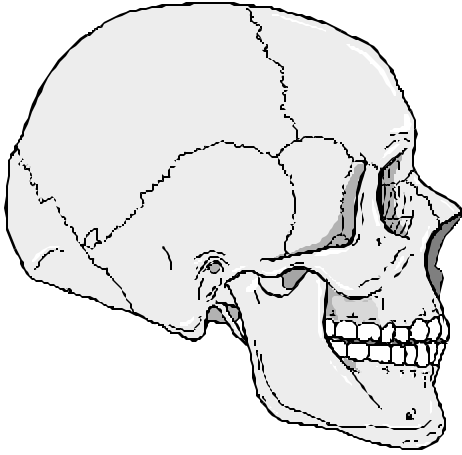


Skull

PCC I: Spring Quarter
Lawrence M. Witmer, PhD
Life Sciences Building, Room 123



READINGS: Moore & Dalley's text: 832–850; Moore & Persaud's Embryology text: 414–419, 216–230

LAB READING: Dissector: 221–223; this handout provides the major source for the lab reading—
BRING THIS HANDOUT TO LAB

I. General Terms

- A. Skull: may or may not include mandible (i.e., sources vary)
- B. Cranium (= neurocranium): that part enclosing the brain
 - 1. Calvaria: superior part
 - 2. Cranial base (= basicranium): inferior part
 - 3. Includes: parietals, temporals, frontal, occipital, sphenoid, ethmoid
 - 4. Calotte: the “skull cap” sawed off for autopsies & dissection
- C. Facial skeleton
 - 1. The rest of the head skeleton
 - 2. Includes: maxillae, zygomatics, palatines, lacrimals, nasals, inferior nasal conchae, vomer, ethmoid, mandible
- D. Sutures: junctures between the individual skull bones

II. Embryology & Development

- A. Organization
 - 1. Portions of the skull
 - a. Neurocranium: surrounding the brain
 - b. Viscerocranium: the jaw apparatus and associated structures
 - 2. Types of ossification
 - a. Endochondral ossification: bones are ossified from cartilaginous precursors
 - b. Intramembranous ossification: bones are ossified directly from mesenchyme investing various structures (e.g., the brain, cartilaginous structures)
- B. Developmental origins of the skull
 - 1. Cartilaginous neurocranium (= chondrocranium)
 - a. Forms from fusion of several primordial cartilages
 - b. Forms structures in skull base via endochondral ossification

- c. Adult bones: occipital, petromastoid part of temporal bone, sphenoid, ethmoid
 - 2. Membranous neurocranium
 - a. Forms bones around the brain via intramembranous ossification
 - b. Adult bones: frontal, parietal
 - 3. Cartilaginous viscerocranium
 - a. Forms from the cartilages of the first two branchial arches via endochondral ossification
 - b. Adult first branchial arch bones: malleus and incus (middle ear ossicles)
 - c. Adult second branchial arch bones: stapes (another middle ear ossicle), styloid process of temporal bone
(note: the second branchial arch also contributes to the lesser horn and part of the body of the hyoid bone and the third branchial arch contributes the rest of the hyoid bone)
 - 4. Membranous viscerocranium
 - a. Forms bones around the maxillary and mandibular prominences of the first branchial arch via intramembranous ossification
 - b. Adult bones: premaxilla, maxilla, zygomatic, palatine, nasal, vomer, lacrimal, squamous part of temporal, mandible
- C. Many of the adult skull bones are compound bones representing fusions of more than one embryonic element
 - 1. Frontal: fusion of right and left elements
 - 2. Occipital: 4 ossification centers
 - 3. Temporal: 8 ossification centers
 - 4. Sphenoid: 14 ossification centers
 - 5. Ethmoid: 3 ossification centers
 - 6. Maxilla: 2 ossification centers
- D. Perinatal skull
 - 1. Proportions
 - a. Large cranium and small face
 - b. Face increases in relative size with growth
 - (1). Eruption of teeth in the maxillae, premaxillae, & mandible
 - (2). Development of paranasal sinuses in the maxilla, frontal, ethmoid, and sphenoid
 - 2. Fontanelles
 - a. Allow molding of the head during parturition; molding also is facilitated by the flexibility of the bones (esp. the frontal)
 - b. Six named fontanelles
 - (1). Unpaired
 - (a). Anterior fontanelle: juncture of frontals & parietals
 - (b). Posterior fontanelle: juncture of parietals & occipital
 - (2). Paired
 - (a). Sphenoidal fontanelle: juncture of frontal, parietal, squamous part of temporal, & greater wing of sphenoid

- (b). Mastoid fontanelle: juncture of parietal, occipital, and petromastoid part of temporal

E. Anomalies

1. Cranioschisis: acrania (absence of the calvaria and often a large vertebral defect) + anencephaly (absence of most of the brain)
2. Craniosynostosis: premature suture closure
 - a. Scaphocephaly: sagittal suture closure: skull becomes long & narrow due to expansion in the frontal and occipital regions
 - b. Acrocephaly (= oxycephaly, turriccephaly, tower skull): coronal suture closure: skull becomes short and high
 - c. Plagiocephaly: unilateral closure of lambdoid and coronal sutures: skull becomes asymmetrical

III. Craniofacial Osteology: based on "views" rather than individual bones

A. Anterior view (= Norma frontalis)

1. Forehead: frontal bone
2. Cheek prominence: zygomatic bone
3. Nares (= anterior nasal aperture)
 - a. Open posteriorly in the nasal cavity
 - b. Bounded by nasals & maxillae (includes premaxillae, which fuse to maxillary bones early in ontogeny)
4. Upper jaw (maxillae) and lower jaw (mandible): tooth-bearing elements
5. Orbit
 - a. Margin: frontal, maxilla, zygomatic
 - b. Superior wall: orbital plate of frontal, sphenoid bones
 - c. Medial wall: orbital lamina (lamina papyracea) of ethmoid bone, lacrimal, sphenoid, and frontal
 - d. Inferior wall: mostly maxilla, also zygomatic & palatine
 - e. Lateral wall: zygomatic bone and greater wing of sphenoid
 - f. Openings within the orbit
 - (1). Superior orbital fissure
 - (a). Largely within sphenoid bone
 - (b). Opens posteriorly into middle cranial fossa
 - (c). Transmits: oculomotor n. (CN III), trochlear n. (CN IV), abducens n. (CN VI), branches of ophthalmic n. (CN V¹), superior ophthalmic v., sympathetics
 - (2). Optic canal
 - (a). Within sphenoid bone
 - (b). Transmits optic n. (CN II), and ophthalmic a.
 - (3). Supraorbital foramen (or notch)
 - (a). Within frontal bone
 - (b). Transmits: supraorbital vessels and nerve
 - (4). Anterior & posterior ethmoidal foramina
 - (a). Within or near suture between frontal & ethmoid bones
 - (b). Transmits: anterior & posterior ethmoidal vessels & nerves

