The Skeletal System

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LEARNING OUTCOMES

As a result of the lesson you will be able to:

- *Define the two subdivisions of the skeleton;*
- *Define several terms that denote surface features of bones;*
- *Name the bones and cavities of the skull and their anatomical features; and identify them from model or diagrams.*

The Skeletal System

- two regions of the skeleton
  - **axial skeleton** – forms the central supporting axis of the body
    - skull, auditory ossicles, hyoid bone, vertebral column, and thoracic cage (ribs and sternum)
  - **appendicular skeleton** – includes the bones of the upper limb and pectoral girdle, and the bones of the lower limb and pelvic girdle

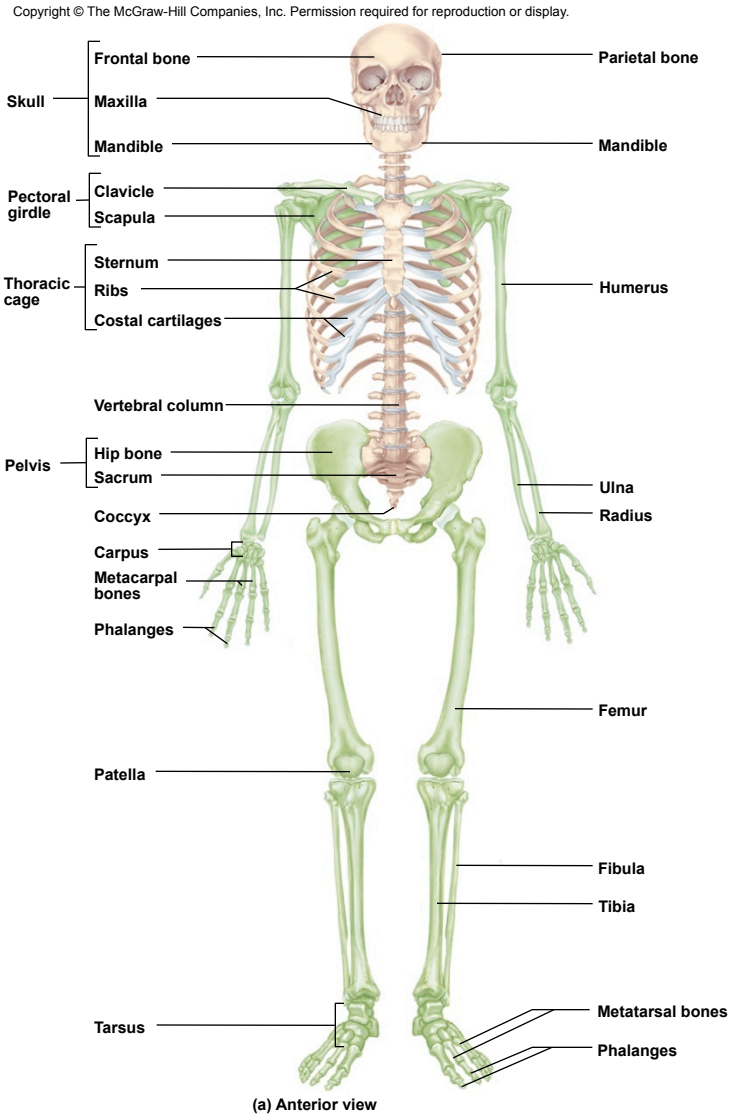
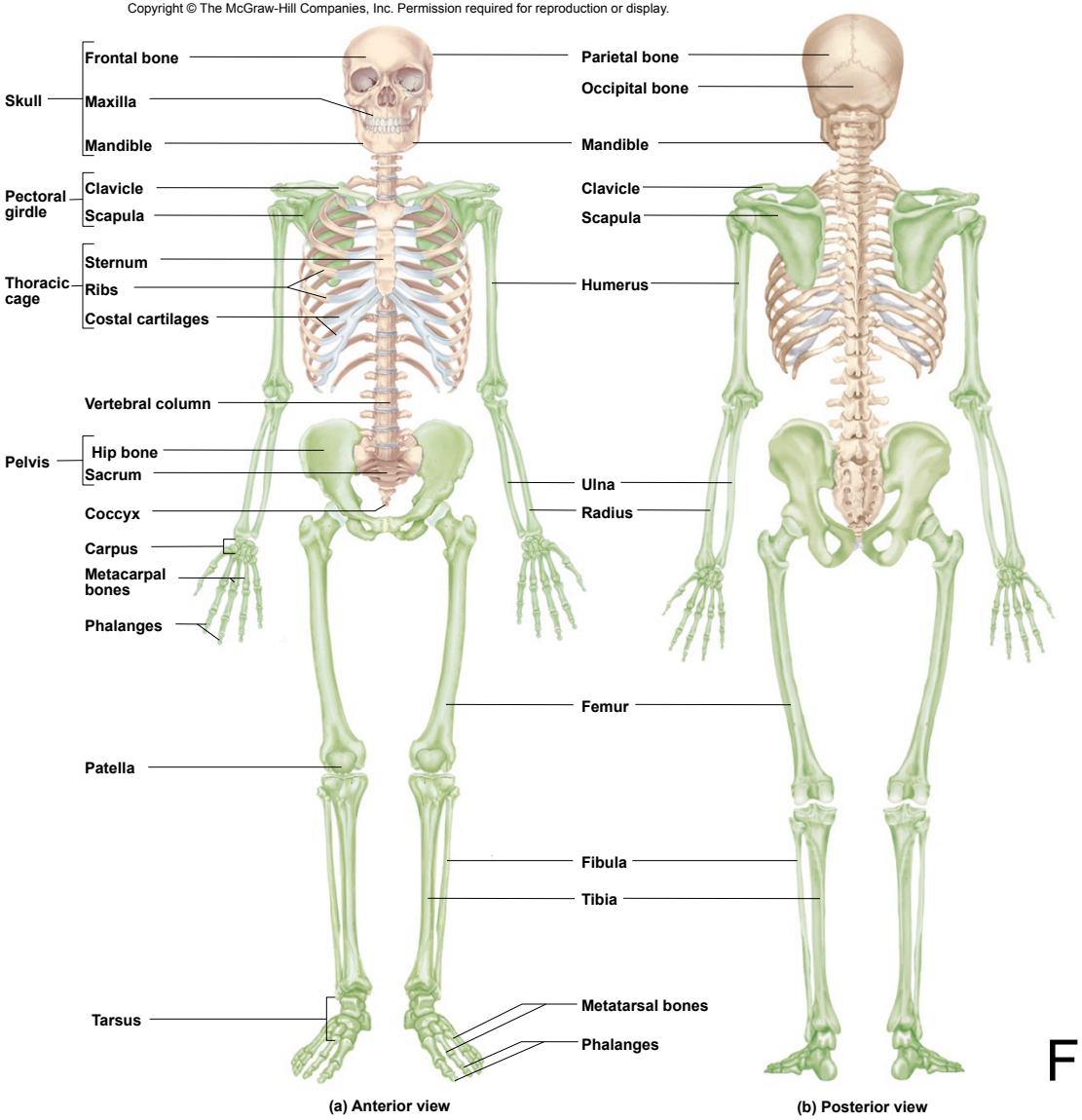


Figure 8.1a

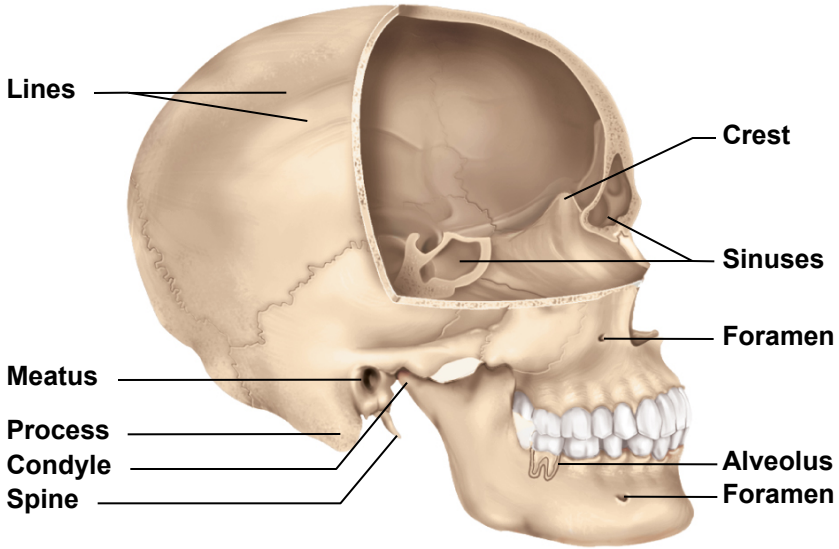
Axial and Appendicular Skeleton



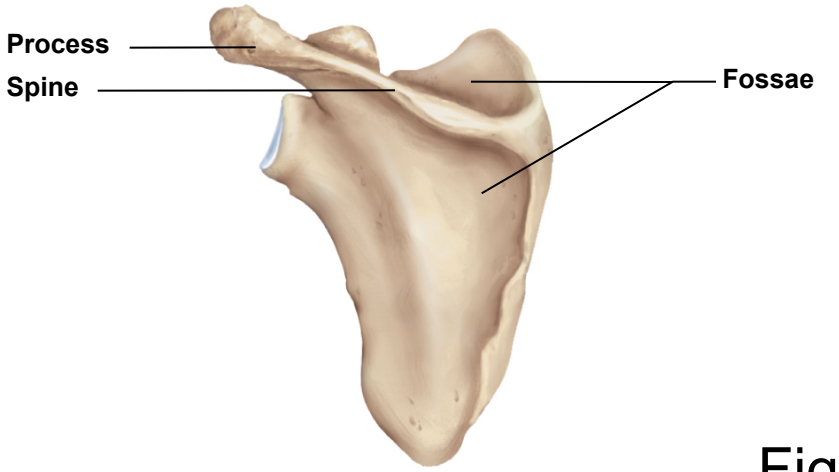
- **axial skeleton** is colored **tan**
  - skull, vertebrae, sternum, ribs, sacrum and hyoid
- **appendicular skeleton** is colored **green**
  - pectoral girdle
  - upper extremity
  - pelvic girdle
  - lower extremity

Figure 8.1

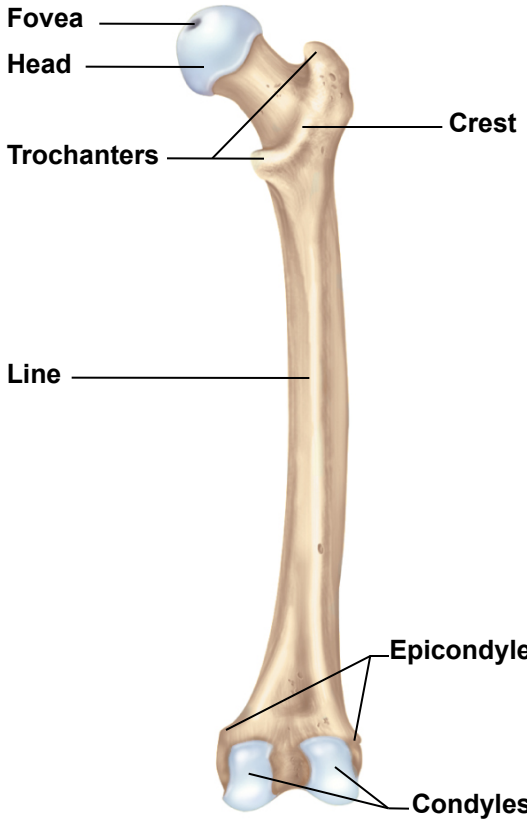
Anatomical Features of Bones



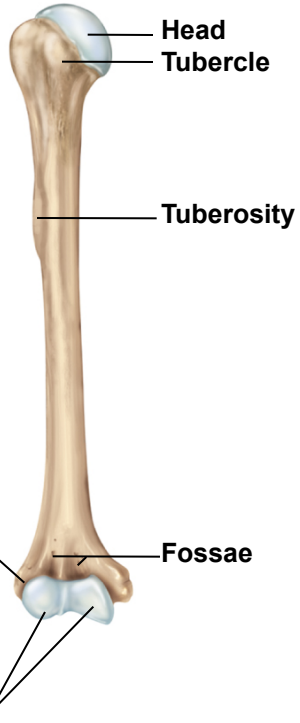
(a) Skull (lateral view)



(b) Scapula (posterior view)



(c) Femur (posterior view)



(d) Humerus (anterior view)

Figure 8.2

The Skull

- **skull** – the most complex part of the skeleton
- **22 bones** joined together by **sutures** (immovable joints)
- **8 cranial bones** surround **cranial cavity** which encloses the **brain**
- **other cavities** – orbits, nasal cavity, oral (buccal) cavity, middle-, and inner ear cavities, and paranasal sinuses
- **paranasal sinuses** – frontal, sphenoid, ethmoid, and maxillary
  - lined by mucous membrane and air-filled
  - lighten the anterior portion of the skull
  - act as chambers that add resonance to the voice
- **foramina** – holes that allow passage for nerves and blood vessels
- **14 facial bones** support teeth, facial and jaw muscles

Frontal Bone

- forms **forehead** and part of the roof of the cranium
- **coronal suture** – posterior boundary of frontal bone
- **supraorbital margin** forms roof of the orbit
- **supraorbital foramen** provides passage for nerve, artery, and vein
- **glabella** – smooth area above root of the nose
- contains **frontal sinus**

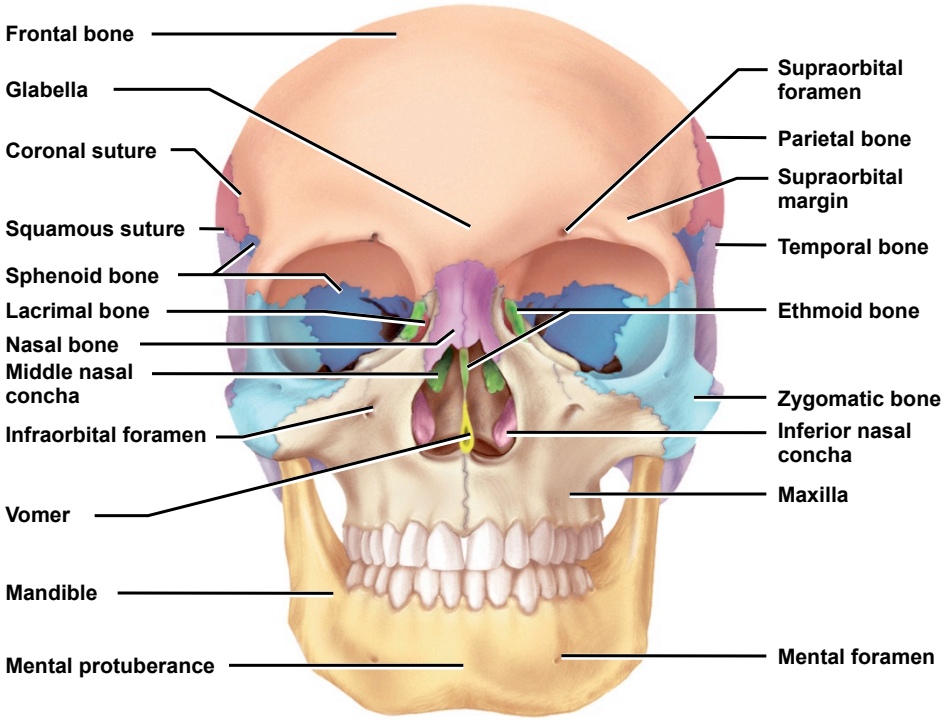


Figure 8.3

Parietal Bone

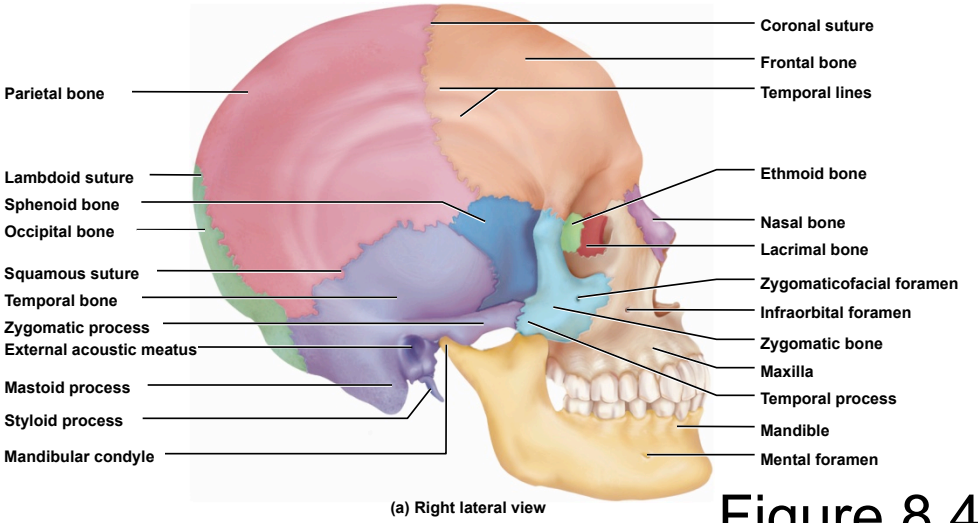


Figure 8.4a

- form most of cranial roof and part of its lateral walls
- bordered by **4 sutures**
  - **sagittal** – between parietal bones
  - **coronal** – at anterior margin
  - **lambdoid** – at posterior margin
  - **squamous** – at lateral border
- two **temporal lines** serve as attachment of the temporalis muscle

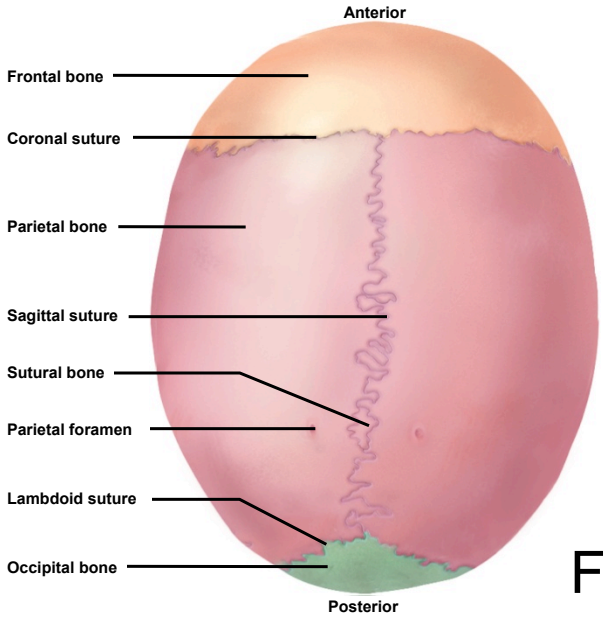


Figure 8.6

Temporal Bone

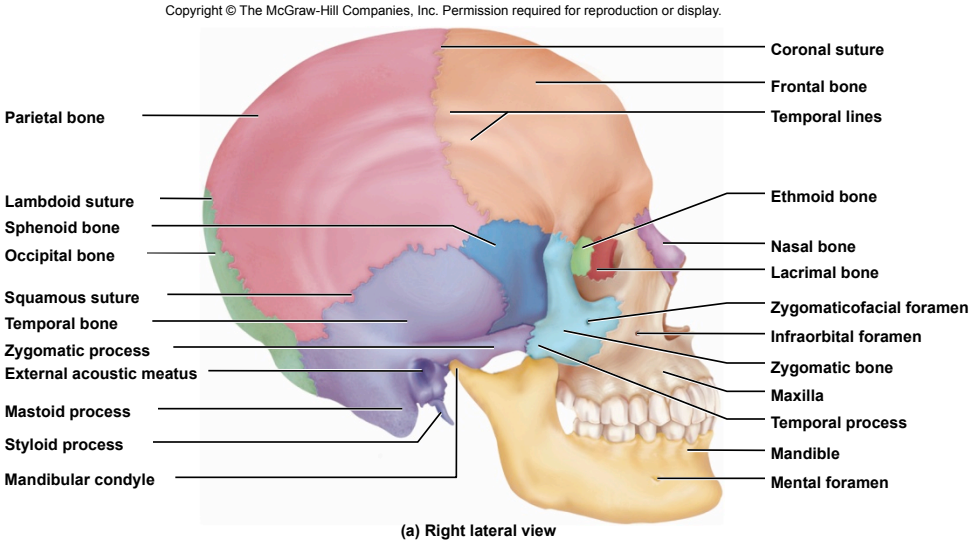


Figure 8.4a

- lateral wall and part of floor of cranial cavity
  - **squamous part**
    - encircled by squamous suture
    - **zygomatic process**
    - **mandibular fossa**
  - **tympanic part**
    - **external auditory meatus**
    - **styloid process**
  - **mastoid part**
    - **mastoid process**
      - mastoiditis from ear infection
    - **mastoid notch**
    - **stylomastoid foramen**
    - **mastoid foramen**

Petrous Portion of Temporal Bone

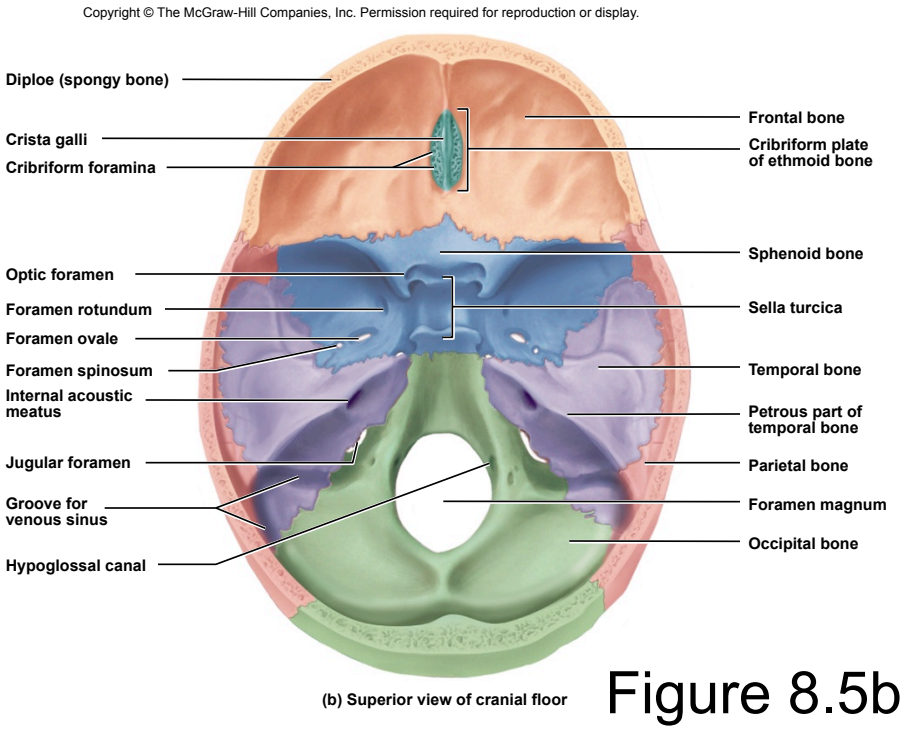
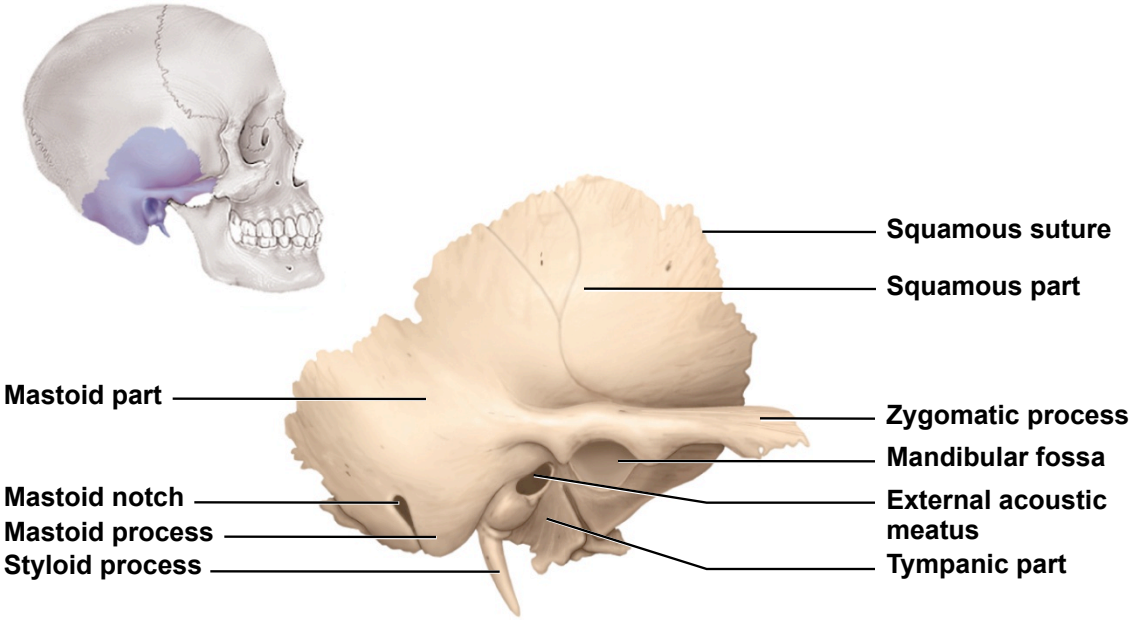


Figure 8.5b

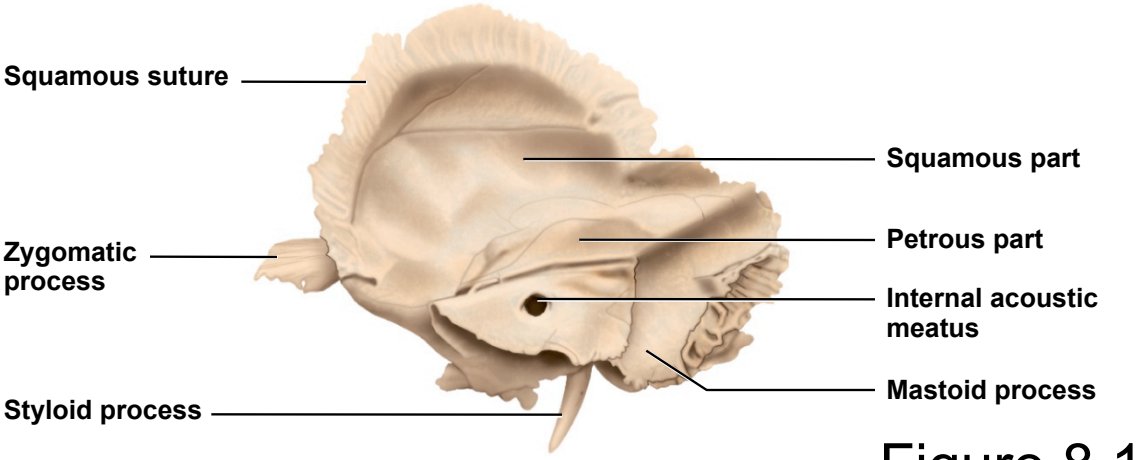
– **petrous part**

- part of cranial floor
- separates middle from posterior cranial fossa
- houses middle and inner ear cavities
- receptors for hearing and sense of balance
- **internal auditory meatus** - opening for CN VII (vestibulocochlear nerve)
- **carotid canal**
- **jugular foramen**

Right Temporal Bone



(a) Lateral surface



(b) Medial surface

Figure 8.10

Occipital Bone

- rear and base of skull
- **foramen magnum** holds spinal cord
- **basilar part**
- skull rests on atlas at **occipital condyles**
- **hypoglossal canal** transmits hypoglossal nerve (CN XII) supplying tongue muscles
- **condylar canal**
- **external occipital protuberance** for **nuchal ligament**
- **superior and inferior nuchal lines** mark neck muscles

