

### The Axial Skeleton

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

### The Skull

- The skull, the body's most complex bony structure, is formed by the cranium and facial bones
- Cranium – protects the brain and is the site of attachment for head and neck muscles
- Facial bones
  - Supply the framework of the face, the sense organs, and the teeth
  - Provide openings for the passage of air and food
  - Anchor the facial muscles of expression

### Anatomy of the Cranium

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

### Frontal Bone

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

### Skull – Anterior View

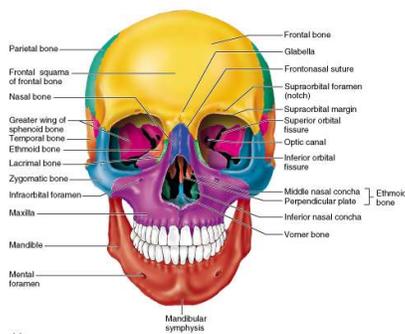


Figure 7.2a

### Skull – Posterior View

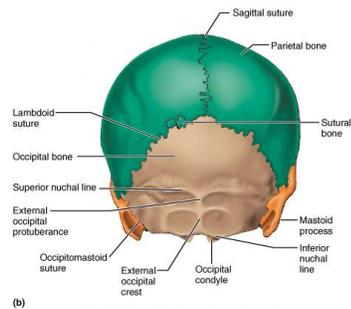


Figure 7.2b

**Parietal Bones and Major Associated Sutures**

- Form most of the superior and lateral aspects of the skull

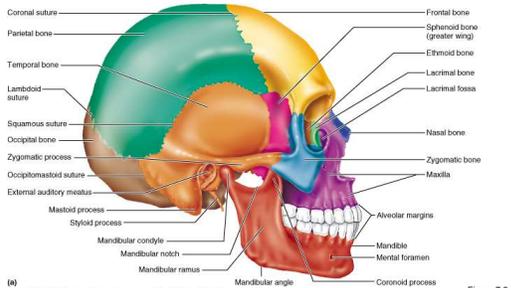


Figure 7.3a

**Parietal Bones and Major Associated Sutures**

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

**Occipital Bone and Its Major Markings**

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

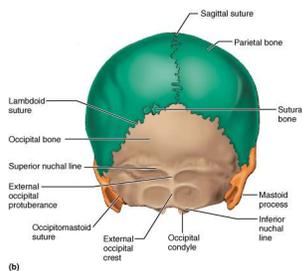


Figure 7.2b

**Occipital Bone and Its Major Markings**

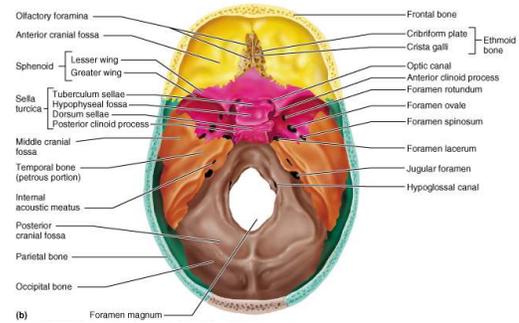


Figure 7.4b

**Temporal Bones**

- Form the inferolateral aspects of the skull and parts of the cranial floor
- Divided into four major regions – squamous, tympanic, mastoid, and petrous

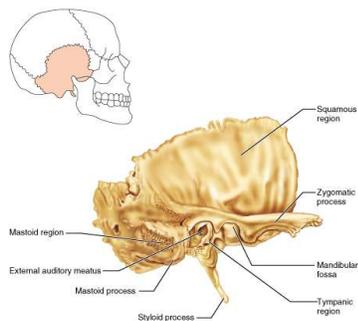


Figure 7.5

**Temporal Bones**

- Major markings include the zygomatic, styloid, and mastoid processes, and the mandibular and middle cranial fossae

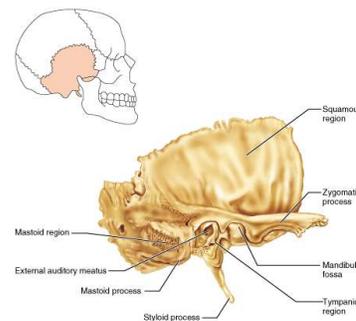


Figure 7.5

### Temporal Bones

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

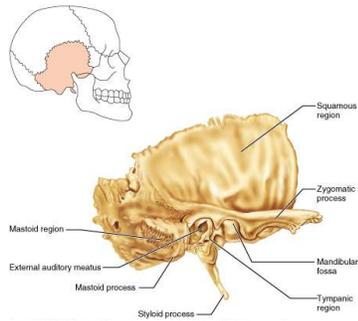


Figure 7.5

### Sphenoid Bone

- Butterfly-shaped bone that spans the width of the middle cranial fossa
- Forms the central wedge that articulates with all other cranial bones
- Consists of a central body, greater wings, lesser wings, and pterygoid processes
- Major markings: the sella turcica, hypophyseal fossa, and the pterygoid processes
- Major openings include the foramina rotundum, ovale, and spinosum; the optic canals; and the superior orbital fissure

### Sphenoid Bone

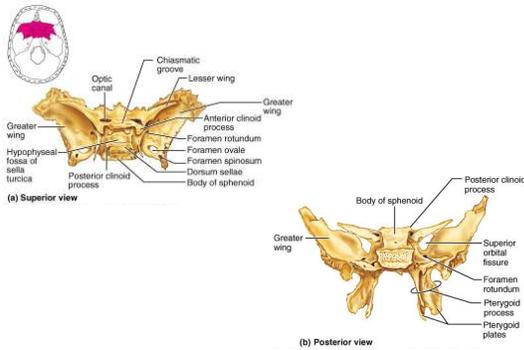


Figure 7.6a, b

### Ethmoid Bone

- Most deep of the skull bones; lies between the sphenoid and nasal bones

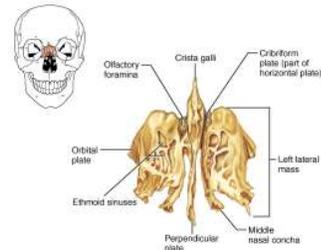


Figure 7.7

### Ethmoid Bone

- Forms most of the bony area between the nasal cavity and the orbits

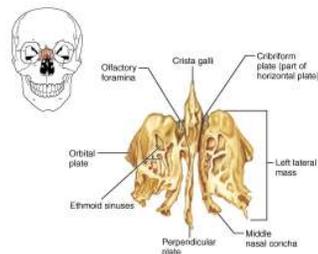


Figure 7.7

### Ethmoid Bone

- Major markings include the cribriform plate, crista galli, perpendicular plate, nasal conchae, and the ethmoid sinuses

