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Skeletal System

Advanced Care Paramedicine

Module: 08

Section: 01

The Skeletal System

- Consists of:
  - Bones
  - Cartilage
  - Ligaments
    - Connect Bone to Bone
  - Tendons
    - Connect Muscle to Bone
- Accounts for 20% of body weight
- They are living tissue

Functions

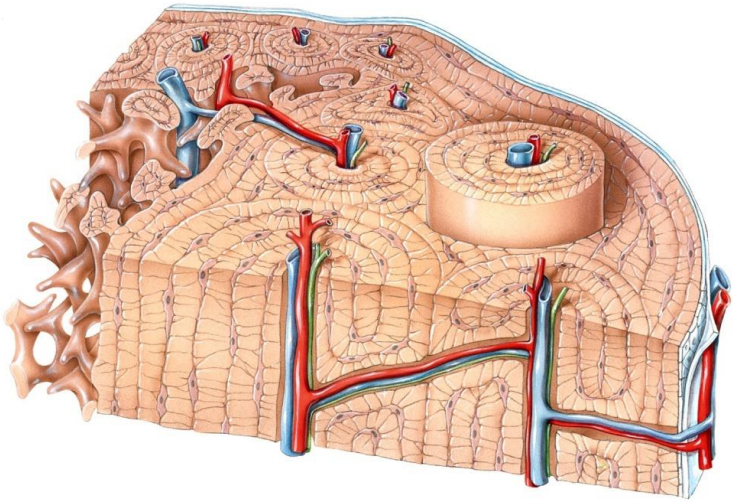
- Support
  - Supports organs and against gravity
- Protection
  - Protects soft organs underneath
- Movement
  - Muscles attached provide movement
- Storage
  - Store and release salts of calcium and phosphorus
  - Store triglycerides in adipose cells of yellow marrow
- Blood Cell Formation
  - Hematopoiesis in the Red Bone Marrow

Tissues of the Skeletal System

- Bone is a dynamic tissue – it is always remodeling (building up and breaking down).
- Like all organ systems (and as part of the even larger musculoskeletal organ system), the skeletal system is made of several different tissues.
  - The two major tissues are bone (osseous tissue) and cartilage.

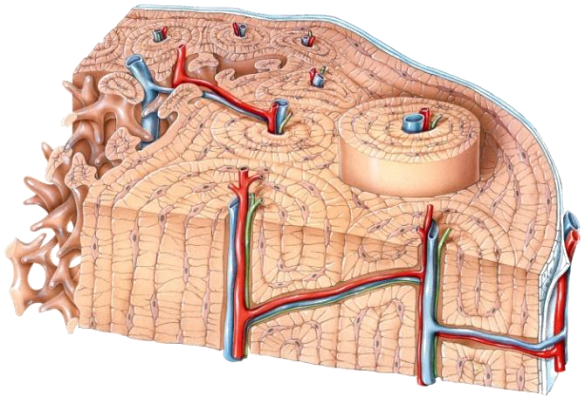
Tissues of the Skeletal System

- Bone is a highly vascularized C.T. with a hard, mineralized extracellular matrix. It is found in the body in two different arrangements:
  - Compact bone
    - most of the bone in this graphic is compact bone
  - Spongy bone
    - is seen as the less organized tissue along the left margin (with the spicules)

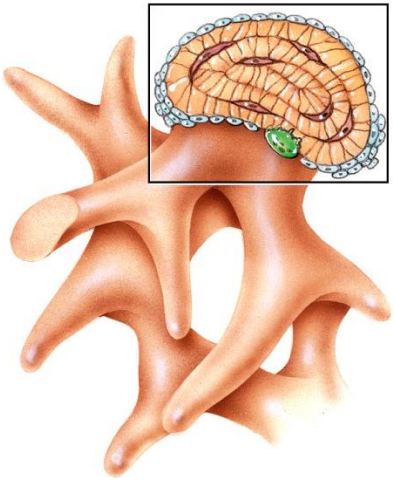


Tissues of the Skeletal System

- Compact bone is good at providing protection and support.
  - It forms the diaphysis of long bones, and the external layer of all bones.
- Spongy bone is lightweight and provides tissue support .
  - It forms much of the epiphysis and the internal cavity of long bones.