- (5). Nasolacrimal canal and groove
 - (a). Between lacrimal and maxilla
 - (b). Transmits: lacrimal sac and nasolacrimal duct
- (6). Inferior orbital fissure
 - (a). Between greater wing of sphenoid, maxilla, and zygomatic, and a very small part of the palatine
 - (b). Opens into the pterygopalatine fossa and thereby into the infratemporal and temporal regions—(i.e., the superior orbital fissure opens *internally* into the brain (cranial cavity) whereas the inferior orbital fissure opens externally into the temporal region)
 - (c). Transmits: maxillary n. (CN V²), infraorbital vessels, branches from the pterygopalatine ganglion
- 6. Foramina for general somatic afferent (sensory) branches of trigeminal n. (CN V) and accompanying vessels: form a vertical line
 - a. Supraorbital foramen (or notch)
 - (1). Within frontal bone
 - (2). Branches of ophthalmic division (CN V¹)
 - b. Infraorbital foramen
 - (1). Within maxillary bone
 - (2). Branches of maxillary division (CN V²)
 - c. Mental foramen
 - (1). Within mandible
 - (2). Branches of mandibular division (CN V³)
- B. Posterior view (= Norma occipitalis)
 - 1. Cranial vault: formed by the parietal bones
 - 2. Occiput
 - a. Formed mostly by occipital bone and a little of the temporal bone
 - b. Area of muscle attachment
 - (1). Highest (= supreme) nuchal line: attachment of epicranial aponeurosis (= galea aponeurotica), which is the aponeurosis between the frontal and occipital bellies of occipitofrontalis
 - (2) Superior nuchal line: attachment of occipitofrontalis, trapezius, sternocleidomastoid, and splenius capitis
 - (3). Between superior & inferior nuchal lines: semispinalis capitis and superior oblique (= obliquus capitis superior)
 - (4). Inferior nuchal line: rectus major and rectus minor (= rectus capitis posterior major and minor)
 - (5). External occipital protuberance: attachment of lig. nuchae
 - (6). Mastoid process: attachment of sternocleidomastoid, splenius capitis, longissimus capitis, and posterior belly of digastric
 - 3. Sutures & landmarks
 - a. Sagittal suture: between parietal bones
 - b. Lambdoid suture: between occipital & parietals

- c. Lambda: point of intersection of sagittal & lambdoid sutures
- 4. Sutural bones: presence is highly variable
- C. Superior view (= Norma verticalis)
 - 1. Dominated by cranial vault: frontal, parietals, occipital
 - 2. Sutures & landmarks
 - a. Coronal suture: between frontal and parietals
 - b. Sagittal suture: between parietal bones
 - c. Lambdoid suture: between occipital & parietals
 - d. Bregma: point of intersection of sagittal & coronal sutures
 - e. Lambda: point of intersection of sagittal & lambdoid sutures
 - 3. Parietal foramina (= emissary v. foramina)
 - a. Situated on either side of the sagittal suture
 - b. Transmit emissary vv. from scalp to intracranial dural venous sinuses
- D. Ventral view (= Norma basalis)
 - 1. Hard palate
 - a. Composed of palatine processes of maxillary bones and horizontal plates of palatine bones
 - b. Teeth: 3 molars, 2 premolars, 1 canine, 2 incisors on each side
 - c. Foramina
 - (1). Within maxilla—incisive canal, fossa, and foramen: transmits nasopalatine nerve and sphenopalatine vessels
 - (2). Within palatine
 - (a). Greater palatine foramen: transmits greater palatine nerve and vessels
 - (b). Lesser palatine foramen: transmits lesser palatine nerve and vessels
 - d. Choana (= posterior nasal aperture)
 - (1). Bounded by palatine, vomer, & sphenoid
 - (2). Opening from nasal cavity into nasopharynx
 - 2. Cheekbone: zygomatic arch, formed by zygomatic bone & zygomatic part of temporal bone
 - 3. Jaw articulation: mandibular fossa
 - 4. Occiput (see above)
 - 5. Cranial base
 - a. Composed of sphenoid, occipital, & temporal
 - b. Occipital condyles: articulate with atlas vertebra (C1), forming atlantooccipital joint
 - c. Site of attachment of numerous muscles that move the head on the neck, close & open the jaws, support the pharynx, & work the tongue
 - (1). On pharyngeal tubercle of occipital bone: pharyngeal raphe (e.g., superior constrictor)
 - (2). On occipital bone anterior to occipital condyles: longus capitis, rectus capitis anterior
 - (3). On occipital bone lateral to occipital condyles: rectus capitis lateralis

- (4). On temporal bone lateral to foramen lacerum: levator veli palatini
 - (5). On sphenoid & temporal: tensor veli palatini
 - (6). Between lateral & medial pterygoid plates of sphenoid: medial pterygoid
 - (7). On external surface of lateral pterygoid plate of sphenoid: lateral pterygoid
 - (8). Styloid process of the temporal: stylohyoid ligament, stylohyoid, styloglossus, stylopharyngeus
- d. Numerous foramina for nerves and vessels
- (1). Occipital bone
 - (a). Foramen magnum: transmits spinal cord
 - (b). Hypoglossal canal (= anterior condylar canal): within base of occipital condyle; transmits hypoglossal n. (CN XII)
 - (c). Condylar fossa, canal, & foramen: variably present; transmits emissary v. from sigmoid sinus to vertebral vv.
 - (2). Between occipital and petrous part of temporal: jugular fossa and foramen—transmits:
 - (a). Superior bulb of internal jugular v., receiving sigmoid sinus
 - (b). Glossopharyngeal n. (CN IX)
 - (c). Vagus n. (CN X)
 - (d). (Spinal) Accessory n. (CN XI)
 - (e). Inferior petrosal sinus
 - (3). Temporal bone
 - (a). Carotid canal: internal carotid a. and carotid plexus (sympathetic nn.)
 - (b). Stylomastoid foramen
 - (i). Termination of facial canal for facial n. (CN VII)
 - (ii). Located between styloid and mastoid processes
 - (c). Some very small openings
 - (i). Tympanic canaliculus: between carotid canal and jugular fossa; transmits tympanic branch of glossopharyngeal n. (CN IX)
 - (ii). Mastoid canaliculus: within jugular fossa; transmits auricular branch of vagus n. (CN X)
 - (iii). Petrotympanic fissure: transmits chorda tympani n.
 - (4). Between petrous temporal and greater wing of sphenoid: bony portion of auditory tube
 - (5). Sphenoid bone (greater wing)
 - (a). Foramen ovale: transmits mandibular n. (CN V³)
 - (b). Foramen spinosum: transmits middle meningeal vessels (branches of maxillary vessels)
 - (6). Between occipital, sphenoid, and temporal—foramen lacerum: plugged with fibrocartilage in life such that nothing truly passes through it, the internal carotid a. passes over it superiorly

E. Lateral view (= Norma lateralis)

1. Cheekbone: processes from zygomatic and temporal
2. Cranial vault: frontal, greater wing of sphenoid, temporal, parietal, occipital
3. Ear opening: external acoustic meatus
4. Mastoid and styloid processes
5. Temporalis origin
 - a. Superior temporal line: attachment of temporalis fascia
 - b. Inferior temporal line: attachment of temporalis muscle
6. Sutures & landmarks
 - a. Coronal suture: between frontal and parietals
 - b. Lambdoid suture: between occipital & parietals
 - c. Squamosal suture: between squamous part of temporal & parietal
 - d. Asterion: point of intersection of lambdoid & squamosal sutures
 - e. Pterion
 - (1). Point of intersection of frontal, parietal, sphenoid, & temporal
 - (2). Clinically important because a branch of the middle meningeal a. runs in an internal calvarial groove that crosses pterion; fractures at pterion may tear the artery & result in extradural hematoma

F. Internal surface of skullcap (= calotte)

1. Sulcus for superior sagittal sinus (a dural venous sinus)
2. Sulcus for middle meningeal vessels on parietal

G. Cranial fossae

1. General
 - a. Internal, superior aspect of the skull
 - b. Three fossae have a step-like arrangement such that each more posterior fossa is located more inferiorly
 - c. Each supports a different portion of the brain
 - (1). Anterior cranial fossa: frontal lobes
 - (2). Middle cranial fossa: temporal lobes
 - (3). Posterior cranial fossa: cerebellum, pons, medulla
2. Anterior cranial fossa
 - a. Formed mostly by frontal, also lesser wing of sphenoid and ethmoid
 - b. Supports the frontal lobes of the cerebrum
 - c. Brain markings on the bone form shallow, sinuous grooves; produced by convolutions (gyri) of the frontal lobe
 - d. Ethmoid bone
 - (1). Crista galli: a median plate of bone to which the falx cerebri (a median dural septum) attaches
 - (2). Cribriform plate: overlain by olfactory bulb of brain
 - e. Lesser wing of sphenoid bone
 - (1). Overhangs the middle cranial fossa
 - (2). Anterior clinoid processes: provides attachment to the tentorium cerebelli (a dural septum)
 - f. Foramina