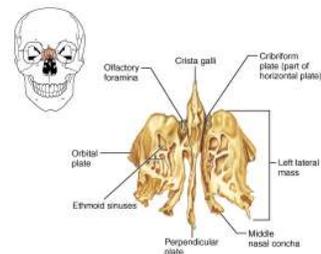


Figure 7.7

### Wormian Bones

- Tiny irregularly shaped bones that appear within sutures

### Facial Bones

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

### Mandible and Its Markings

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

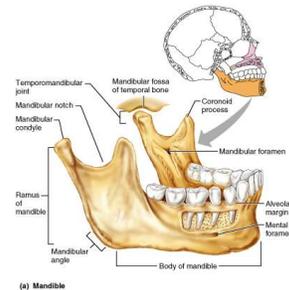


Figure 7.8a

### Maxillary Bones

- Medially fused bones that make up the upper jaw and the central portion of the facial skeleton

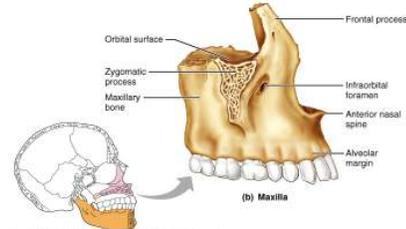


Figure 7.8b

### Maxillary Bones

- Facial keystone bones that articulate with all other facial bones, except the mandible

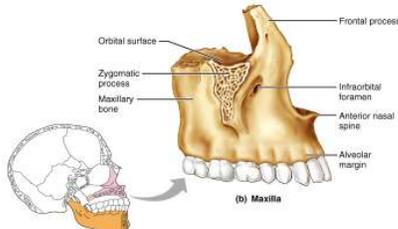


Figure 7.8b

### Maxillary Bones

- Their major markings include palatine, frontal, and zygomatic processes, the alveolar margins, inferior orbital fissure, and the maxillary sinuses

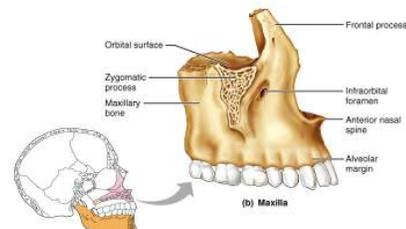


Figure 7.8b

### Zygomatic Bones

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

### Other Facial Bones

- Nasal bones – thin medially fused bones that form the bridge of the nose
- Lacrimal bones – contribute to the medial walls of the orbit and contain a deep groove called the lacrimal fossa that houses the lacrimal sac
- Palatine bones – two bone plates that form portions of the hard palate, the posterolateral walls of the nasal cavity, and a small part of the orbits

### Other Facial Bones

- Vomer – plow-shaped bone that forms part of the nasal septum
- Inferior nasal conchae – paired, curved bones in the nasal cavity that form part of the lateral walls of the nasal cavity

### Anterior and Posterior Aspects of the Skull

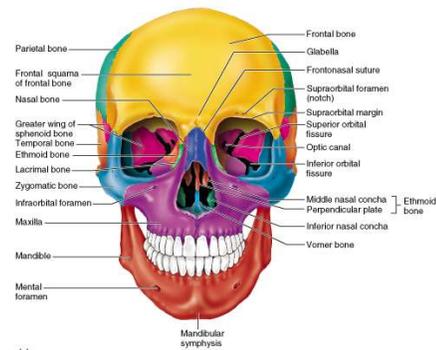


Figure 7.2a

### Anterior and Posterior Aspects of the Skull

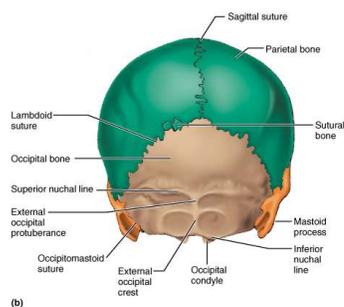


Figure 7.2b

### Lateral Aspects of the Skull

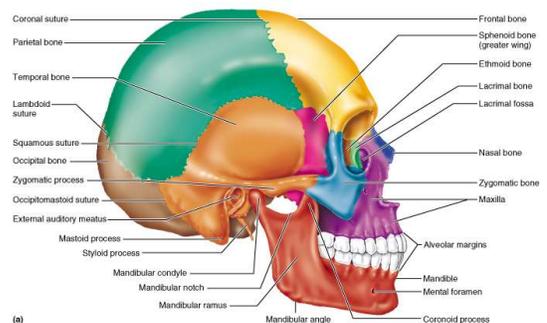
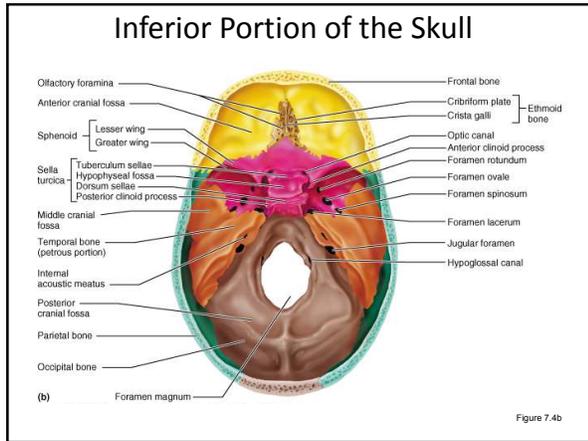
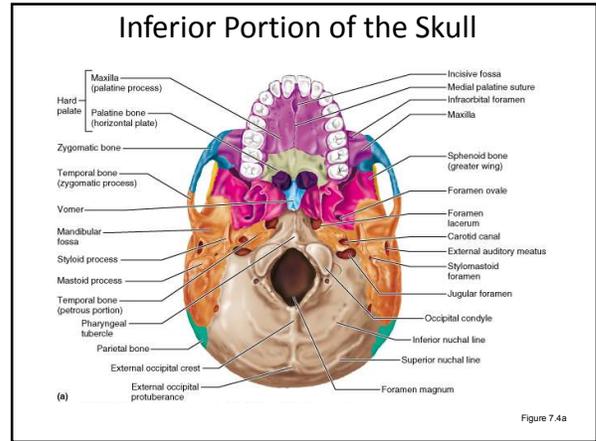
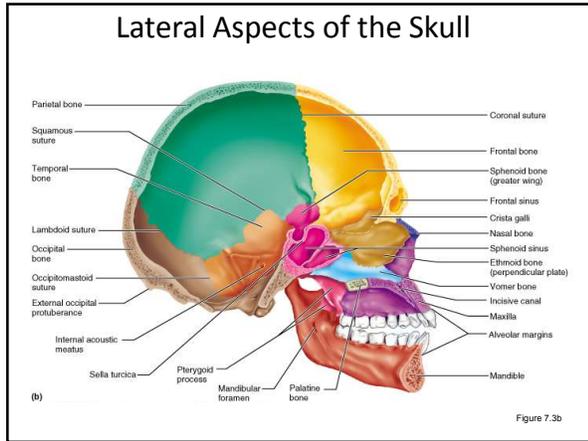
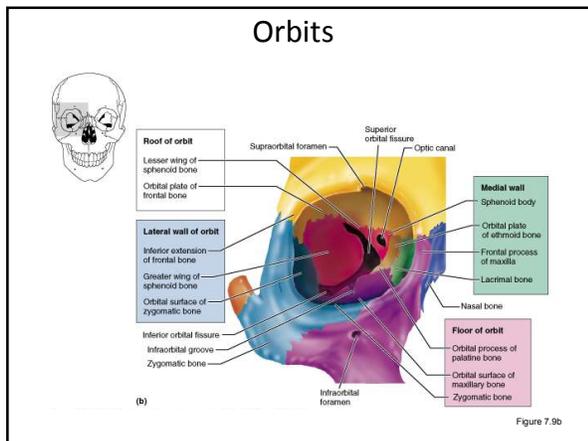