Compact bone



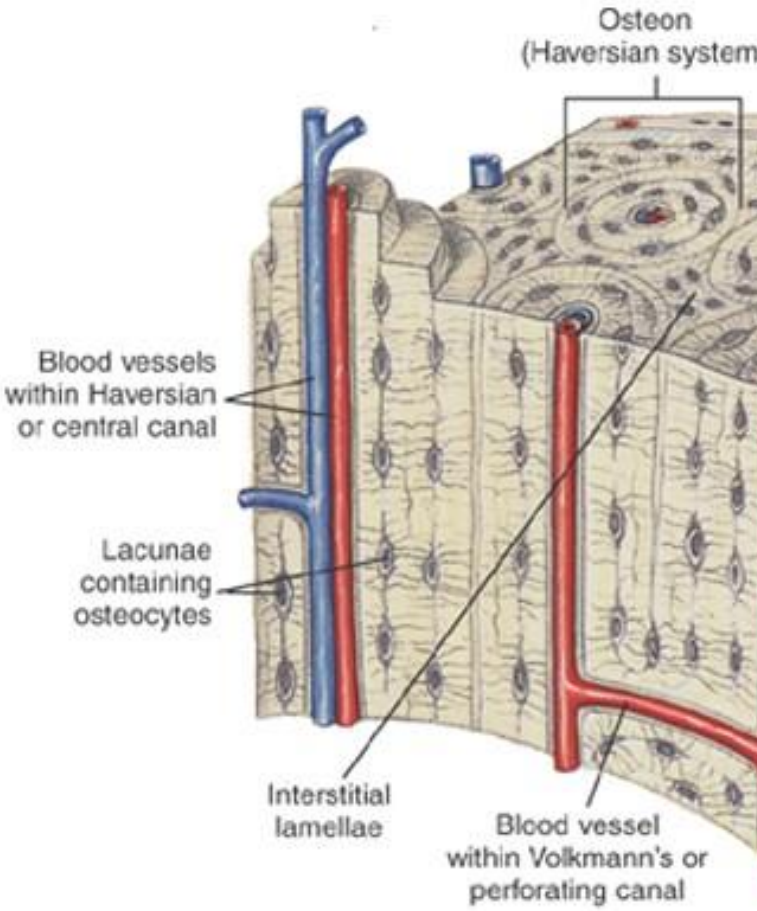
Spongy bone

Structure

- Compact
  - Very dense and hard on the outside
  - Main structure is the osteon, which are elongated cylindrical tubes that act like pillars to give support
  - Osteons are tightly packed to give the appearance of a solid mass
  - The center of each osteon contains a Haversian canal (osteonic canal)
  - The osteonic canal is surrounded by rings of (lamellae) matrix

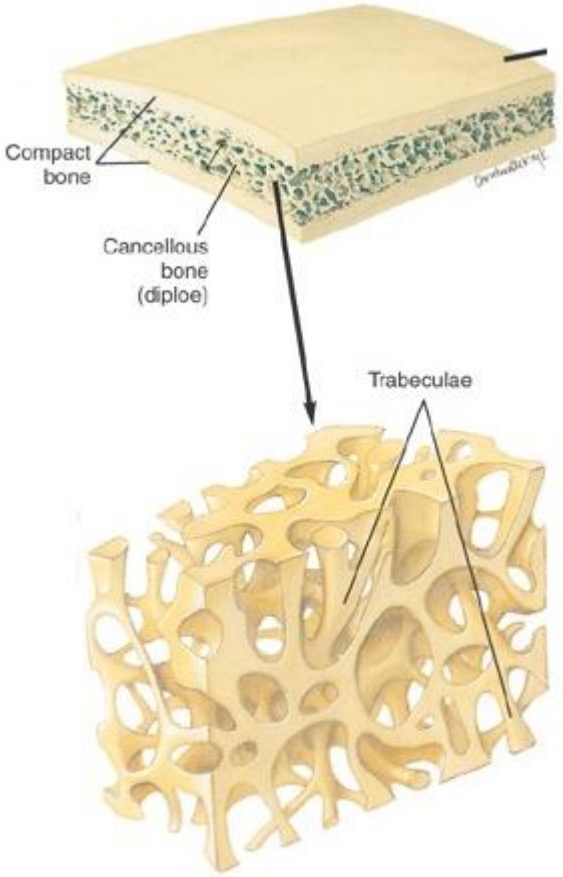
Structure

- Compact
  - Within the matrix are spaces called lacunae
  - In theses spaces are osteocytes (bone cells)
  - From the lacunae are small channels (canaliculi) which radiate out to the osteonic canal
  - Blood vessels are found in the osteonic canals running parallel to the long axis of the bone
  - These vessels are interconnected by Volkmann's Canals which lead to the vessels on the surface