- (1). Foramina within cribriform plate: olfactory nerve fibers pierce foramina to enter olfactory bulb
 - (2). Anterior & posterior ethmoidal foramina: for vessels and nerves of the same name
 - (3). Foramen cecum: for emissary v. from nasal cavity to superior sagittal sinus; variable & relatively unimportant
3. Middle cranial fossa
- a. Separated from:
 - (1). Anterior cranial fossa by ridges from lesser wings
 - (2). Posterior cranial fossa by dorsum sellae and superior border of petrous part of temporal
 - b. Formed by sphenoid and temporal
 - c. Supports temporal lobe of cerebrum
 - d. Sella turcica
 - (1). Saddle-shaped, central portion of sphenoid
 - (2). Tuberculum sellae: anteriorly situated; divides hypophyseal area from optic nerve area
 - (3). Hypophyseal fossa: for pituitary
 - (4). Dorsum sellae: posteriorly situated
 - (5). Posterior clinoid processes: at tips of dorsum sellae
 - e. Foramina
 - (1). Optic canals
 - (a). Within sphenoid, just medial to anterior clinoid processes
 - (b). Transmits: optic n., ophthalmic a.
 - (2). Crescent of foramina within greater wing
 - (a). Superior orbital fissure: four cranial nerves (CN III, IV, V¹, VI) & ophthalmic vv.
 - (b). Foramen rotundum: maxillary n. (CN V²)
 - (c). Foramen ovale: mandibular n. (CN V³), accessory meningeal a.
 - (d). Foramen spinosum: middle meningeal vessels; note: vessels enscribe a prominent groove within the middle cranial fossa
 - (3). Foramen lacerum: located at apex of petrous temporal
 - (a). Filled with fibrocartilage inferiorly
 - (b). Superiorly, internal carotid a. and carotid plexus pass over (not through) the foramen
 - (4). Greater petrosal hiatus and groove
 - (a). Slit at posterolateral apex of foramen lacerum
 - (b). Transmits greater petrosal n. & an artery (petrosal branch of middle meningeal a.)
4. Posterior cranial fossa
- a. Formed mostly by occipital, also temporal and sphenoid
 - b. Supports cerebellum, pons, and medulla

- c. Grooves for intracranial sinuses
 - (1). Transverse sinus: right groove is usually larger because sagittal sinus dumps into it; tentorium cerebelli attaches on either side of the groove
 - (2). Sigmoid sinus: from transverse sinus to jugular foramen
- d. Internal occipital crest: divides cerebellar fossae
- e. Internal occipital protuberance: attachment of dura
- f. Clivus: sloping portion of occipital leading to sphenoid: supports pons and medulla
- g. Foramina
 - (1). Foramen magnum
 - (a). Large, unpaired
 - (b). Communication between cranial cavity & vertebral canal
 - (c). Transmits: medulla, meninges, spinal roots of spinal accessory n. (CN XI), vertebral vessels, spinal vessels
 - (2). Jugular foramen (see above, section III.D.5.d.(2))
 - (3). Hypoglossal canal
 - (a). Between jugular foramen and foramen magnum
 - (b). Transmits hypoglossal n. (CN XII)
 - (4). Condylar canal: variable; emissary v.
 - (5). Internal acoustic meatus
 - (a). Within petrous temporal
 - (b). Transmits: facial n. (CN VII; including nervus intermedius), vestibulocochlear n (CN VIII), and vessels

H. Mandible

- 1. Ramus
 - a. Condylar process (with head and neck): articulates with the mandibular fossa of the temporal bone
 - b. Coronoid process: attachment of temporalis muscle
 - c. Mandibular notch: separates condylar & coronoid
 - d. Mandibular foramen
 - (1). Entrance to mandibular canal
 - (2). Transmits inferior alveolar nerves & vessels
 - e. Lingula: attachment of sphenomandibular ligament
 - f. Mylohyoid groove: for mylohyoid n. & vessels
- 2. Body
 - a. Alveolar process: tooth-bearing portion
 - b. Mental foramen
 - (1). Exit of mandibular canal
 - (2). Transmits mental n. (CN V¹) and vessels
 - c. Mylohyoid line: attachment of mylohyoid muscle
 - d. Mental symphysis, tubercles, and protuberance: chin
 - e. Mental spine (= genial tubercles): attachment of genioglossus
- 3. Angle: juncture of ramus & body; attachment of masseter & medial pterygoid

SELF TEST

1. Describe the differences between the cartilaginous and membranous neurocranium and viscerocranium. To which adult bones does each type contribute?
2. Name the muscle “scars” on the occiput and provide at least two examples of muscle attachments for each.
3. What are the sagittal, lambdoid, coronal, and squamosal sutures? Between which bones do they lie? What are the names of the landmarks that lie at their intersections?
4. Why are fractures to the cranial base both so common and so serious?
5. List the exits of all the cranial nerves and major blood vessels.

SAMPLE QUESTION

- A helmet-less hockey player receives a hard blow to the temple from a slap-shot puck. In addition to a concussion, the individual shows signs of extradural hematoma. What is the most likely cause of this injury?
- A. The blow fractured the superior orbital fissure with resultant tearing of the superior ophthalmic veins
 - B. The blow fractured the skull in the area of pterion with resultant tearing of the middle meningeal artery
 - C. The blow fractured the cranial base with resultant tearing of the internal jugular vein
 - D. The blow cracked the calvaria with resultant tearing of emissary veins
 - E. The blow fractured the frontal bone with resultant tearing of the supraorbital vessels

cartilaginous neurocranium
 membranous neurocranium
 cartilaginous viscerocranium
 membranous viscerocranium