Figure 7.3a



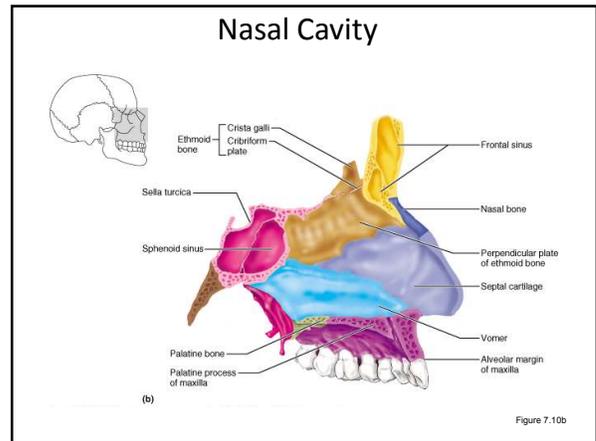
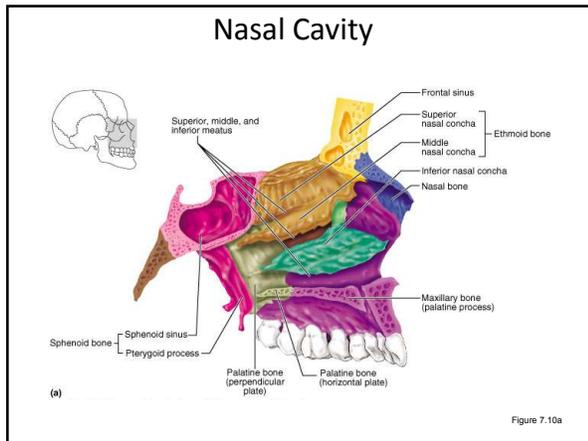
### Orbits

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

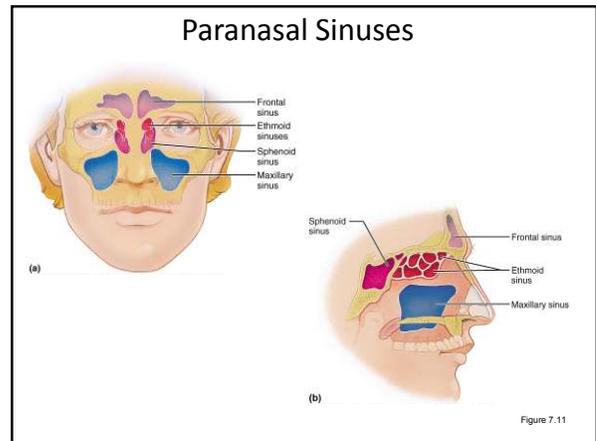


### Nasal Cavity

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



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

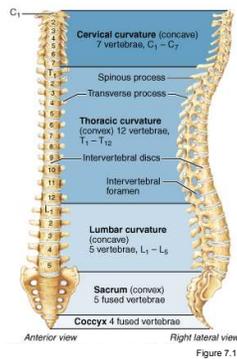


- ### Hyoid Bone
- Not actually part of the skull, but lies just inferior to the mandible in the anterior neck
  - Only bone of the body that does not articulate directly with another bone
  - Attachment point for neck muscles that raise and lower the larynx during swallowing and speech
- 
- Figure 7.12

- ### Vertebral Column
- Formed from 26 irregular bones (vertebrae) connected in such a way that a flexible curved structure results
    - Cervical vertebrae – 7 bones of the neck
    - Thoracic vertebrae – 12 bones of the torso
- 
- Figure 7.13

### Vertebral Column

- Lumbar vertebrae – 5 bones of the lower back
- Sacrum – bone inferior to the lumbar vertebrae that articulates with the hip bones



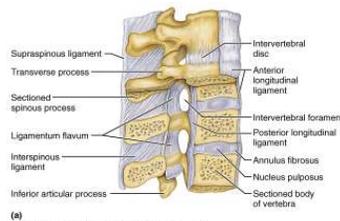
Anterior view Right lateral view Figure 7.13

### Vertebral Column: Curvatures

- Posteriorly concave curvatures – cervical and lumbar
- Posteriorly convex curvatures – thoracic and sacral
- Abnormal spine curvatures include scoliosis (abnormal lateral curve), kyphosis (hunchback), and lordosis (swayback)

### Vertebral Column: Ligaments

- Anterior and posterior longitudinal ligaments – continuous bands down the front and back of the spine from the neck to the sacrum
- Short ligaments that connect adjoining vertebrae together