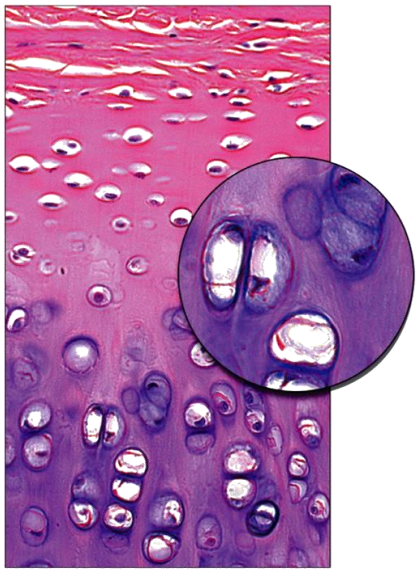
Structure

- Spongy (Cancellous)
  - Is lighter and less dense
  - Consists of plates and bars of bone next to small cavities containing red bone marrow
  - The plates are called trabeculae which are organized to give maximum strength
  - They follow the lines of stress and can realign if the direction of stress changes
  - The canaliculi connect to the adjacent cavities to receive their blood supply

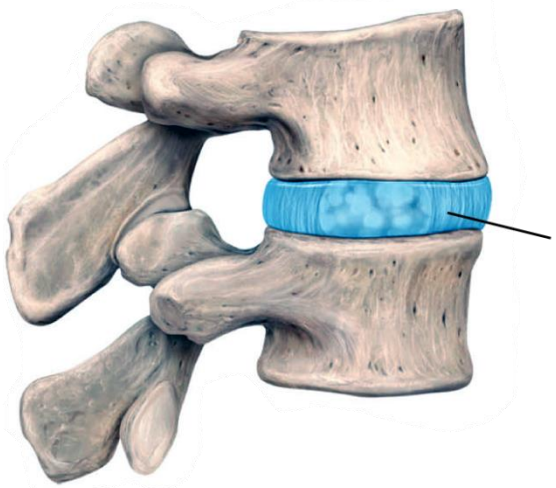


Tissues of the Skeletal System

- Cartilage is a poorly vascularized C.T. with a matrix composed of chondroitin sulfate and various fibers.
  - Fiber types distinguish hyaline cartilage from fibrocartilage or elastic cartilage.