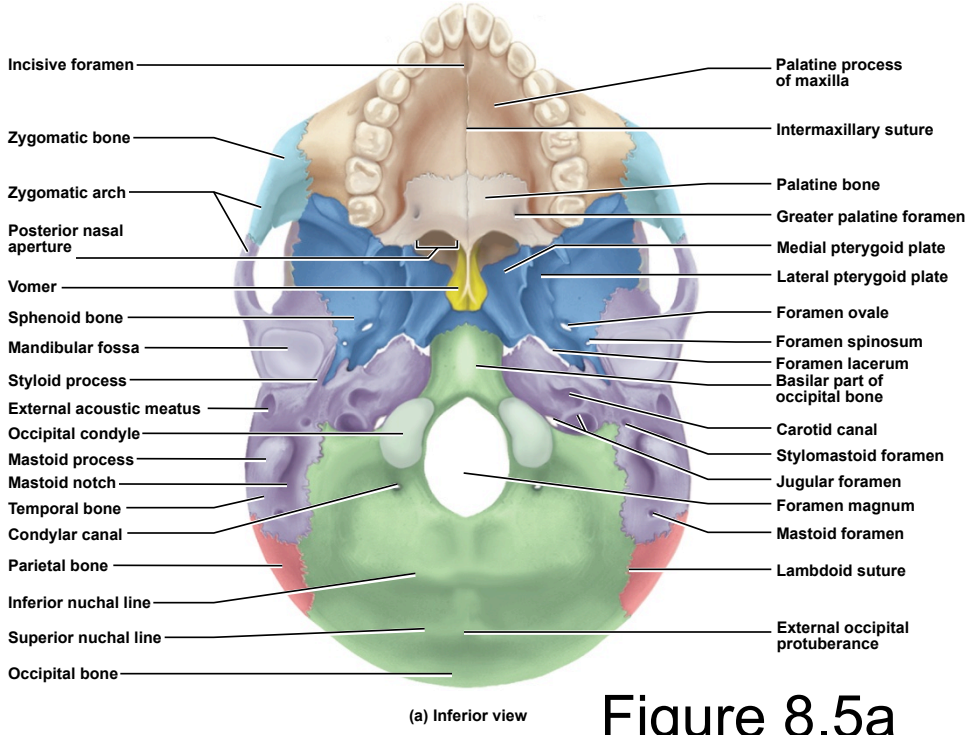
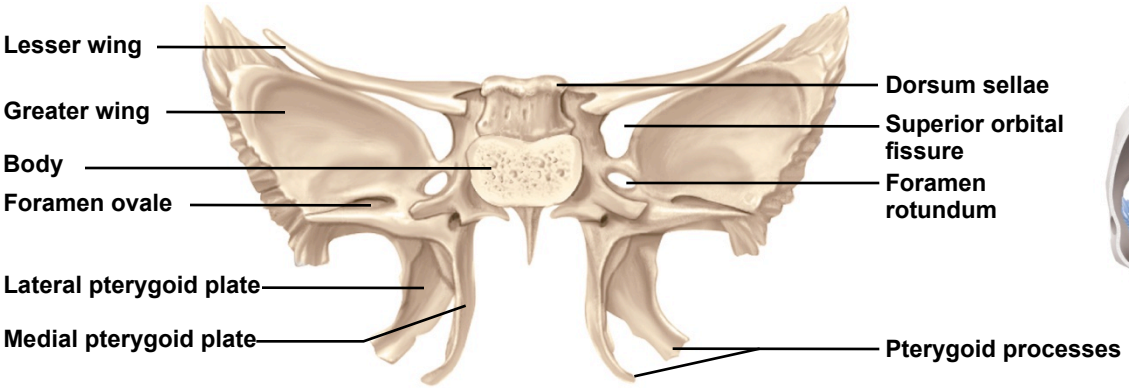


Figure 8.5a

Sphenoid Bone



(b) Posterior view

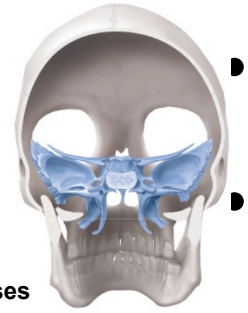
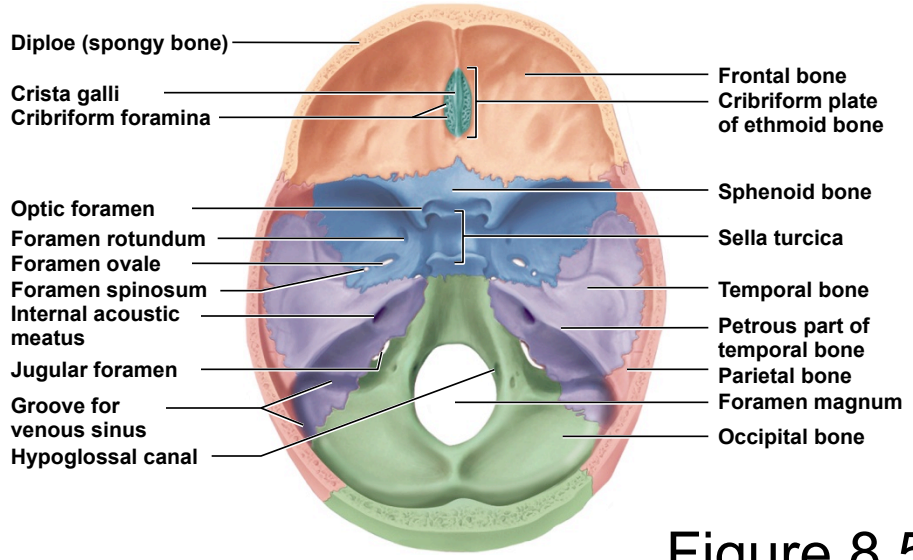


Figure 8.11b

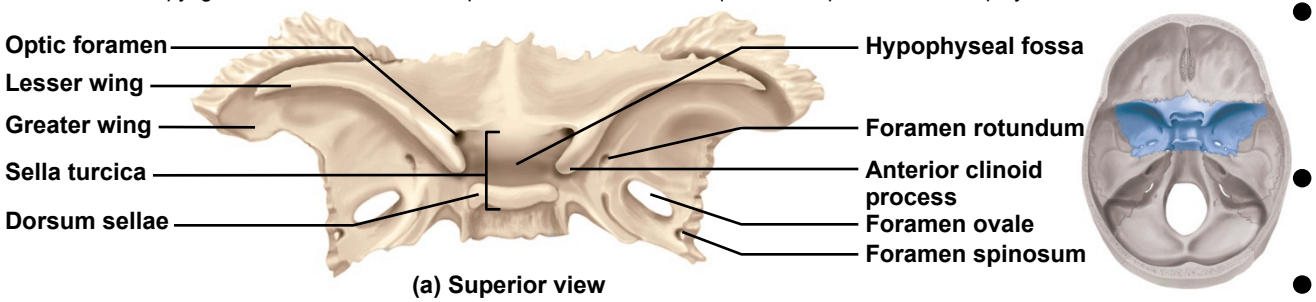
- body
- greater wing
- lesser wing
- optic foramen
- anterior clinoid processes
- superior orbital fissure



(b) Superior view of cranial floor

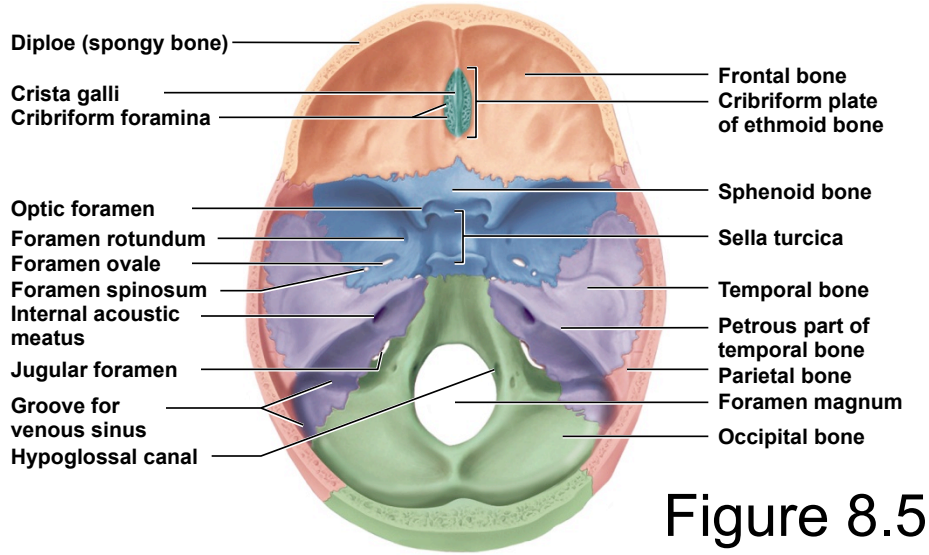
Figure 8.5b

Sphenoid Bone



(a) Superior view

Figure 8.11a

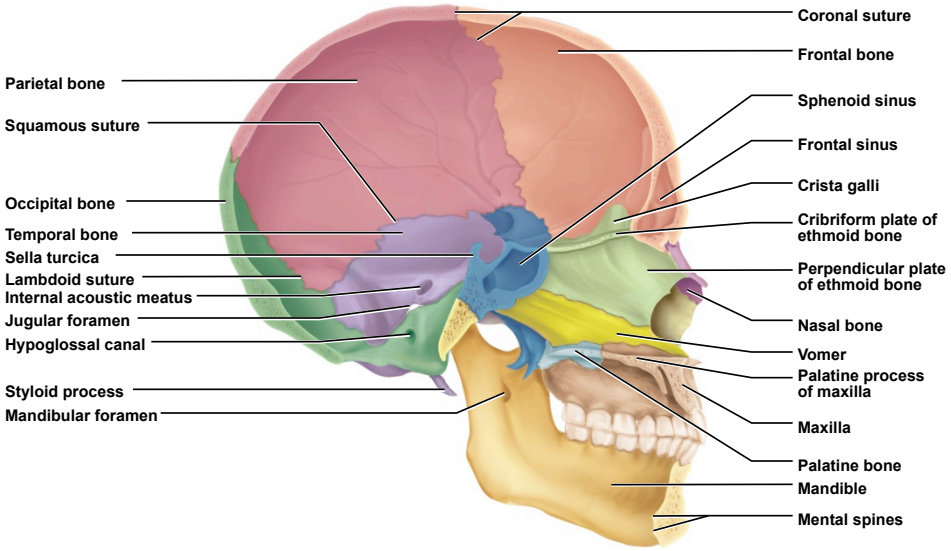


(b) Superior view of cranial floor

Figure 8.5b

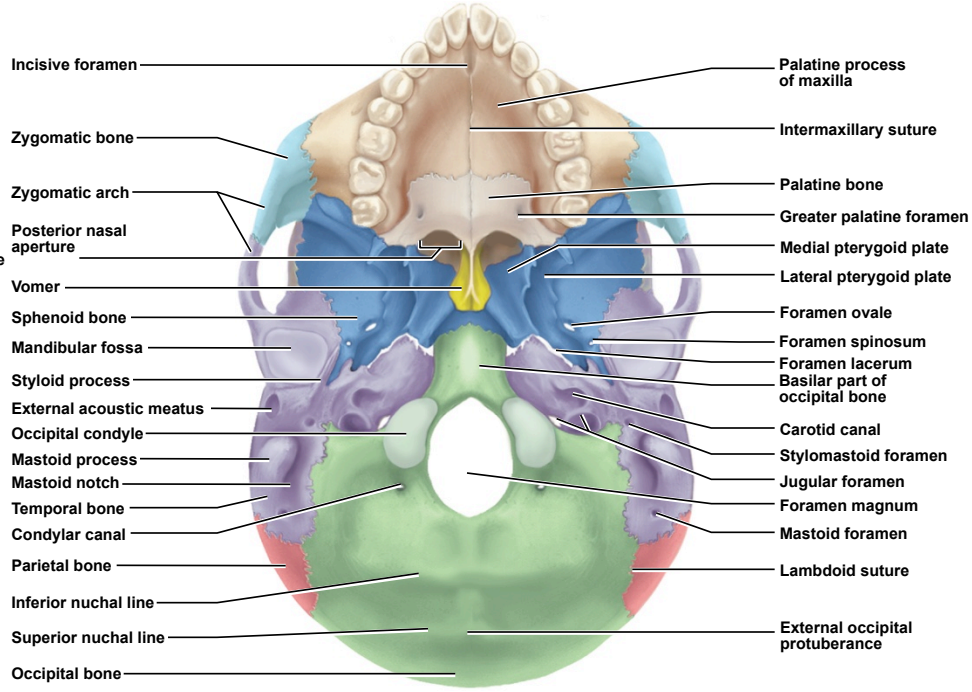
- **foramen rotundum**
- **foramen ovale**
- **foramen lacerum**
- **posterior nasal apertures** or **choanae**
- **medial pterygoid plate**
- **lateral pterygoid plate**
- **sphenoid sinus**

Sphenoid Bone



(b) Median section

Figure 8.4b



(a) Inferior view

Figure 8.5a

sphenoid sinus

Ethmoid Bone

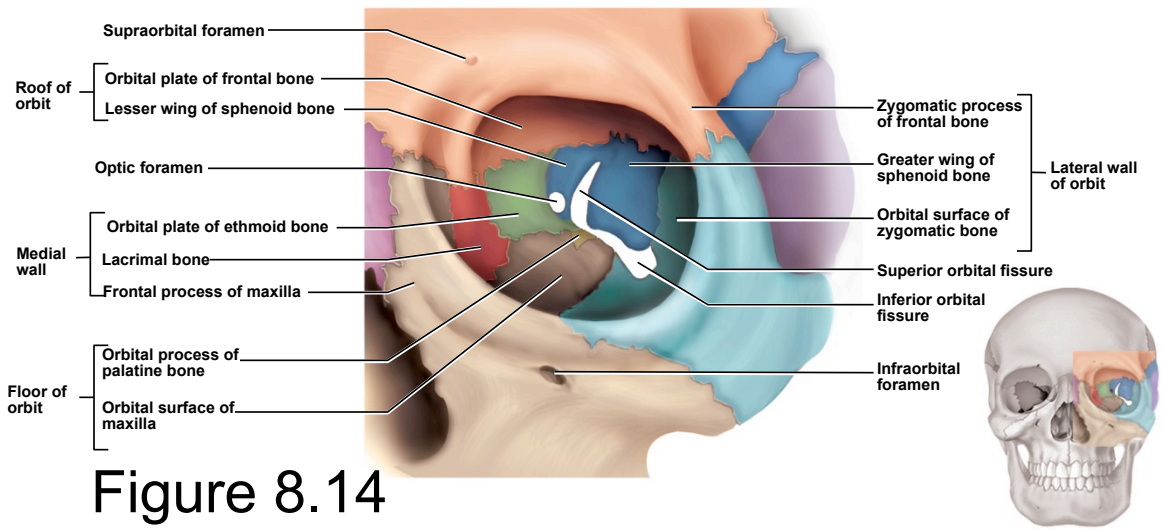


Figure 8.14

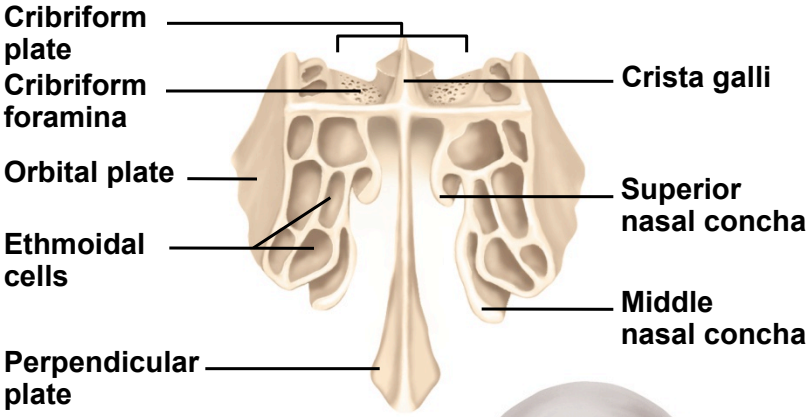


Figure 8.12

- between the eyes
- contributes to medial wall of orbit
- lateral walls and roof of nasal cavity, and nasal septum
- **three major portions** of this porous, delicate bone
- **perpendicular plate** forms superior two-thirds of nasal septum
- **cribriform plate** – forms roof of nasal cavity
  - **crista galli** – attachment point for meninges
  - **cribriform (olfactory) foramina**
- **labyrinth –** large mass on each side of perpendicular plate
  - **ethmoid cells** in the make up ethmoid sinuses
  - **orbital plate**

Ethmoid Bone

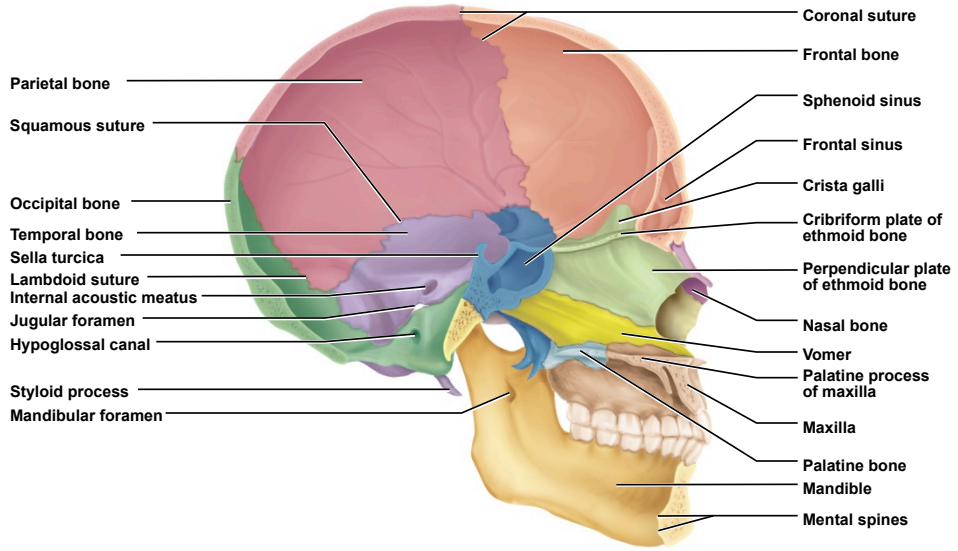


Figure 8.4b

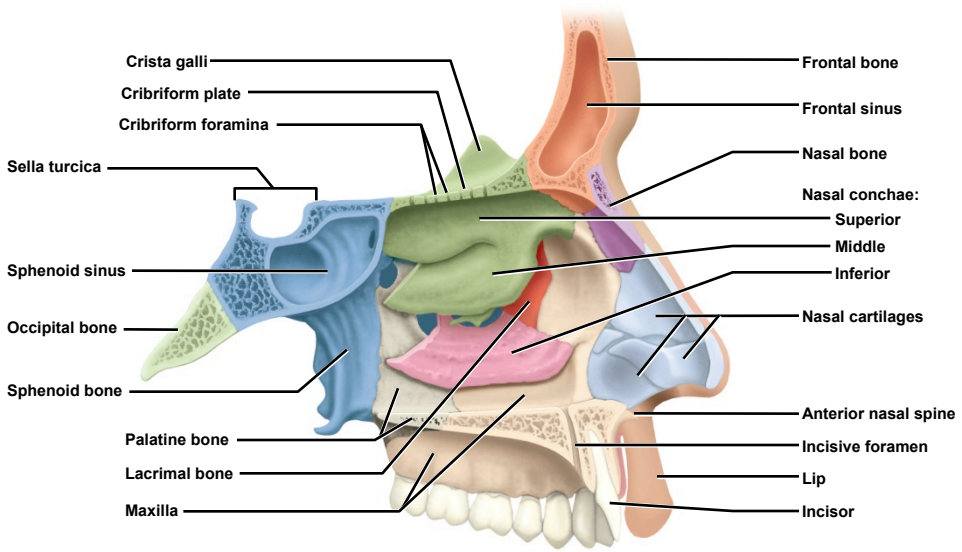
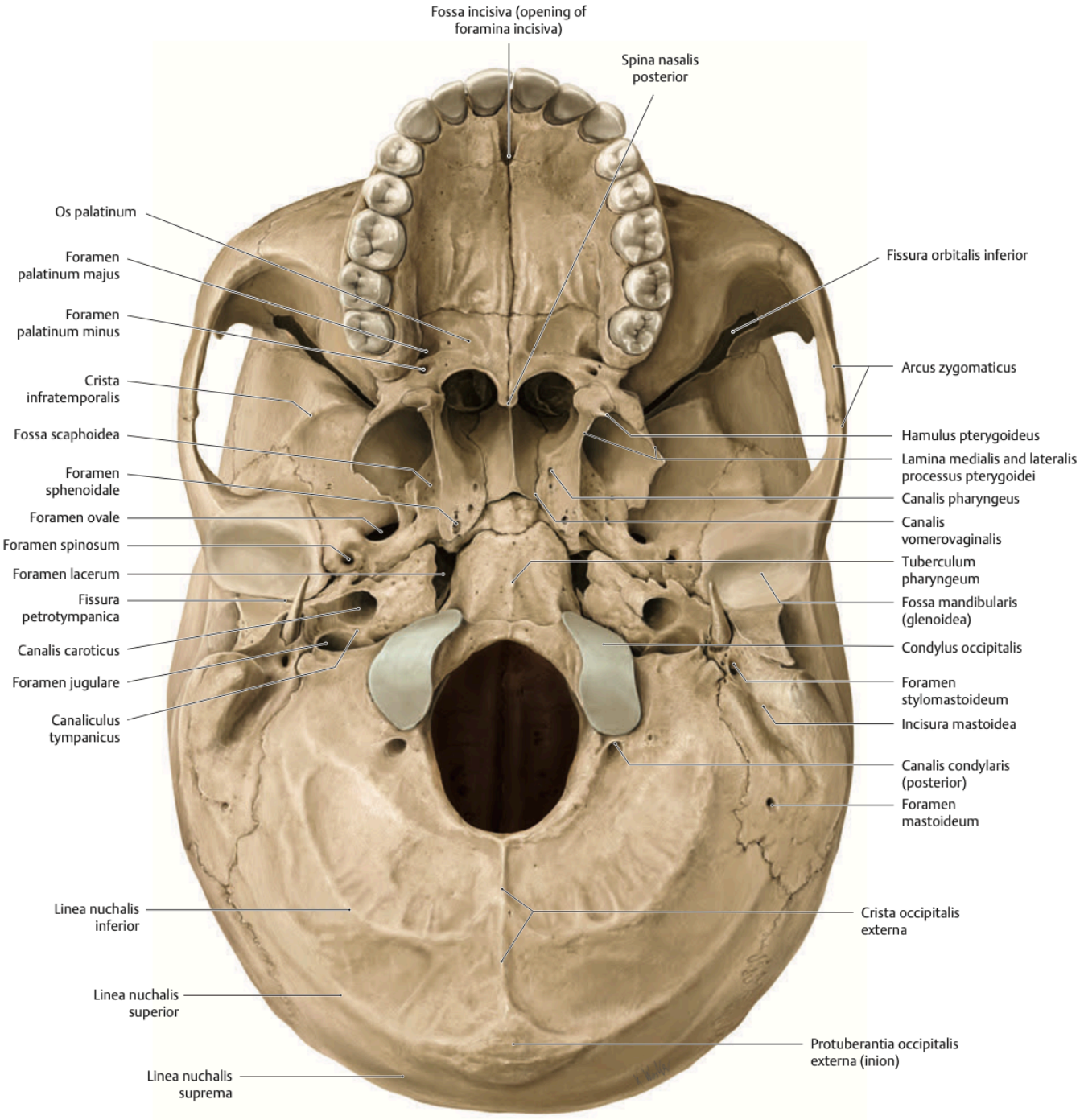
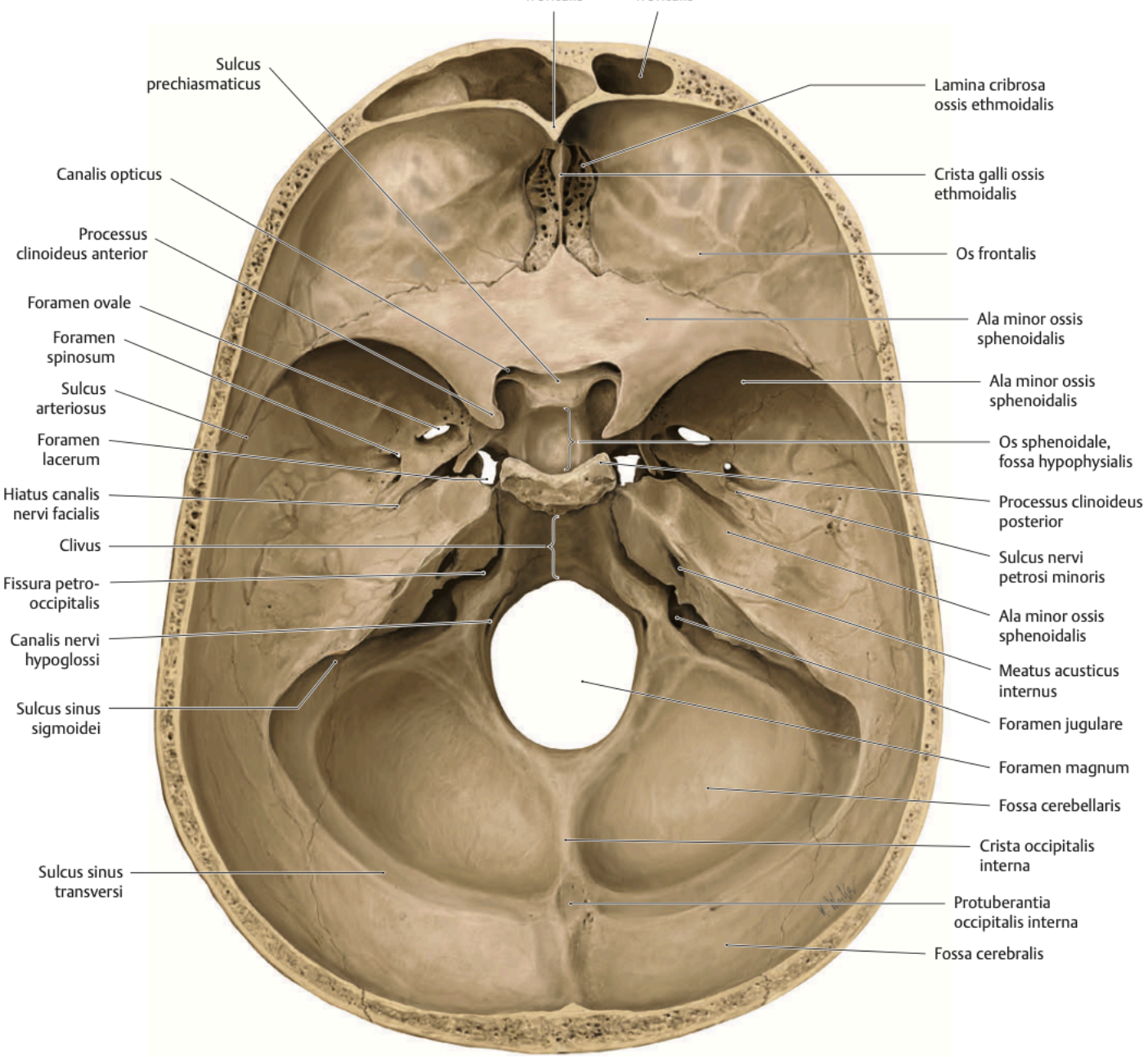