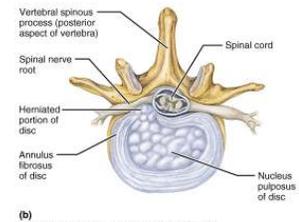


(a)

Figure 7.14a

### Vertebral Column: Intervertebral Discs

- Cushionlike pad composed of two parts
  - Nucleus pulposus – inner gelatinous nucleus that gives the disc its elasticity and compressibility
  - Annulus fibrosus – surrounds the nucleus pulposus with a collar composed of collagen and fibrocartilage



(b)

Figure 7.14b

### General Structure of Vertebrae

- Body or centrum – disc-shaped, weight-bearing region
- Vertebral arch – composed of pedicles and laminae that, along with the centrum, encloses the vertebral foramen
- Vertebral foramina – make up the vertebral canal through which the spinal cord passes

### General Structure of Vertebrae

- Spinous process project posteriorly, and transverse processes project laterally
- Superior and inferior articular processes – protrude superiorly and inferiorly from the pedicle-lamina junctions
- Intervertebral foramina – lateral openings formed from notched areas on the superior and inferior borders of adjacent pedicles

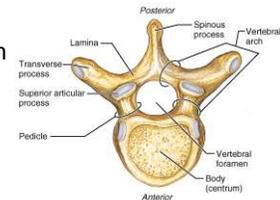


Figure 7.15

### Cervical Vertebrae

- Seven vertebrae (C<sub>1</sub>-C<sub>7</sub>) are the smallest, lightest vertebrae
- C<sub>3</sub>-C<sub>7</sub> are distinguished with an oval body, short spinous processes, and large, triangular vertebral foramina
- Each transverse process contains a transverse foramen

### Cervical Vertebrae

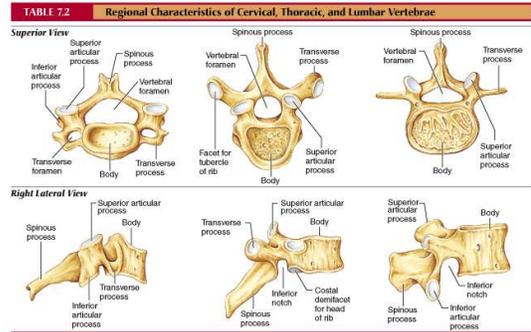


Table 7.2

### Cervical Vertebrae: The Atlas (C<sub>1</sub>)

- The atlas
  - Has no body and no spinous process
  - Consists of anterior and posterior arches, and two lateral masses
  - The superior surface of lateral masses articulate with the occipital condyles

### Cervical Vertebrae: The Atlas (C<sub>1</sub>)

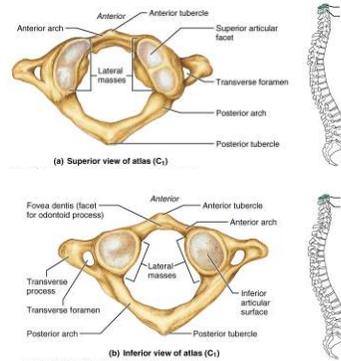


Figure 7.16a, b

### Cervical Vertebrae: The Axis (C<sub>2</sub>)

- The axis has a body, spine, and vertebral arches as do other cervical vertebrae

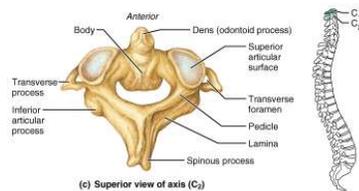


Figure 7.16c

### Cervical Vertebrae: The Axis (C<sub>2</sub>)

- Unique to the axis is the dens, or odontoid process, which projects superiorly from the body and is cradled in the anterior arch of the atlas

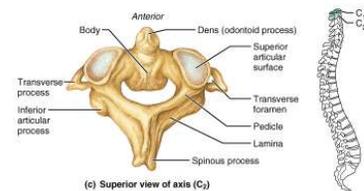


Figure 7.16c

### Cervical Vertebrae: The Axis (C<sub>2</sub>)

- The dens is a pivot for the rotation of the atlas

(c) Superior view of axis (C<sub>2</sub>)

Figure 7.16c

### Cervical Vertebrae: The Atlas (C<sub>2</sub>)

(a) Cervical vertebrae

Figure 7.17a

### Thoracic Vertebrae

- There are twelve vertebrae (T<sub>1</sub>-T<sub>12</sub>) all of which articulate with ribs
- Major markings include two facets and two demifacets on the heart-shaped body, the circular vertebral foramen, transverse processes, and a long spinous process
- The location of the articulate facets prevent flexion and extension, but allow rotation of this area of the spine

### Thoracic Vertebrae

(b) Thoracic vertebrae

Figure 7.17b

### Lumbar Vertebrae

- The five lumbar vertebrae (L<sub>1</sub>-L<sub>5</sub>) are located in the small of the back and have an enhanced weight-bearing function
- They have short, thick pedicles and laminae, flat hatchet-shaped spinous processes, and a triangular-shaped vertebral foramen
- Orientation of articular facets lock the lumbar vertebrae together to provide stability

### Lumbar Vertebrae

(c) Lumbar vertebrae

Figure 7.17c

### Sacrum and Coccyx

- The sacrum
  - Consists of five fused vertebrae (S<sub>1</sub>-S<sub>5</sub>), which shape the posterior wall of the pelvis
  - It articulates with L<sub>5</sub> superiorly, and with the auricular surfaces of the hip bones
  - Major markings include the sacral promontory, transverse lines, alae, dorsal sacral foramina, sacral canal, and sacral hiatus
- Coccyx (Tailbone)
  - The coccyx is made up of four (in some cases three to five) fused vertebrae that articulate superiorly with the sacrum

### Sacrum and Coccyx

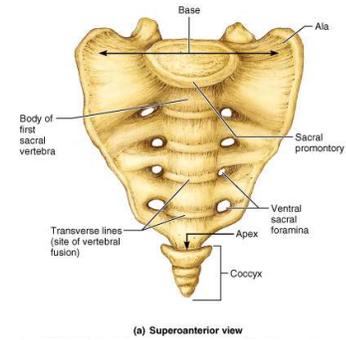


Figure 7.18a

### Sacrum and Coccyx

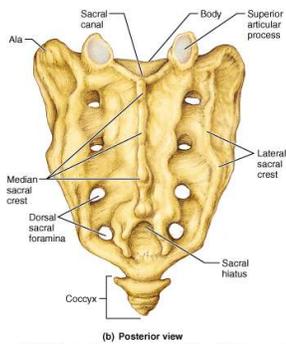


Figure 7.18b

### Bony Thorax (Thoracic Cage)

- The thoracic cage is composed of the thoracic vertebrae dorsally, the ribs laterally, and the sternum and costal cartilages anteriorly
- Functions
  - Forms a protective cage around the heart, lungs, and great blood vessels
  - Supports the shoulder girdles and upper limbs
  - Provides attachment for many neck, back, chest, and shoulder muscles
  - Uses intercostal muscles to lift and depress the thorax during breathing

