:

Cephalic Index=Maximum BreadthMaximum Length×100\text{Cephalic Index} = \frac{\text{Maximum Breadth}}{\text{Maximum Length}} \times 100Cephalic Index=Maximum LengthMaximum Breadth?×100

- **Length:** From *glabella ? occipital point*.
- **Breadth:** Between *parietal tubera*.

Types:

- **Dolichocephalic** ? < 75 (long-headed; primitive races).
- **Mesaticephalic** ? 75–80 (average; transitional).
- **Brachycephalic** ? > 80 (short-headed; advanced races).

Facial Angle:

- Angle between:
    1. Line from *nasion ? basion* (base line).
    2. Line from *basion ? prosthion* (upper incisor point).

- Smaller angle ? more developed brain and smaller face (seen in evolved humans).

Abnormal Crania:

- **Oxycephaly (acrocephaly):** Tower skull; premature closure of coronal and sphenoid sutures.
- **Scaphocephaly:** Boat-shaped skull; premature closure of sagittal suture.

Mandible

- **Largest and strongest facial bone.**
- Develops from **first pharyngeal arch**.
- Consists of:
    1. **Body:** Horseshoe-shaped, lodges lower teeth.
    2. **Rami (two):** Project upward and backward from body.

Body

- **Surfaces:**
    - *Outer surface:* Mental protuberance, mental foramen, oblique line.
    - *Inner surface:* Mylohyoid line, sublingual and submandibular fossae.
- **Borders:**

- *Upper border (alveolar)* ? contains sockets for teeth.
- *Lower border (base)* ? gives attachment to platysma.

- **Landmarks:**
  - *Symphysis menti:* Midline fusion site.
  - *Mental protuberance:* Chin prominence.
  - *Mental foramen:* Below 2nd premolar; transmits mental nerve and vessels.

Ramus

- **Surfaces:**
  - *Lateral:* Masseter insertion.
  - *Medial:* Pterygoid tuberosity for medial pterygoid attachment.
- **Borders:**
  - *Anterior:* Oblique ridge ? temporal crest.
  - *Posterior:* Thick, rounded, parotid gland behind it.
  - *Superior:* Two processes — coronoid (anterior) and condylar (posterior).
- **Features:**
  - *Mandibular notch* between the processes.

- *Lingula:* Tongue-shaped projection guarding mandibular foramen.

Attachments and Relations

- **Coronoid process:** Temporalis insertion.
- **Condylar process:** Pterygoid fovea ? lateral pterygoid insertion.
- **Lower border:** Platysma origin.
- **Inner surface:** Mylohyoid line ? mylohyoid muscle.
- **Inferior surface:** Digastric and geniohyoid origins.

Foramina and Relations to Nerves/Vessels

- **Mandibular foramen:** Entry of inferior alveolar nerve and vessels.
- **Mental foramen:** Exit of mental nerve and vessels.
- **Mandibular canal:** Connects these two foramina; transmits same neurovascular bundle.

Ossification

- **Primary center:** Each half develops from **Meckel's cartilage** (membranous ossification).
- **Secondary centers:**
  - *Condylar process* – endochondral.
  - *Coronoid process*, *mental protuberance*, *alveolar part* – membranous.

- Ossification starts at **6th week intrauterine life** near future mental foramen.

Age Changes

1. **At Birth:** Angle ~140°; no teeth; mental foramen near lower border.
2. **Adult:** Angle ~110°; eruption of teeth enlarges alveolar part; mental foramen mid-level.
3. **Old Age:** Teeth lost; alveolar bone resorbed; angle widens (~140°–160°); chin projects forward.

Structures Related to Mandible

- **Laterally:** Masseter, buccinator, facial artery and vein.
- **Medially:** Mylohyoid, hyoglossus, lingual nerve, and submandibular gland.
- **Posteriorly:** Parotid gland, facial nerve branches.
- **Superiorly:** Alveolar nerves and vessels.

Clinical Anatomy

- **Fractures:**
    - Common at neck of condyle, angle, and symphysis menti.
    - Bilateral fracture ? airway obstruction due to tongue fall-back.
- **Inferior alveolar nerve injury** ? numbness of lower lip and chin.

- **Tooth extraction** ? may injure mandibular canal.
- **Old age bone resorption** ? ill-fitting dentures due to alveolar loss.

Maxilla

General Description

- **Second largest facial bone** (after mandible).
- **Forms:**
  - Upper jaw.
  - Parts of **face, nose, mouth, orbit,** and **pterygopalatine & infratemporal fossae**.
- **Each maxilla** has a **body** and **four processes**: *frontal, zygomatic, alveolar, and palatine.*

Side Determination

1. **Anterior surface:** Medial end has a deep **nasal notch**.
2. **Posterior surface:** Convex; faces infratemporal fossa.
3. **Alveolar border:** Downward with tooth sockets; convex outward.
4. **Frontal process:** Longest process directed upward.
5. **Medial surface:** Has large irregular opening — **maxillary hiatus** (for maxillary sinus).

Features

1. Body

- **Pyramidal shape** with 4 surfaces:
  - **Anterior (facial):**
    - Contains infraorbital foramen (infraorbital vessels and nerve).
    - Canine fossa below foramen, canine eminence above canine socket.
  - **Orbital surface (superior):**
    - Forms large part of **floor of orbit**.
    - Infraorbital groove ? canal.
  - **Nasal surface (medial):**
    - Forms **lateral wall of nose**; has **maxillary hiatus** for sinus opening.
  - **Infratemporal surface (posterior):**
    - Forms anterior wall of infratemporal fossa; marked by maxillary tuberosity with foramina for posterior superior alveolar vessels and nerves.

2. Processes

- **Frontal Process:**
  - Forms lateral boundary of nose and medial wall of orbit.
  - Articulates with frontal bone and nasal bone.

- **Zygomatic Process:**
    - Extends laterally; joins zygomatic bone forming cheek prominence.
- **Alveolar Process:**
    - Bears 8 sockets for upper teeth; deepest ? canine socket.
    - Buccinator originates posteriorly near first molar.
- **Palatine Process:**
    - Horizontal plate forming **anterior 3/4 of hard palate** and **floor of nasal cavity**.
    - Medial border raised into nasal crest ? receives vomer.
    - Anterior part forms **incisor crest** ? anterior nasal spine.

Articulations of Maxilla

1. **Superiorly:** Nasal, frontal, lacrimal bones.
2. **Medially:** Ethmoid, inferior nasal concha, vomer, palatine, opposite maxilla.
3. **Laterally:** Zygomatic bone.