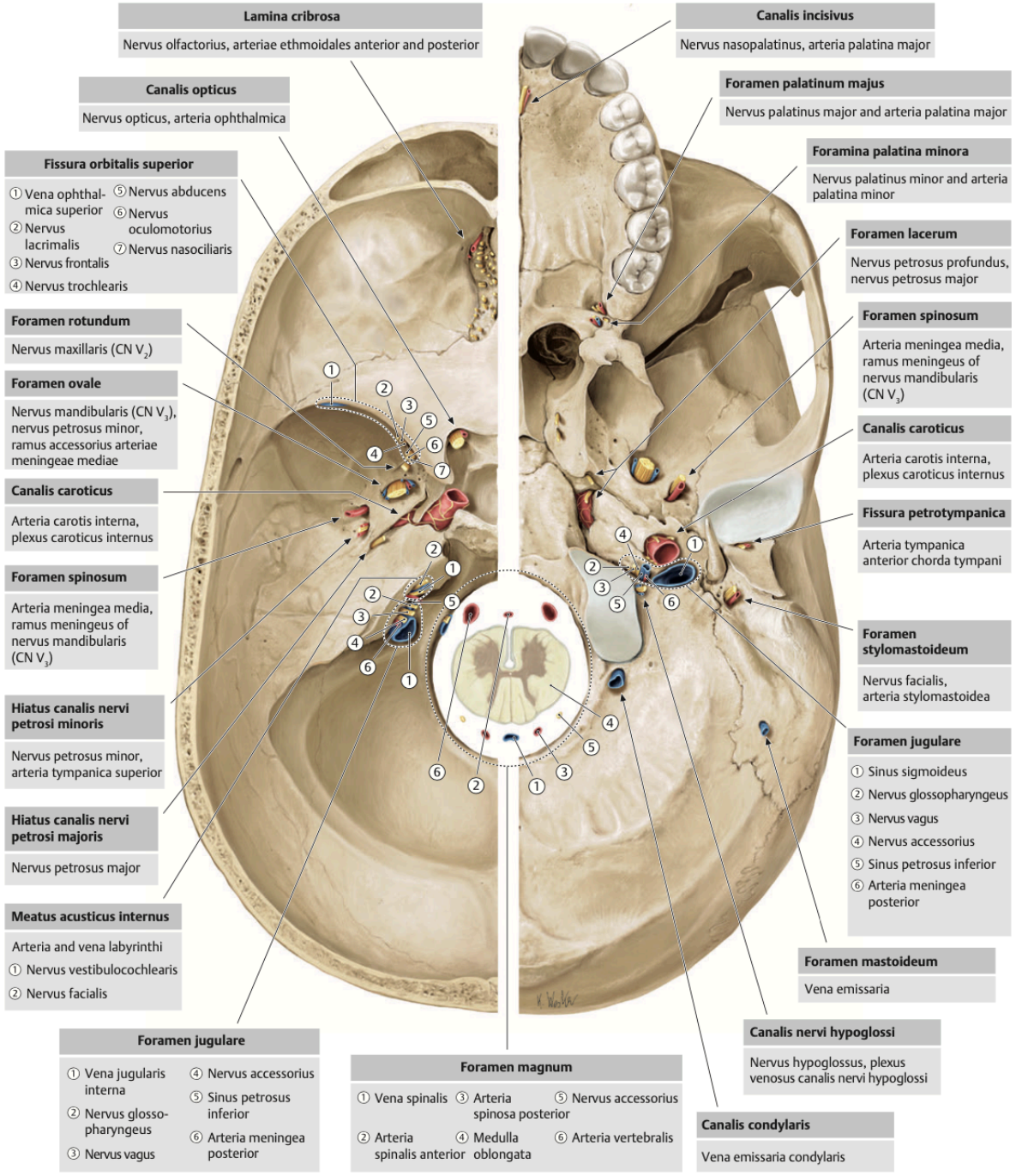
Figure 8.13

superior and middle concha

perpendicular plate of nasal septum


Fossa incisiva (opening of foramina incisiva)
Spina nasalis posterior
Os palatinum
Foramen palatinum majus
Foramen palatinum minus
Crista infratemporalis
Fossa scaphoidea
Foramen sphenoidale
Foramen ovale
Foramen spinosum
Foramen lacerum
Fissura petrotympanica
Canalis caroticus
Foramen jugulare
Canaliculus tympanicus
Fissura orbitalis inferior
Arcus zygomaticus
Hamulus pterygoideus
Lamina medialis and lateralis processus pterygoidei
Canalis pharyngeus
Canalis vomerovaginalis
Tuberculum pharyngeum
Fossa mandibularis (glenoidea)
Condylus occipitalis
Foramen stylomastoideum
Incisura mastoidea
Canalis condylaris (posterior)
Foramen mastoideum
Linea nuchalis inferior
Crista occipitalis externa
Linea nuchalis superior
Protuberantia occipitalis externa (inion)
Linea nuchalis suprema


Sulcus prechiasmaticus
Canalis opticus
Processus clinoideus anterior
Foramen ovale
Foramen spinosum
Sulcus arteriosus
Foramen lacerum
Hiatus canalis nervi facialis
Clivus
Fissura petro-occipitalis
Canalis nervi hypoglossi
Sulcus sinus sigmoidei
Sulcus sinus transversi
Lamina cribrosa ossis ethmoidalis
Crista galli ossis ethmoidalis
Os frontalis
Ala minor ossis sphenoidalis
Ala minor ossis sphenoidalis
Os sphenoidale, fossa hypophysialis
Processus clinoideus posterior
Sulcus nervi petrosi minoris
Ala minor ossis sphenoidalis
Meatus acusticus internus
Foramen jugulare
Foramen magnum
Fossa cerebellaris
Crista occipitalis interna
Protuberantia occipitalis interna
Fossa cerebralis


Lamina cribrosa
Nervus olfactorius, arteriae ethmoidales anterior and posterior
Canalis opticus
Nervus opticus, arteria ophthalmica
Fissura orbitalis superior
① Vena ophthalmica superior
② Nervus lacrimalis
③ Nervus frontalis
④ Nervus trochlearis
⑤ Nervus abducens
⑥ Nervus oculomotorius
⑦ Nervus nasociliaris
Foramen rotundum
Nervus maxillaris (CN V2)
Foramen ovale
Nervus mandibularis (CN V3), nervus petrosus minor, ramus accessorius arteriae meningeae mediae
Canalis caroticus
Arteria carotis interna, plexus caroticus internus
Foramen spinosum
Arteria meningea media, ramus meningeus of nervus mandibularis (CN V3)
Hiatus canalis nervi petrosi minoris
Nervus petrosus minor, arteria tympanica superior
Hiatus canalis nervi petrosi majoris
Nervus petrosus major
Meatus acusticus internus
Arteria and vena labyrinthi
① Nervus vestibulocochlearis
② Nervus facialis
Canalis incisivus
Nervus nasopalatinus, arteria palatina major
Foramen palatinum majus
Nervus palatinus major and arteria palatina major
Foramina palatina minora
Nervus palatinus minor and arteria palatina minor
Foramen lacerum
Nervus petrosus profundus, nervus petrosus major
Foramen spinosum
Arteria meningea media, ramus meningeus of nervus mandibularis (CN V3)
Canalis caroticus
Arteria carotis interna, plexus caroticus internus
Fissura petrotympanica
Arteria tympanica anterior chorda tympani
Foramen stylomastoideum
Nervus facialis, arteria stylomastoidea
Foramen jugulare
① Sinus sigmoideus
② Nervus glossopharyngeus
③ Nervus vagus
④ Nervus accessorius
⑤ Sinus petrosus inferior
⑥ Arteria meningea posterior
Foramen mastoideum
Vena emissaria
Canalis nervi hypoglossi
Nervus hypoglossus, plexus venosus canalis nervi hypoglossi
Canalis condylaris
Vena emissaria condylaris
Foramen jugulare
① Vena jugularis interna
② Nervus glossopharyngeus
③ Nervus vagus
④ Nervus accessorius
⑤ Sinus petrosus inferior
⑥ Arteria meningea posterior
Foramen magnum
① Vena spinalis
② Arteria spinalis anterior
③ Arteria spinosa posterior
④ Medulla oblongata
⑤ Nervus accessorius
⑥ Arteria vertebralis

Bony opening	Cranial bone	Nerves and blood vessels
Carotid canal	Temporal bone	Internal carotid artery
Foramen ovale	Sphenoid bone	Mandibular division of trigeminal nerve (cranial nerve V)
Foramen rotundum	Sphenoid bone	Trigeminal nerve (cranial nerve V)
Hypoglossal canal	Occipital bone	Hypoglossal nerve (cranial nerve XII)
Internal acoustic meatus (inner ear canal)	Temporal bone	Facial nerve (cranial nerve VII) Auditory nerve (cranial nerve VIII)
Jugular foramen	Occipital and temporal bones	Internal jugular vein Glossopharyngeal nerve (cranial nerve IX) Vagus nerve (cranial nerve X) Accessory nerve (cranial nerve XI)
Stylomastoid foramen	Temporal bone	Facial nerve (cranial nerve VII)

Facial Bones

- **facial bones** (14)– those that have no direct contact with the brain or meninges
  - support the teeth
  - give shape and individuality to the face
  - form part of the orbital and nasal cavities
  - provide attachments for muscles of facial expression and mastication

2 maxillae
2 palatine bones
2 zygomatic bones
2 lacrimal bones
2 nasal bones
2 inferior nasal conchae
1 vomer
1 mandible

Maxillary Bones

- largest facial bones
- forms upper jaw and meet each other at a median ***intermaxillary suture***
  - **alveolar processes** are bony points between teeth
  - **alveolus** - sockets that hold teeth
- forms inferomedial wall of orbit
  - **infraorbital foramen**
  - **inferior orbital fissure**
- forms most of the hard palate
  - **palatine process**
  - **palate** – forms the roof of the mouth and floor of nasal cavity
  - **incisive foramen**
  - palate allows us to chew while breathing
  - ***cleft palate*** and ***cleft lip***

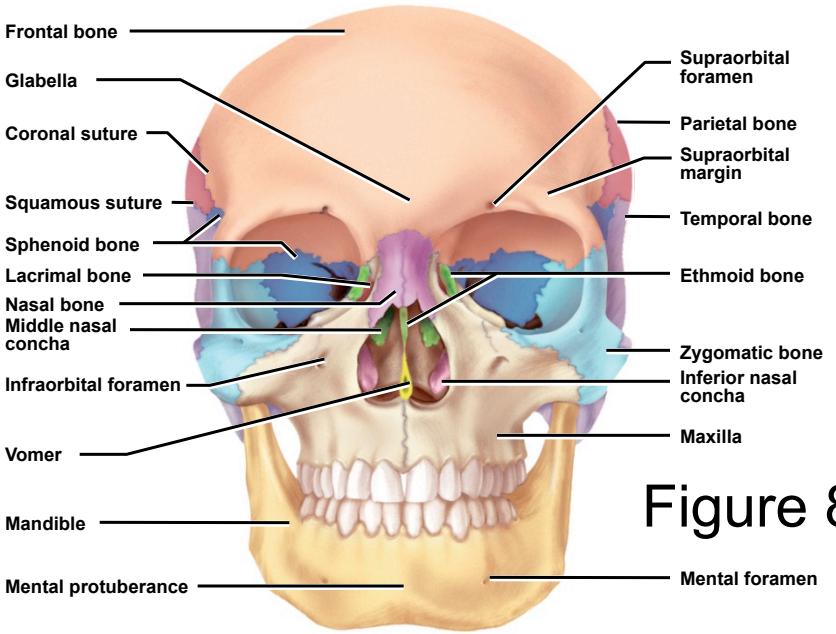


Figure 8.3

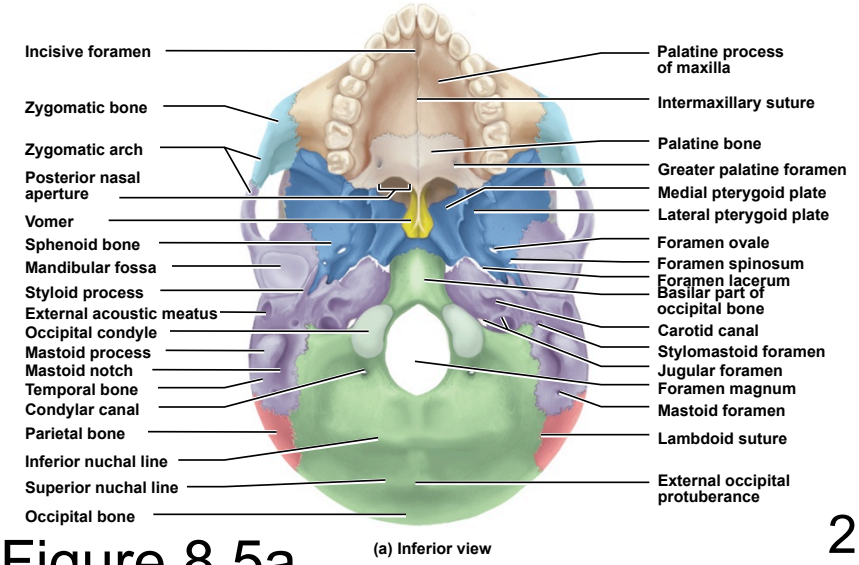


Figure 8.5a

Location of Maxillary Sinus

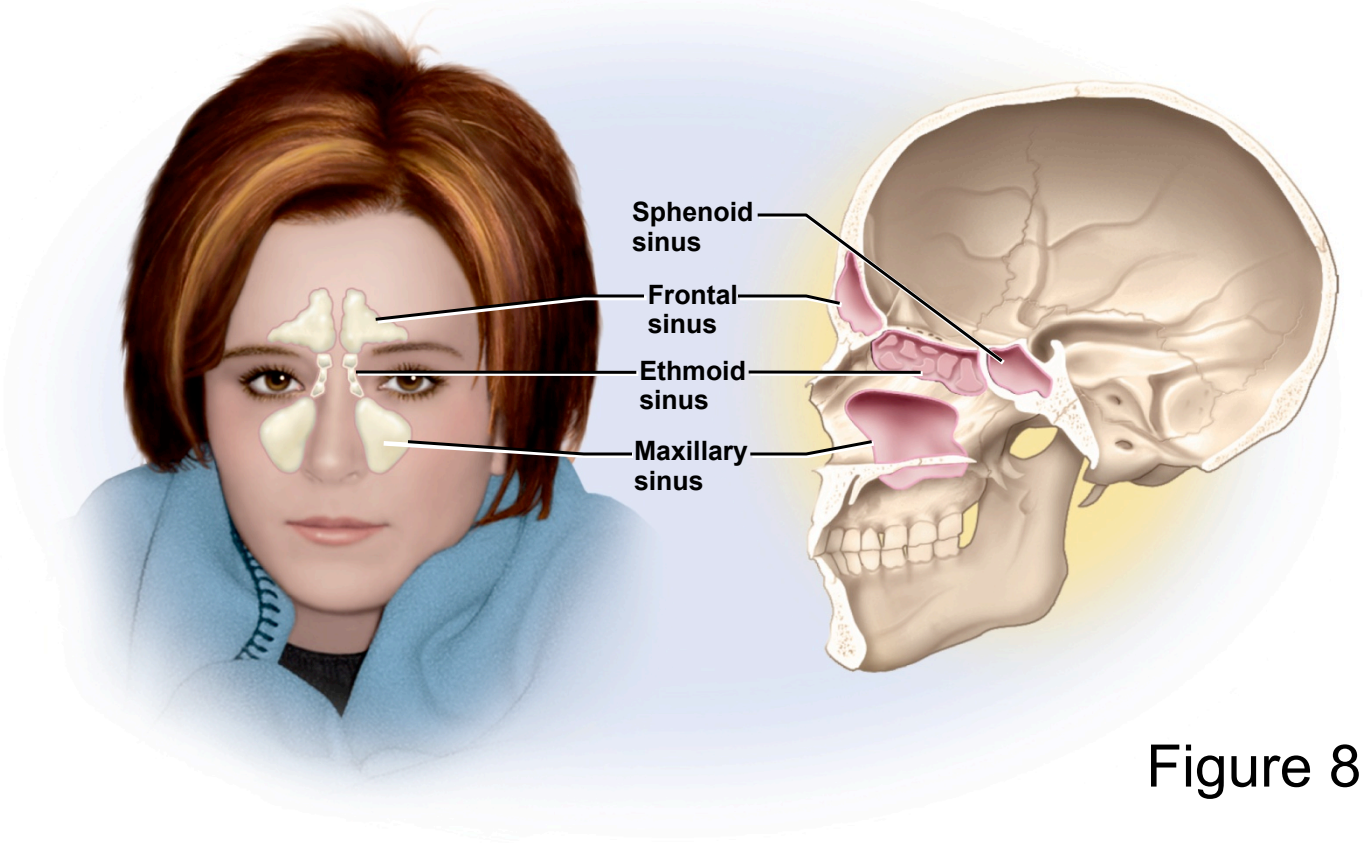


Figure 8.8

- **maxillary sinus** fills maxillae bone
- larger in volume than frontal, sphenoid ethmoid sinuses

Palatine Bones

- L-shaped bone
- form the posterior portion of the hard palate
- part of lateral nasal cavity wall
- part of the orbital floor
- **greater palatine foramina**

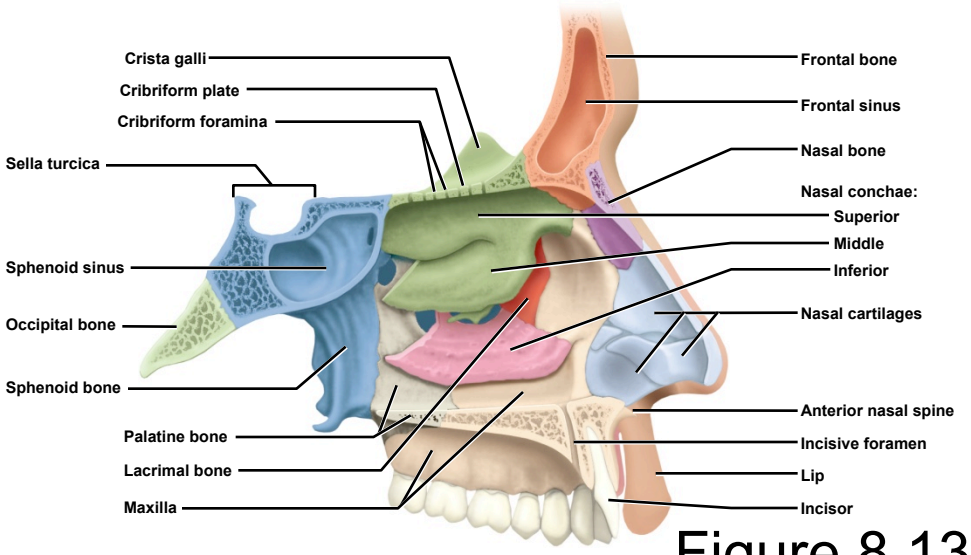


Figure 8.13

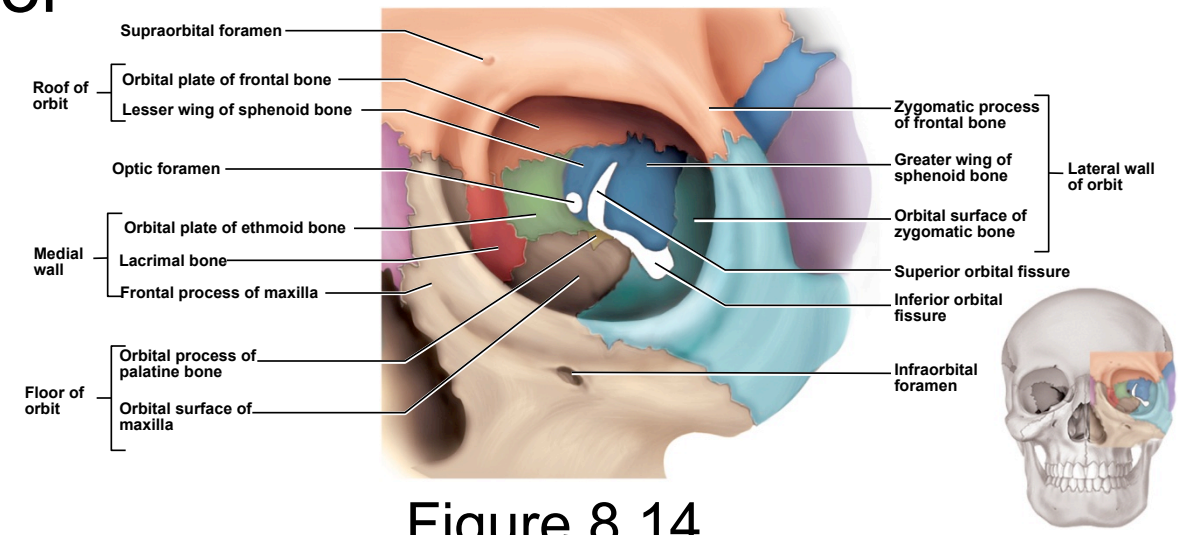


Figure 8.14

Zygomatic Bones

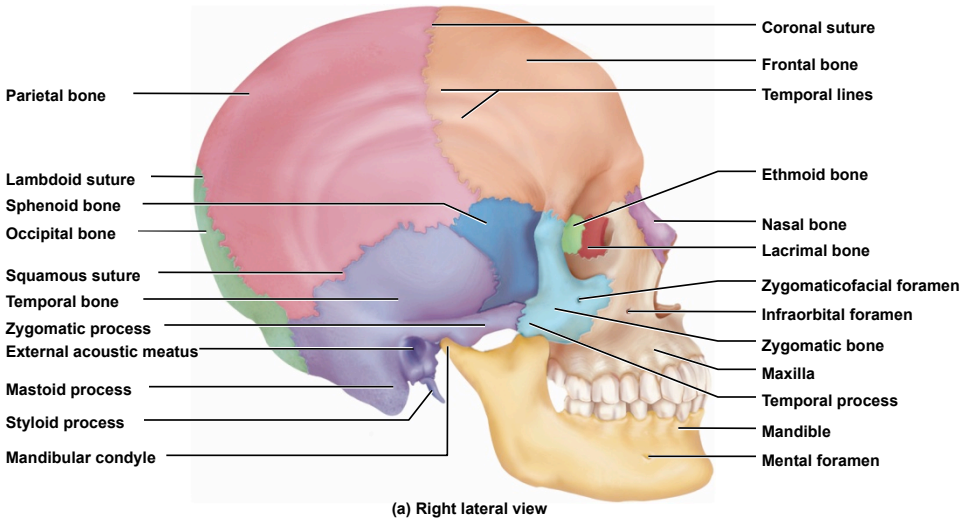


Figure 8.4a

- forms angles of the cheekbones and part of lateral orbital wall
- **zygomaticofacial foramen**
- **zygomatic arch** is formed **from *temporal process of zygomatic bone*** and ***zygomatic process of temporal bone***

Lacrimal Bones

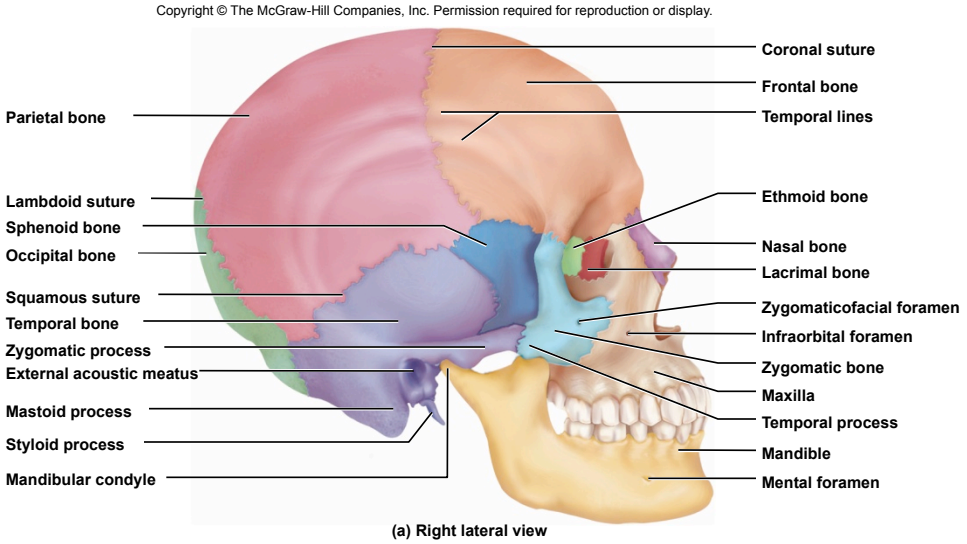


Figure 8.4a

- form part of medial wall of each orbit
- smallest bone of skull
- **lacrimal fossa** houses lacrimal sac in life
  - tears collect in lacrimal sac and drain into nasal cavity

Nasal Bones

- forms bridge of nose
- supports cartilages that shape lower portion of the nose
- often fractured by blow to the nose

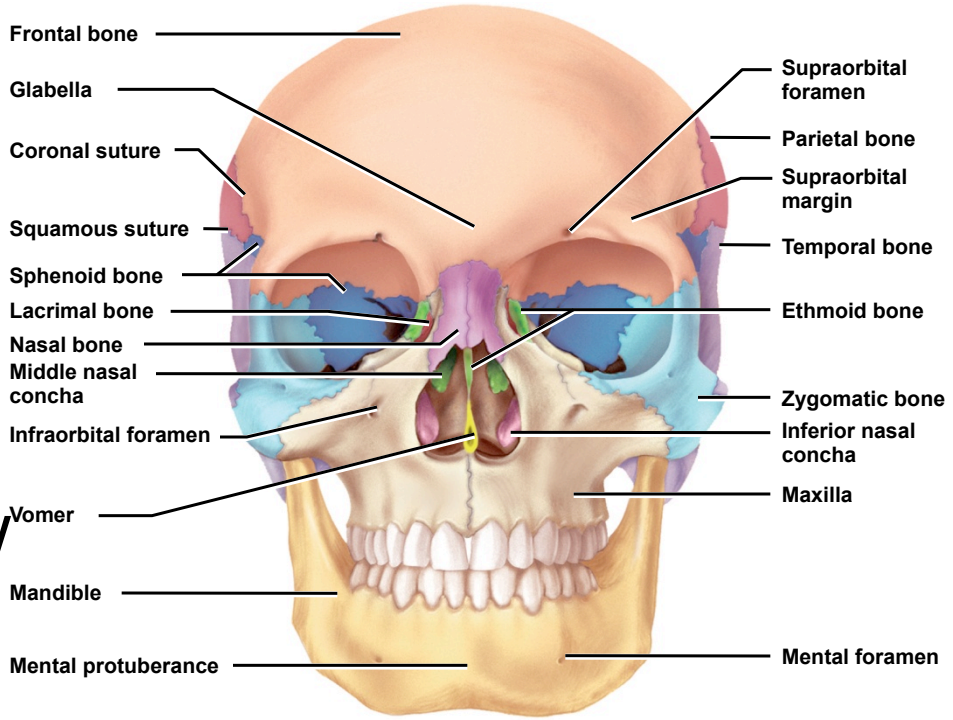


Figure 8.3

Inferior Nasal Conchae

- three conchae in the nasal cavity
  - superior and middle are part of the ethmoid bone
- **inferior nasal concha** is a separate bone
- largest of the three