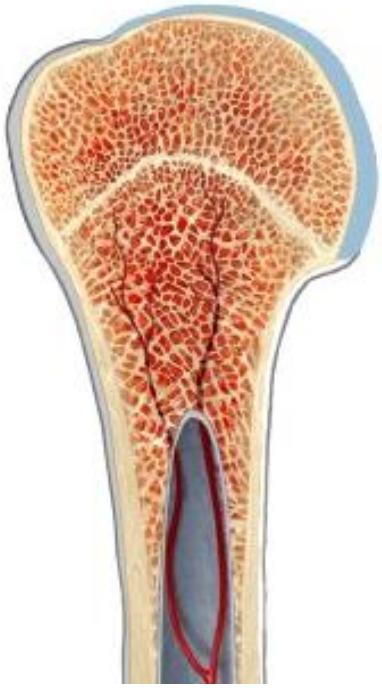


Hyaline cartilage

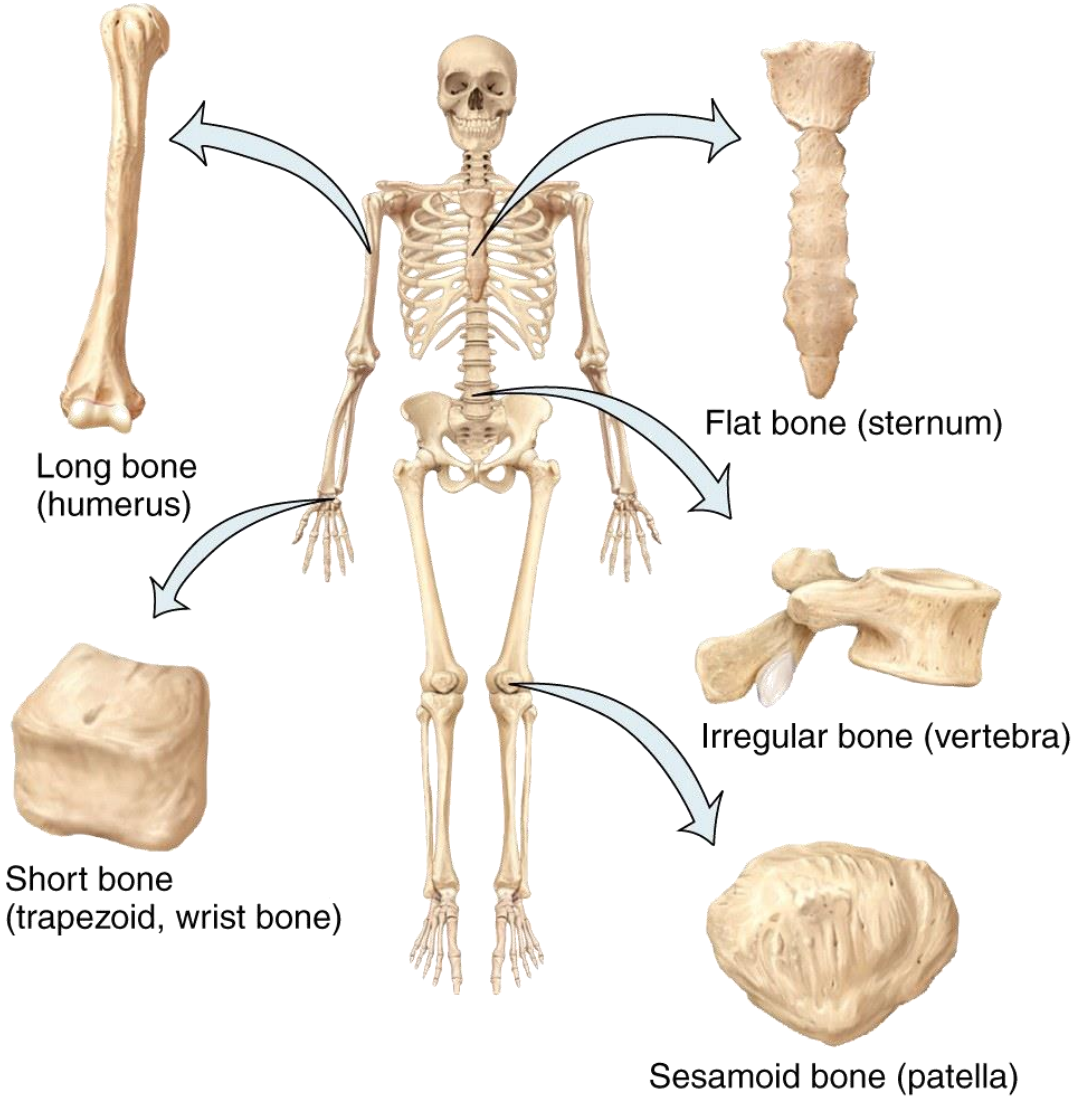


Tissues of the Skeletal System

- Articular cartilage is the thin layer of hyaline cartilage covering the epiphysis of long bones.
  - Articular cartilage is found where the bone forms an articular (joint) surface where one bone moves against another bone.



Bone Structure



Classifications

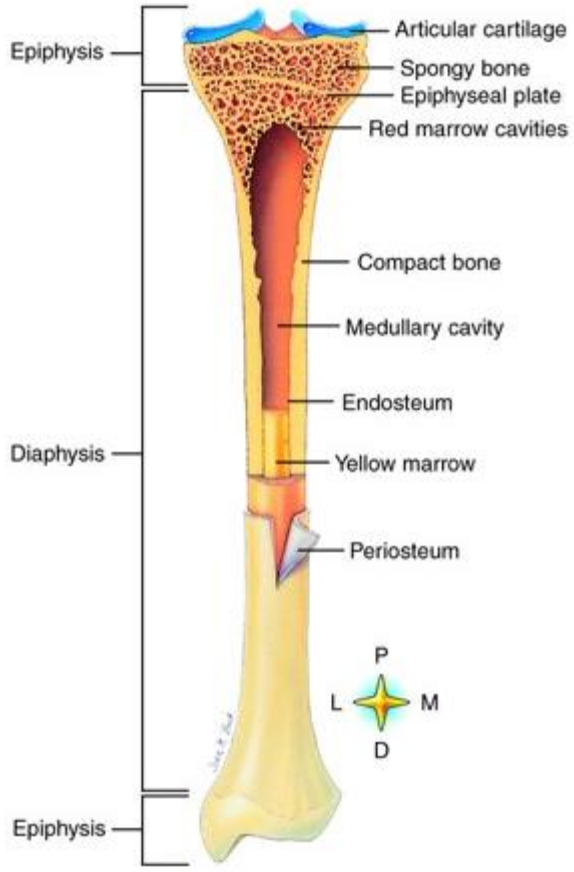
- Long
  - Longer than they are wide
  - Are primarily compact bone, but may have a large amount of spongy bone at each end
  - Femur, Ulna, Radius, Tibia, Fibula
- Short
  - Cube like
  - Primarily spongy bone covered with a thin layer of compact
  - Tarsals and Carpals