Ossification

- **Membranous ossification** from **three centres**:
    1. One for maxilla proper (above canine fossa; appears at 6th week IUL).

2. Two for **premaxilla (os incisivum)**:
    - *Main centre* above incisive fossa (7th week).
    - *Paraseptal/prevomerine centre* at ventral nasal septum margin (10th week).

- Premaxilla fuses early with alveolar process, but trace may remain till midlife.

Age Changes

1. **At Birth:**
    - Transverse and anteroposterior diameters > vertical.
    - Frontal process prominent.
    - Body mainly alveolar; tooth sockets reach orbital floor.
    - Maxillary sinus shallow furrow.
2. **Adult:**
    - Vertical diameter greatest; sinus enlarged; alveolar process developed.
3. **Old Age:**
    - Alveolar process resorbed; bone height reduced; returns to infantile form.

Parietal Bone

General Description

- Two **parietal bones** form roof and sides of skull vault.
- Each bone is **quadrilateral** with outward convexity.

Side Determination

- **Outer surface:** Convex and smooth.
- **Inner surface:** Concave with meningeal grooves.
- **Anteroinferior angle:** Pointed; has groove for **anterior division of middle meningeal artery**.

Features

- **Two surfaces, four borders, four angles.**

Surfaces

1. **Outer (convex):** Smooth, shows parietal eminence.
2. **Inner (concave):** Grooves for meningeal vessels and sagittal sinus impressions.

Borders

1. **Superior (sagittal):** Articulates with opposite parietal at sagittal suture.
2. **Inferior (squamosal):** Articulates with squamous temporal.
3. **Anterior (frontal):** Articulates with frontal bone at coronal suture.
4. **Posterior (occipital):** Articulates with occipital bone at lambdoid suture.

Angles

1. **Anterosuperior (frontal)** – anterior fontanelle (closes 18 months).
2. **Anteroinferior (sphenoidal)** – sphenoidal fontanelle (closes 3 months).
3. **Posterosuperior (occipital)** – posterior fontanelle (closes 3 months).
4. **Posteroinferior (mastoid)** – mastoid fontanelle (closes ~12 months).

Occipital Bone

Anatomical Position

- Concave forwards.
- Encloses **foramen magnum**, the largest skull foramen — communication between cranial cavity and vertebral canal.
- Each side bears an **occipital condyle** articulating with the atlas vertebra.

Features

Occipital bone divided into:

1. **Squamous part** – above, below, and behind foramen magnum.
2. **Basilar part** – in front of foramen magnum (basi-occiput).
3. **Condylar (lateral) part** – on each side of foramen magnum.

Squamous Part

- Two surfaces (external convex, internal concave).
- Four borders (two lambdoid upper, two mastoid lower).
- Angles: one superior and two lateral.

Basilar Part

- Articulates anteriorly with basisphenoid.
- Quadrilateral; has superior and inferior surfaces and four borders.

Condylar Part

- **Inferior surface:** Occipital condyles + hypoglossal canal.
- **Superior surface:** Related to posterior cranial fossa.

Frontal Bone

Anatomical Position

- **Squamous part:** Vertical, convex forwards (forehead).
- **Orbital plates:** Thin, horizontal; project backwards forming orbital roof.
- **Nasal part:** Directed forwards and downwards.

Features

1. **Outer surface:**
    - Frontal tuberosity, superciliary arches, glabella.
    - **Frontal sinuses** between outer and inner tables.
    - **Metopic suture** (may persist).
    - **Supraorbital notch/foramen** for supraorbital nerve and vessels.
    - **Zygomatic process**, temporal line.
2. **Inner surface:** Sagittal sulcus & frontal crest for falx cerebri.
3. **Orbital plates:** Separated by **ethmoidal notch** (occupied by cribriform plate of ethmoid).
    - Present **lacrimal fossa** (anterolateral) and **trochlear spine** (anteromedial).
4. **Nasal part:** Between supraorbital margins; articulates with nasal bone, frontal process of maxilla, and lacrimal bone.

Temporal Bone

Side Determination

- **Squamous part** – plate-like, directed upwards and laterally.
- **Zygomatic process** – strong, projects forwards.
- **Petrous part** – triangular, directed medially.

- **External acoustic meatus** – directed laterally.

Features

Temporal bone has four parts:

1. **Squamous part** – outer temporal surface forms part of temporal fossa; has groove for middle temporal artery; supramastoid crest and suprameatal triangle.

2. **Petromastoid part** – includes petrous (pyramid-shaped) and mastoid regions.

    - Houses structures of middle and internal ear.

    - Superior border grooved by superior petrosal sinus (attachment of tentorium cerebelli).

    - Posterior border helps form jugular foramen.

3. **Tympanic part** – curved plate forming floor and walls of external acoustic meatus; upper and lower margins enclose root of styloid process.

4. **Styloid process** – slender projection downward, forward and medially; gives attachment to 3 muscles (styloglossus, stylohyoid, stylopharyngeus) and 2 ligaments (stylohyoid, stylomandibular).

Sphenoid Bone

General Description

- Wedge-shaped (“spheno” = wedge); resembles a bat with outstretched wings.

- **Parts:** Body, two greater wings, two lesser wings, two pterygoid processes.

Body of Sphenoid

- Six surfaces; contains paired **sphenoidal air sinuses**.
- **Superior (cerebral) surface:**
    - Articulates with ethmoid (anteriorly) and basiocciput (posteriorly).
    - Landmarks: Jugum sphenoidale, Sulcus chiasmaticus, Tuberculum sellae, Sella turcica (with pituitary fossa), Dorsum sellae, and Clivus.
- **Inferior surface:** Rostrum of sphenoid, sphenoidal conchae, vaginal processes of medial pterygoid plate.
- **Anterior surface:** Sphenoidal crest articulates with perpendicular plate of ethmoid to form part of nasal septum; openings of sphenoidal sinuses present.

Greater Wings

- Project laterally from body; form part of **middle cranial fossa**, **lateral skull wall**, and **orbit**.
- Surfaces:
    - Cerebral (upper) – temporal lobe impressions.
    - Lateral – forms temporal and infratemporal fossae.
    - Orbital – forms posterior part of lateral orbital wall.
- Openings: Foramen rotundum, foramen ovale, foramen spinosum.