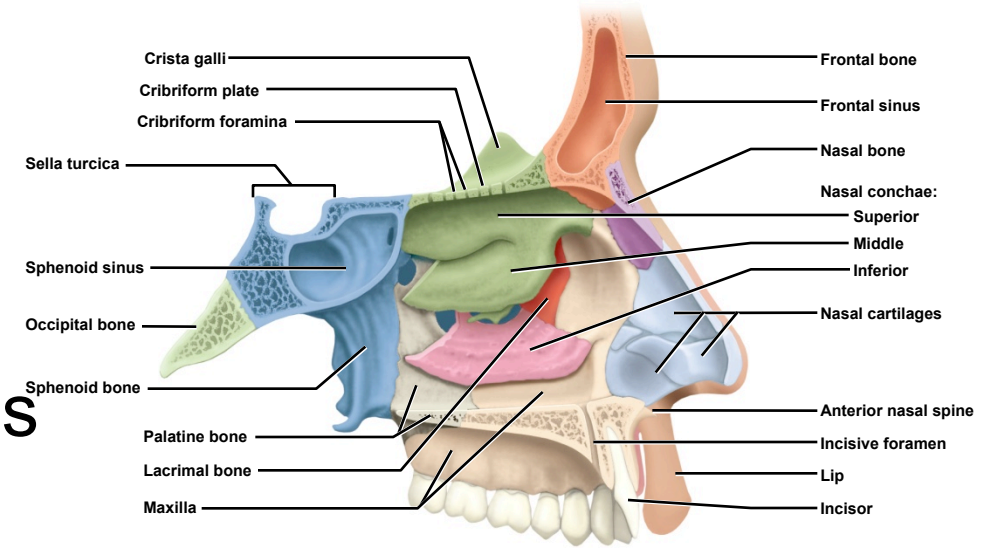


Figure 8.13

Vomer

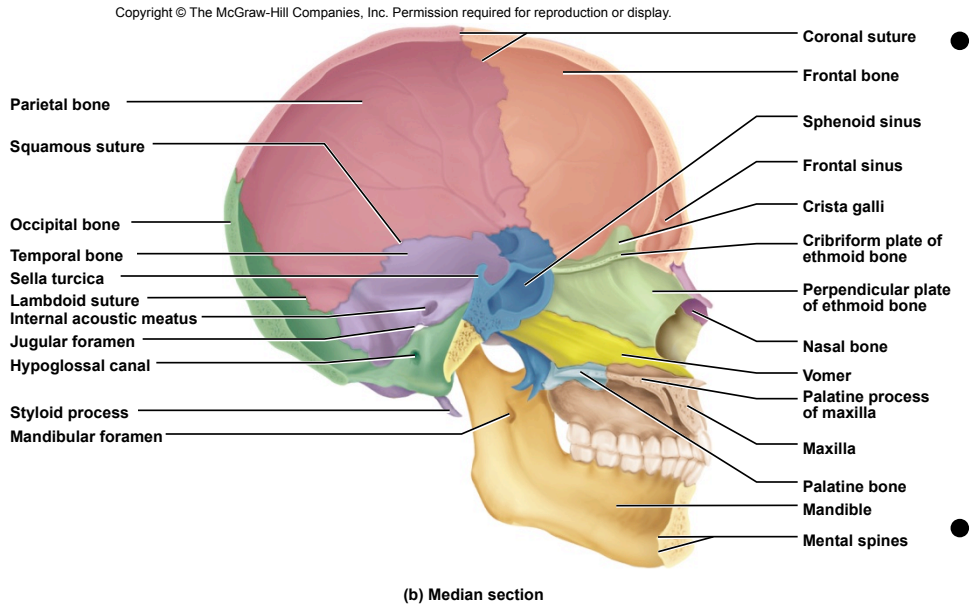


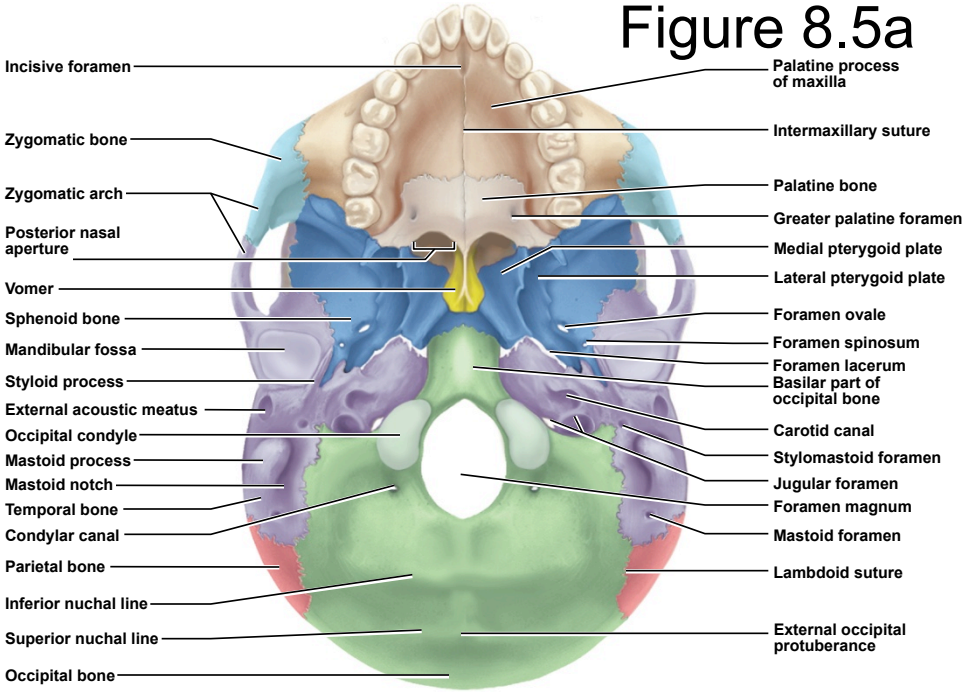
Figure 8.4b

- inferior half of the nasal septum
  - superior half formed by perpendicular plate of ethmoid
- supports cartilage that forms the anterior part of the nasal septum

Mandible

- strongest bone of the skull
- only bone of skull that moves noticeably
- supports lower teeth
- provides attachments for muscles of facial expression and mastication
- **mental symphysis** – median cartilaginous joint in fetus
  - develops as two separate bones in fetus
  - ossifies in early childhood
- **mental protuberance** – point of chin
- two major parts on each side
  - **body** – supports teeth
  - **ramus** – articulates with cranium
    - **angle** – where body and ramus meet
- **alveolar processes** between teeth
- **mental foramen**
- **mental spines**

Figure 8.5a



(a) Inferior view

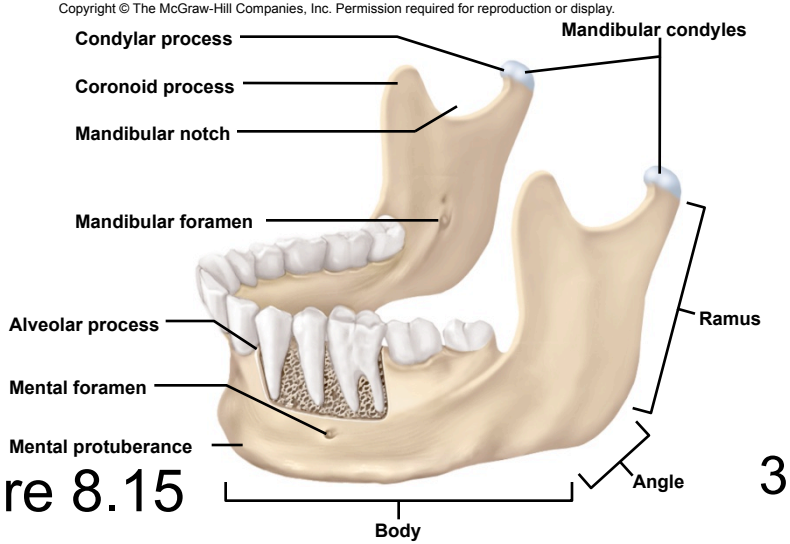


Figure 8.15

Ramus, Angle and Body of Mandible

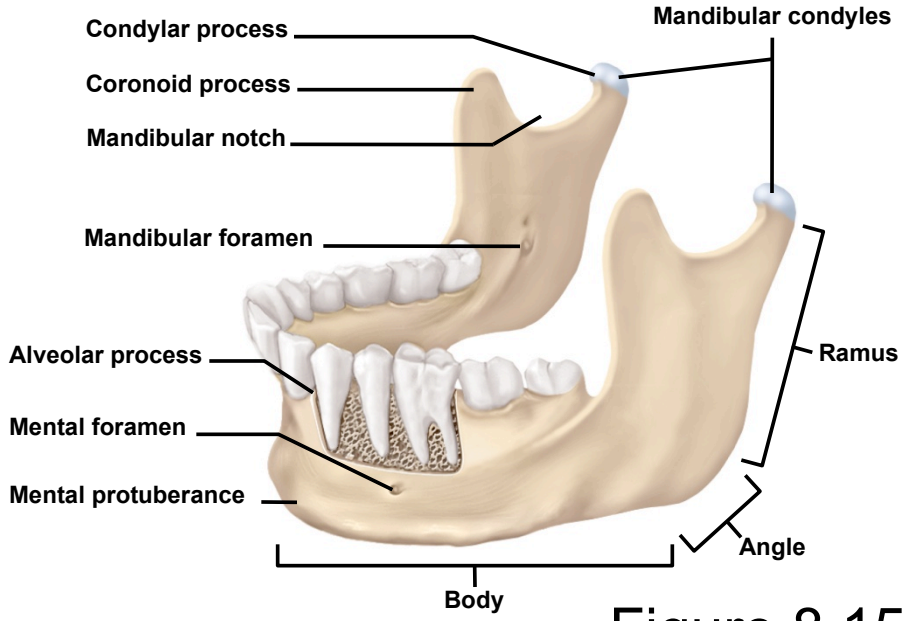


Figure 8.15

- **condylar process** bears the **mandibular condyle –** oval knob that articulates with the mandibular fossa of the temporal bone forming the hinge **temporomandibular joint (TMJ)**
- **coronoid process** – point of insertion of temporalis muscle
- **mandibular notch**
- **mandibular foramen**

Bones Associated With Skull

- **auditory ossicles**
  - three in each middle-ear cavity
  - **malleus**, **incus**, and **stapes**
- **hyoid bone**
  - slender u-shaped bone between the chin and larynx
  - does not articulate with any other bone
  - suspended from styloid process of skull by muscle and ligament
  - **body** and **greater and lesser horns (cornua)**
  - fractured hyoid bone is evidence of strangulation

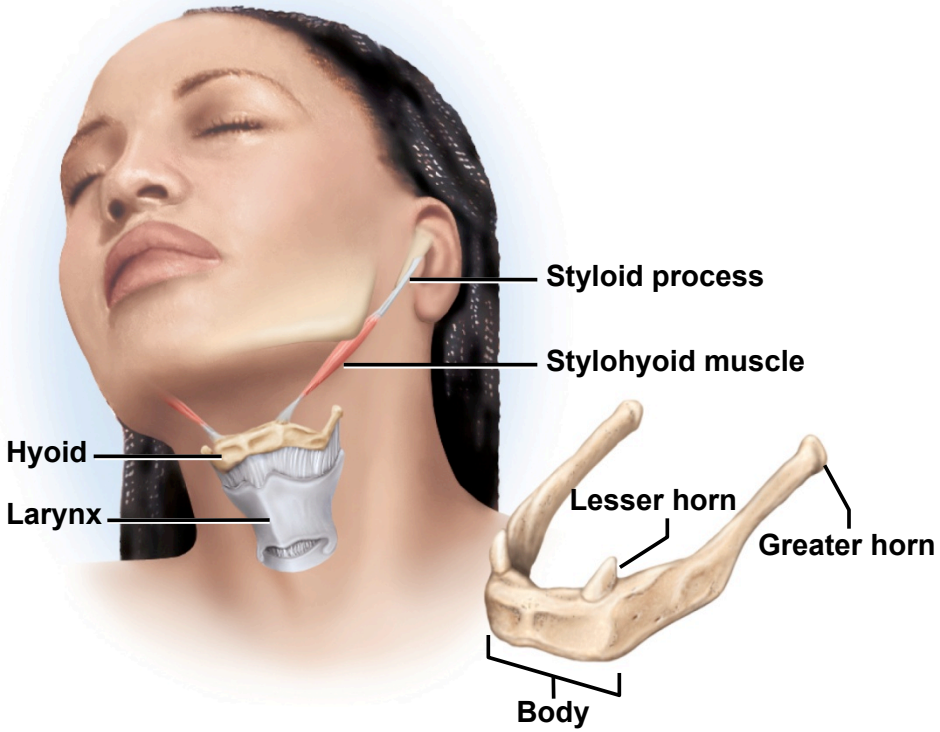


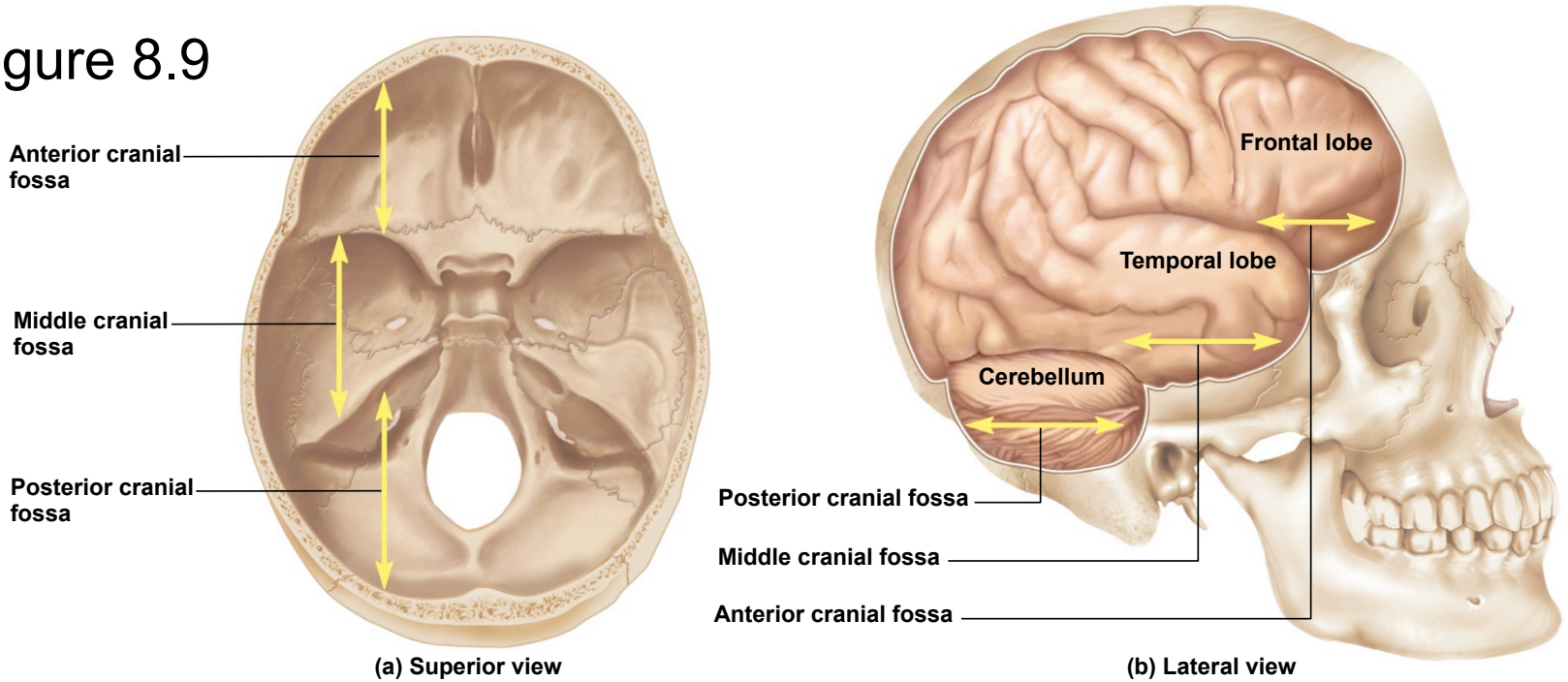
Figure 8.16

Major Skull Cavities

Figure 8.7

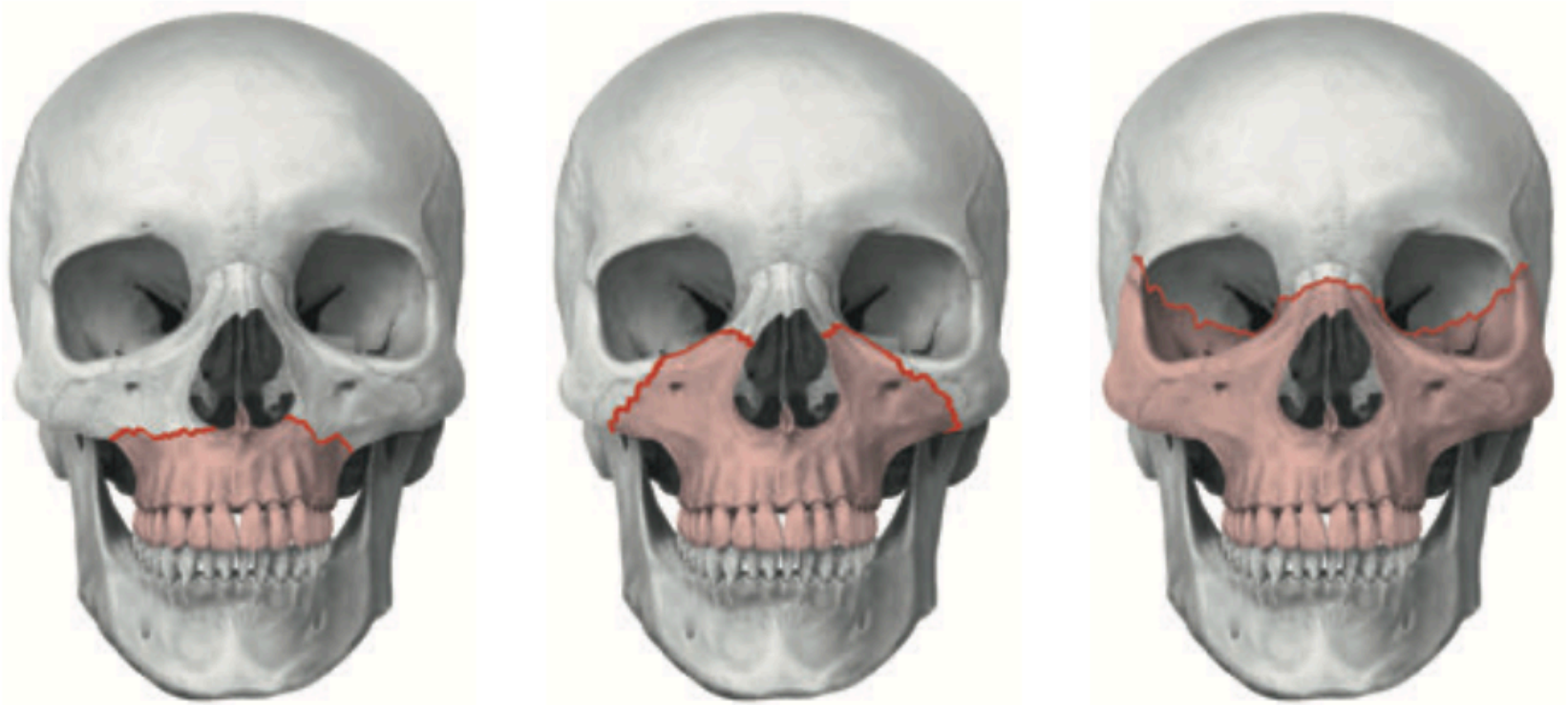
Cranial Fossa

Figure 8.9



- **cranium (braincase)** – protects the brain and associated sense organs
  - swelling of the brain inside the rigid cranium may force tissue through foramen magnum resulting in death
  - consists of two parts: the **calvaria** (skullcap) and the cranial **base**
- **base** is divided into three basins that comprise the cranial floor
  - **anterior cranial fossa** holds the frontal lobe of the brain
  - **middle cranial fossa** holds the temporal lobes of the brain
  - **posterior cranial fossa** contains the cerebellum

Le Fort classification of midfacial fractures



I II III

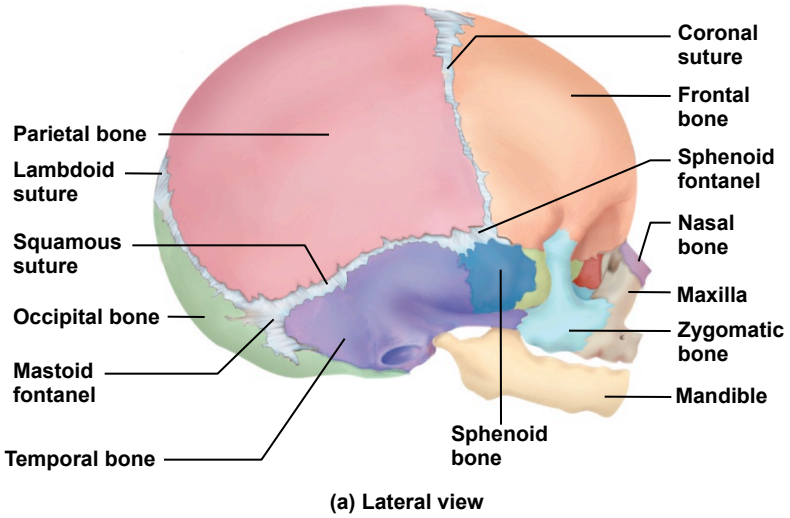
Le Fort classification of midfacial fractures

Le Fort I: This fracture line runs across the maxilla and above the palatum durum. The maxilla is separated from the upper facial skeleton, disrupting the integrity of the sinus maxillaris (*low transverse fracture*).

Le Fort II: The fracture line passes across the sinus maxillaris, os ethmo- idale, maxilla, and os zygomaticum, creating a *pyramid fracture* that disrupts the integrity of the orbita.

Le Fort III: The facial skeleton is separated from the base of the skull. The main fracture line passes through the orbitae, and the fracture may additionally involve the ossa ethmoidalia, sinus frontales, sinus sphenoi- dales, and ossa zygomatica.

Skull in Infancy and Childhood



- **fontanels** - spaces between unfused bones
  - filled with fibrous membrane
  - allow shifting of bones during birth and growth of brain
  - **anterior**, **posterior**, **sphenoid** (anterolateral), and **mastoid** (posterolateral **fontanels**
- two frontal bones fuse by age 6 (**metopic suture**)
- skull reaches adult size by 8 or 9 years of age

Figure 8.17

The Vertebral Column (Spine)

- **functions**
  - supports the skull and trunk
  - allows for their movement
  - protects the spinal cord
  - absorbs stress of walking, running, and lifting
  - provides attachments for limbs thoracic cage, and postural muscles

- **33 vertebrae with intervertebral discs** of **fibrocartilage** between most of them

- adult vertebral column averages 71 cm. (28 in.) long
  - intervertebral discs account for about one-quarter of its length
  - person is 1% shorter when they go to bed
  - compression squeezes water out during the day and absorbs water when compression removed during sleep

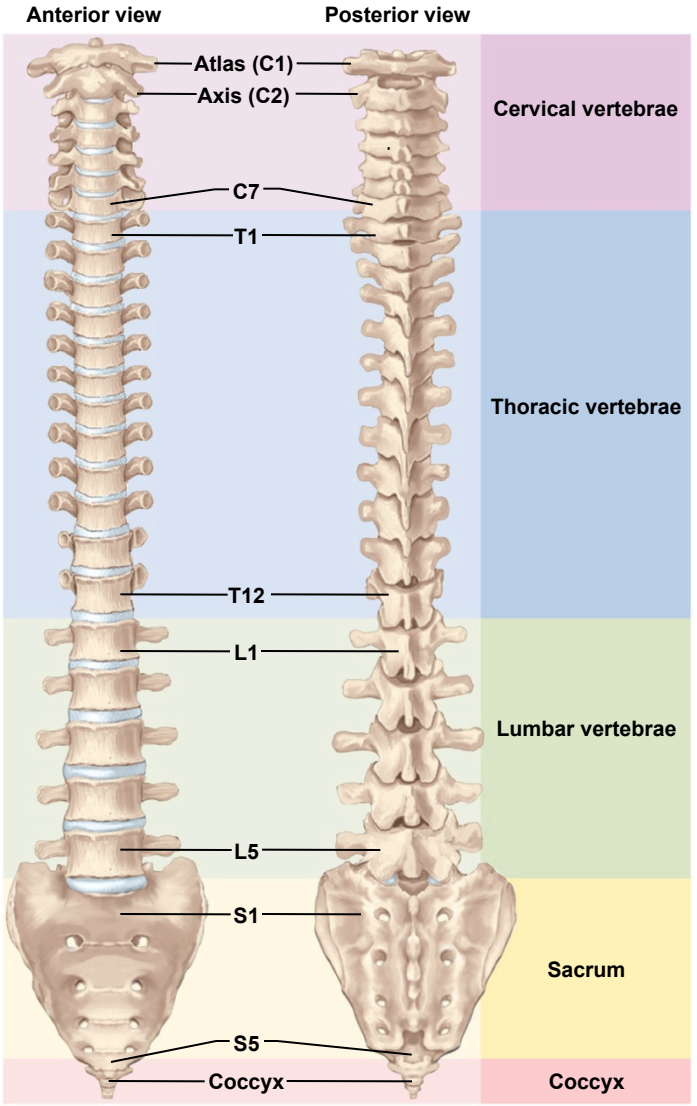


Figure 8.18

The Vertebral Column (Spine)

- five vertebral groups
  - **7 cervical** in the neck
  - **12 thoracic** in the chest
  - **5 lumbar** in lower back
  - **5 fused sacral** at base of spine
  - **4 fused** coccygeal
- variations in number of lumbar and sacral vertebrae occur in 1 in 20 people