Classifications

- Flat
  - Thin, flat and usually curved
  - Middle layer of spongy (diploe) with outer layer of compact (inner and outer tables)
  - Cranial bones
- Irregular
  - Any that do not meet the other 3 classes
  - Primarily spongy with compact covering
  - Vertebrae

General Features of the Long Bone

- Diaphysis
  - Formed from compact bone surrounding hollow spaces (medullary cavities) which contain yellow bone marrow
- Epiphysis
  - Spongy bone with a thin layer of compact
  - The end which meets another one is covered with hyaline cartilage called articular cartilage
- Epiphyseal plate (growth plate)
  - When complete replaced by epiphyseal line



General Features of the Long Bone

- Periosteum
  - The outer layer of the bone is covered by tough fibrous tissue
  - Heavily supplied with nerve fibers, lymphatic vessels, blood vessels and osteoblasts
  - The blood vessels enter the diaphysis through openings called nutrient formina
- Medullary cavity
  - Lined with thinner layer of tissue called the endosteum
  - This contains the osteoclasts
- Each bone has surface markings that make it unique

Bone Formation

- Ossification or osteogenesis is the process of forming new bone. Bone formation occurs in four situations:
  - Formation of bone in an embryo
  - Growth of bones until adulthood
  - Remodeling of bone
  - Repair of fractures

Bone Formation

- Osteogenesis occurs by two different methods, beginning about the 6th week of embryonic development.
  - Intra-membranous ossification produces spongy bone.
    - This bone may subsequently be remodeled to form compact bone.
  - Endochondral ossification is a process whereby cartilage is replaced by bone.
    - Forms both compact and spongy bone.

Development and Growth

- Cells involved:
  - Osteoblasts — bone forming
  - Osteocytes — mature cells
  - Osteoclasts — break down and reabsorb

Development

- Intramembranous ossification
  - Involves the replacement of sheet like tissues of membranes in bony tissue
  - Bones formed this way are called intramembranous bones
    - Certain flat bones of the skull and some irregular bones
    - Bones first formed as connective tissue membranes
    - Osteoblasts enter the membrane and surround themselves with bony matrix (now become osteocytes)

Development

- Endochondral ossification
  - Involves the replacement of hyaline cartilage with bony tissue
  - Most bones are formed this way and are called endochondral bone
    - First formed as hyaline cartilage (first few months)
    - Perichondrium that surrounds the cartilage becomes infiltrated with blood vessels and osteoblasts and changes into periosteum (8th month)

Development

- Endochondral ossification
  - Osteoblasts form compact bone around diaphysis
  - Cartilage in the center disintegrates
  - Osteoblasts penetrate this cartilage and replace it with spongy bone (the primary ossification center)
  - Ossification continues from the center to the ends
  - After spongy bone is developed in the epiphysis osteoclasts breakdown the new bone to form the medullary cavity
  - Cartilage in epiphysis continues to grow giving length

Development

- Endochondral ossification
  - Secondary ossification centers develop (after birth) in the epiphysis and operates the same except none is broken down to form cavity
  - When complete, hyaline cartilage has been totally replaced except 2 areas
    - Articular cartilage
    - Epiphyseal plate

Growth

- Grow at the epiphyseal plate similar to endochondral ossification
- Cartilage in this area grows by mitosis
- As cells (chondrocytes) disintegrate osteoblasts move in and ossify
- Continues throughout childhood and adolescent years until it slows then stops (usually in early 20's)
- When growth stops, spongy bone in epiphyseal plate ossifies to form the epiphyseal line
- Growth is influenced by the growth hormone released from the anterior pituitary gland and the sex hormones