Lesser Wings

- Thin, triangular plates projecting laterally from upper body; form posterior part of orbital roof.
- **Superior surface:** Forms part of anterior cranial fossa.
- **Inferior surface:** Forms roof of orbit.
- Posterior edge gives **anterior clinoid process** for tentorium cerebelli attachment.

Pterygoid Processes

- Two perpendicular plates descending from junction of body and greater wings.
- Each process has **medial** and **lateral pterygoid plates** enclosing **pterygoid fossa**.
- **Medial plate:** Ends in pterygoid hamulus (acts as pulley for tensor veli palatini).
- **Lateral plate:** Provides attachment for medial and lateral pterygoid muscles.

Ethmoid Bone

- A light, cuboidal bone situated at the **anterior base of skull**, between the two orbits.
- Forms:
    - Part of **medial orbital wall**
    - Part of **nasal septum**

- **Lateral walls** of nasal cavity

Parts:

1. **Cribriform Plate**
2. **Perpendicular Plate**
3. **Two Labyrinths**

Cribriform Plate

- Horizontal perforated lamina in **ethmoidal notch of frontal bone**.
- Foramina transmit **olfactory nerve rootlets**.
- **Crista galli** – median tooth-like projection for **falx cerebri** attachment; lateral to it lies the foramen for the **anterior ethmoidal nerve**.

Perpendicular Plate

- Thin lamina descending from the underside of cribriform plate.
- Forms **upper part of nasal septum**.
- Anteriorly articulates with septal cartilage, posteriorly with vomer.

Labyrinths

- Paired cubical masses on either side of perpendicular plate, suspended from cribriform plate.

- Contain **ethmoidal air cells** — anterior, middle, and posterior groups.
- **Surfaces:**
  - *Anterior* ? articulates with frontal process of maxilla.
  - *Posterior* ? with sphenoidal concha.
  - *Superior* ? with orbital plate of frontal bone.
  - *Inferior* ? with nasal surface of maxilla.
  - *Lateral* ? forms **medial orbital wall**.
  - *Medial* ? gives **superior & middle nasal conchae**, with corresponding meatuses beneath each.

Vomer

- Thin, flat bone forming **posteroinferior part of nasal septum**.
- **Features:**
  - Right and left surfaces grooved by **nasopalatine nerves**.
  - **Superior border** ? bifid (alae) enclosing groove for **rostrum of sphenoid**.
  - **Inferior border** ? articulates with nasal crests of maxillae and palatine bones.
  - **Anterior border** ? joins perpendicular plate (above) and septal cartilage (below).

- **Posterior border** ? free, separating posterior nasal apertures.

Inferior Nasal Conchae

- Two **independent curved laminae**, forming lower part of lateral nasal wall.
- **Surfaces:**
  - *Medial convex* ? vascular grooves.
  - *Lateral concave* ? forms medial wall of inferior meatus.
- **Borders:**
  - *Superior* ? articulates with lacrimal, maxilla, ethmoid, palatine.
  - *Inferior* ? free and spongy.
- **Ends:** Posterior sharper than anterior.

Zygomatic Bones

- Two small quadrilateral bones forming **cheek prominence**.
- Contribute to **floor and lateral wall of orbit** and **walls of temporal and infraorbital fossae**.

Surfaces:

1. **Lateral** – has zygomaticofacial foramen.
2. **Temporal** – concave, with zygomaticotemporal foramen.
3. **Orbital** – smooth, may have zygomatico-orbital foramen.

Borders: Orbital, maxillary, temporal, posteroinferior, posteromedial.
Processes:

- *Frontal process* (upward).
- *Temporal process* (backward; forms zygomatic arch with temporal bone).

Nasal Bones

- Two small oblong bones forming **bridge of nose**.
- **Surfaces:**
  - *Outer:* Convex.
  - *Inner:* Concave; vertical groove for anterior ethmoidal nerve.
- **Borders:**
  - *Superior:* Articulates with frontal bone.
  - *Inferior:* With lateral nasal cartilage.
  - *Medial:* With opposite nasal bone.

- *Lateral:* With frontal process of maxilla.

Lacrimal Bones

- Smallest and most delicate skull bones; form **anterior part of medial orbital wall**.
- **Surfaces:**
  - *Lateral (orbital):* Divided by posterior lacrimal crest ? anterior lacrimal fossa (for lacrimal sac).
  - *Medial (nasal):* Forms part of middle meatus of nose.
- **Borders:**
  - *Anterior:* With frontal process of maxilla.
  - *Posterior:* With orbital plate of ethmoid.
  - *Superior:* With frontal bone.
  - *Inferior:* With orbital surface of maxilla.

Palatine Bones

- Two L-shaped bones forming **posterior part of nasal cavity**.
- Contribute to **lateral nasal wall, roof of mouth, floor of orbit,** and **pterygopalatine fossa**.

- **Parts:**
    1. **Horizontal plate** – posterior ¼ of hard palate; pierced by greater palatine foramen.
    2. **Perpendicular plate** – forms part of nasal wall.
- **Processes:**
    - *Pyramidal* – downward; has **lesser palatine foramina**.
    - *Orbital* – upward; forms posterior orbital floor.
    - *Sphenoidal* – upward/medial; articulates with medial pterygoid plate.

Hyoid Bone

General Features

- **U-shaped bone** in anterior midline of neck between mandible and thyroid cartilage.
- Level: Opposite **C3 vertebra**.
- Suspended by muscles and ligaments.
- **Function:** Provides attachment for **tongue, floor of mouth, pharynx, and larynx** muscles.

Parts:

- **Body** – central, convex anteriorly, concave posteriorly.
- **Greater Cornua** – long posterior projections ending in tubercles.

- **Lesser Cornua** – small conical eminences at junction of body and greater horns.

Attachments on Hyoid Bone

- **Above (Suprahyoid):** Geniohyoid, Mylohyoid, Stylohyoid, Digastric.
- **Below (Infrahyoid):** Sternohyoid, Omohyoid, Thyrohyoid.
- **Posteriorly:** Middle pharyngeal constrictor.
- **Ligaments:** Stylohyoid ligament (from styloid process to lesser cornu).

Development

- Derived from **2nd (Reichert's cartilage)** and **3rd branchial arches**.
- Ossification centers appear in body and cornua; fusion complete in adulthood.

Clinical Anatomy

- **Fracture of hyoid** ? common in strangulation.
- **Displacement** ? impairs speech and swallowing.
- **Infections** ? may spread through fascial spaces connected to its muscle attachments.