### Bony Thorax (Thoracic Cage)

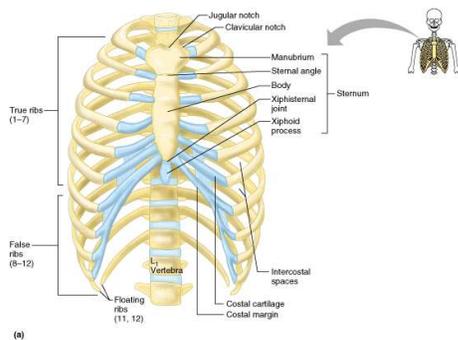


Figure 7.19a

### Bony Thorax (Thoracic Cage)

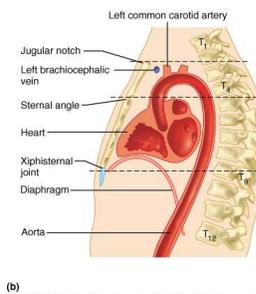


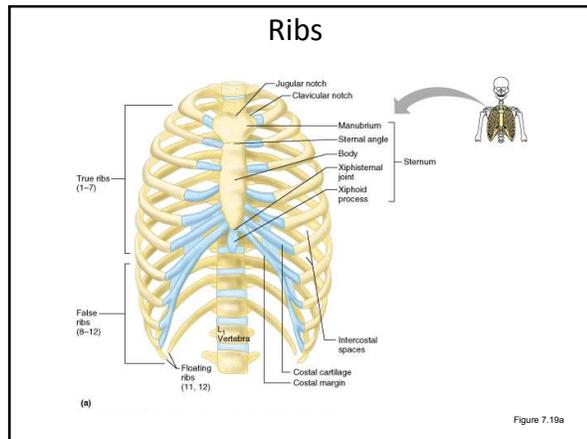
Figure 7.19b

## Sternum (Breastbone)

- A dagger-shaped, flat bone that lies in the anterior midline of the thorax
- Results from the fusion of three bones – the superior manubrium, the body, and the inferior xiphoid process
- Anatomical landmarks include the jugular (suprasternal) notch, the sternal angle, and the xiphisternal joint

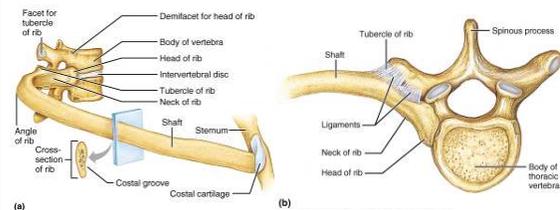
## Ribs

- There are twelve pair of ribs forming the flaring sides of the thoracic cage
- All ribs attach posteriorly to the thoracic vertebrae
- The superior 7 pair (true, or vertebrosteral ribs) attach directly to the sternum via costal cartilages
- Ribs 8-10 (false, or vertebrocondral ribs) attach indirectly to the sternum via costal cartilage
- Ribs 11-12 (floating, or vertebral ribs) have no anterior attachment



## Structure of a Typical True Rib

- Bowed, flat bone consisting of a head, neck, tubercle, and shaft

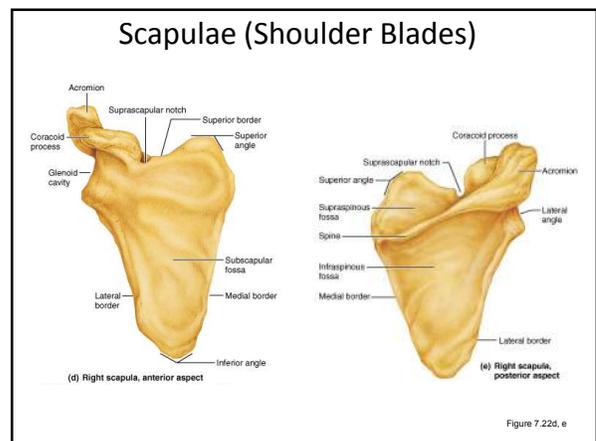
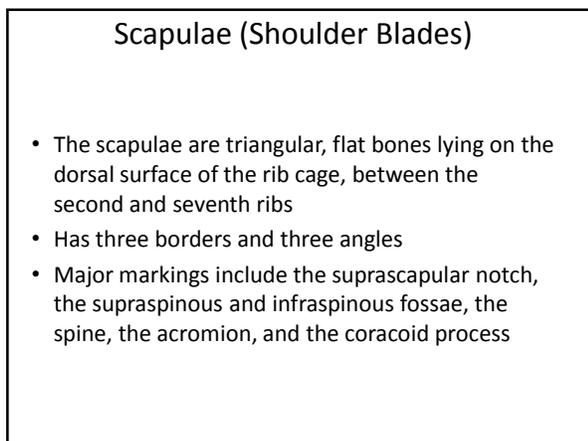
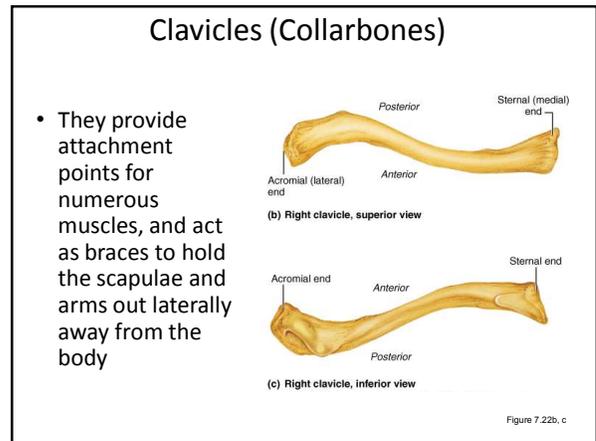
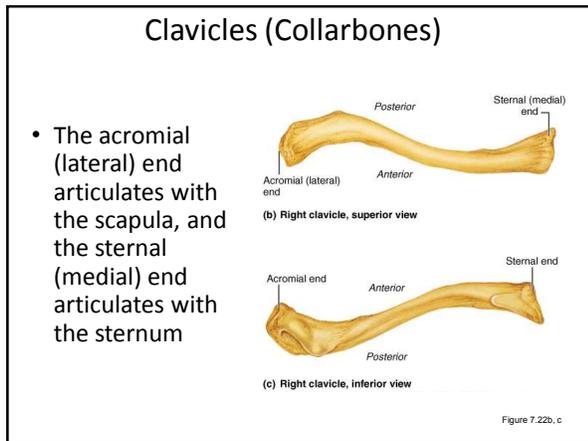
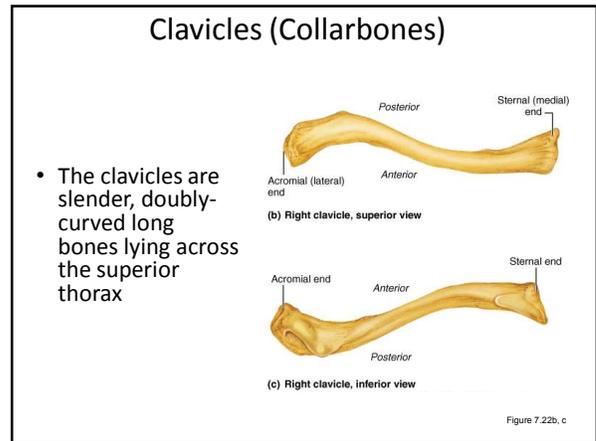
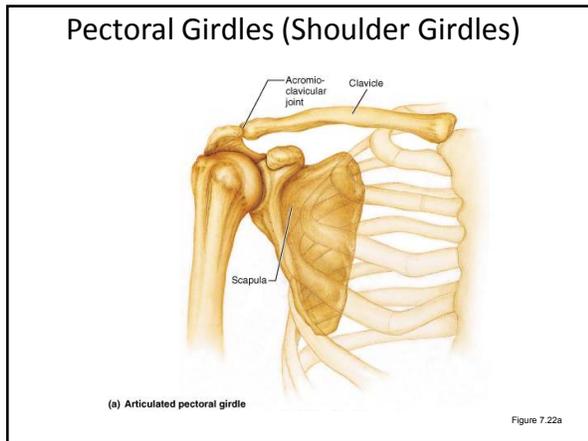