Growth

- Even though growth has stopped increasing length they can continue to grow in thickness or diameter.
- This is dependant on life style or weight
- An increase in diameter is called appositional growth
  - Osteoblasts in periosteum form compact bone around the external surface
  - Osteoclasts in the endosteum break down bone keeping the medullary cavity in proportion
  - This allows growth with no excessive gain in weight of bone

THE SKELETAL SYSTEM

Divisions

- Contains 206 named bones

- Two divisions
  - Axial Skeleton
  - Appendicular Skeleton

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The Skeletal System

AXIAL SKELETON

Divisions

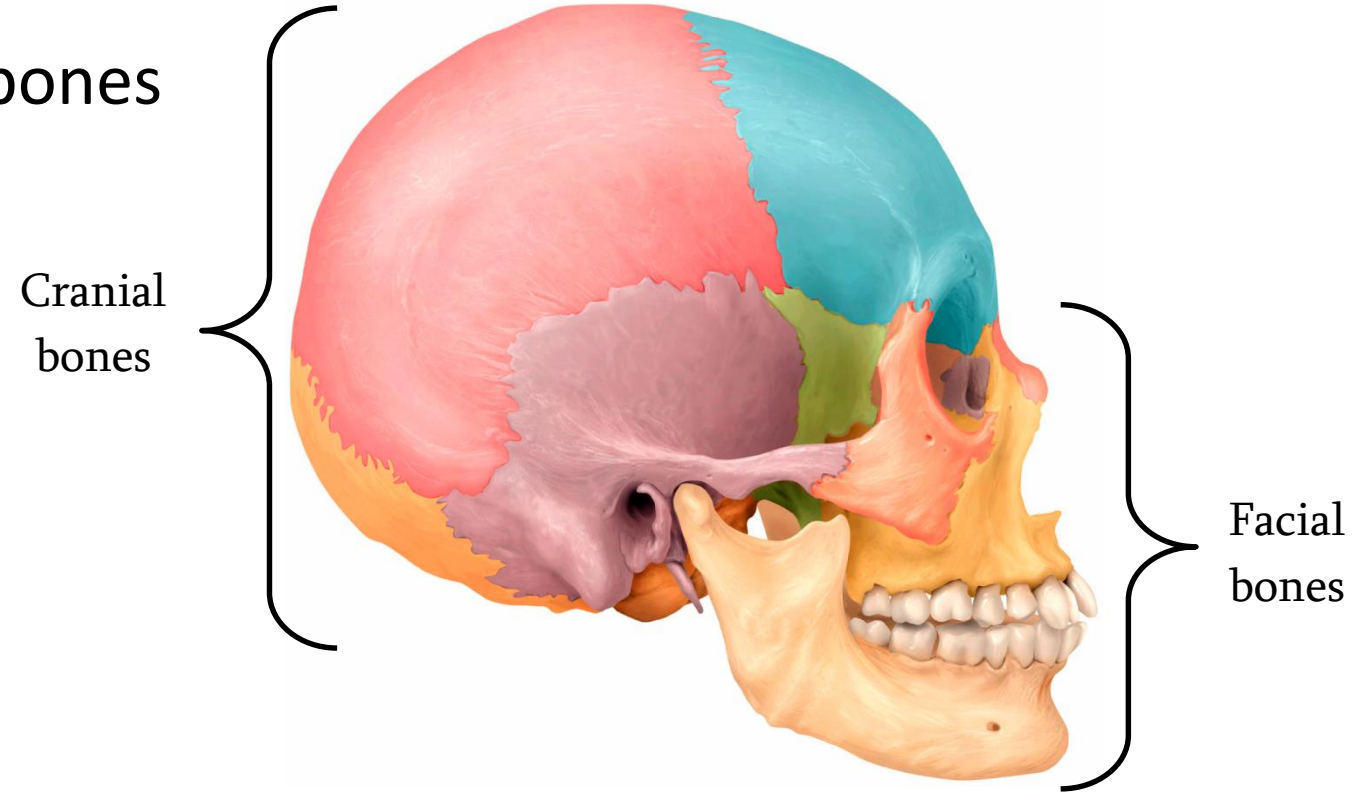
- Axial Skeleton
  - 80 bones form the vertical axis
  - Include:
    - Cranium
    - Vertebrae
    - Sternum
    - Ribs