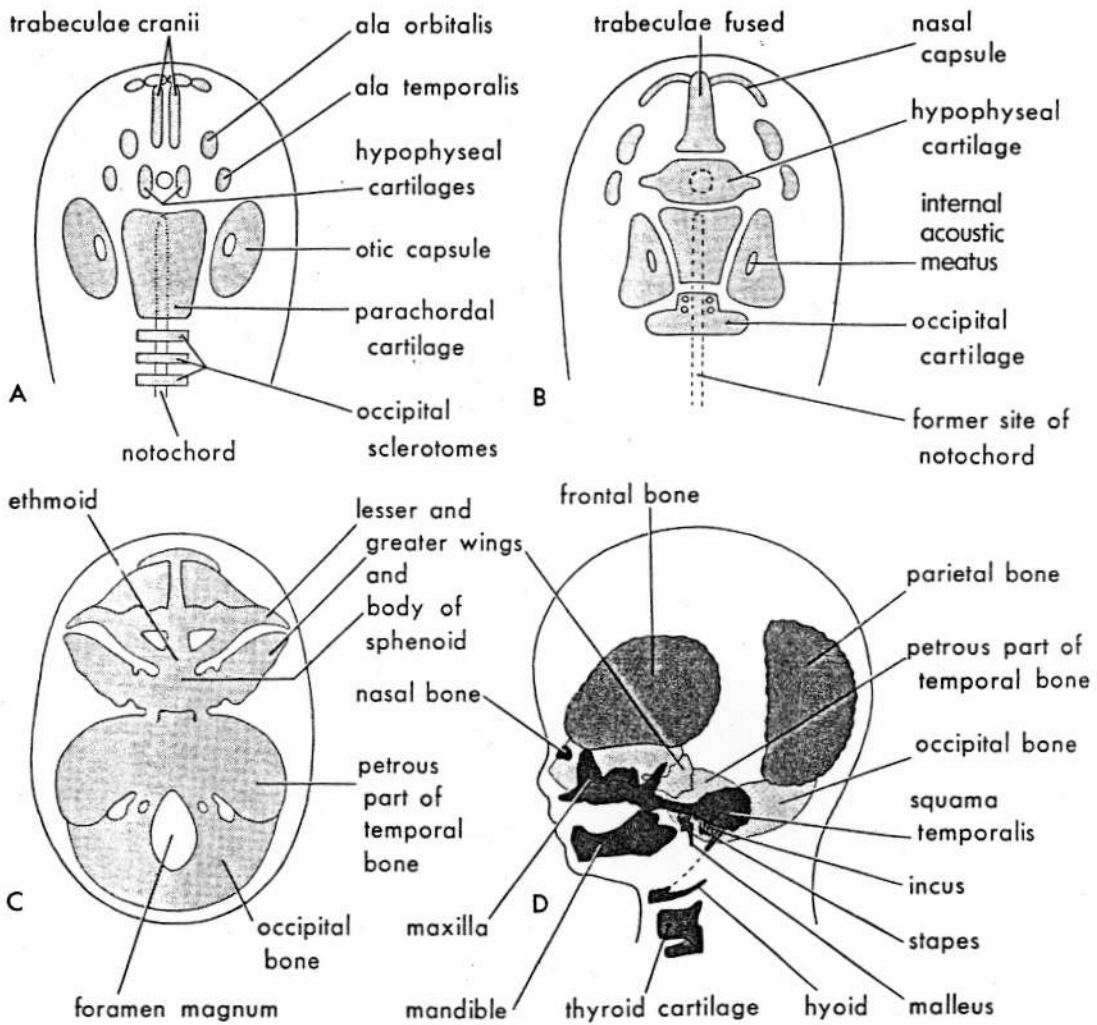


Figure 16-8. Diagrams illustrating development of the skull. A to C show the base of the developing skull as viewed superiorly; D is a lateral view. A, Six weeks, showing the various cartilages that will fuse to form the chondrocranium. B, Seven weeks after fusion of some of the paired cartilages. C, 12 weeks, showing the cartilaginous base of the skull or chondrocranium formed by the fusion of various cartilages. D, 20 weeks, indicating the derivation of the bones of the fetal skull. The sides and roof of the skull (calvaria) develop from the mesenchyme investing the brain that undergoes intramembranous ossification.

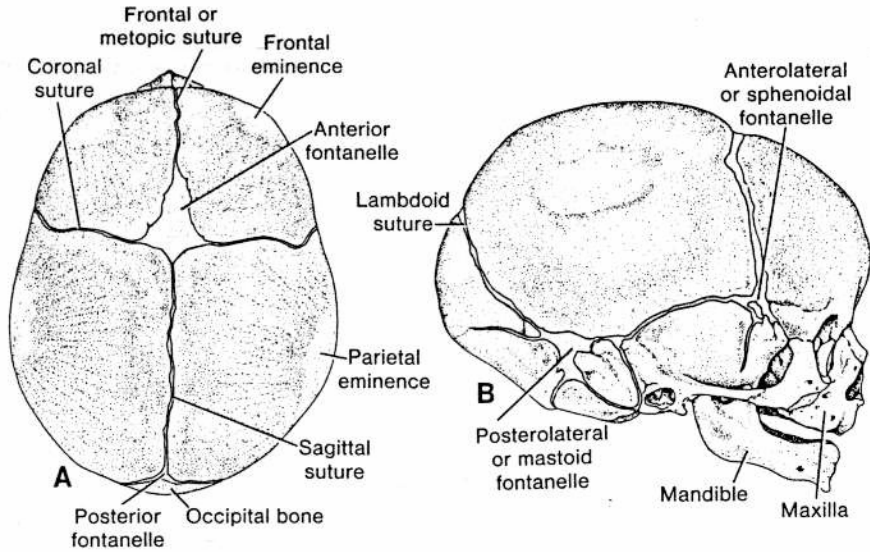


Figure 9-3. Skull of a newborn, seen from above and the right side. Note the anterior and posterior fontanelles and the sutures. The posterior fontanelle closes about 3 months after birth; the anterior fontanelle about the middle of the second year. Many of the sutures disappear during adult life.

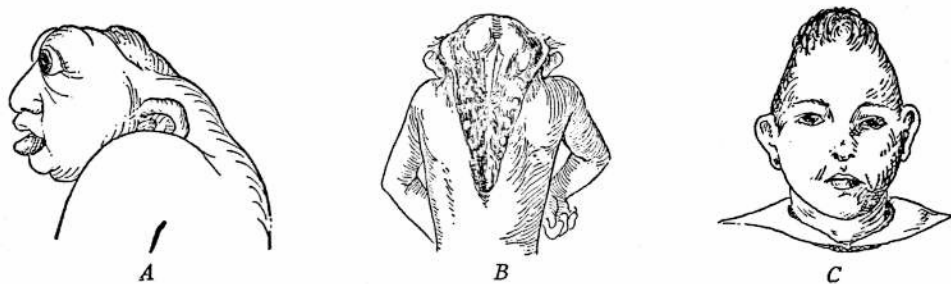


Fig. 384. Anomalies of the human axial skeleton. *A*, Cranioschisis, or acrania, in a newborn. *B*, Cranio-rachischisis in a newborn. *C*, Scaphocephaly.

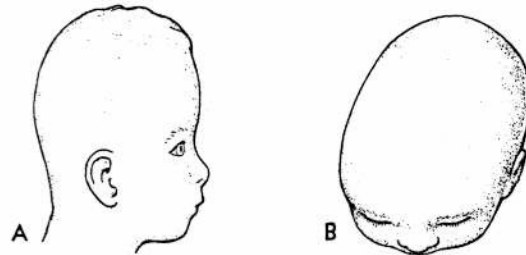


Figure 16-11. Drawing illustrating two types of skull anomaly. *A*, Oxycephaly (turricephaly), showing the towerlike skull resulting from premature closure of the coronal suture. *B*, Plagiocephaly, a type of asymmetrical skull resulting from premature closure of the coronal and lambdoid sutures on the left side.

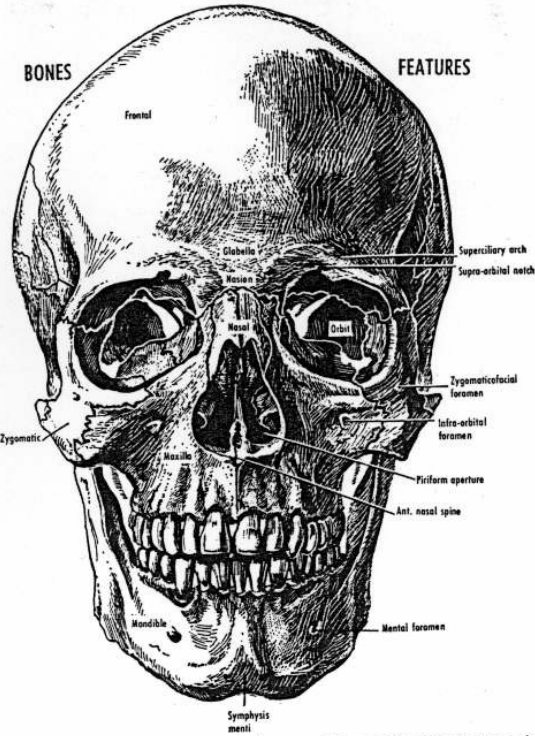


FIGURE 24-1
SKULL: (FRONTAL VIEW)

1. Frontal bone
2. Parietal bone
3. Supraorbital foramen, or notch, on superciliary arch
4. Superior orbital fissure in sphenoid bone
5. Lacrimal bone
6. Infraorbital foramen in maxillary bone
7. Middle nasal concha and perpendicular plate, both ethmoid bone
8. Vomer bone, the inferior portion of nasal septum
9. Mental foramen in body of mandible
10. Optic foramen
11. Nasal bone
12. Inferior orbital fissure
13. Zygomatic bone
14. Inferior nasal concha
15. Alveolar processes
16. Angle of mandible