Cervical Vertebrae

Identification

- **Total:** 7 cervical vertebrae.
- **Typical:** 3rd to 6th.
- **Atypical:** 1st (atlas), 2nd (axis), and 7th (vertebra prominens).
- **Characteristic feature:** Presence of **foramina transversaria** in transverse processes — transmit **vertebral artery, veins, and sympathetic nerve**.

Typical Cervical Vertebrae (C3–C6)

Body

- Small, **broader side-to-side** than anteroposteriorly.
- **Superior surface:** Concave transversely, with raised **uncinate processes**.
- **Inferior surface:** Saddle-shaped — convex transversely, concave anteroposteriorly.
- Anterior border projects downward and may hide the disc.

Vertebral Foramen

- **Large and triangular**, accommodating cervical enlargement of spinal cord.

Vertebral Arch

- **Pedicles:** Directed backward and laterally; notches equal in size.
- **Laminae:** Long and narrow; thinner above than below.

- **Articular processes:**
    - Superior ? directed **upward and backward**.
    - Inferior ? directed **downward and forward**.
    - Together form **articular pillars**.
- **Spine:** Short and bifid; notch filled by **ligamentum nuchae**.

Transverse Processes

- Each has **anterior and posterior roots** ending in **tubercles**, joined by **costotransverse bar**.
- **Anterior root:** Represents costal element; gives origin to **scalenus anterior**, **longus capitis**, and **longus colli**.
- **Posterior tubercle:** Gives origin to **scalenus medius**, **scalenus posterior**, and **levator scapulae**; insertion to **splenius cervicis** and **longissimus cervicis**.
- **Foramen transversarium:** Transmits **vertebral artery, veins, and sympathetic branch** .
- **C6 anterior tubercle** ? **carotid tubercle**, landmark for compressing common carotid artery.

Attachments

- **Anterior longitudinal ligament:** Upper/lower margins of body (front).
- **Posterior longitudinal ligament:** Back of body.

- **Basivertebral veins:** Perforate posterior surface.
- **Muscles:** Deep neck muscles attach to spinous processes.

Ossification (Typical Cervical Vertebra)

- **Primary centers (3):**
    1. One for centrum (appears at 3–4 months IUL).
    2. One for each neural arch (9–10 weeks IUL).
- **Fusion:**
    - Neural arches fuse posteriorly by **1 year**.
    - Neurocentral synchondrosis fuses by **3 years**.
- **Secondary centers (6):**
    - 2 annular epiphyses (upper and lower body surfaces).
    - 2 tips of transverse processes.
    - 2 tips of bifid spine.
    - Appear at puberty; fuse by **25 years**.

First Cervical Vertebra (Atlas)

General Features

- Named after Titan *Atlas*, who supported the heavens.
- **Ring-shaped**, with **no body and no spine**.
- Consists of:
    - **Anterior arch**
    - **Posterior arch**
    - **Two lateral masses**
    - **Two transverse processes**

Parts

- **Anterior Arch:**
    - Has **anterior tubercle** (for longus colli insertion).
    - Posterior surface bears **facet for dens** of axis.
- **Posterior Arch:**
    - Forms two-fifths of ring.
    - Has **posterior tubercle** instead of spine.

- Groove on superior surface behind lateral mass ? **vertebral artery and first cervical nerve**.

- **Lateral Masses:**
  - **Superior articular facet:** Concave, directed upward and medially; articulates with occipital condyles ? **atlanto-occipital joint**.
  - **Inferior articular facet:** Circular, flat, directed downward and medially; articulates with axis ? **atlantoaxial joint**.
  - **Transverse processes:** Large, perforated by foramen transversarium.

Ossification (Atlas)

- **Primary centers:**
  1. One for each neural arch (7th week IUL).
  2. One for anterior arch (appears 1st year postnatal).
- **Fusion:**
  - Arches fuse posteriorly by **3–4 years**.
  - Anterior arch unites with lateral masses by **6 years**.
  - Sometimes body of atlas fuses with dens of axis.

Second Cervical Vertebra (Axis)

- Also called **epistropheus**.
- **Most distinctive feature: Odontoid process (dens)** — represents body of atlas fused to axis.

Features

- **Body:** Small; bears dens projecting upward.
- **Dens:** Conical; has anterior facet for atlas; posterior groove for transverse ligament.
- **Vertebral Foramen:** Large and triangular.
- **Laminae:** Thick and strong; spine large and bifid.
- **Superior articular facets:** Face upward and laterally.
- **Inferior facets:** Face downward and forward — typical cervical orientation.
- **Transverse processes:** Small with foramina transversaria; no anterior tubercles.

Function

- Pivot joint between dens and atlas ? **rotation of head**.
- Forms **atlantoaxial joint** (median and lateral components).

Seventh Cervical Vertebra (Vertebra Prominens)

Features

- **Largest cervical vertebra** with **long, thick, non-bifid spine**—prominent and palpable at the root of the neck.
- **Transverse processes:** Large; posterior root larger than anterior; anterior tubercle absent.
- **Foramen transversarium:** Small or double, often does **not transmit the vertebral artery**, only an accessory vein.

Attachments

- **Spine tip:** Ligamentum nuchae, trapezius, rhomboid minor, serratus posterior superior, splenius capitis, semispinalis thoracis, spinalis cervicis, interspinales, multifidus.
- **Transverse process:**
    - Posterior tubercle ? **suprapleural membrane**.
    - Lower border ? **levator costarum**.

Note: Sometimes, the **anterior root** of the transverse process remains separate, forming a **cervical rib** of variable size.

Ossification

- Similar to typical cervical vertebrae.
- Additionally, **separate centers for each costal process** appear at the **6th month of intrauterine life** and fuse with the body and transverse process by **5–6 years**

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Clinical Anatomy

- **Cervical rib** arises from the C7 vertebra and attaches to the first rib near scalenus anterior insertion.
    - May **compress the brachial plexus** and **subclavian artery** ? *Tingling pain* along medial forearm and hand, *weakness/paralysis* of palm muscles.
- **Osteophytes** at cervical joints (Luschka's joints) ? press cervical spinal nerves ? *pain, numbness, vertigo (vertebrobasilar insufficiency)*.
- **Prolapsed cervical disc** common near C6–C7 ? *pain in lateral forearm, hand, and thenar wasting*.
- **Hangman's fracture** – pedicle fracture of axis; spinal canal widens without cord injury.
- **Occipitalization of atlas** ? fusion with occipital bone; may compress spinal cord.
- **Judicial hanging** ? odontoid process fractures, injuring medulla and causing death

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Ossification of Cranial Bones

- **Intramembranous ossification:**
    - Quicker process; occurs directly in vascular mesenchyme.