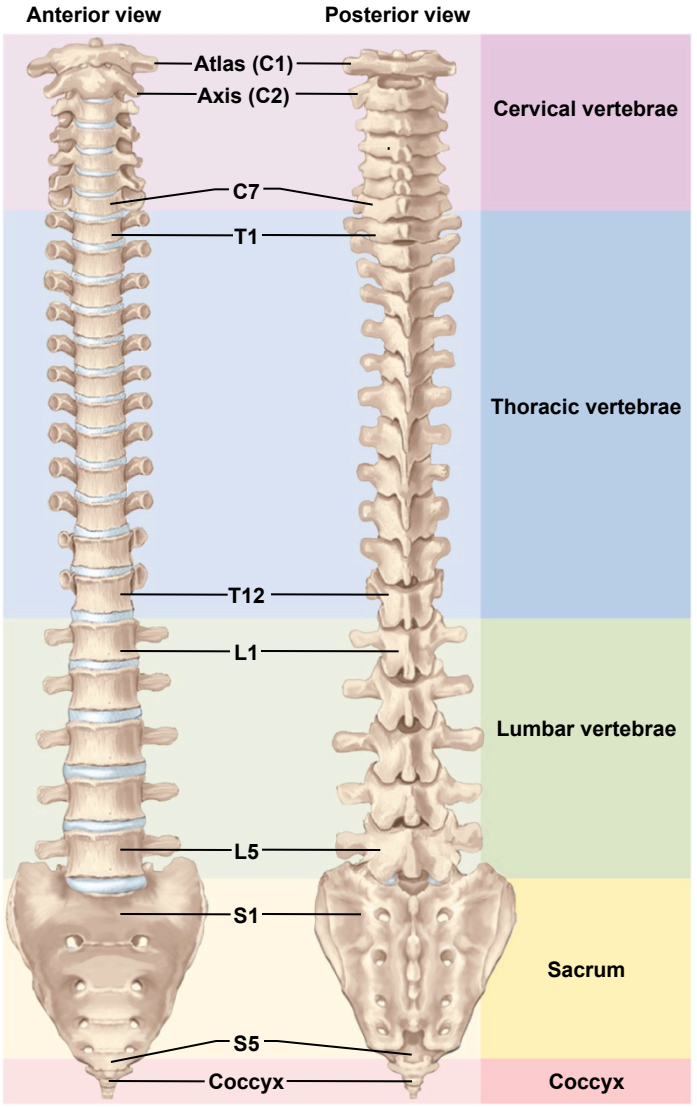


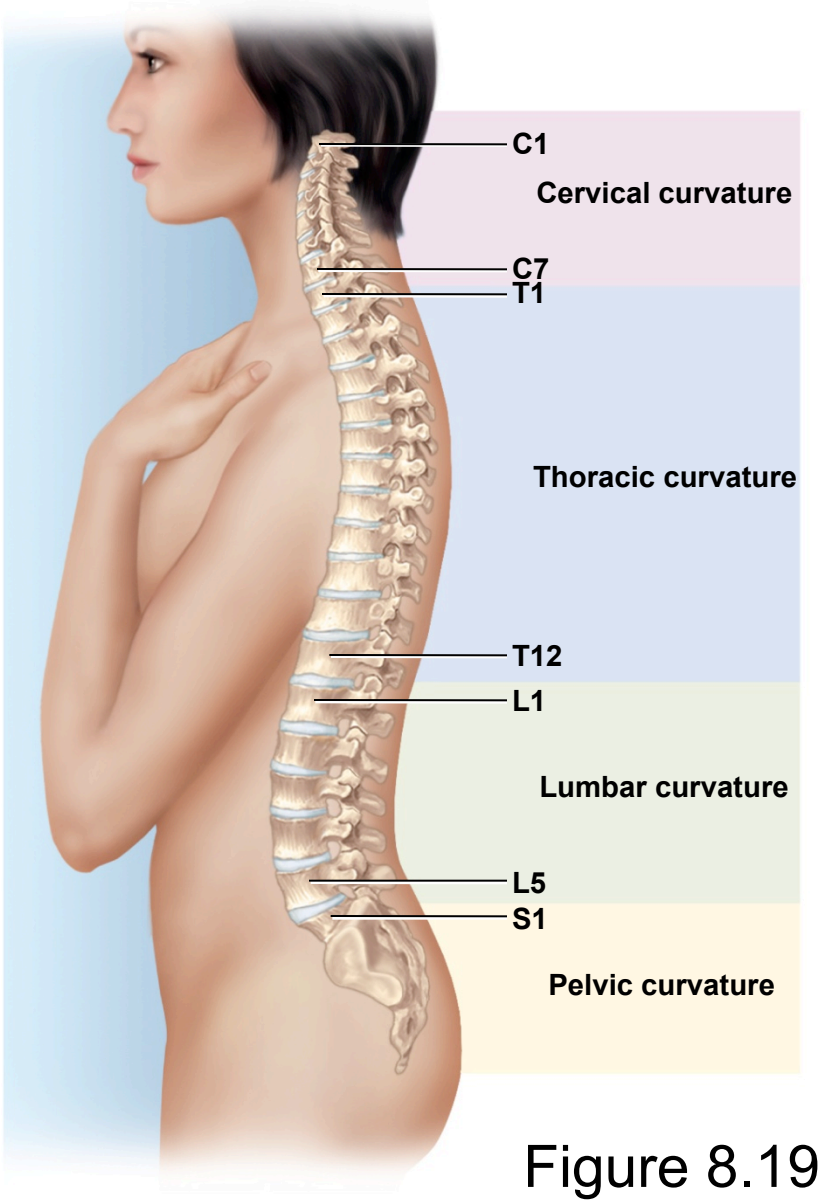
Figure 8.18

Newborn Spinal Curvature

- spine exhibits one continuous C-shaped curve at birth
- known as primary curvature

Figure 8.20

Adult Spinal Curvatures



- s-shaped vertebral column with **four normal curvatures**
  - **cervical**
  - **thoracic**
  - **lumbar**
  - **pelvic**
- **primary curvatures** – present at birth
  - **thoracic and pelvic**
- **secondary curvatures** – develop later
  - **cervical and lumbar**
  - lifting head as it begins to crawl develops cervical curvature
  - walking upright develops lumbar curvature

Figure 8.19

Abnormal Spinal Curvatures

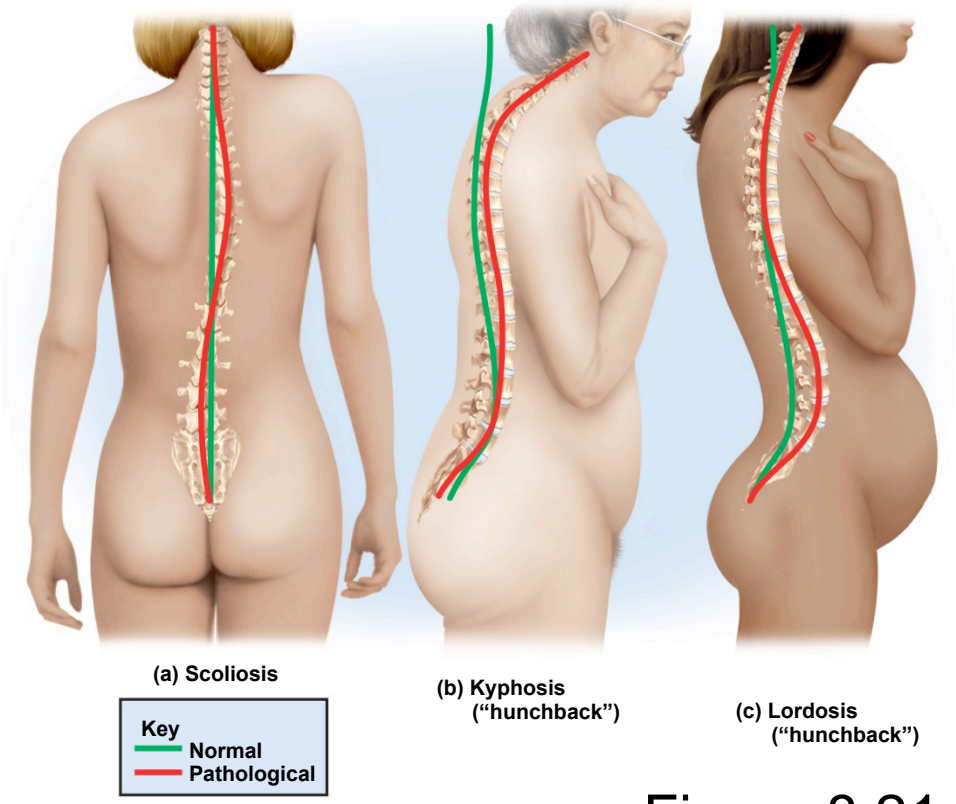


Figure 8.21

- from disease, paralysis of trunk muscles, poor posture, pregnancy, or congenital defect

- **scoliosis** – abnormal lateral curvature
  - most common
  - usually in thoracic region
  - particularly of adolescent girls
  - developmental abnormality in which the body and arch fail to develop on one side of the vertebrae

- **kyphosis** (hunchback) – exaggerated thoracic curvature
  - usually from osteoporosis, also osteomalacia or spinal tuberculosis, or wrestling or weightlifting in young boys

- **lordosis** (swayback) – exaggerated lumbar curvature
  - is from pregnancy or obesity

General Structure of Vertebra

- **body** (centrum)
  - mass of spongy bone that contains red bone marrow
  - covered with thin shell of compact bone
  - weight bearing portion
  - rough superior and inferior surfaces provide firm attachment for intervertebral discs
- **vertebral foramina**
  - collectively form **vertebral canal** for spinal cord
- **vertebral arch**
  - composed of two parts on each side
  - **pedicle** – pillarlike and **lamina** - platelike
- **spinous process**
  - projection extending from the apex of arch
  - extends posteriorly and downward
- **transverse process**
  - extends laterally from point where pedicel and lamina meet
- **superior articular processes**
  - project upward from one vertebra and meets **inferior articular processes** from the vertebra above
- **facets**
  - flat articular surfaces covered with hyaline cartilage

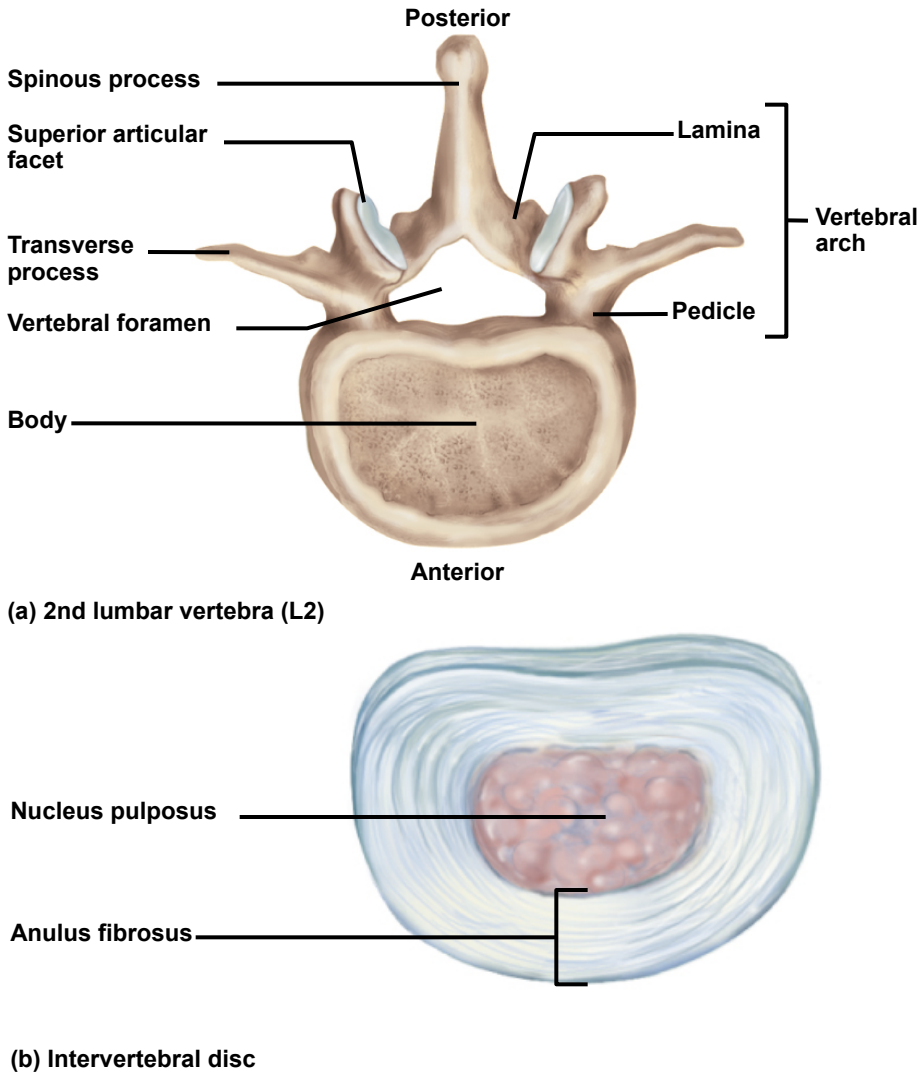
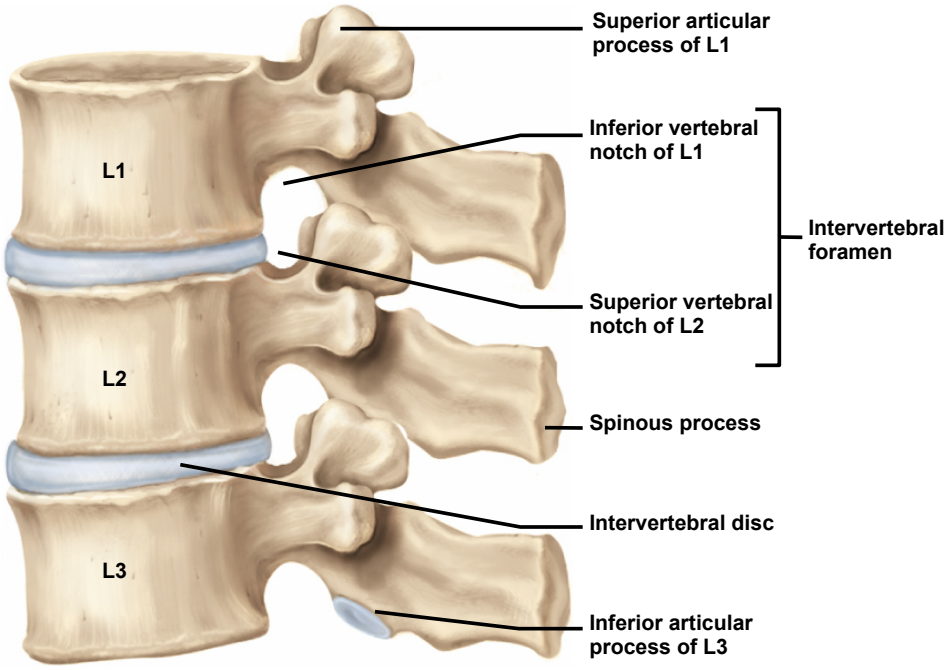


Figure 8.22

Intervertebral Foramen and Discs



(b) Left lateral view

Figure 8.23b

- **intervertebral foramen**
  - when two vertebrae are joined they exhibit and opening between their pedicles
  - passageway for spinal nerves
  - **inferior vertebral notch** in the pedicle of the upper vertebra
  - **superior vertebral notch** in the pedicle of the lower vertebra
- **intervertebral discs (23)**
  - first one between C2 and C3
  - last one between L5 and sacrum
  - pad consisting of:
    - **nucleus pulposus** - inner gelatinous mass
    - **anulus fibrosus** – outer ring of fibrocartilage
  - bind vertebrae together
  - support weight of the body
  - absorb shock
  - **herniated disc** (‘ruptured’ or ‘slipped’ disc) puts painful pressure on spinal nerve or spinal cord

Cervical Vertebra C1 - Atlas

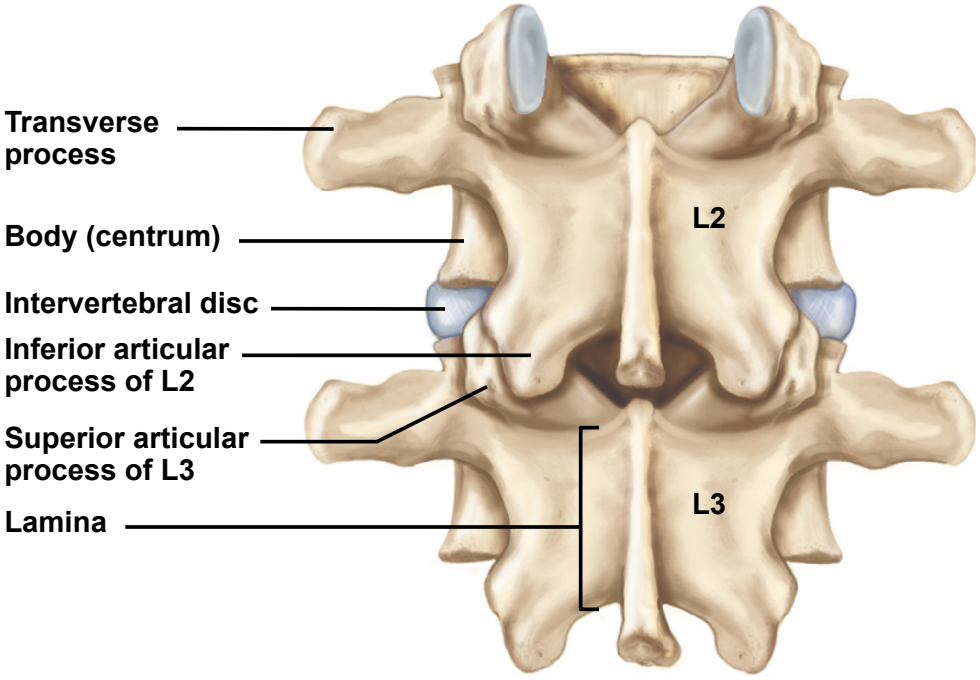


Figure 8.23a (a) Posterior (dorsal) view

- **atlas (C1)**
  - supports the head
  - has **no body**
  - a delicate ring surrounding a large vertebral foramen
  - **lateral masses** with **superior articular facets**
    - articulates with occipital condyles
    - allows nodding motion of skull gesturing ‘yes’
  - **inferior articular facets** articulate with C2
  - **anterior and posterior arches**
  - **anterior and posterior tubercles**

Cervical Vertebra C2 - Axis

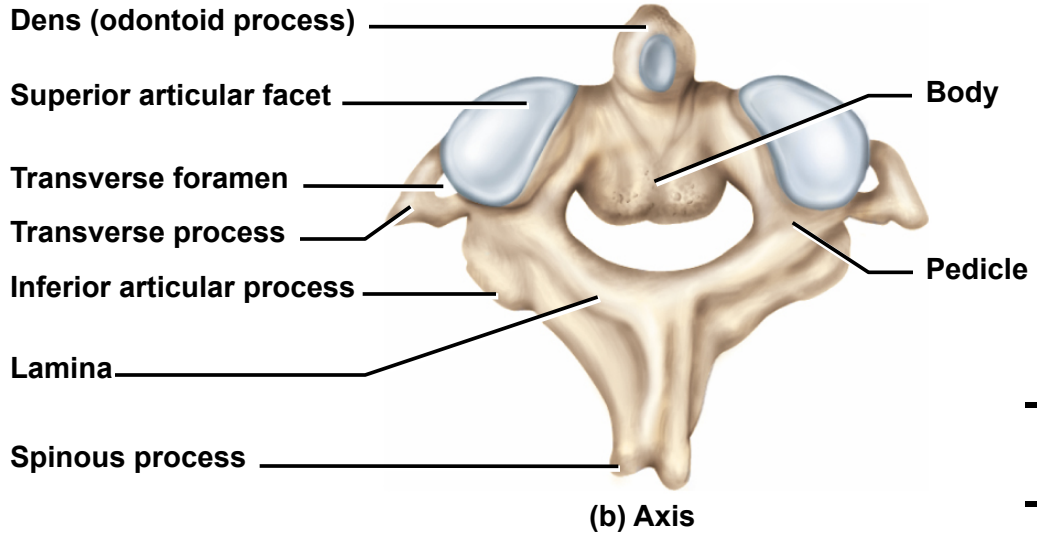


Figure 8.24b

- **axis (C2)**
  - allows rotation of the head gesturing 'no'
  - **dens** or **odontoid process** – prominent knob on its anterosuperior side
    - forms as an independent ossification center during first year of life
    - fuses with axis by age 3 to 6 years
    - projects into **vertebral foramen** of the atlas
    - held in place by a **transverse ligament**
  - **atlanto-occipital joint** – joint between atlas and cranium
  - **atlantoaxial joint** – joint between the atlas and axis

Atlas and Axis Articulation

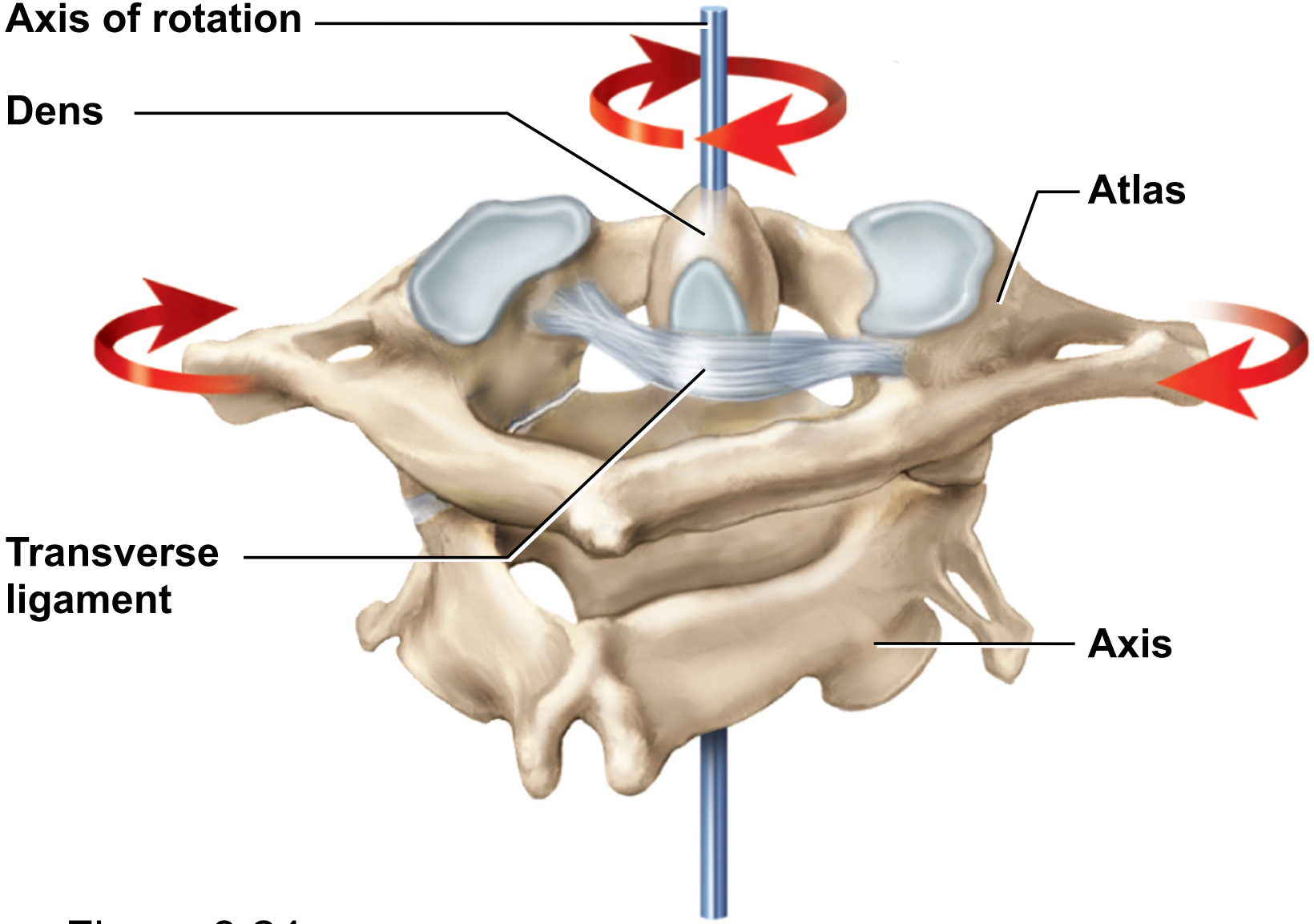


Figure 8.24c

(c) Atlantoaxial joint

Typical Cervical Vertebrae

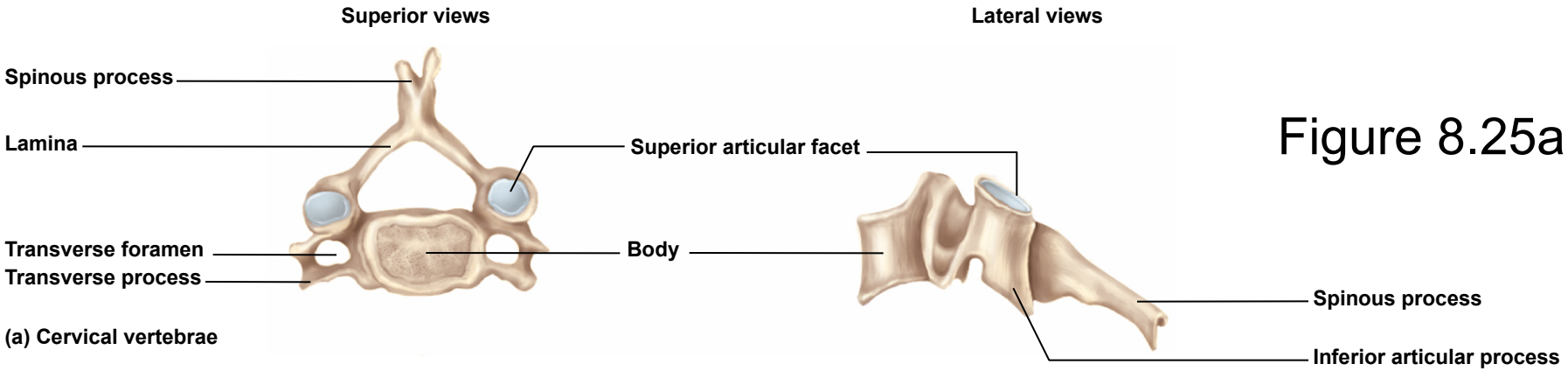


Figure 8.25a

- C1-C7 are the smallest and lightest vertebrae, other than the coccygeals
- **bifid** or forked spinous process in C2 to C6
- small body and larger vertebral foramen
- **transverse foramen** in each short **transverse process**
  - provides passage and protection for:
    - **vertebral arteries** – supply blood to the brain
    - **vertebral veins** – drain blood from various neck structures
  - transverse foramen only found in cervical vertebrae
- **C7 vertebra prominens** – spinous process not bifid and especially long
  - prominent bump on the lower back of the neck
  - convenient landmark for counting vertebrae

Typical Thoracic Vertebrae

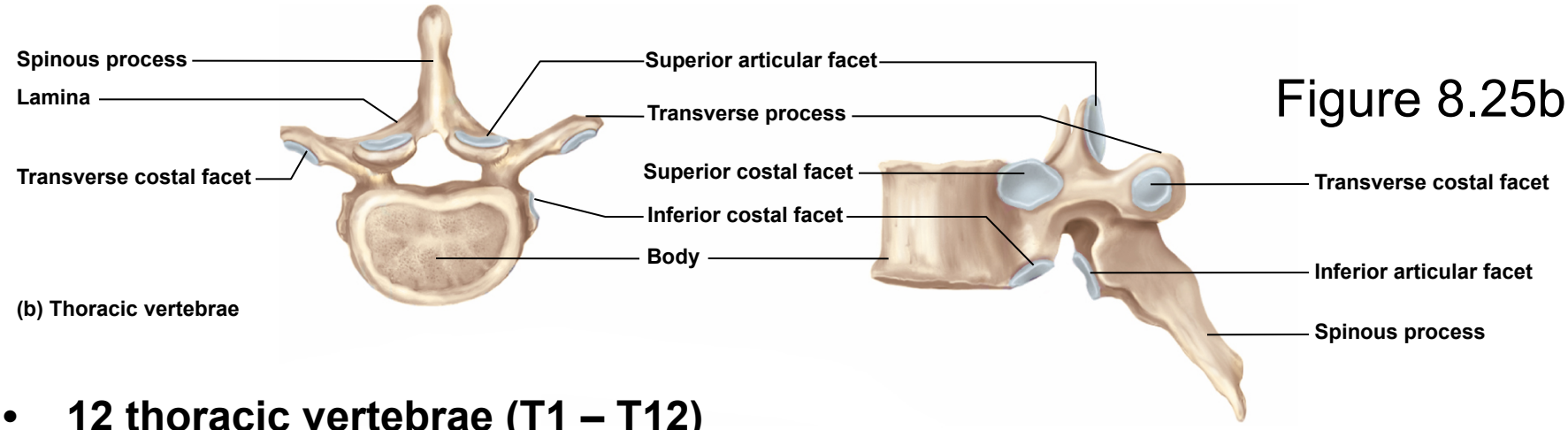


Figure 8.25b

- **12 thoracic vertebrae (T1 – T12)**
  - corresponds to the 12 pairs of ribs attached to them
- **spinous processes** pointed and angled sharply downward
- **larger body** than cervical but, smaller than lumbar
- **costal facets** for attachment of ribs
  - on body as small, smooth, slightly concave spots
- **transverse costal facets** at end of each transverse process on T1 – T10
  - provide second point of articulation for ribs 1 to 10
- **inferior and superior costal** facets on vertebral body
  - - in most cases, ribs insert between the two vertebra