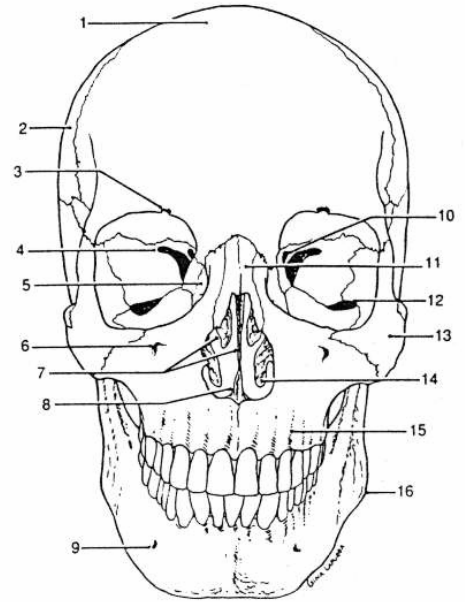
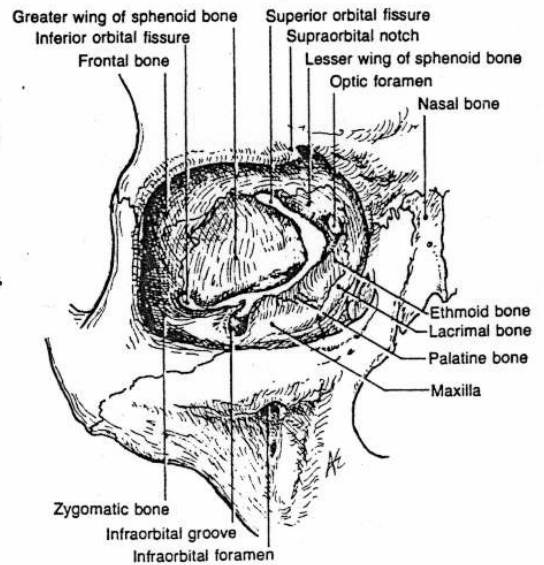
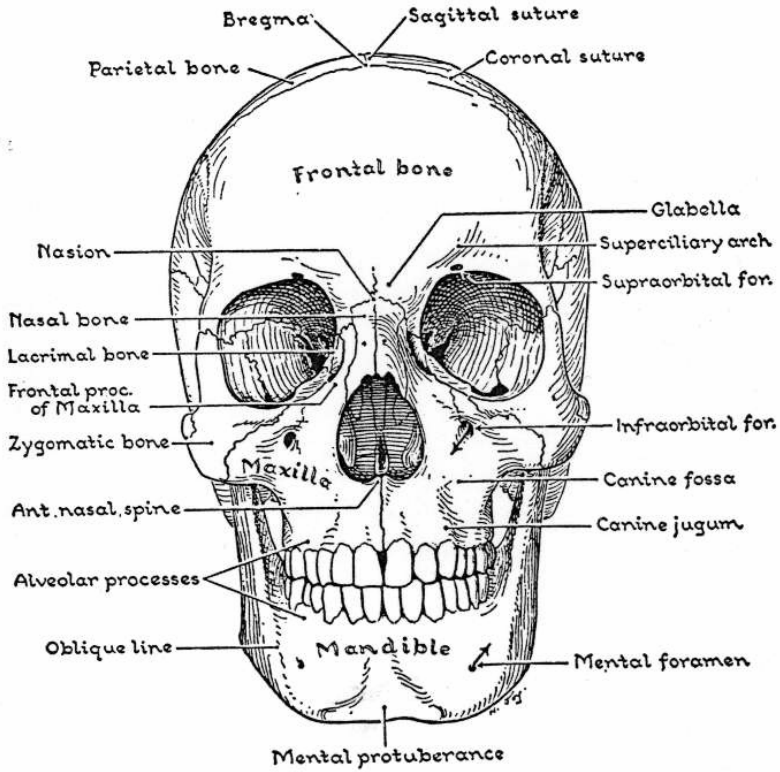
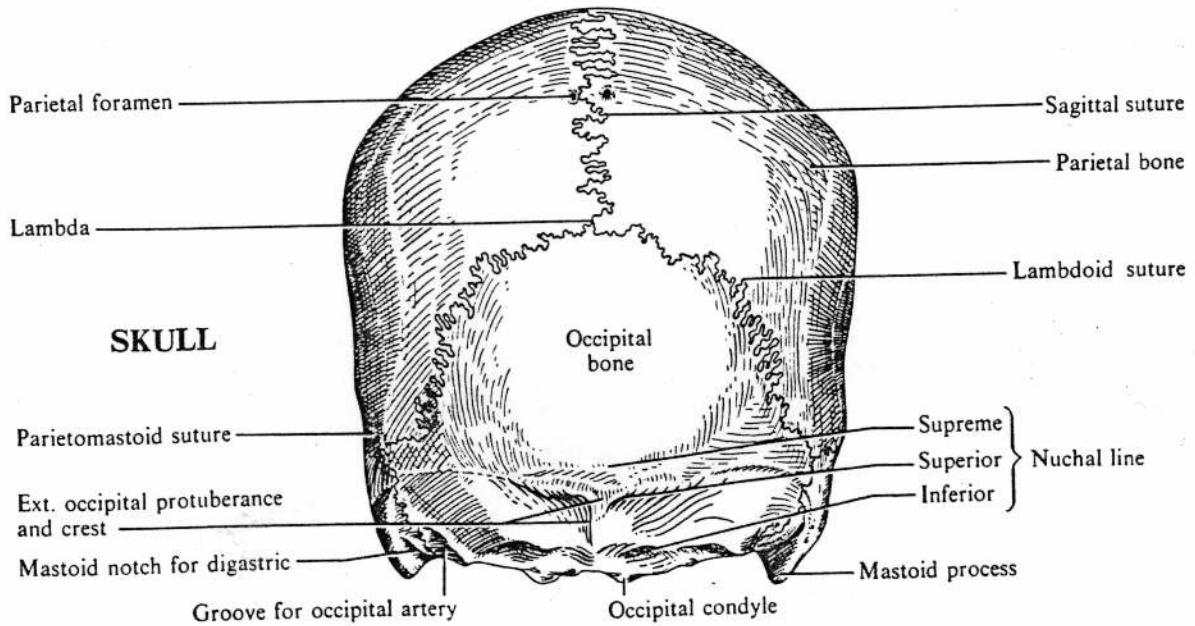
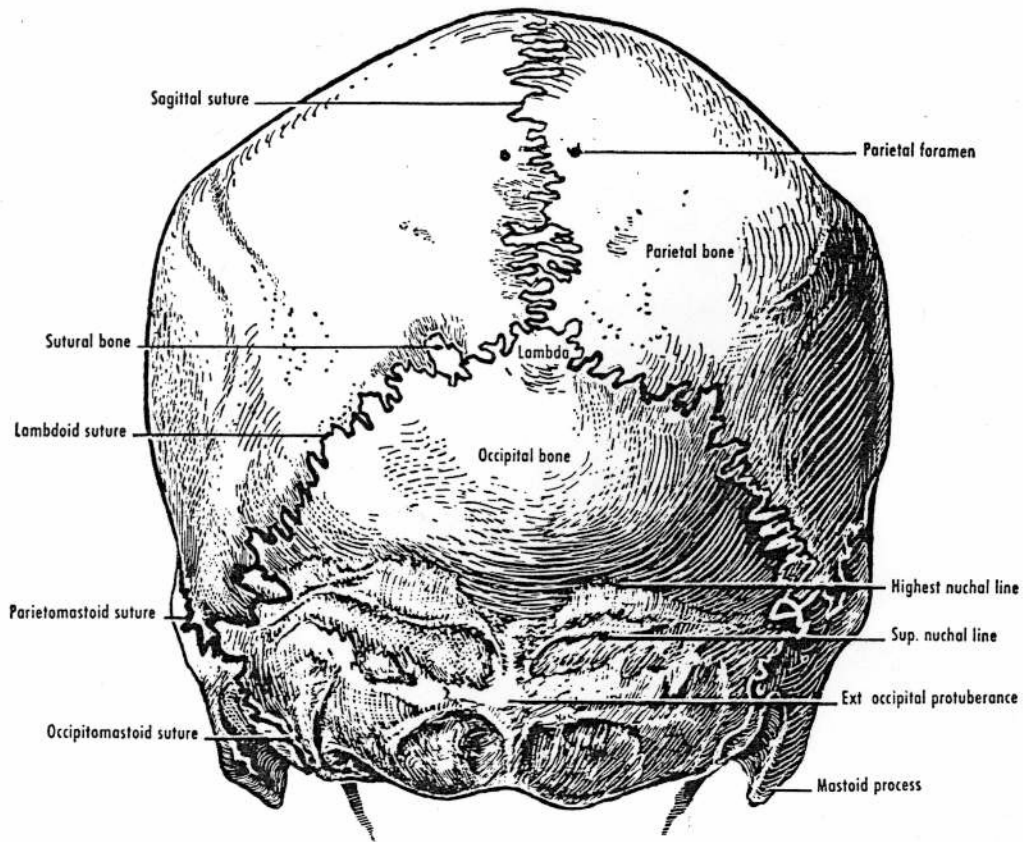