- Bones forming the **calvaria (skull cap)** — *frontal, parietal, squamous temporal,* and *upper occipital* — ossify in membrane.
- Functionally designed to **protect the brain**, allowing rapid growth and flexibility at sutures and fontanelles

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Development of Neurocranium

Membranous Part

- Derived from **mesenchyme** around the developing brain.
- **Sources of mesenchyme:**
  1. **Neural crest cells** ? roof and sides of cranial vault.
  2. **Para-axial mesoderm** ? small part of occipital region.
- **Ossification type:** Membranous ossification.

Examples:

- **Frontal Bone:**
  - Ossifies in membrane.
  - Two centers (8th week) near frontal eminences; separated at birth by a suture that usually fuses early.

- *Metopic suture* may persist in 3–8% adults.

- **Parietal Bone:**
  - Two centers (7th week) near parietal eminence; fuse soon.

- **Occipital Bone:**
  - Ossifies partly in membrane, partly in cartilage.
  - Above highest nuchal line ? membranous; below ? cartilaginous.
  - Interparietal bone may persist if separation occurs.

- **Temporal Bone:**
  - Squamous and tympanic parts ? membrane; petromastoid and styloid ? cartilage.
  - Styloid process from 2nd branchial arch; tympanohyal before birth, stylohyal after.

- **Sphenoid Bone:**
  - **Presphenoidal part:** Anterior body + lesser wings (6 centers).
  - **Postsphenoidal part:** Posterior body + greater wings + pterygoid processes (8 centers)

Foramina of Skull Bones and Their Contents

The foramina of the skull transmit **cranial nerves, arteries, veins, and emissary veins**. They are grouped according to the **cranial fossae** in which they are located.

Anterior Cranial Fossa

FORAMEN / APERTURE	TRANSMITS / CONTENTS
Foramen caecum	Emissary vein to superior sagittal sinus from upper part of nose
Cribriform plate of ethmoid	Olfactory nerve rootlets
Anterior ethmoidal foramen	Anterior ethmoidal nerve and vessels
Posterior ethmoidal foramen	Posterior ethmoidal vessels
Groove for superior sagittal sinus	Superior sagittal sinus

Middle Cranial Fossa

FORAMEN / APERTURE	CONTENTS
Optic canal	Optic nerve and ophthalmic artery
Superior orbital fissure	Oculomotor (III), Trochlear (IV), Ophthalmic (V?), Abducent (VI) nerves, Ophthalmic veins, Sympathetic fibers
Foramen rotundum	Maxillary nerve (V?)
Foramen ovale	Mandibular nerve (V?), accessory meningeal artery, emissary vein
Foramen spinosum	Middle meningeal artery and vein, meningeal branch of V?

FORAMEN / APERTURE	CONTENTS
Foramen lacerum	Filled with fibrocartilage; transmits emissary veins and meningeal branch from ascending pharyngeal artery
Carotid canal	Internal carotid artery and sympathetic plexus
Hiatus for greater petrosal nerve	Greater petrosal nerve
Hiatus for lesser petrosal nerve	Lesser petrosal nerve

Posterior Cranial Fossa

FORAMEN / APERTURE	CONTENTS
Internal acoustic meatus	Facial (VII) and Vestibulocochlear (VIII) nerves, labyrinthine vessels
Jugular foramen	Glossopharyngeal (IX), Vagus (X), Accessory (XI) nerves, internal jugular vein, inferior petrosal and sigmoid sinuses
Hypoglossal canal	Hypoglossal nerve (XII)
Foramen magnum	Medulla oblongata, meninges, vertebral arteries, spinal roots of accessory nerve, tectorial membrane, apical ligament of dens
Condylar canal	Emissary vein connecting sigmoid sinus with suboccipital plexus

FORAMEN / APERTURE	CONTENTS
Mastoid foramen	Emissary vein to sigmoid sinus, meningeal branch of occipital artery

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Miscellaneous Foramina

FORAMEN / APERTURE	CONTENTS
Stylomastoid foramen	Facial nerve (VII), stylomastoid artery
Infraorbital foramen (maxilla)	Infraorbital nerve and vessels
Mental foramen (mandible)	Mental nerve and vessels
Incisive foramen (maxilla)	Nasopalatine nerves
Greater palatine foramen	Greater palatine nerve and vessels
Lesser palatine foramina	Lesser palatine nerves and vessels
Zygomaticofacial foramen	Zygomaticofacial nerve
Zygomaticotemporal foramen	Zygomaticotemporal nerve
Parietal foramen	Emissary vein to superior sagittal sinus
Mastoid foramen	Emissary vein and meningeal branch of occipital artery

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Clinical Notes

- **Emissary veins** serve as potential pathways for infection from scalp to intracranial sinuses.

- **Jugular foramen syndrome (Vernet's)** ? paralysis of IX, X, XI nerves.
- **Fracture involving foramen lacerum or carotid canal** ? injury to internal carotid artery or sympathetic plexus ? *Horner's syndrome*.
- **Superior orbital fissure syndrome** ? ophthalmoplegia with sensory loss in forehead.

Mnemonics

Bones Forming the Orbit

Mnemonic — **"Some Friendly Zebras Play Easy Music"**

- **S** ? Sphenoid
- **F** ? Frontal
- **Z** ? Zygomatic
- **P** ? Palatine
- **E** ? Ethmoid
- **M** ? Maxilla

Foramina in Greater Wing of Sphenoid

Mnemonic — **"ROSpy's Hole"**

- **R** ? Foramen **Rotundum**

- **O** ? Foramen **Ovale**
- **S** ? Foramen **Spinosum**
- **p** ? (sometimes) **Petrosal** canal

Bones Containing Air Sinuses

Mnemonic — **“FEMS”**

- **F** ? Frontal
- **E** ? Ethmoid
- **M** ? Maxilla
- **S** ? Sphenoid

Parts of Occipital Bone

Mnemonic — **“Save Boys Carefully”**

- **S** ? Squamous part
- **B** ? Basilar part
- **C** ? Condylar parts (lateral)

Openings in the Posterior Cranial Fossa

Mnemonic — **“JIM FM”**

- **J** ? Jugular foramen
- **I** ? Internal acoustic meatus
- **M** ? Mastoid foramen
- **F** ? Foramen magnum
- **M** ? Hypoglossal canal (Medial to jugular)

Cranial Nerves Passing Through Superior Orbital Fissure

Mnemonic — **“Live Free And Happy”**

- **L** ? Lacrimal nerve
- **F** ? Frontal nerve
- **A** ? Abducent nerve
- **H** ? branches of Oculomotor and Trochlear nerves

Facts to Remember

- The **skull** is composed of **22 bones** — 8 cranial and 14 facial.
- **Cranial bones**: Frontal, Parietal (2), Temporal (2), Occipital, Sphenoid, Ethmoid.
- **Facial bones**: Maxilla (2), Zygomatic (2), Nasal (2), Lacrimal (2), Palatine (2), Inferior nasal conchae (2), Vomer, Mandible.