Lumbar Vertebrae

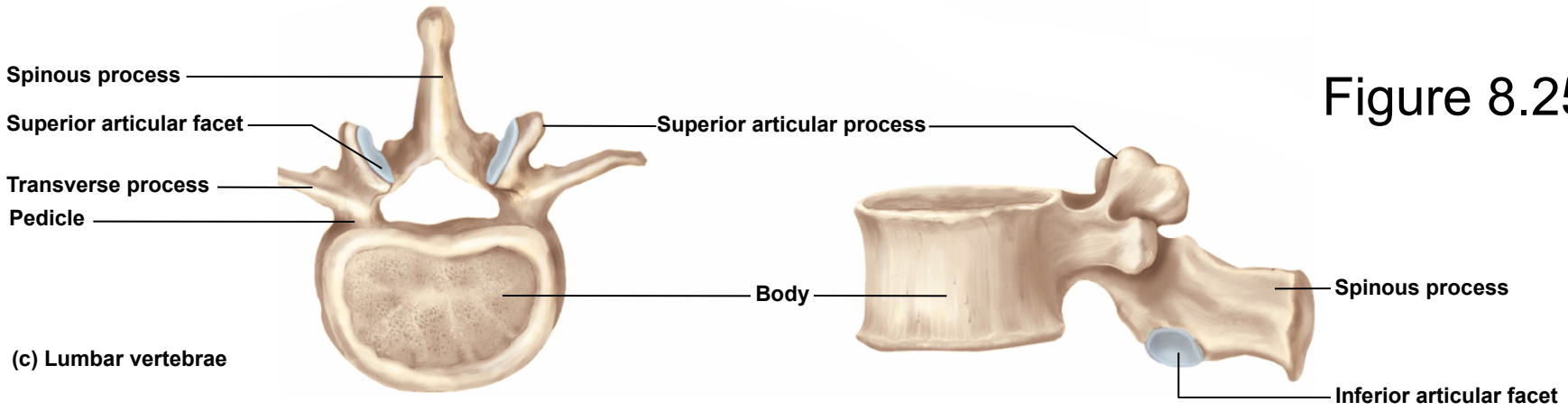


Figure 8.25c

- 5 lumbar vertebrae (L1 – L5)
- thick, stout body
- blunt, squarish spinous process
- **superior articular processes** face medially
  - lumbar region resistant to twisting movements

Sacrum (Anterior View)

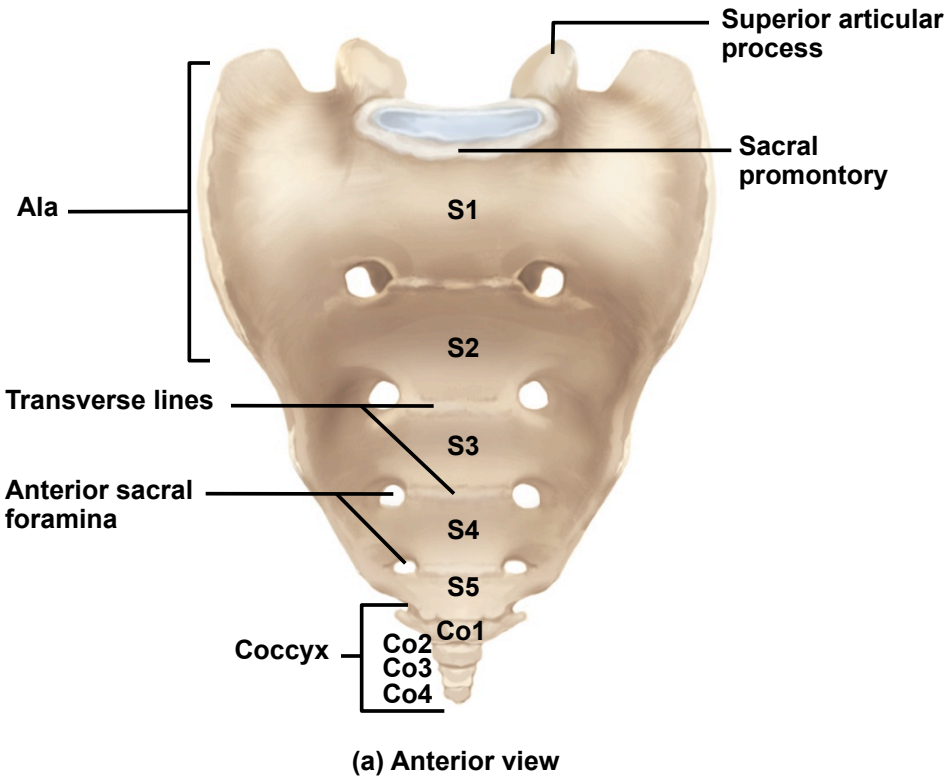
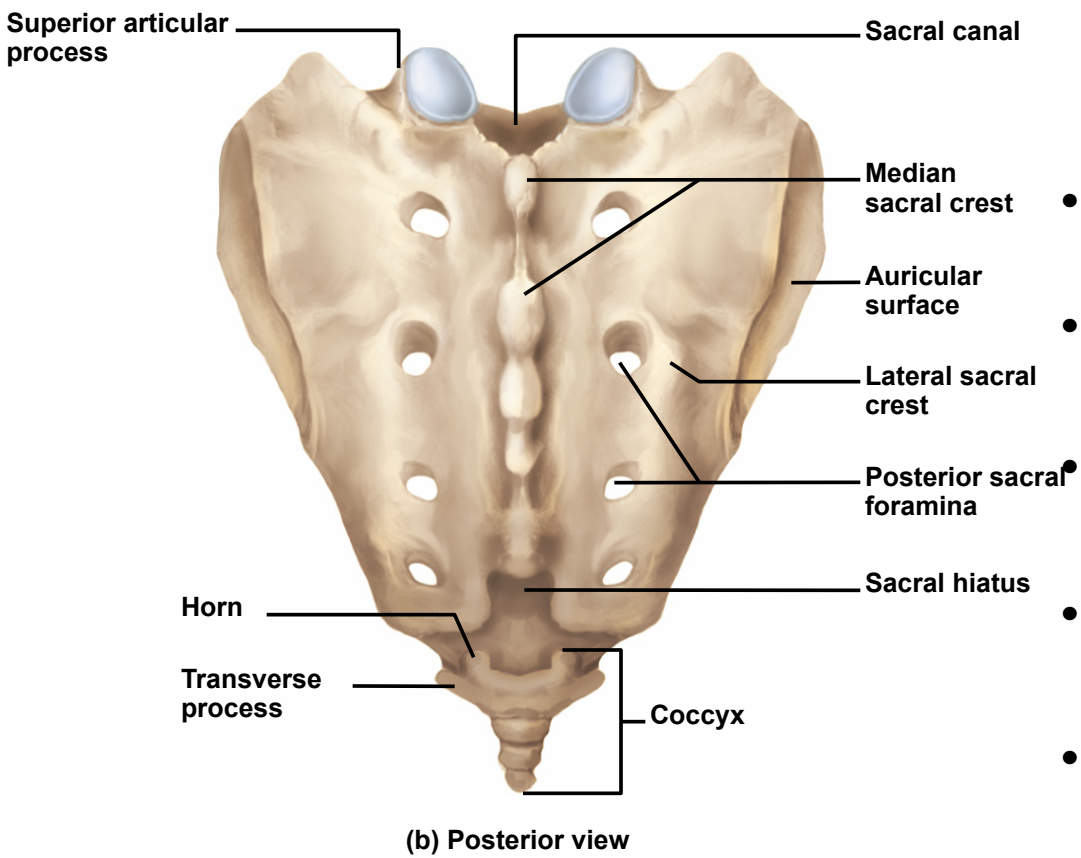


Figure 8.26a

- **sacrum** – bony plate that forms the posterior wall of the pelvic cavity
- once considered the **seat of the soul**
- in children, five separate sacral vertebrae (S1 – S5)
- begin fusion around age 16 and complete fusion by age 26
- anterior surface
  - smooth and concave
  - 4 transverse lines indicate line of fusion of vertebrae
  - 4 pair of large **anterior sacral (pelvic) foramina**
    - allow for passage of nerves and arteries into the pelvic organs
- **sacral promontory** on S1 supports L5

Sacrum (Posterior View)



(b) Posterior view

Figure 8.26b

- posterior surface very rough
- **median sacral crest**
  - formed from fusion of spinous processes
- **lateral sacral crest**
  - less prominent, and on either side of median sacral crest
  - formed from the fusion of the transverse processes
- **posterior sacral foramina**
  - 4 pairs of openings for spinal nerves that supply gluteal region and lower limbs
- **sacral canal** runs through sacrum and ends as **sacral hiatus**
  - contains spinal nerve roots
- **auricular surface** is part of **sacroiliac (SI) joint** formed with hip bone
- **superior articular processes** on S1
  - articulates with L5
- **alae** – pair of large, rough, winglike extensions lateral to the superior articular processes

Coccyx

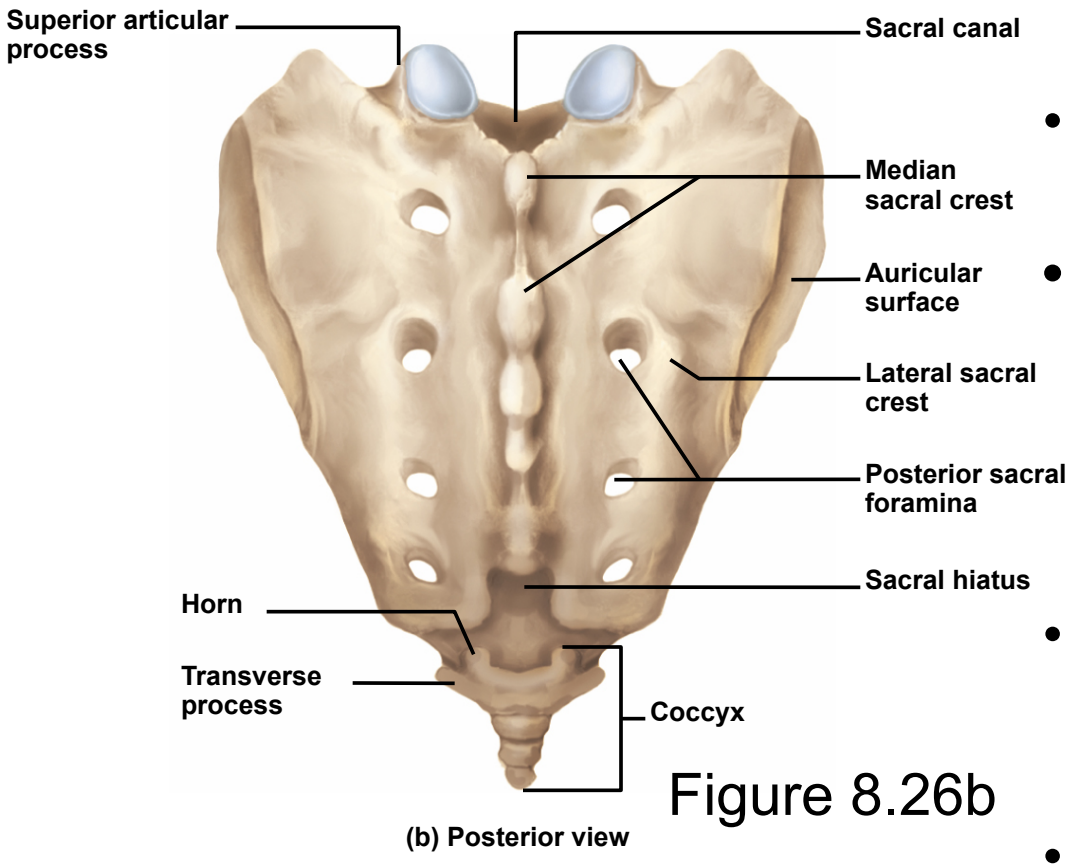


Figure 8.26b

- **coccyx** – usually consists of four small vertebrae (Co1 – Co4)
  - sometimes five
- fuse into a single, triangular bone by age 20 – 30
- **horns (cornua)** on Co1
  - serves as attachment points for ligaments that bind the coccyx to the sacrum
- fractured during difficult childbirth or by hard fall on buttocks
- provide attachment for muscles of the pelvic floor

Thoracic Cage

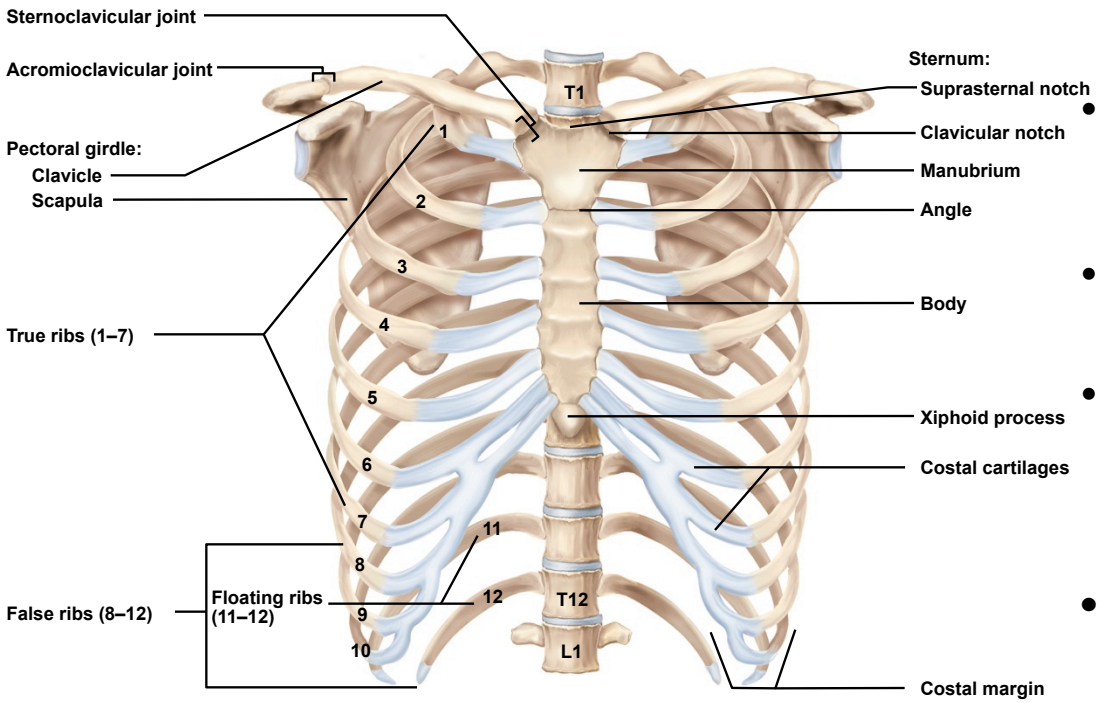


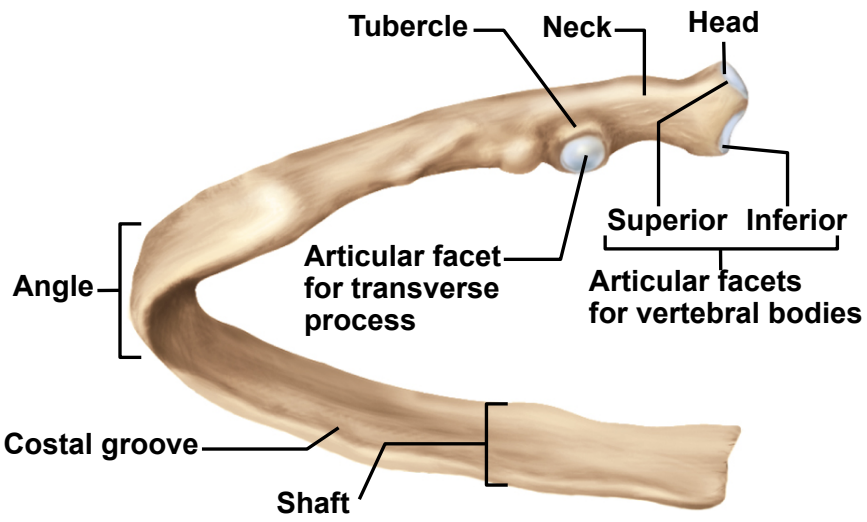
Figure 8.27

- consists of **thoracic vertebrae**, **sternum** and **ribs**
- forms conical enclosure for lungs and heart
- provides attachment for pectoral girdle and upper limbs
- broad **base** and narrower **apex**
- rhythmically expanded by respiratory muscles to draw air into the lungs
- **costal margin** – inferior border of thoracic cage formed by the downward arc of ribs
- protect **thoracic organs**, but also the **spleen**, most of the **liver**, and to some extent the **kidneys**

Sternum

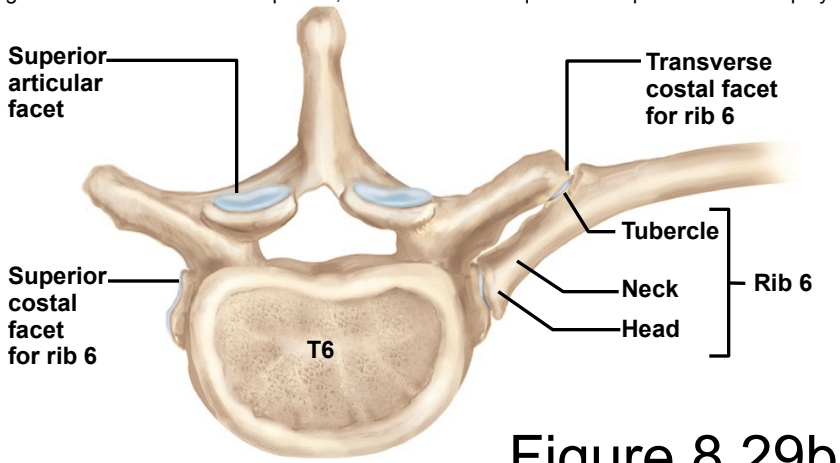
- **sternum** (breastbone) – bony plate anterior to the heart
- divided into **three regions**:
  - **manubrium**
    - broad superior portion
    - **suprasternal (jugular) notch** medially
    - **clavicular notches** – articulate with clavicle
    - ribs attach along scalloped lateral margins
  - **body (gladiolus)**
    - longest part of sternum
    - **sternal angle** – point where body joins manubrium
    - ribs attach along scalloped lateral margins
  - **xiphoid**
    - inferior end of sternum
    - attachment for some of abdominal muscles
    - in cardiopulmonary resuscitation, improperly performed chest compressions can drive xiphoid process into the liver and cause a fatal hemorrhage

Ribs



(b) Ribs 2–10

Figure 8.28b

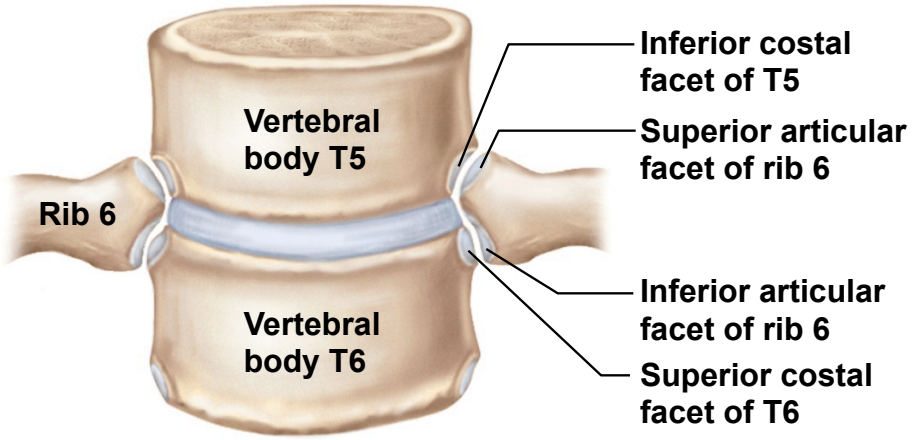


(b) Superior view

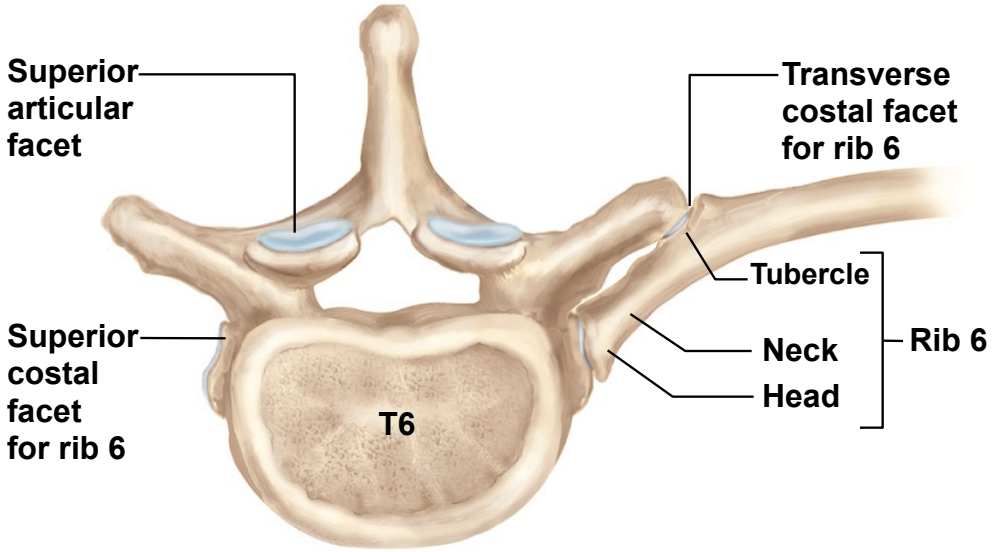
Figure 8.29b

- **12 pairs of ribs**
  - no difference between sexes
  - **posterior (proximal) end** attached to vertebral column
  - **anterior (distal) ends** mostly attached to the sternum
  - **costal cartilages** composed of **hyaline cartilage** attach anterior ends to sternum
- **head** – portion of the rib that articulates with the thoracic vertebrae
  - superior articular facet
  - inferior articular facet
- **neck** – narrow portion distal to the head
- **tubercle** – wider rough area distal to the neck
  - articulates with **transverse costal facet** of vertebra
- **angle –** lateral curve of rib
- **shaft** – long, gentle sloping, bladelike portion of rib
  - **costal groove** on inferior margin of shaft

Articulation of Rib 6 with Vertebrae T5 and T6



(a) Anterior view



(b) Superior view

Figure 8.29

True and False Ribs

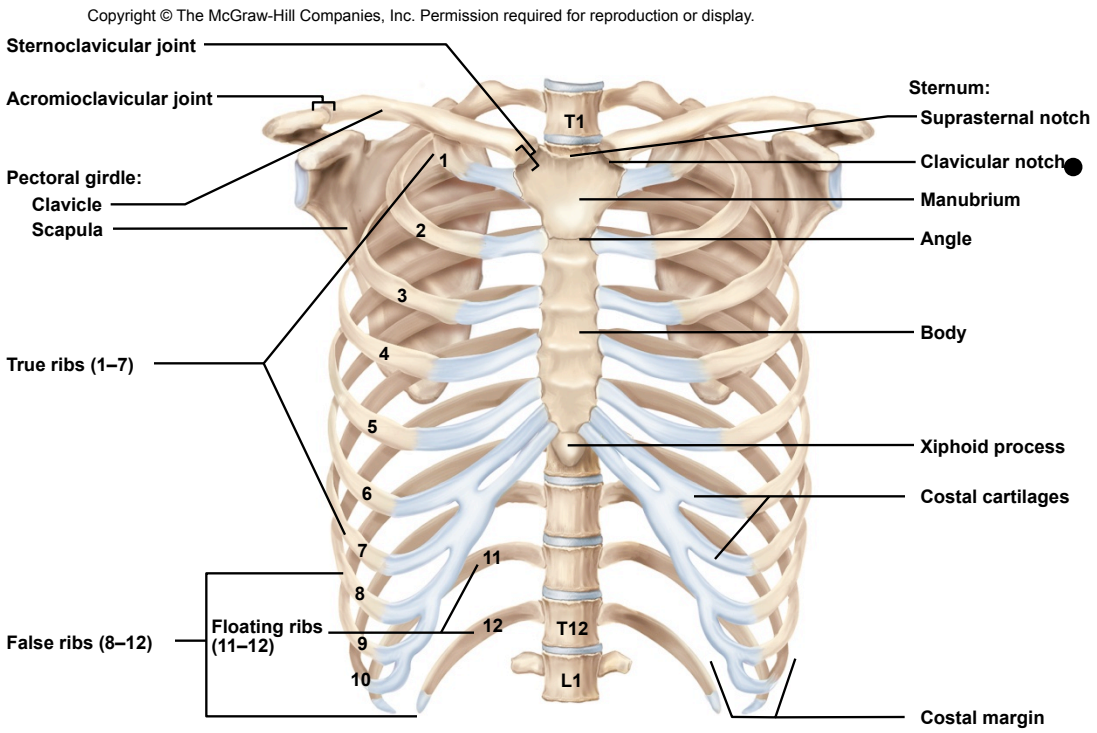


Figure 8.27

- **true ribs (ribs 1 to 7)**
  - each has its own costal cartilage connecting it to the sternum
- **false ribs (ribs 8-12)**
  - lack independent cartilaginous connection to the sternum
  - **floating ribs (ribs 11 – 12)**
    - articulate with bodies of vertebrae T11 and T12
    - do not have tubercles
    - do not attach to transverse processes of the vertebra
    - **no cartilaginous connection to the sternum or any of the higher costal cartilages**

Pectoral Girdle

- **pectoral girdle** (shoulder girdle) – supports the arm
- consists of two bones on each side of the body
  - **clavicle** (collarbone) and **scapula** (shoulder blade)
- clavicle articulates medially to the sternum and laterally to the scapula
  - **sternoclavicular joint**
  - **acromioclavicular joint**
- scapula articulates with the humerus
  - **glenohumeral joint -** shoulder joint
  - easily dislocated due to loose attachment

Clavicle

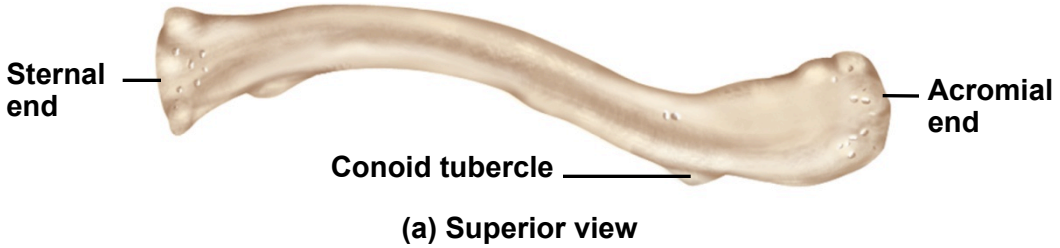


Figure 8.30

- **clavicle** - S-shaped, somewhat flattened bone
- **inferior** – grooves and ridges for muscle attachment
- **sternal end** - rounded head
- **acromial end** – flattened
  - **conoid tubercle** – roughened tuberosity near acromial end
  - ligament attachment
- braces the shoulder keeping upper limb away from the midline of the body
- most frequently fractured bone in the body

Scapula

- **scapula** – named for its resemblance to a spade or shovel
- triangular plate that posteriorly overlies ribs 2 to 7
  - **three sides** - superior, medial (vertebral) and lateral (axillary) borders
  - **three angles** – superior, inferior, and lateral angles
- **suprascapular notch** – conspicuous notch on superior border
  - provides passage for a nerve
- **spine** – transverse ridge on posterior surface
  - **supraspinous fossa** – indentation superior to the spine
  - **infraspinous fossa** – broad surface inferior to the spine
- **subscapular fossa** – concave, anterior surface of scapula
- complex **lateral angle of scapula** has three main features:
  - **acromion** – platelike extension of the spine
    - forms apex of the shoulder
    - **articulates with the clavicle** – the sole point of attachment of the scapula and the upper limb to the rest of the skeleton
  - **coracoid process** – shaped like a bent finger
    - provides attachment for tendons of the biceps brachii and other arm muscles
  - **glenoid cavity** – shallow socket that articulates with the head of the humerus
    - forming **glenohumeral joint**