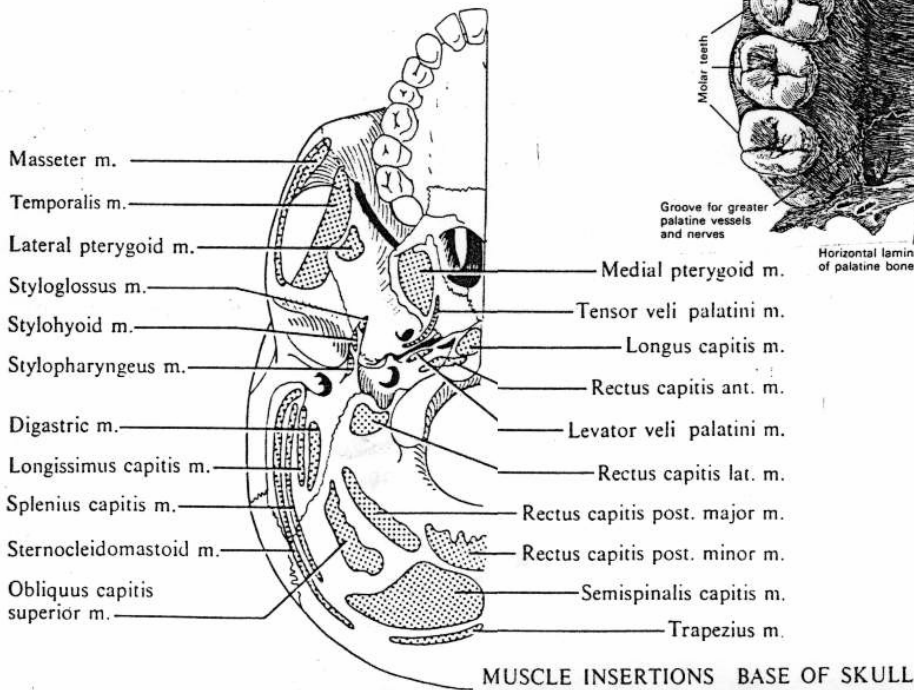
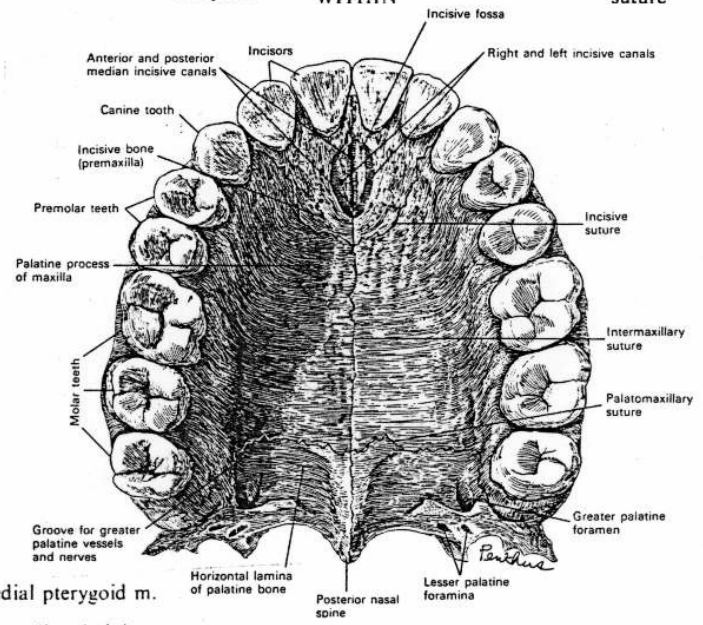
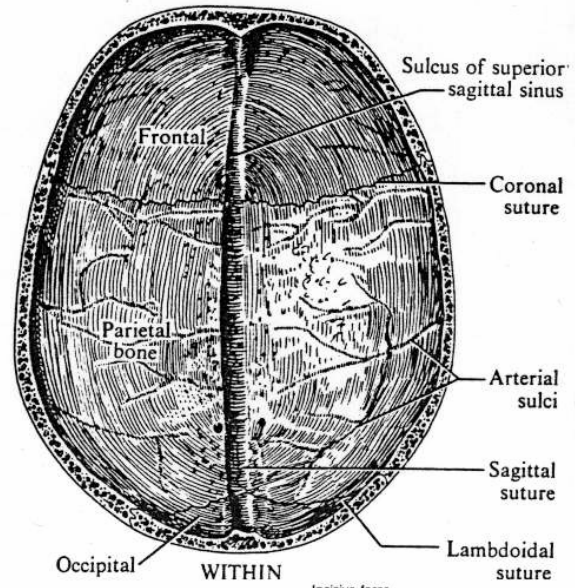
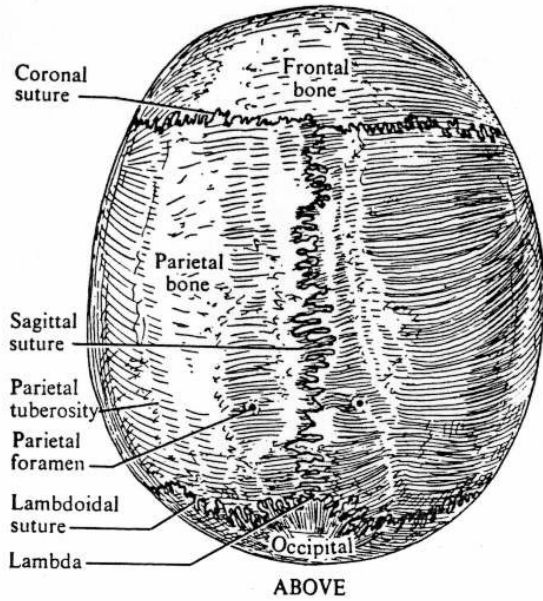