## Appendicular Skeleton

- The appendicular skeleton is made up of the bones of the limbs and their girdles
- Pectoral girdles attach the upper limbs to the body trunk
- Pelvic girdle secures the lower limbs

## Pectoral Girdles (Shoulder Girdles)

- The pectoral girdles consist of the anterior clavicles and the posterior scapulae
- They attach the upper limbs to the axial skeleton in a manner that allows for maximum movement
- They provide attachment points for muscles that move the upper limbs



### The Upper Limb

- The upper limb consists of the arm (brachium), forearm (antebrachium), and hand (manus)
- Thirty-seven bones form the skeletal framework of each upper limb

### The Upper Limb

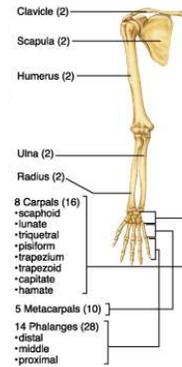


Table 7.3

### Arm

- The humerus is the sole bone of the arm
- It articulates with the scapula at the shoulder, and the radius and ulna at the elbow
- Major markings
  - Proximal humerus includes the head, anatomical and surgical necks, greater and lesser tubercles, and the intertubercular groove
  - Distal humerus includes the capitulum, trochlea, medial and lateral epicondyles, and the coronoid and olecranon fossae
  - Medial portion includes the radial groove and the deltoid process

### Arm

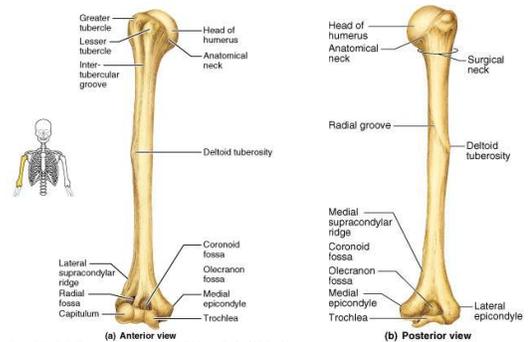


Figure 7.23 a, b

### Forearm

- The bones of the forearm are the radius and ulna
- They articulate proximally with the humerus and distally with the wrist bones
- They also articulate with each other proximally and distally at small radioulnar joints
- Interosseous membrane connects the two bones along their entire length

### Forearm

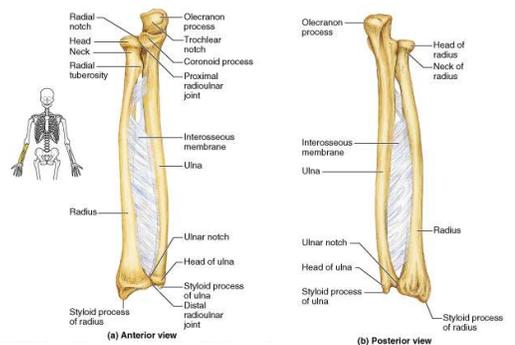


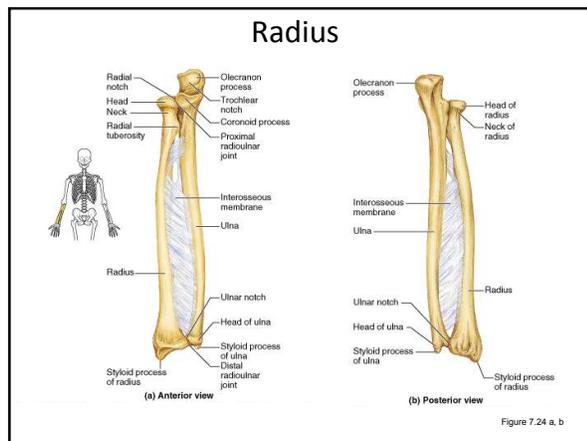
Figure 7.24 a, b

## Ulna

- The ulna lies medially in the forearm and is slightly longer than the radius
- Forms the major portion of the elbow joint with the humerus
- Its major markings include the olecranon, coronoid process, trochlear notch, radial notch, and the styloid process