Scapula

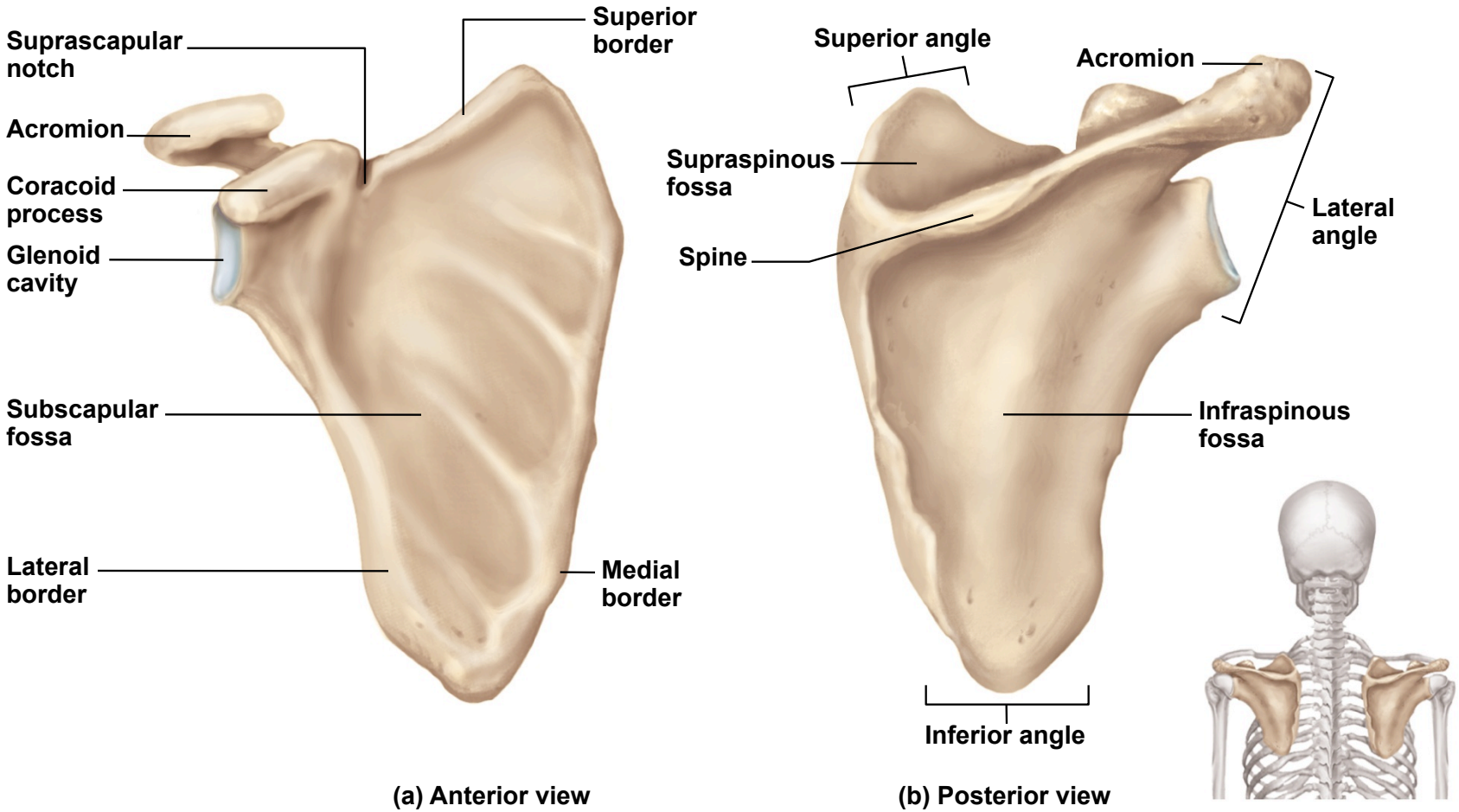


Figure 8.31

Upper Limb

- upper limb is divided into **four regions** containing a total of **30 bones per limb**
  - **brachium** (arm proper) – extends from shoulder to elbow
    - contains only one bone - **humerus**
  - **antebrachium** (forearm) – extends from elbow to wrist
    - contains two bones - **radius** and **ulna**
  - **carpus** (wrist)
    - contains 8 small bones arranged in 2 rows
  - **manus** (hand)
    - 19 bones in 2 groups
      - **5 metacarpals** in palm
      - **14 phalanges** in fingers

Humerus

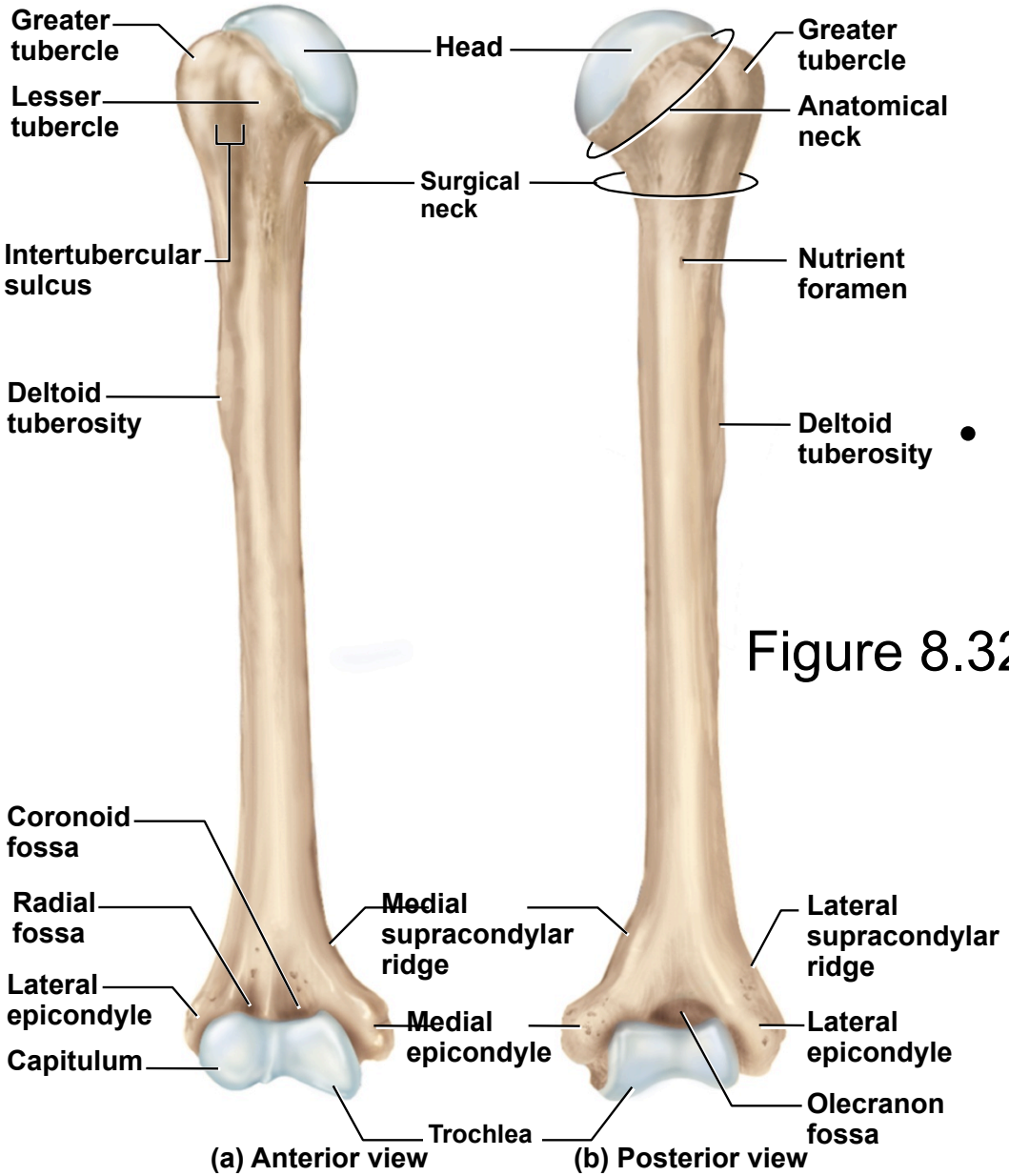
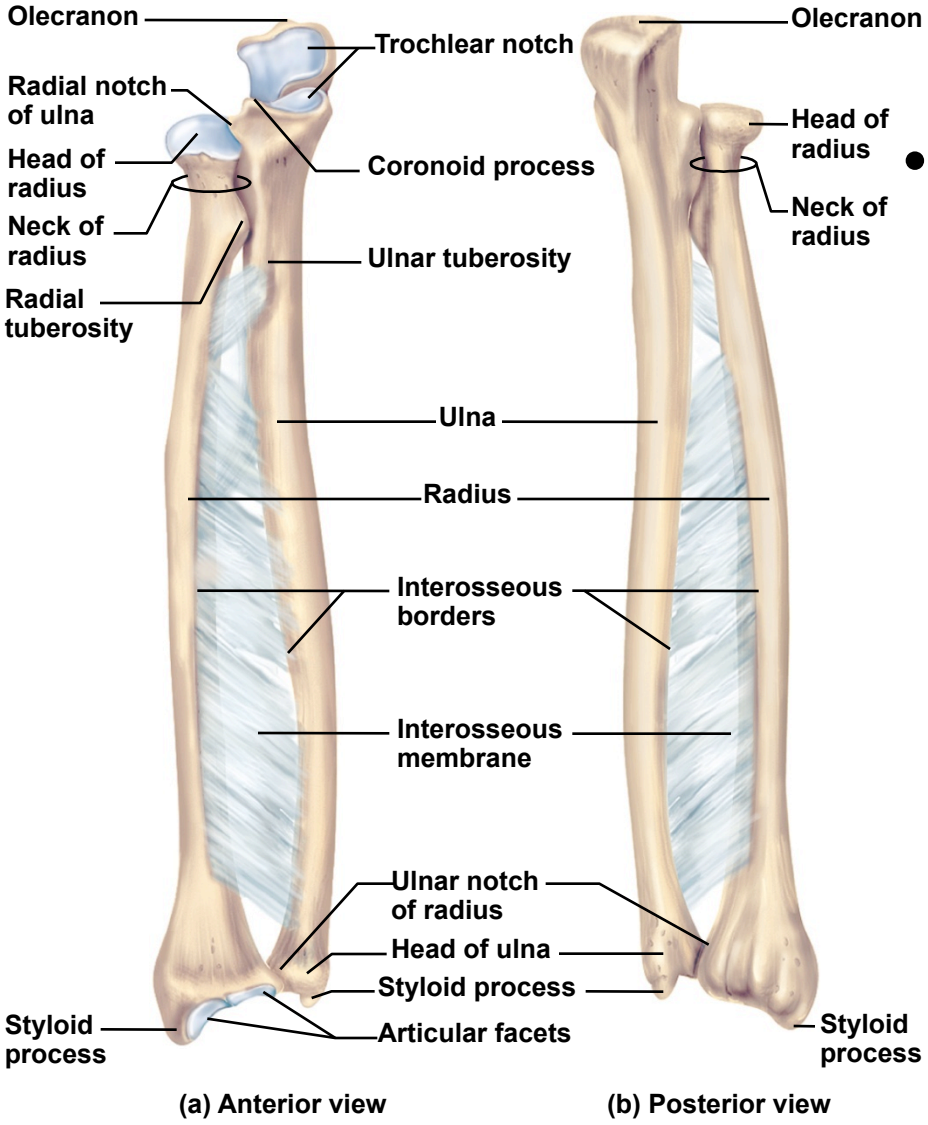


Figure 8.32

- **proximal end**
  - hemispherical **head** that articulates with the **glenoid cavity** of scapula
  - **anatomical neck**
  - **greater** and **lesser tubercles** and deltoid tuberosity
  - **intertubercular sulcus** holds biceps tendon
  - **surgical neck**
- **distal end**
  - rounded **capitulum** articulates with head of radius
  - **trochlea** articulates with ulna
  - **lateral** and **medial epicondyles**
  - **lateral** and **medial supracondylar ridges**
  - **olecranon fossa** holds olecranon process of ulna
  - **coronoid fossa**
  - **radial fossa**

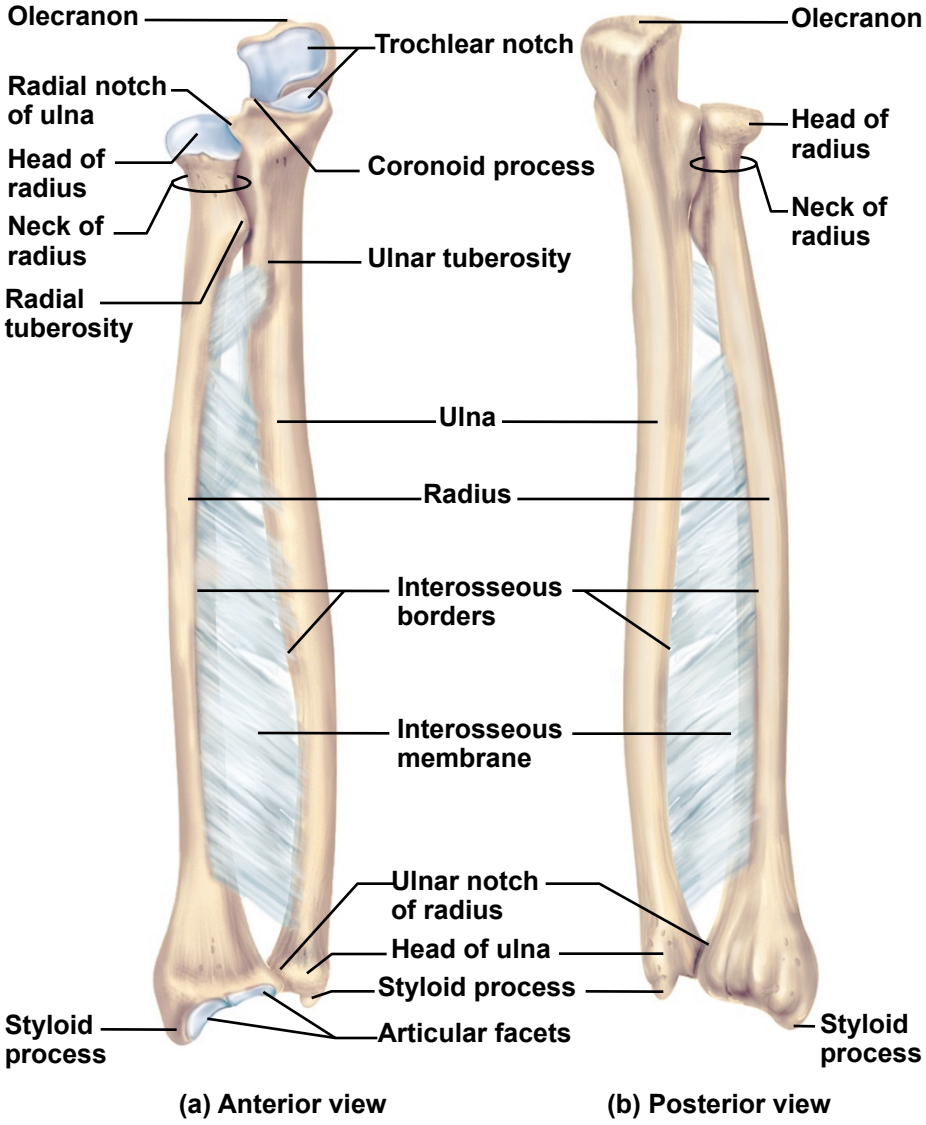
Radius



- **radius**
  - **head** – disc-shape, allows for rotation around the longitudinal axis of the bone during pronation and supination of hand
    - superior surface articulates with **capitulum** on humerus
    - side of disc spins on **radial notch** on ulna
  - **neck**
  - **radial tuberosity** for biceps muscle
  - **styloid process** can be palpated near thumb
  - **ulnar notch**

Figure 8.33

Ulna and Interosseous Membrane



- **ulna**
  - **trochlear notch** articulates with trochlea of humerus
  - **olecranon** – bony point at back of elbow
  - **coronoid process**
  - **radial notch** holds head of radius
  - **styloid process**

- **interosseous membrane**
  - ligament **attaches radius to ulna** along interosseous margin of each bone
  - enables the two elbow joints to share the load

Figure 8.33

Carpal Bones

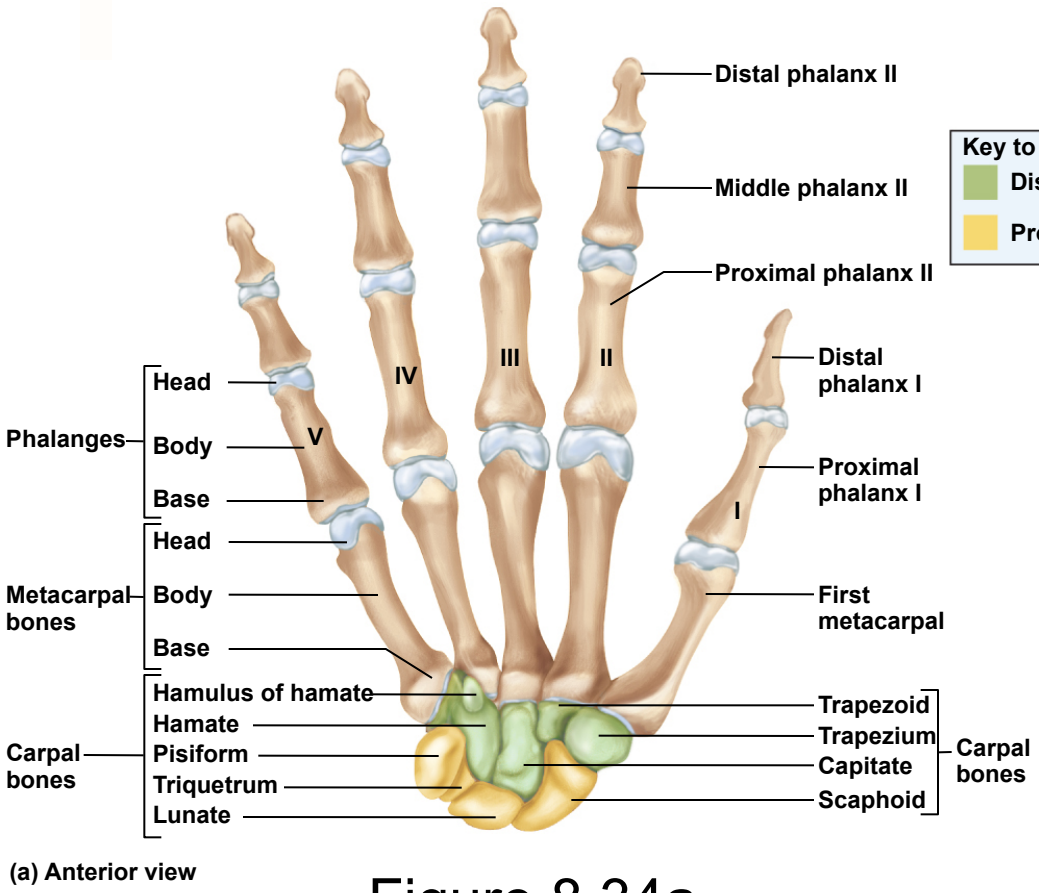


Figure 8.34a

- 8 bones form wrist
  - allow movements of flexion, extension, abduction and adduction
- 2 rows (4 bones each)
  - **proximal row** –
  - **scaphoid, lunate, triquetrum**, and **pisiform**
    - pisiform is a sesamoid developed by age 9 to12 in tendon of *flexor carpi ulnaris muscle*
  - **distal row** - **trapezium, trapezoid, capitate,** and **hamate**

Metacarpals and Phalanges

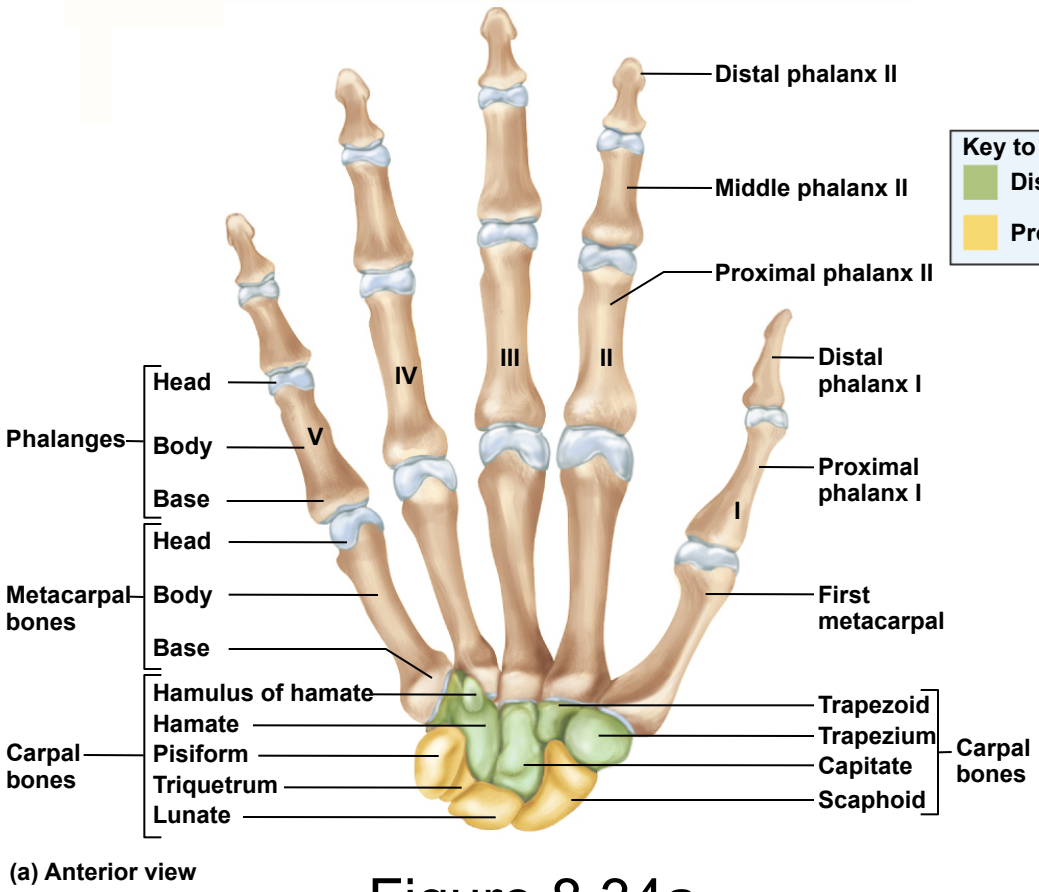


Figure 8.34a

- **metacarpals -** bones of the palm
  - **metacarpal I** proximal to base of thumb
  - **metacarpal V** proximal to base of little finger
  - proximal **base**, **body**, and distal **head**
- **phalanges** - bones of the fingers
  - thumb or **pollex** has **two phalanges**
    - proximal and distal phalanx
  - fingers have **three phalanges**
    - proximal, middle and distal phalanx

Pelvic Girdle

- **pelvic girdle** – consists of a complete ring composed of three bones
  - two **hip (coxal) bones**
    - also called **ossa coxae** or **innominate bones**
  - **sacrum** that is also part of the vertebral column

- **pelvis** – bowl-shaped structure composed of the two coxal bones and sacrum as well as their ligaments and muscles that line the pelvic cavity and form its floor
  - supports trunk on the lower limbs and protects viscera, lower colon, urinary bladder, and internal reproductive organs

- **sacroiliac joint** - joins hipbone to the vertebral column
  - **auricular surface** of ileum to **auricular surface** of sacrum

- anteriorly, **interpubic disc** – pad of fibrocartilage joins pubic bones

- **pubic symphysis** – the interpubic disc and adjacent regions of the pubic bone on each side

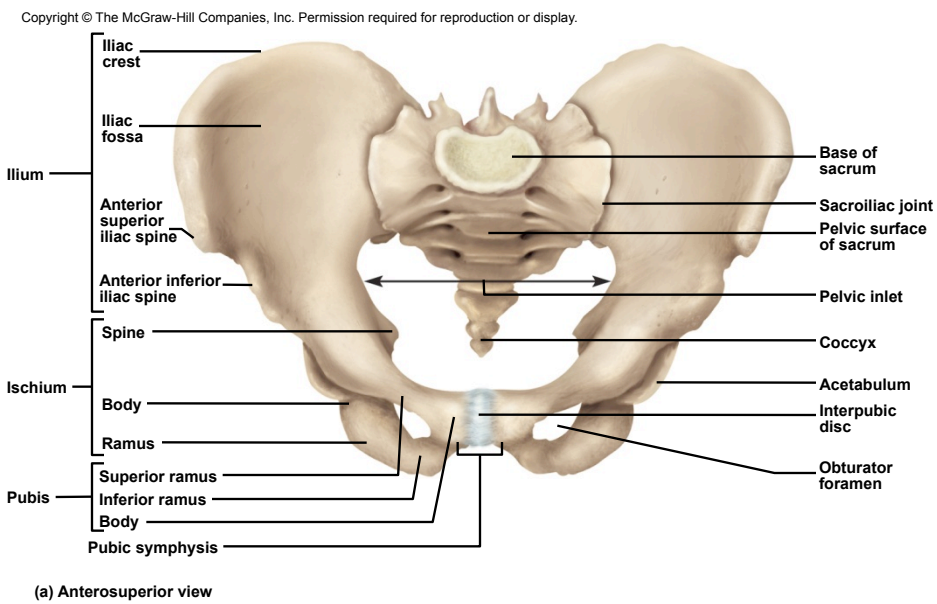


Figure 8.35a

Pelvic Inlet and Outlet

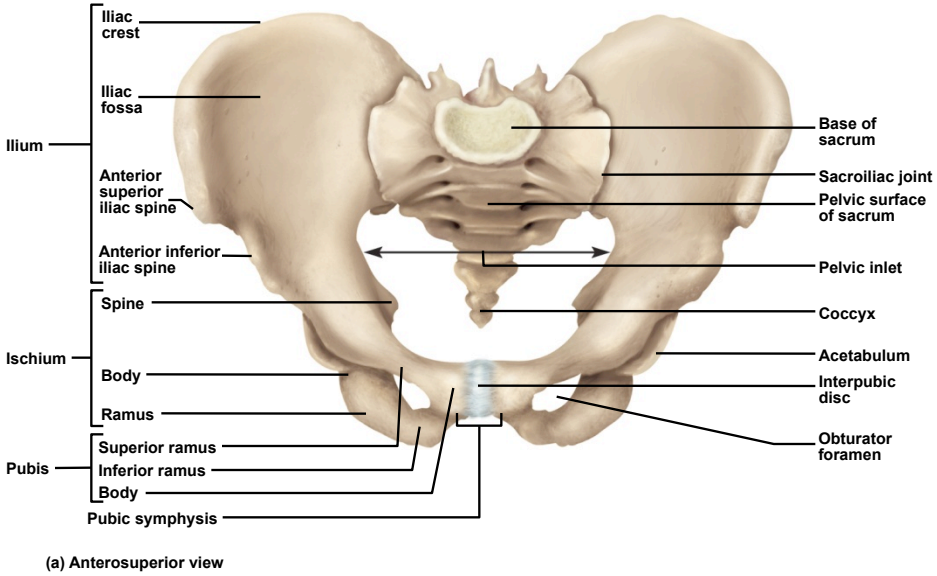


Figure 8.35a

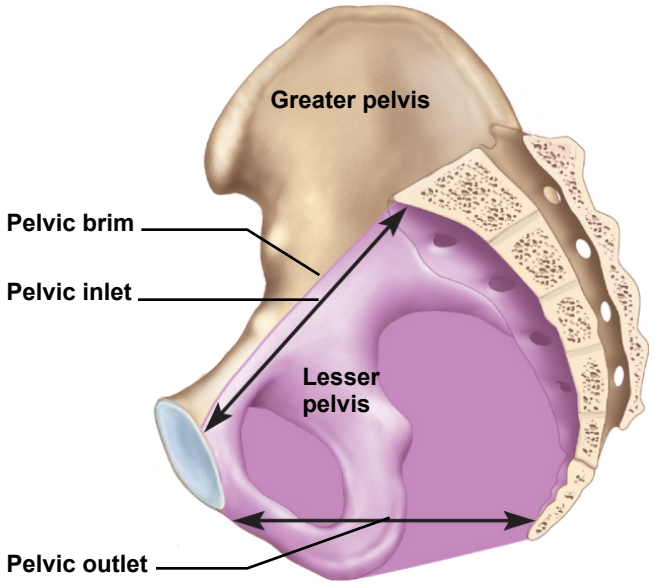


Figure 8.35b

- **greater (false) pelvis** – between flare of the hips
- **lesser (true) pelvis** – narrower and below
- **pelvic brim** – round margin that separates the two
- **pelvic inlet** – opening circumscribed by brim that infant's head must pass during birth
- **pelvic outlet** – lower margin of the lesser pelvis