- The **largest paranasal sinus** ? Maxillary sinus.
- The **strongest facial bone** ? Mandible.
- **Frontal air sinuses** open into the **middle meatus of nose**.
- **Vomer** forms the lower and posterior part of nasal septum.
- **Hyoid bone** lies opposite **C3 vertebra** and does not articulate with any other bone.
- **Styloid process** arises from the **petrous part of the temporal bone**.
- **Atlas (C1)** has no body or spine, and **Axis (C2)** bears the **dens** for rotation.
- **C7** spine is the most palpable in the neck — the **vertebra prominens**.
- **Emissary veins** form dangerous routes for intracranial infection spread.
- **Foramen magnum** transmits the **medulla, meninges, vertebral arteries, and spinal roots of accessory nerves**.
- **Fontanelles**:
    - *Anterior* ? closes by 18 months.
    - *Posterior* ? closes by 3 months.
- **Sutures of skull**: Coronal, Sagittal, Lambdoid, Squamous.
- **Cranial capacity:**
    - Male ~1500 cc

    - Female ~1300 cc

- **Cephalic index:** 75–80 = mesaticephalic (normal range).
- **Occipital bone** articulates with **atlas at atlanto-occipital joint** allowing nodding movement.
- **Parietal bones** form the major part of cranial vault.
- **Ethmoid bone** contains **olfactory foramina** for smell transmission.
- **Temporal bone** houses **organ of hearing and balance**.

Clinicoanatomical Problems

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1. Blow-out Fracture of Orbit

- **Cause:**
  A blunt force directed to the eyeball (e.g., by a ball or fist).
- **Anatomy involved:**
  The **floor of orbit** (formed by the maxilla) is the weakest part and gives way.
- **Result:**
    - Displacement of orbital fat and inferior rectus into the **maxillary sinus**.
    - **Diplopia (double vision)** due to entrapment of inferior rectus.
    - **Infraorbital nerve injury** ? anesthesia of cheek and upper lip.

- **Radiograph:** Fluid level in maxillary sinus.

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2. Fracture of Middle Cranial Fossa (Base of Skull Fracture)

- **Cause:**
  High-velocity head trauma.

- **Anatomy involved:**
  Fracture lines run through **petrous temporal bone** and **sphenoid**.

- **Clinical features:**
  - **Otorrhea (CSF from ear)** if tympanic membrane ruptures.
  - **Battle's sign:** Bruising over mastoid due to blood extravasation.
  - **Facial paralysis** if facial canal injured.
  - **Hearing loss** due to involvement of inner ear structures.

- **Diagnosis:** CSF–blood mixture "halo sign" on gauze.

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3. Pterion Fracture

- **Definition:**
  Fracture at the junction of **frontal, parietal, sphenoid, and temporal bones**.

- **Importance:**
  Lies over the **anterior division of middle meningeal artery**.

- **Consequence:**

- Tear of the artery ? **epidural hematoma**.
- Rapid intracranial pressure rise ? brain compression, herniation, death if untreated.

- **Treatment:**
  Emergency burr hole (above zygoma, posterior to pterion) for clot evacuation.

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4. Fracture of Mandible

- **Common sites:**
  - Neck of condyle.
  - Angle of mandible.
  - Symphysis menti.
- **Clinical features:**
  - Malocclusion of teeth.
  - Pain and crepitus on movement.
  - Bilateral fracture ? **tongue falls backward**, causing airway obstruction.
- **Treatment:** Intermaxillary fixation or surgical plating.

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5. Fracture of Base of Skull (Anterior Cranial Fossa)

- **Clinical features:**
  - **CSF rhinorrhea** (clear nasal discharge).

- **Panda eyes / raccoon eyes** due to periorbital ecchymosis.
- **Anosmia** due to olfactory nerve injury.

- **Structures involved:** Cribriform plate of ethmoid, frontal bone, nasal roof.

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6. Cervical Rib Syndrome

- **Anatomy:**
  Cervical rib arises from the **7th cervical vertebra**.
- **Structures compressed:**
  - Lower trunk of **brachial plexus**.
  - **Subclavian artery**.
- **Symptoms:**
  - Tingling, pain, numbness along medial forearm.
  - Weakness of intrinsic hand muscles.
  - Occasionally cold, pale upper limb (arterial compression).
- **Treatment:** Surgical removal of cervical rib if severe.

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7. Occipitalization of Atlas

- **Definition:**
  Fusion of the **atlas (C1)** with the **occipital bone**.

- **Effects:**
  - Limitation of head movements.
  - Compression of spinal cord or vertebral artery ? neurological symptoms.

---

8. Craniosynostosis

- **Definition:**
  Premature fusion of cranial sutures.
- **Types:**
  - **Scaphocephaly:** Early closure of sagittal suture ? long, narrow skull.
  - **Oxycephaly:** Closure of coronal and sphenoid sutures ? high tower skull.
- **Effect:** Abnormal skull shape, increased intracranial pressure.

---

9. Fracture of Hyoid Bone

- **Cause:** Manual strangulation or hanging.
- **Clinical Significance:**
  - Fracture indicates **homicidal strangulation** (forensic importance).
  - Leads to pain, dysphagia, and speech difficulty.

---

10. Fracture of Axis (Hangman’s Fracture)

- **Mechanism:** Hyperextension of head (judicial hanging or road accident).
- **Anatomy:** Bilateral fracture of **pars interarticularis** of C2.
- **Effect:**
    - Spinal canal widens; cord usually spared.
    - May cause death if medulla affected.

Frequently Asked Questions

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1. How many bones form the skull?

- The skull is formed by **22 bones**.
    - **Cranial bones:** 8
    - **Facial bones:** 14

---

2. Which are the unpaired bones of the skull?

- **Unpaired cranial bones:** Frontal, Occipital, Sphenoid, Ethmoid.
- **Unpaired facial bones:** Vomer, Mandible.