Figure 42-3 Anterior aspect of the skull. Observe that the supra-orbital notch, infra-orbital foramen, and mental foramen are approximately in a vertical line. They transmit branches of divisions 1, 2, and 3 of the trigeminal nerve, respectively.







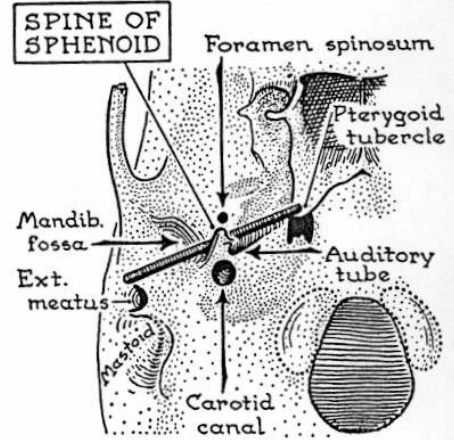
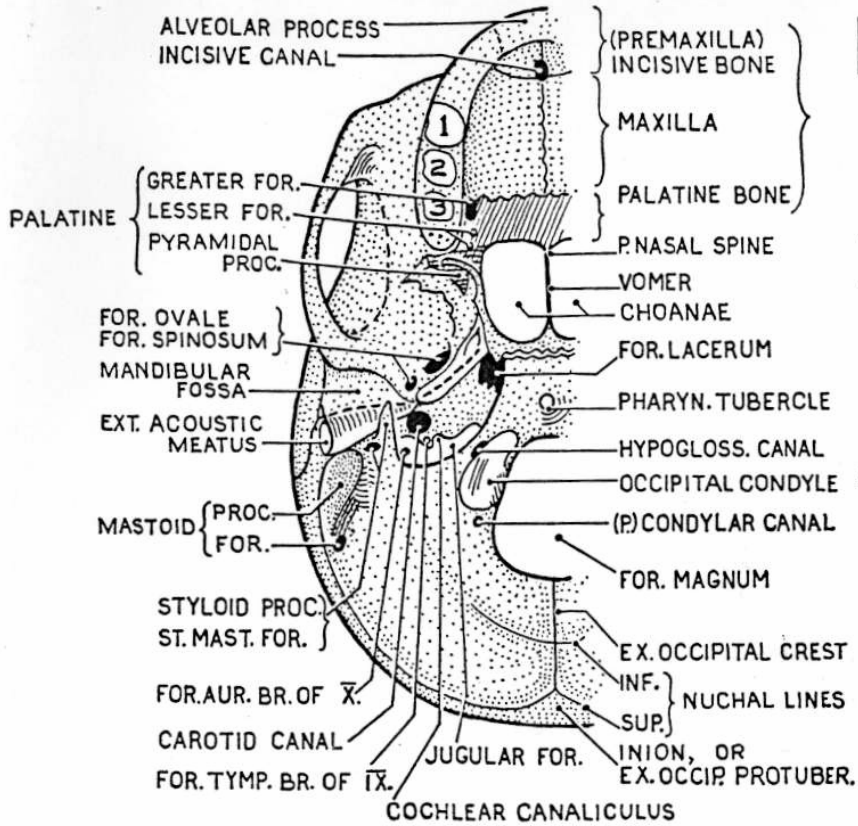


Figure 46.10. Oblique line on exterior of base of skull.

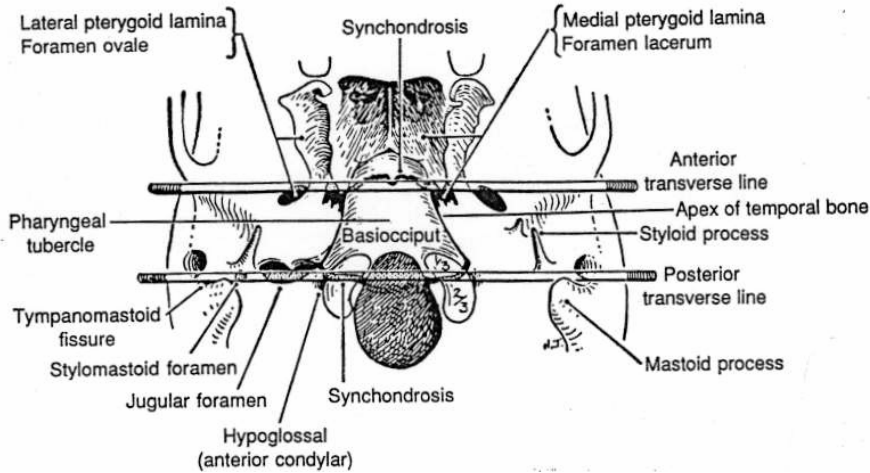
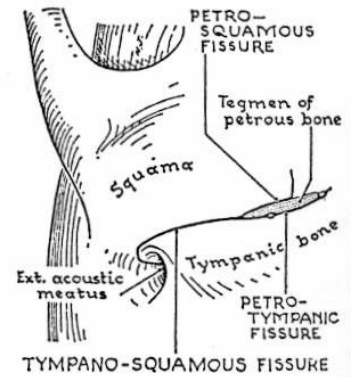
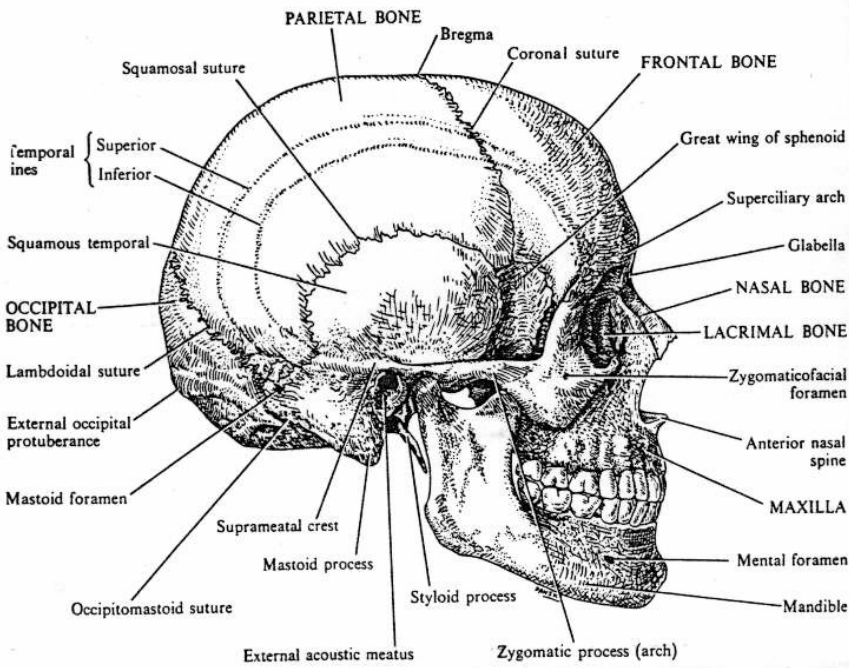
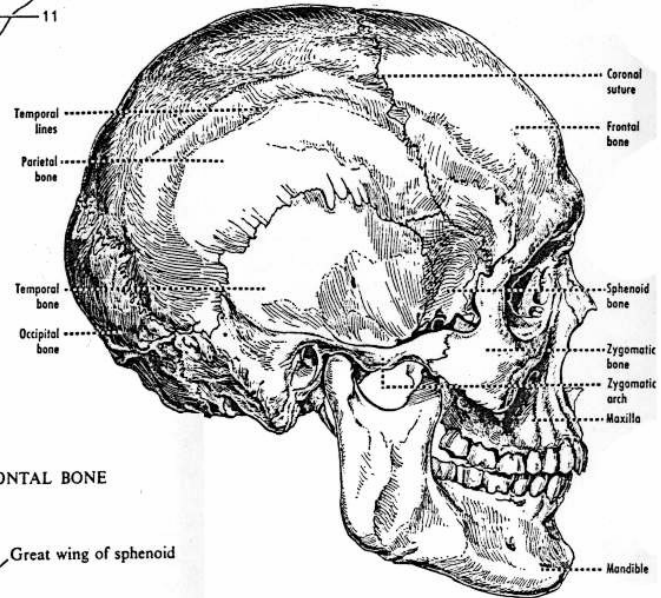
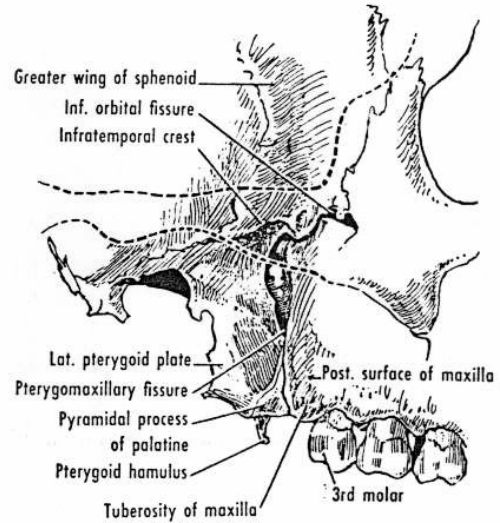
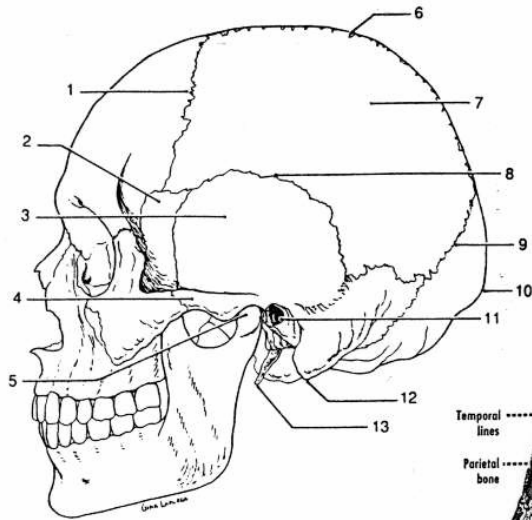
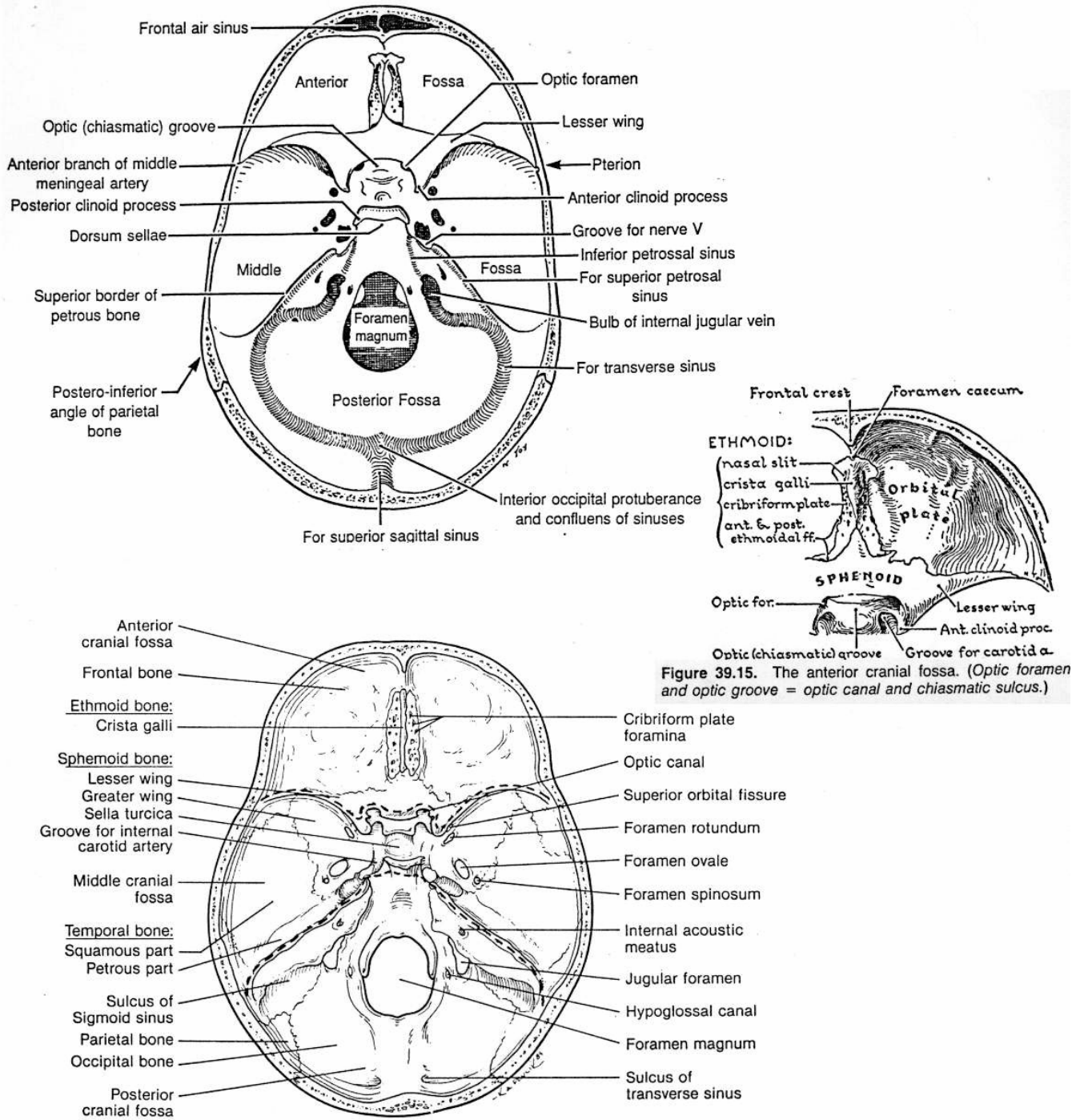