Hip Bone

- three distinct features of hip bone
  - **iliac crest** – superior crest of hip
  - **acetabulum** – the hip socket
  - **obturator foramen** – large hole below acetabulum
- each adult hip bone is formed by the fusion of **three childhood bones**
  - **ileum**
    - the largest
    - extends from the **iliac crest** to the center of the acetabulum
    - **anterior and posterior superior spine**
    - **anterior and posterior inferior spines**
    - **greater sciatic notch** and **iliac fossa**
  - **ischium**
    - inferioposterior portion of hip
    - heavy **body** with prominent **spine**
    - **lesser sciatic notch**
    - **ischial tuberosity**
    - **ramus**
  - **pubis (pubic bone)**
    - most anterior portion of the hip bone
    - **body**, **superior** and **inferior ramus**

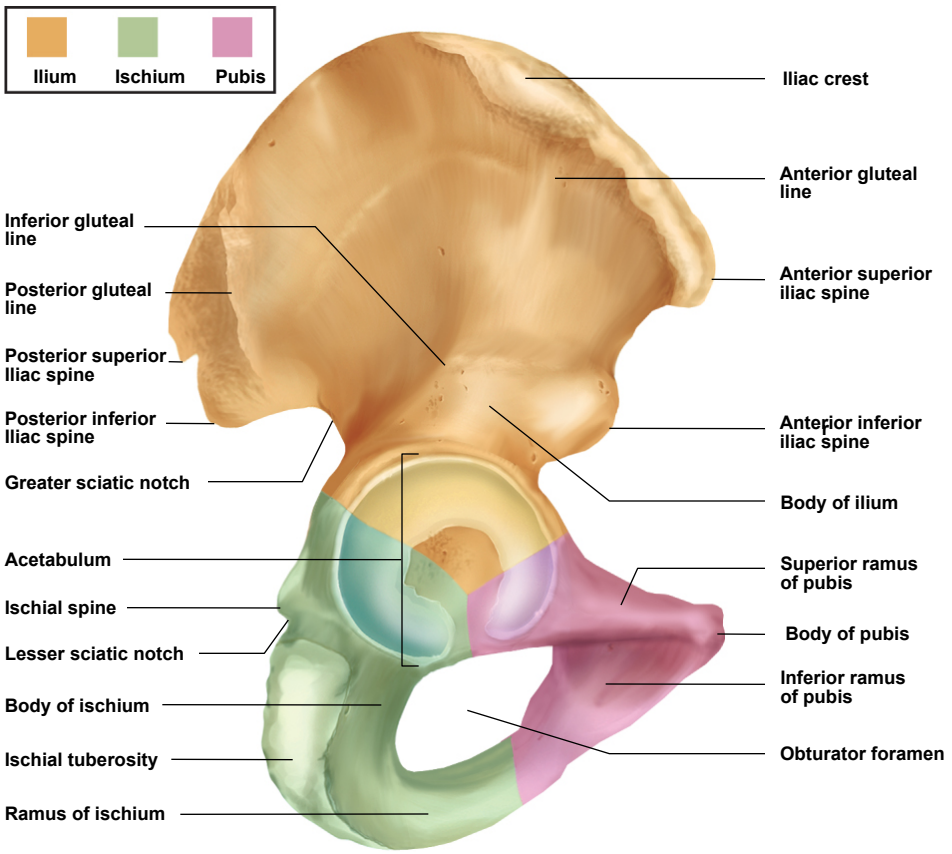


Figure 8.36a

Comparison of Male and Female

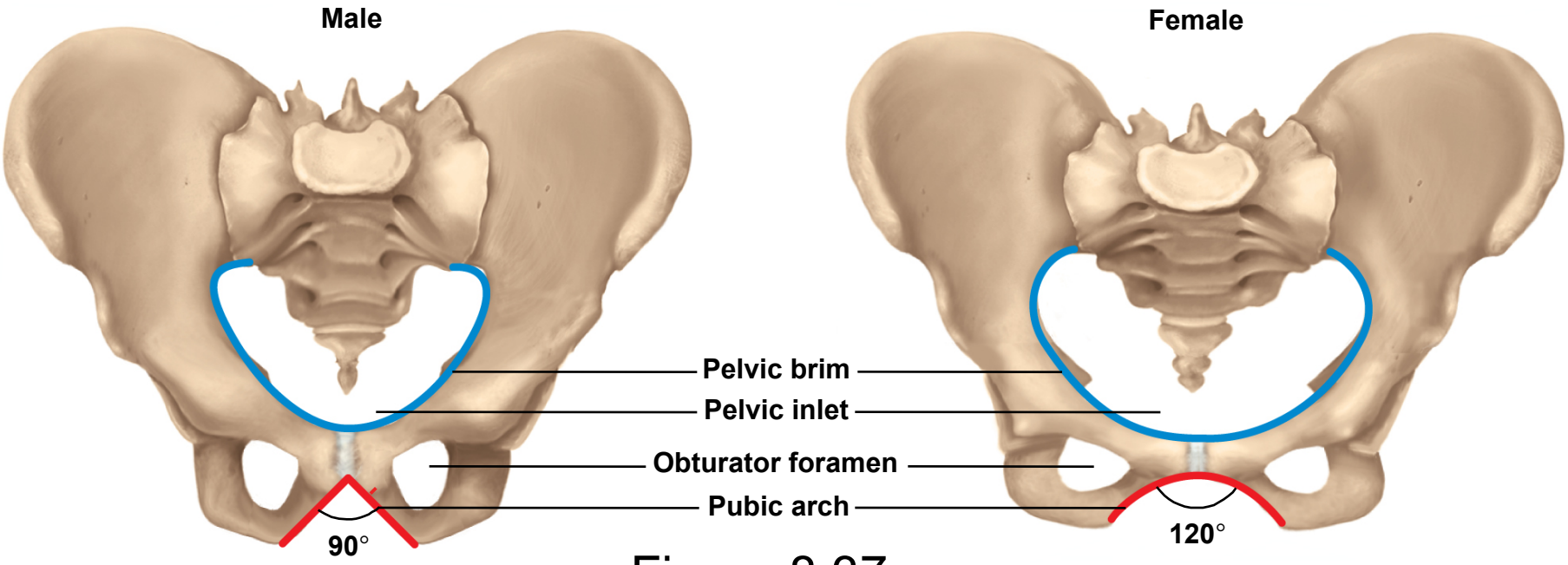


Figure 8.37

- male - heavier and thicker due to forces exerted by stronger muscles
- female - wider and shallower, and adapted to the needs of pregnancy and childbirth, larger pelvic inlet and outlet for passage of infant's head

Lower Limb

- lower limb divided into **four regions** containing **30 bones** per limb
  - **femoral region** (thigh) – extends from hip to knee region
    - contains the **femur** and **patella**
  - **crural region** (leg proper) – extends from knee to ankle
    - contains medial **tibia** and lateral **fibula**
  - **tarsal region** (tarsus) – ankle – the union of the crural region with the foot
    - tarsal bones are considered part of the foot
  - **pedal region** (pes) - foot
    - composed of 7 tarsal bones, 5 metatarsals, and 14 phalanges in the toes

Femur

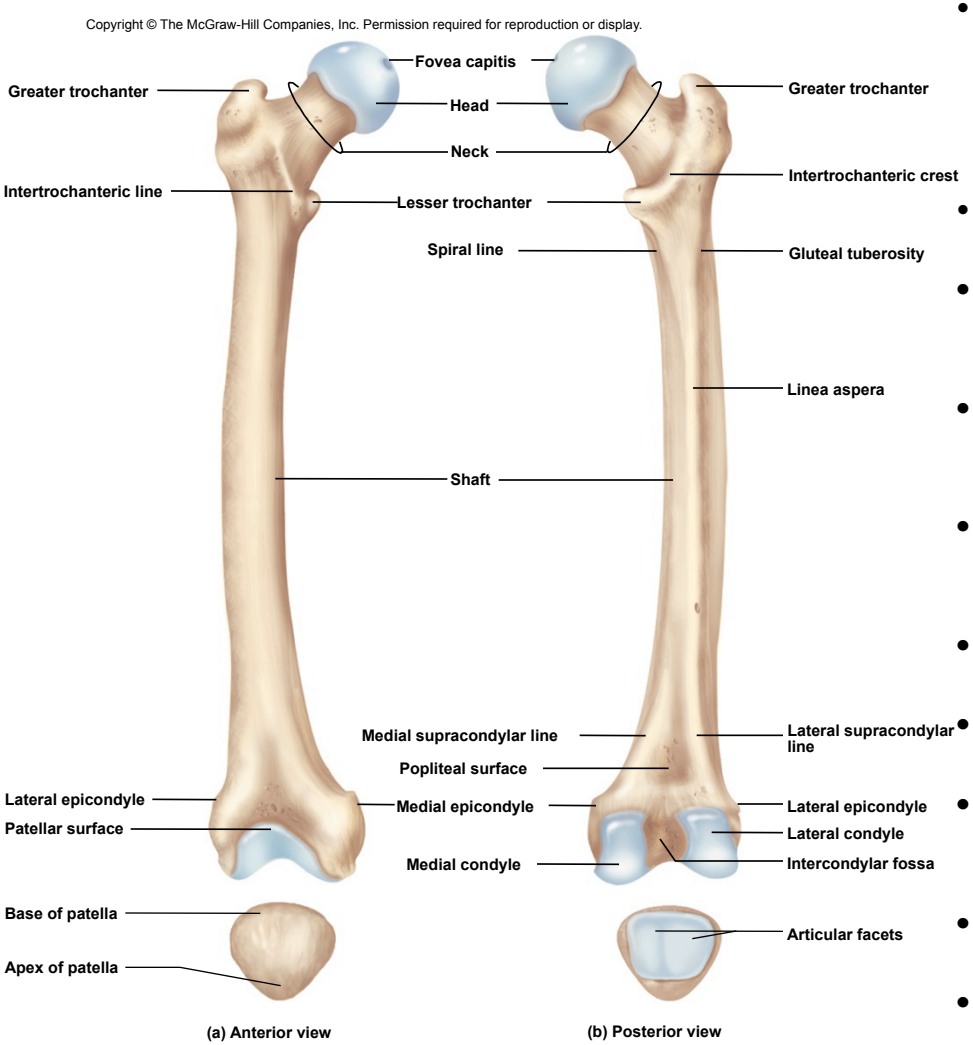
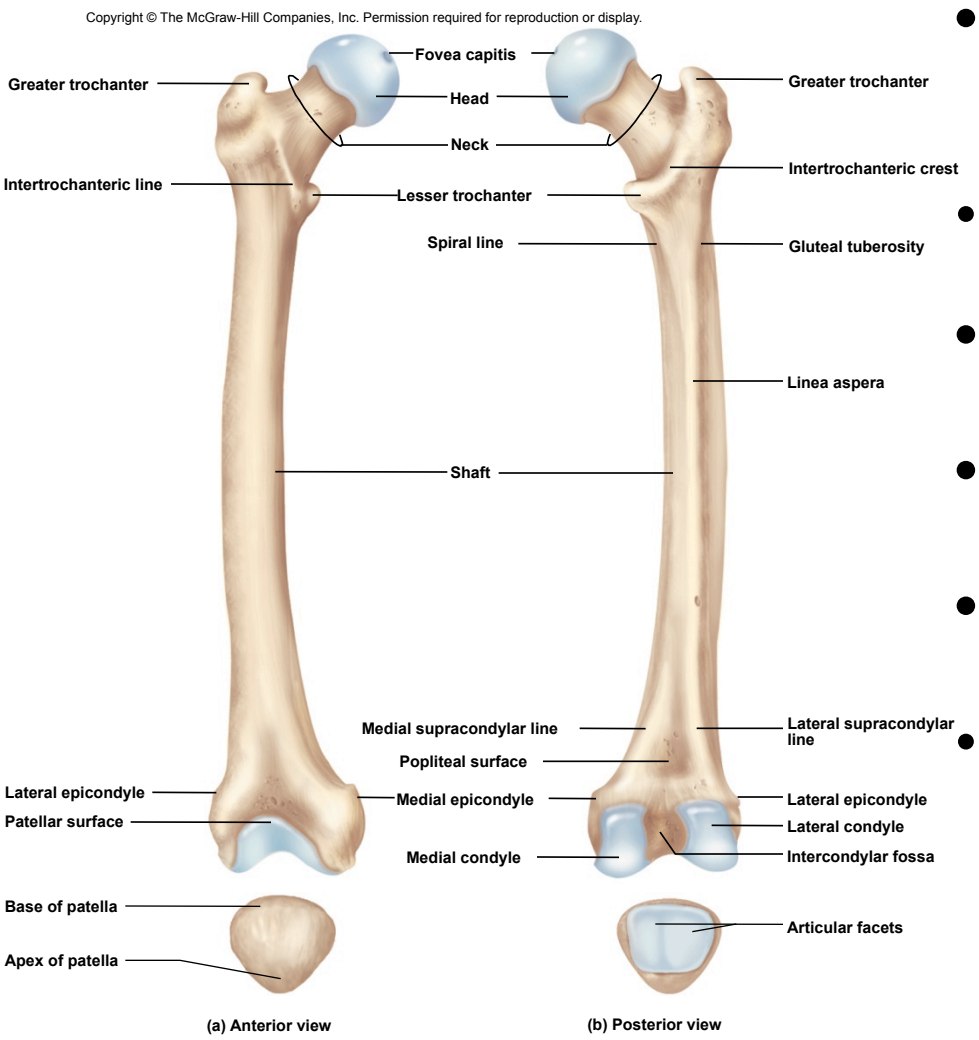


Figure 8.38

- longest and strongest bone of the body
- hemispherical **head** that articulates with the acetabulum of the pelvis
  - forms ball-and-socket joint
  - **fovea capitis** – pit in head of femur for attachment of a ligament
- constricted **neck**
- **greater** and **lesser trochanters** for muscle attachment
- **intertrochanteric crest** – thick oblique ridge on the posterior surface that connects the trochanters
- **intertrochanteric line** – more delicate ridge on the anterior surface that connects trochanters
- **linea aspera** – ridge on posterior of the shaft
- **spiral (pectineal) line** and **gluteal tuberosity**
- **media**l and **lateral condyles** and **epicondyles** found distally
- **intercondylar fossa**
- **patellar** and **popliteal surface**

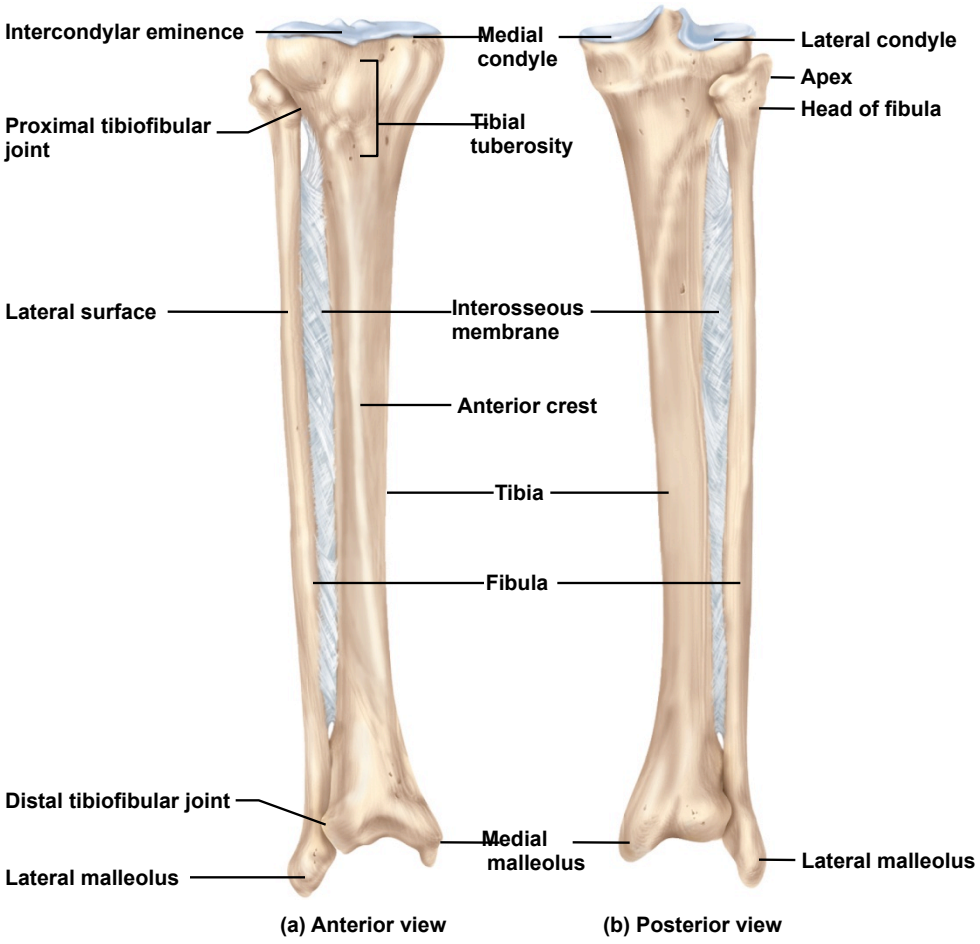
Patella (Kneecap)



- **patella** - triangular sesamoid bone embedded in tendon of the knee
- cartilaginous at birth
  - ossifies at 3 to 6 year
- **base** – broad, superior portion
- **apex** – pointed, inferior portion
- **articular facets** – shallow, posterior portion
- *quadriceps femoris tendon* extends from the anterior muscle of the thigh to the patella
  - continues as the **patellar ligament** from the patella to the tibia

Figure 8.38

Tibia



- **tibia** - thick, medial, weight-bearing bone
  - only weight bearing bone of the crural region
  - broad superior **head**
  - **medial** and **lateral condyles**
    - fairly flat articular surfaces
    - articulate with condyle of femur
  - **intercondylar eminence** – ridge separating condyles
  - **tibial tuberosity** – attachment of quadricep muscles
  - **anterior crest** – sharp, angular
  - **medial malleolus** – bony knob on inside of ankle

Figure 8.39

Fibula

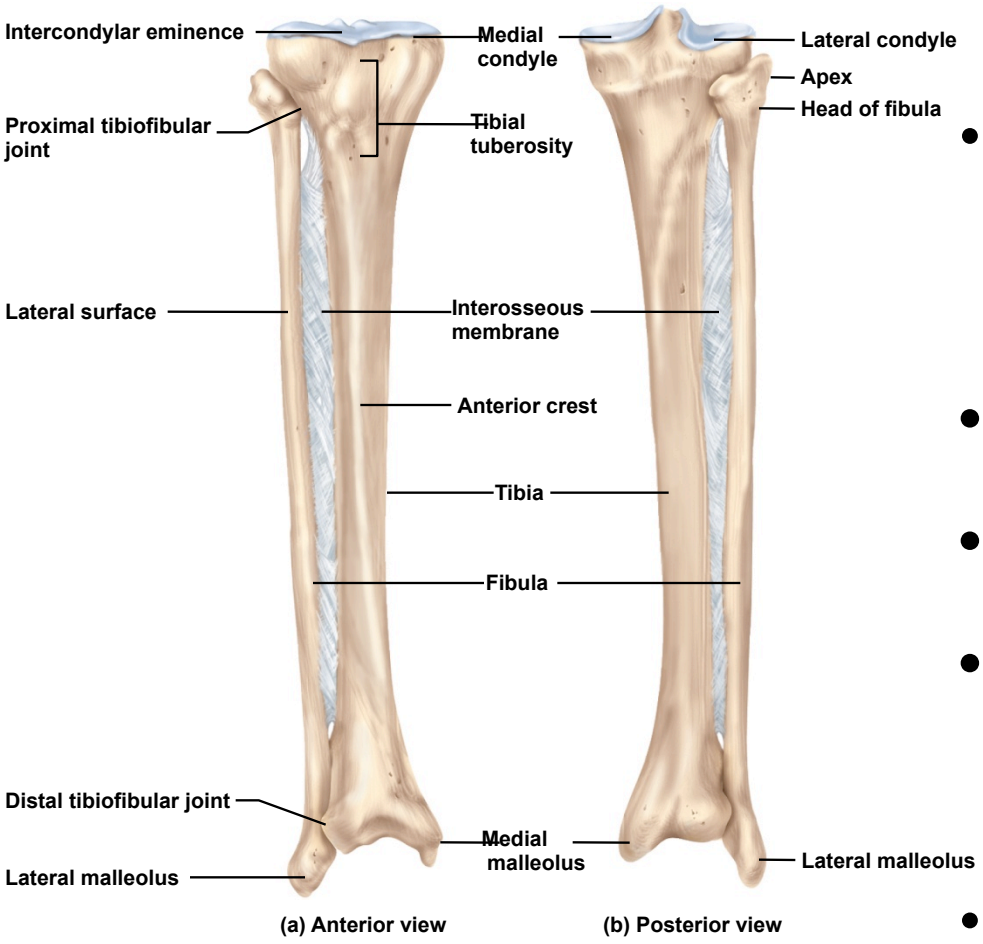
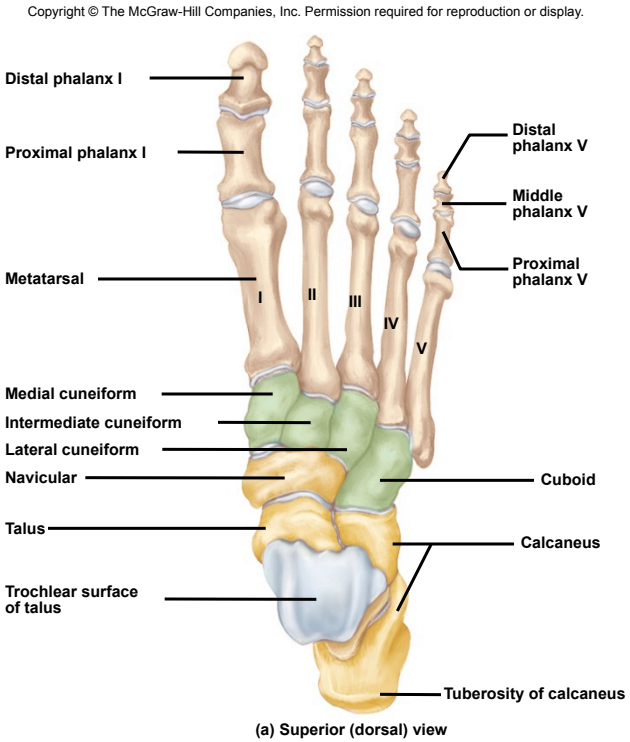
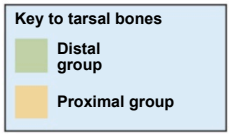


Figure 8.39

- **fibula** – slender, lateral strut that helps stabilizes ankle
- does not bear any body weight
  - spare bone tissue for grafts
- **head** - proximal end
- **apex** – point of the head
- **lateral malleolus** - distal expansion, bony knob on lateral side of ankle
- joined to tibia by **interosseous membrane**

The Ankle and Foot

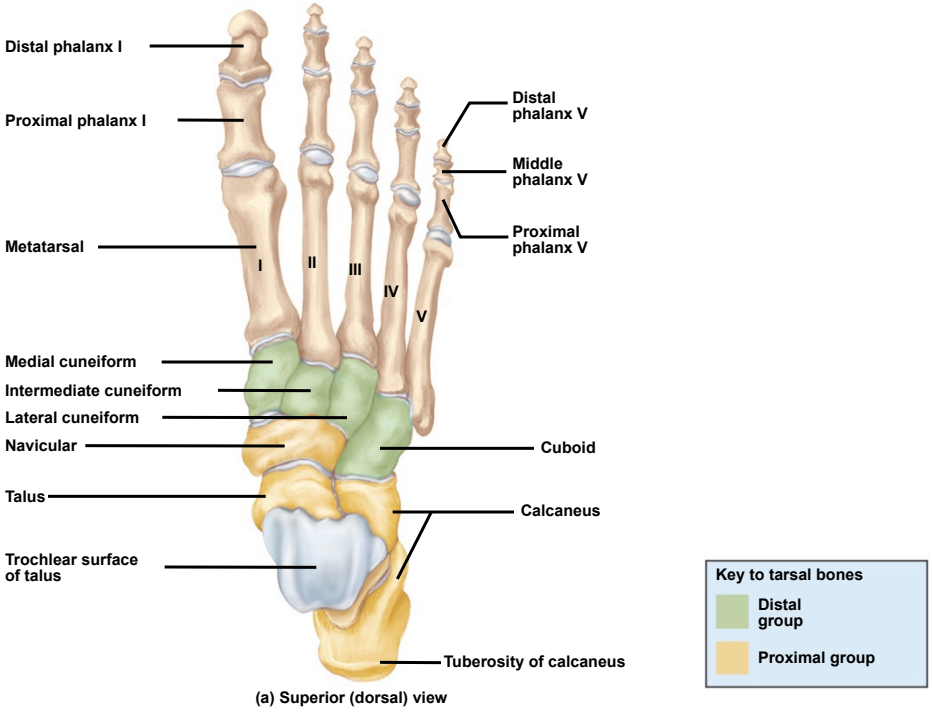




- **tarsal bones** – arranged in proximal and distal groups
- tarsal bones are shaped and arranged differently from carpal bones due to load-bearing role of the ankle
- **calcaneus** – largest tarsal bone
  - forms heel
  - distal portion is point of attachment for **calcaneal (Achilles) tendon**
- **talus** is most superior tarsal bone
  - forms ankle joint with tibia and fibula
  - sits upon calcaneus and articulates with navicular
- **proximal row** of tarsal bones
  - talus, calcaneus, and navicular
- **distal row** of tarsal bones
  - medial, intermediate and lateral cuneiforms and cuboid

Figure 8.40a

The Foot



(a) Superior (dorsal) view

- remaining bones of foot are similar in name and arrangement to the hand
- **metatarsals**
  - metatarsal I is proximal to the great toe (hallux)
  - metatarsal V is proximal to the little toe
  - proximal base, intermediate shaft, and distal head
- **phalanges**
  - 2 in great toe
    - proximal and distal phalanx
  - 3 in all other toes
    - proximal, middle and distal phalanx

Figure 8.40a