## Radius

- The radius lies opposite (lateral to) the ulna and is thin at its proximal end, widened distally
- The superior surface of the head articulates with the capitulum of the humerus
- Medially, the head articulates with the radial notch of the ulna
- Major markings include the radial tuberosity, ulnar notch, and styloid process



## Hand

- Skeleton of the hand contains wrist bones (carpals), bones of the palm (metacarpals), and bones of the fingers (phalanges)



## Carpus (Wrist)

- Consists of eight bones
  - Scaphoid, lunate, triquetral, and pisiform proximally
  - Trapezium, trapezoid, capitate, and hamate distally

## Metacarpus (Palm)

- Five numbered (1-5) metacarpal bones radiate from the wrist to form the palm
  - Their bases articulate with the carpals proximally, and with each other medially and laterally
  - Heads articulate with the phalanges

### Phalanges (Fingers)

- Each hand contains 14 miniature long bones called phalanges
- Fingers (digits) are numbered 1-5, beginning with the thumb (pollex)
- Each finger (except the thumb) has three phalanges – distal, middle, and proximal
- The thumb has no middle phalanx

### Hand



Figure 7.26

### Pelvic Girdle (Hip)

- The hip is formed by a pair of hip bones (os coxae, or coxal)
- Together with the sacrum and the coccyx, these bones form the bony pelvis
- The pelvis
  - Attaches the lower limbs to the axial skeleton with the strongest ligaments of the body
  - Transmits weight of the upper body to the lower limbs
  - Supports the visceral organs of the pelvis

### Pelvic Girdle (Hip)

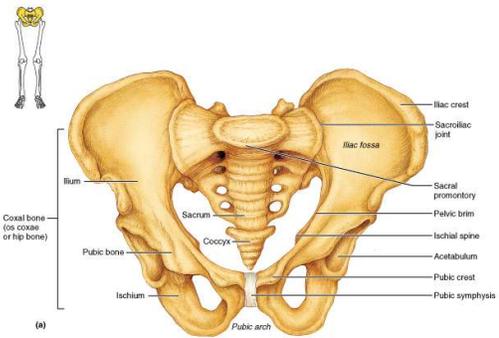


Figure 7.27a

### Ilium

- The ilium is a large flaring bone that forms the superior region of the coxal bone
- It consists of a body and a superior winglike portion called the *ala*
- The broad posterolateral surface is called the *gluteal surface*
- The auricular surface articulates with the sacrum (sacroiliac joint)
- Major markings include the iliac crests, four spines, greater sciatic notch, iliac fossa, arcuate line, and the pelvic brim

### Ilium

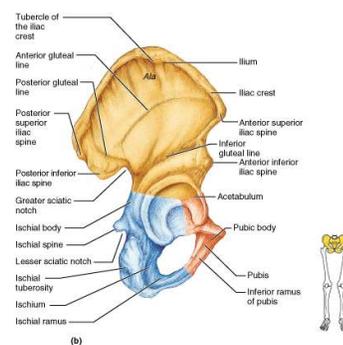
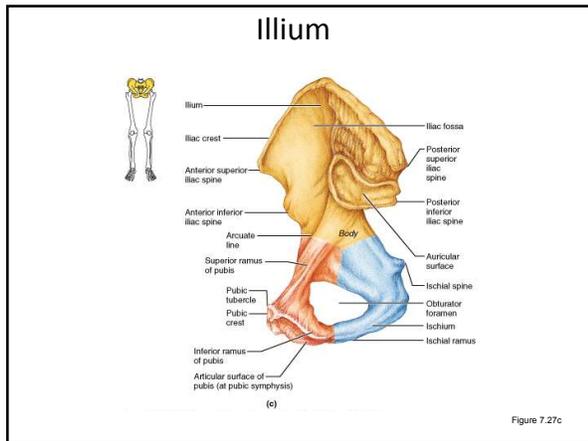


Figure 7.27b

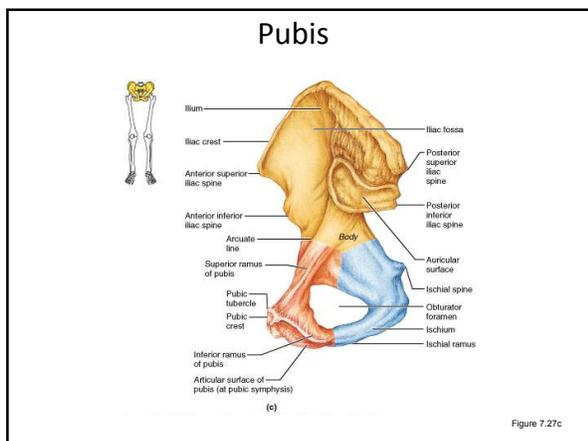
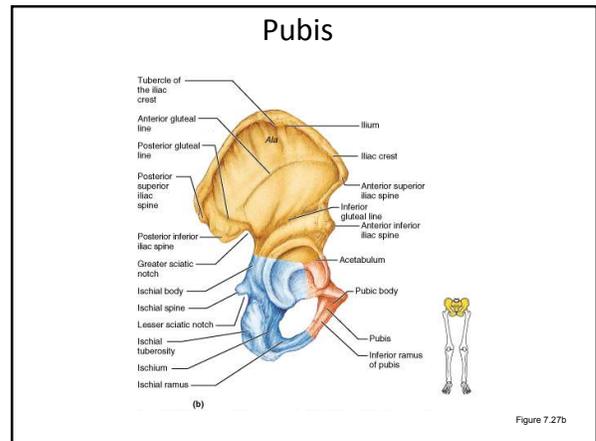


### Ischium

- The ischium forms the posteroinferior part of the hip bone
- The thick body articulates with the ilium, and the thinner ramus articulates with the pubis
- Major markings include the ischial spine, lesser sciatic notch, and the ischial tuberosity

### Pubis

- The pubic bone forms the anterior portion of the hip bone
- It articulates with the ischium and the ilium
- Major markings include superior and inferior rami, the pubic crest, pubic tubercle, pubic arch, pubic symphysis, and obturator foramen (along with ilium and ischium)