FIGURE 24-2
SKULL (LATERAL VIEW)

1. Coronal suture
2. Sphenoid bone—greater wing
3. Temporal bone
4. Zygomatic arch
5. Condylod process in the mandibular fossa
6. Sagittal suture
7. Parietal bone
8. Squamosal suture
9. Lambdoidal suture
10. External occipital protuberance of occipital bone
11. External acoustic meatus
12. Mastoid process of the temporal bone
13. Styloid process of the temporal bone





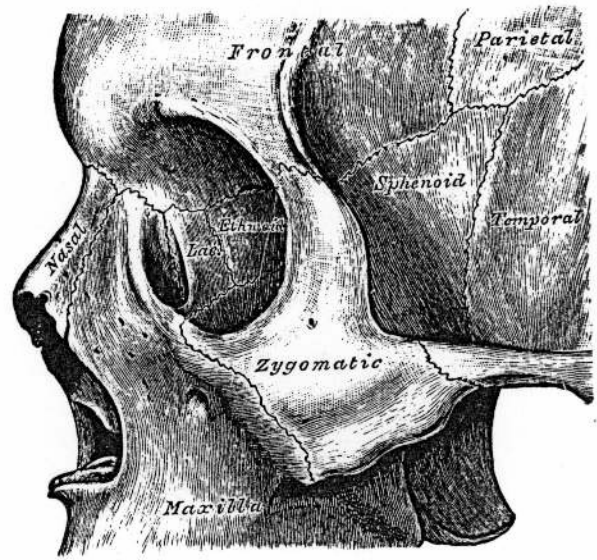
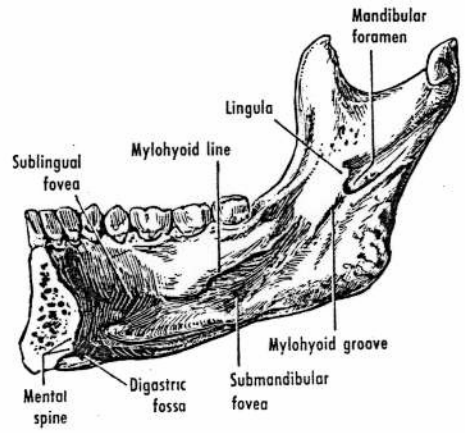
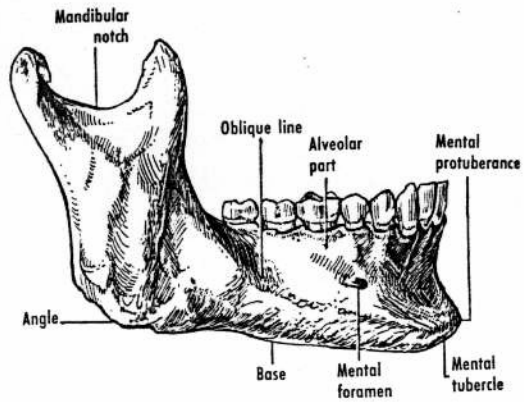


FIG. 4-127. Left zygomatic bone in situ.