---

3. Which bones form the orbit?

- **Frontal, Ethmoid, Maxilla, Zygomatic, Sphenoid, Lacrimal, Palatine.**

---

4. What are the paranasal air sinuses and their openings?

- **Frontal sinus** ? Middle meatus of nose.
- **Ethmoidal sinuses:**
  - Anterior ? Middle meatus.
  - Middle ? Ethmoidal bulla.
  - Posterior ? Superior meatus.
- **Sphenoidal sinus** ? Sphenoethmoidal recess.
- **Maxillary sinus** ? Middle meatus (via semilunar hiatus).

---

5. What are the parts of the occipital bone?

- **Four parts around foramen magnum:**
  1. **Squamous** (behind)
  2. **Basilar** (in front)
  3. **Two condylar parts** (lateral)

---

6. What is the pterion and its clinical importance?

- **Pterion** is the H-shaped junction of **frontal, parietal, sphenoid (greater wing), and temporal bones**.
- It overlies the **anterior branch of the middle meningeal artery**.

- Fracture causes **epidural hemorrhage** ? neurosurgical emergency.

---

7. Name the bones containing paranasal sinuses.

- **Frontal, Ethmoid, Maxilla, Sphenoid.**

---

8. What are fontanelles and when do they close?

- **Fontanelles** are membranous gaps between developing cranial bones in infants.
    - **Anterior fontanelle** ? closes by 18 months.
    - **Posterior fontanelle** ? closes by 3 months.
    - **Anterolateral (sphenoidal)** ? closes by 3 months.
    - **Posterolateral (mastoid)** ? closes by 1 year.

---

9. Which vertebra is called the “vertebra prominens”?

- The **seventh cervical vertebra (C7)**, because of its long, non-bifid, palpable spine.

---

10. What is the dens (odontoid process)?

- **Upward projection from body of the axis (C2)**.
- Represents the **body of atlas (C1)** that has fused with the axis.
- Acts as a **pivot for rotation** of the head.

---

11. What is the significance of the hyoid bone?

- Lies opposite **C3 vertebra**.
- Suspended by muscles; does not articulate with any other bone.
- Supports **tongue, floor of mouth, and larynx**.
- Fracture ? sign of **strangulation** in forensic medicine.

---

12. What is the clinical significance of emissary veins?

- Connect extracranial and intracranial venous systems.
- Serve as **routes of infection spread** from scalp ? dural venous sinuses.

---

13. What are the sutures of the skull?

- **Coronal suture** – between frontal and parietals.
- **Sagittal suture** – between two parietals.
- **Lambdoid suture** – between parietal and occipital.
- **Squamous suture** – between parietal and temporal bones.

---

14. What is the clinical importance of the maxillary sinus?

- **Largest paranasal sinus**, prone to infection due to poor drainage (opening high on medial wall).

- In **maxillary sinusitis**, pain referred to **upper molar teeth** because of common innervation (infraorbital nerve).

---

15. What is the characteristic feature of cervical vertebrae?

- Presence of **foramen transversarium** in each transverse process (for vertebral vessels).
- **Bifid spinous process** (except C1 & C7).
- **Triangular vertebral foramen**.

---

16. What is craniosynostosis?

- Premature closure of cranial sutures ? abnormal skull shape.
- **Scaphocephaly:** Sagittal suture closes early.
- **Oxycephaly:** Coronal suture closes early.

---

17. What structures pass through the foramen magnum?

- **Medulla oblongata**, **meninges**, **vertebral arteries**, **spinal roots of accessory nerve**, **tectorial membrane**, **apical ligament of dens**.

---

18. What is the difference between male and female skull?

- **Male:** Heavier, larger, more muscular markings, sloping forehead, square chin.
- **Female:** Lighter, smaller, rounded chin, vertical forehead, prominent frontal and parietal eminences.

---

19. What is the function of nasal conchae?

- Increase surface area of nasal cavity ? warm, moisten, and filter air.
- Create turbulence to improve olfaction and air conditioning.

---

20. What is the clinical importance of the pterygoid hamulus?

- Acts as a **pulley for tensor veli palatini** muscle during swallowing and speech.

Multiple Choice Questions

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1. The total number of bones forming the skull is:
a) 20
b) 21
? **c) 22**
d) 24