### Comparison of Male and Female Pelvic Structure

- Female pelvis
  - Tilted forward, adapted for childbearing
  - True pelvis defines birth canal
  - Cavity of the true pelvis is broad, shallow, and has greater capacity
- Male pelvis
  - Tilted less forward
  - Adapted for support of heavier male build and stronger muscles
  - Cavity of true pelvis is narrow and deep

Comparison of Male and Female Pelvic Structure

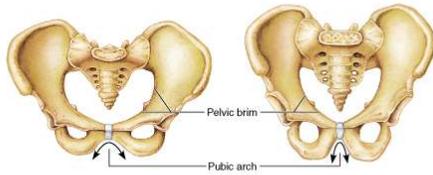


Table 7.4

Male vs. Female Pelvic Structure

| Characteristic   | Female  | Male   |
|------------------|---|--|
| Bone thickness   | Lighter, thinner, and smoother                  | Heavier, thicker, and more prominent markings  |
| Pubic arch/angle | 80°-90°   | 50°-60°  |
| Acetabula        | Small; farther apart                            | Large; closer together                         |
| Sacrum           | Wider, shorter; sacral curvature is accentuated | Narrow, longer; sacral promontory more ventral |
| Coccyx           | More movable; straighter                        | Less movable; curves ventrally                 |

Lower Limbs

- The three segments of the lower limb are the thigh, leg, and foot
- They carry the weight of the erect body, and are subjected to exceptional forces when one jumps or runs

Femur

- The sole bone of the thigh is the femur, the largest and strongest bone in the body
- It articulates proximally with the hip and distally with the tibia and fibula

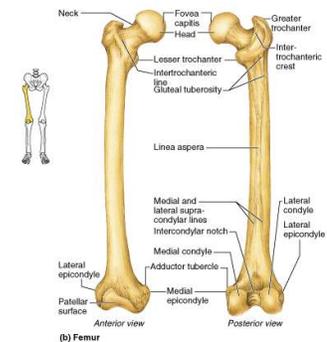


Figure 7.28b

Femur

- Major markings include the head, fovea capitis, greater and lesser trochanters, gluteal tuberosity, lateral and medial condyles and epicondyles, linea aspera, patellar surface,

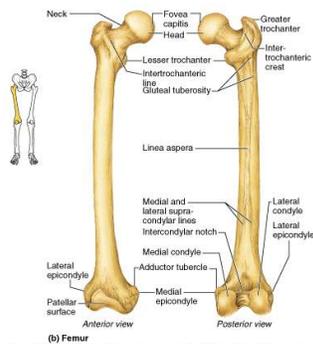


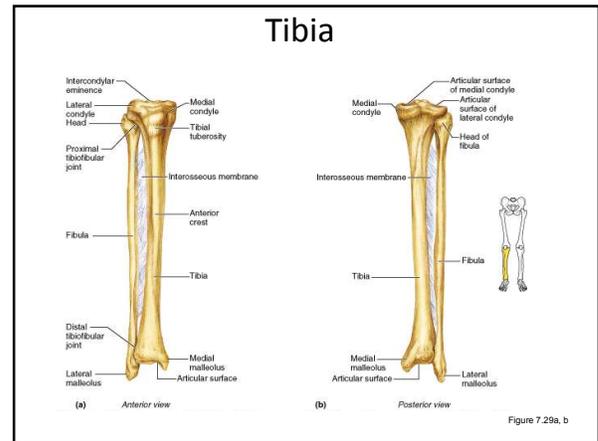
Figure 7.28b

Leg

- The tibia and fibula form the skeleton of the leg
- They are connected to each other by the interosseous membrane
- They articulate with the femur proximally and with the ankle bones distally
- They also articulate with each other via the immovable tibiofibular joints

### Tibia

- Receives the weight of the body from the femur and transmits it to the foot
- Major markings include medial and lateral condyles, intercondylar eminence, the tibial tuberosity, anterior crest, medial malleolus, and fibular notch



### Fibula

- Sticklike bone with slightly expanded ends located laterally to the tibia
- Major markings include the head and lateral malleolus

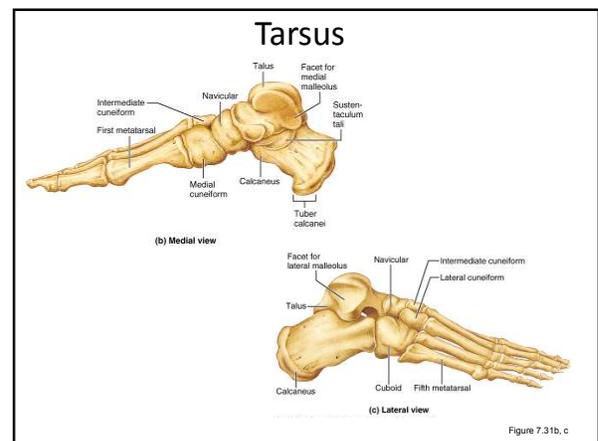
### Foot

- The skeleton of the foot includes the tarsus, metatarsus, and the phalanges (toes)
- The foot supports body weight and acts as a lever to propel the body forward in walking and running



### Tarsus

- Composed of seven bones that form the posterior half of the foot
- Body weight is carried primarily on the talus and calcaneus
- Talus articulates with the tibia and fibula superiorly, and the calcaneus inferiorly
- Other tarsus bones include the cuboid and navicular, and the medial, intermediate, and lateral cuneiforms



### Calcaneus

- Forms the heel of the foot
- Carries the talus on its superior surface
- Point of attachment for the calcaneal (Achilles) tendon of the calf muscles

### Metatarsus and Phalanges

- Metatarsals
  - Five (1-5) long bones that articulate with the proximal phalanges
  - The enlarged head of metatarsal 1 forms the “ball of the foot”



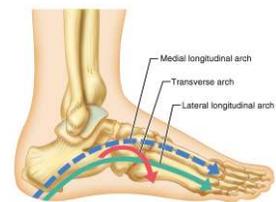
### Metatarsus and Phalanges

- Phalanges
  - The 14 bones of the toes
  - Each digit has three phalanges except the hallux, which has no middle phalanx



### Arches of the Foot

- The foot has three arches maintained by interlocking foot bones and strong ligaments
- Arches allow the foot to hold up weight



### Arches of the Foot

- The arches are:
  - Lateral longitudinal – cuboid is keystone of this arch
  - Medial longitudinal – talus is keystone of this arch
  - Transverse – runs obliquely from one side of the foot to the other