---

2. Which of the following bones is unpaired?
a) Parietal
b) Temporal
? **c) Frontal**
d) Nasal

---

3. The pterion is the junction of all the following bones, except:
a) Frontal
b) Parietal
? **c) Occipital**
d) Sphenoid

---

4. Which of the following structures passes through the foramen rotundum?

a) Ophthalmic nerve

? **b) Maxillary nerve**

c) Mandibular nerve

d) Middle meningeal artery

---

5. The foramen spinosum transmits:

? **a) Middle meningeal artery**

b) Mandibular nerve

c) Facial nerve

d) Internal carotid artery

---

6. The dens (odontoid process) represents:

? **a) Body of atlas**

b) Body of axis

c) Neural arch of atlas

d) Neural arch of axis

---

7. The hyoid bone is located opposite the level of:

a) C2 vertebra

? **b) C3 vertebra**

c) C4 vertebra

d) C5 vertebra

---

8. The largest paranasal sinus is:

a) Frontal

b) Sphenoidal

? **c) Maxillary**

d) Ethmoidal

---

9. The bone forming the posterior ¼ of the hard palate is:

a) Maxilla

? **b) Palatine bone**

c) Vomer

d) Sphenoid

---

10. The foramen magnum transmits all, except:

a) Vertebral arteries

b) Spinal roots of accessory nerve

? **c) Internal carotid artery**

d) Medulla oblongata

---

11. The characteristic feature of cervical vertebrae is the presence of:

? **a) Foramen transversarium**

b) Large body

c) Long spinous process

d) Costal facets

---

12. The middle meningeal artery is a branch of:

? **a) Maxillary artery**

b) Internal carotid artery

c) Ascending pharyngeal artery

d) Occipital artery

---

13. The bone forming the upper part of nasal septum is:

a) Vomer

? **b) Perpendicular plate of ethmoid**

c) Sphenoid

d) Maxilla

---

14. The nerve passing through the cribriform plate of ethmoid bone is:

? **a) Olfactory nerve**

b) Optic nerve

c) Oculomotor nerve

d) Trochlear nerve

---

15. The external acoustic meatus is present in the:

? **a) Temporal bone**

b) Sphenoid bone

c) Parietal bone

d) Frontal bone

---

16. The parietal bones articulate with each other at the:

? **a) Sagittal suture**

b) Coronal suture

c) Lambdoid suture

d) Squamous suture

---

17. The weakest part of orbit is its:

? **a) Floor (maxillary part)**

b) Roof

c) Lateral wall

d) Medial wall

---

18. The “dangerous area” for epidural hemorrhage in skull fracture is:

? **a) Pterion region**

b) Mastoid region

c) Occipital protuberance

d) Temporal fossa

---

19. The anterior fontanelle closes by:

a) 3 months

b) 6 months

? **c) 18 months**

d) 2 years

---

20. The hyoid bone gives attachment to all, except:

? **a) Sternothyroid**

b) Mylohyoid

c) Stylohyoid

d) Geniohyoid

---

21. The bone forming posterior nasal spine is:

? **a) Palatine bone**

b) Vomer

c) Maxilla

d) Nasal bone

---

22. The inferior nasal concha is:

? **a) A separate bone**

b) Part of ethmoid bone

c) Part of maxilla

d) Part of sphenoid bone

---

23. The skull bone containing internal ear is:

? **a) Temporal bone**

b) Sphenoid bone

c) Parietal bone

d) Occipital bone

---

24. The foramen lacerum transmits:

? **a) Emissary vein and meningeal branch of ascending pharyngeal artery**

b) Internal carotid artery

c) Facial nerve

d) Maxillary nerve

---

25. The ossification of cranial bones is mainly:

? **a) Membranous**

b) Endochondral

c) Mixed

d) None of the above

---

26. The vertebra without a body and spine is:

? **a) Atlas (C1)**

b) Axis (C2)

c) C7

d) C5

---

27. The nerve injured in fracture at pterion is branch of:

? **a) Maxillary artery** (middle meningeal artery injury)

b) Facial artery

c) Occipital artery

d) Superficial temporal artery

---

28. The cranial capacity is greater in:

? **a) Males**

b) Females

c) Children

d) Elderly

---

29. The bone articulating with all other cranial bones is:

? **a) Sphenoid**

b) Ethmoid

c) Frontal

d) Occipital

---

30. The function of nasal conchae is to:

? **a) Increase surface area and warm inspired air**

b) Allow smell

c) Filter air only

d) Act as resonators

Viva Voce Questions

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1. What are the principal divisions of the skull?

- **Cranial part (neurocranium)** – encloses the brain.
- **Facial part (viscerocranium)** – forms the skeleton of the face.

---

2. Name the cavities formed within the skull.

- **Cranial cavity**
- **Orbital cavities (2)**
- **Nasal cavity**
- **Oral cavity**
- **Ear cavities (2)**

---

3. Which bones form the floor of the anterior cranial fossa?

- **Frontal bone**, **Ethmoid bone**, and **Lesser wings of sphenoid**.

---

4. Which foramina are found in the greater wing of sphenoid bone?

- **Foramen rotundum**, **Foramen ovale**, and **Foramen spinosum**.

---

5. Which bone forms the posterior part of the hard palate?

- **Horizontal plate of palatine bone.**

---

6. Which bone forms the upper part of nasal septum?

- **Perpendicular plate of ethmoid bone.**

---

7. What is the weakest part of the orbital wall?

- **Floor of orbit** (formed by maxilla) ? may fracture in blow-out injuries.

---

8. Which bone forms the prominence of the cheek?

- **Zygomatic bone.**

---

9. Name the bones taking part in the formation of nasal septum.

- **Vomer**, **Perpendicular plate of ethmoid**, and **Septal cartilage**.

---

10. Which bone forms the lateral wall of the nasal cavity?

- **Maxilla**, **Ethmoid**, **Palatine**, **Lacrimal**, and **Inferior nasal concha**.

---

11. What are the typical features of a cervical vertebra?

- **Foramen transversarium**, **bifid spine**, and **triangular vertebral foramen**.

---

12. What are the peculiar features of the atlas (C1)?

- Has **no body or spine**.
- Has **anterior and posterior arches**.
- Bears **large lateral masses** for occipital condyles.

13. What is the main feature of the axis (C2)?

- Presence of **odontoid process (dens)** projecting upward from the body.

---

14. Why is the 7th cervical vertebra called “vertebra prominens”?

- It has a **long, thick, non-bifid spine** that is easily palpable at the root of the neck.

---

15. What is the function of the foramen magnum?

- It allows passage of **medulla oblongata**, **meninges**, **vertebral arteries**, and **spinal roots of accessory nerve (XI)**.

---

16. What is the function of nasal conchae?

- To **increase surface area** of nasal mucosa for warming, humidifying, and filtering inspired air.

---

17. What is the level of the hyoid bone?

- Opposite the **C3 vertebra**.

---

18. What type of ossification occurs in cranial vault bones?

- **Membranous ossification.**

---

19. What type of ossification occurs in the base of the skull?

- **Endochondral ossification.**

---

20. Name the air sinuses of skull and their functions.

- **Frontal, Ethmoidal, Maxillary, Sphenoidal** – lighten the skull, warm inspired air, and add resonance to voice.

---

21. What are fontanelles?

- Membranous gaps at junctions of developing cranial bones in infants that allow skull growth.

---

22. What is the clinical importance of the pterion?

- Lies over the **anterior branch of middle meningeal artery** ? fracture here causes **epidural hematoma**.

---

23. Which bone contributes to the floor of the orbit and the roof of the maxillary sinus?

- **Maxilla.**

---

24. Which foramina open on the face?

- **Supraorbital, Infraorbital, and Mental foramina** (transmit nerves and vessels of same name).

---

25. Which bones form the hard palate?

- **Palatine processes of maxillae** (anterior ¾) and **horizontal plates of palatine bones** (posterior ¼).

---

26. What are the auditory ossicles?

- **Malleus, Incus, and Stapes** – transmit sound vibrations to the inner ear.

---

27. What is the function of the mastoid air cells?

- **Air-filled spaces** in the mastoid part of temporal bone that communicate with middle ear and help in pressure regulation.

---

28. What is the clinical significance of a fracture at the base of skull?

- May cause **CSF rhinorrhea or otorrhea**, **facial paralysis**, or **hearing loss**, depending on the site.

---

29. Which bone houses the organ of hearing and balance?

- **Petrous part of the temporal bone.**

---

30. What is the difference between male and female skulls?

- **Male:** Heavy, large, muscular ridges prominent.
- **Female:** Light, small, rounded features, smoother surface.