Bones of the Skull

- The skull protects and supports the brain and special sense organs.
- Besides forming the large cranial cavity, the skull also forms several smaller cavities.
  - Nasal cavity
  - Orbits (eye sockets)
  - Paranasal sinuses
  - Small cavities which house organs involved in hearing and equilibrium

Bones of the Skull

- The bones of the skull are grouped into two categories:
  - Cranial bones
  - Facial bones



Bones of the Skull

Cranial Bones (8)

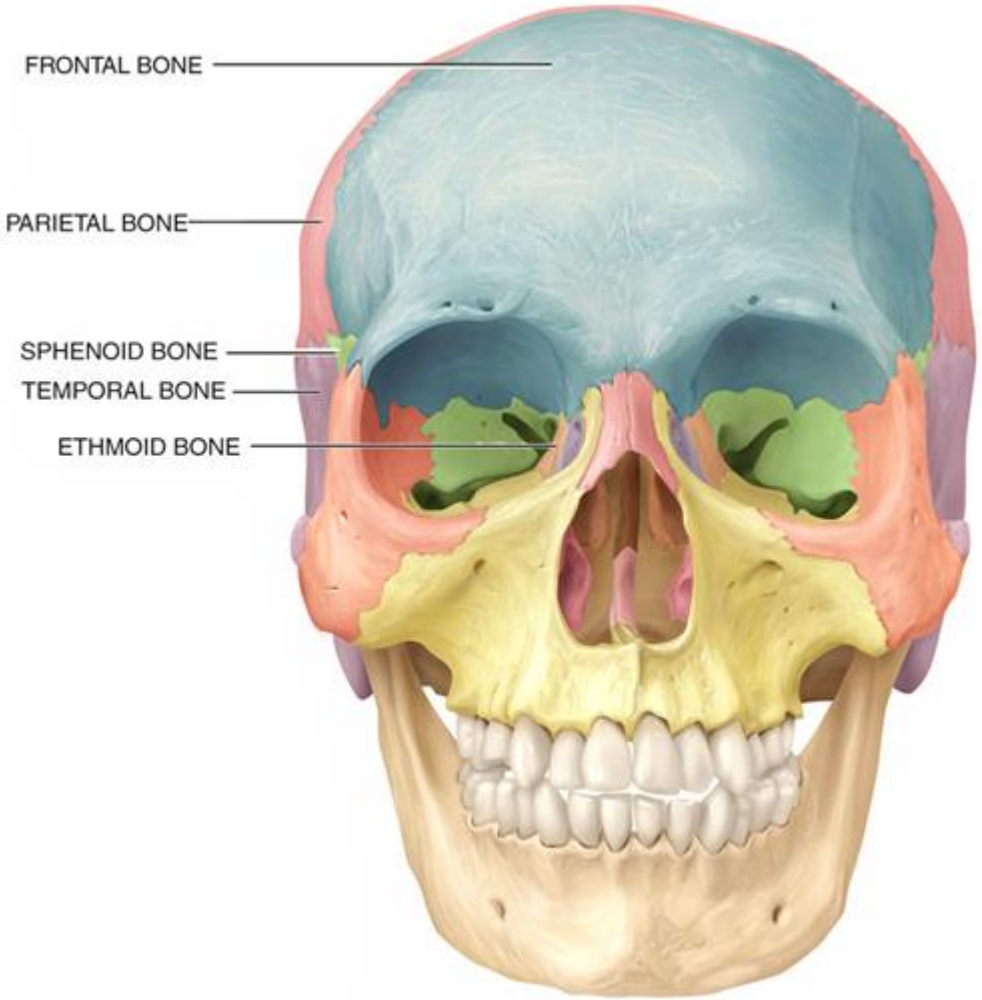
- Frontal bone (1)
- Parietal bone (2)
- Temporal bone (2)
- Occipital bone (1)
- Sphenoid bone (1)
- Ethmoid bone (1)

Facial Bones (14)

- Mandible (1)
- Maxilla (2)
- Zygomatic bone (2)
- Nasal bones (2)
- Lacrimal bones (2)
- Palatine bones (2)
- Inf. Nasal conchae (2)
- Vomer (1)

Bones of the Skull

- Neurocranium has 8 bones:
  - Frontal
  - Occipital
  - Ethmoid
  - Sphenoid
  - Temporal
  - Parietal



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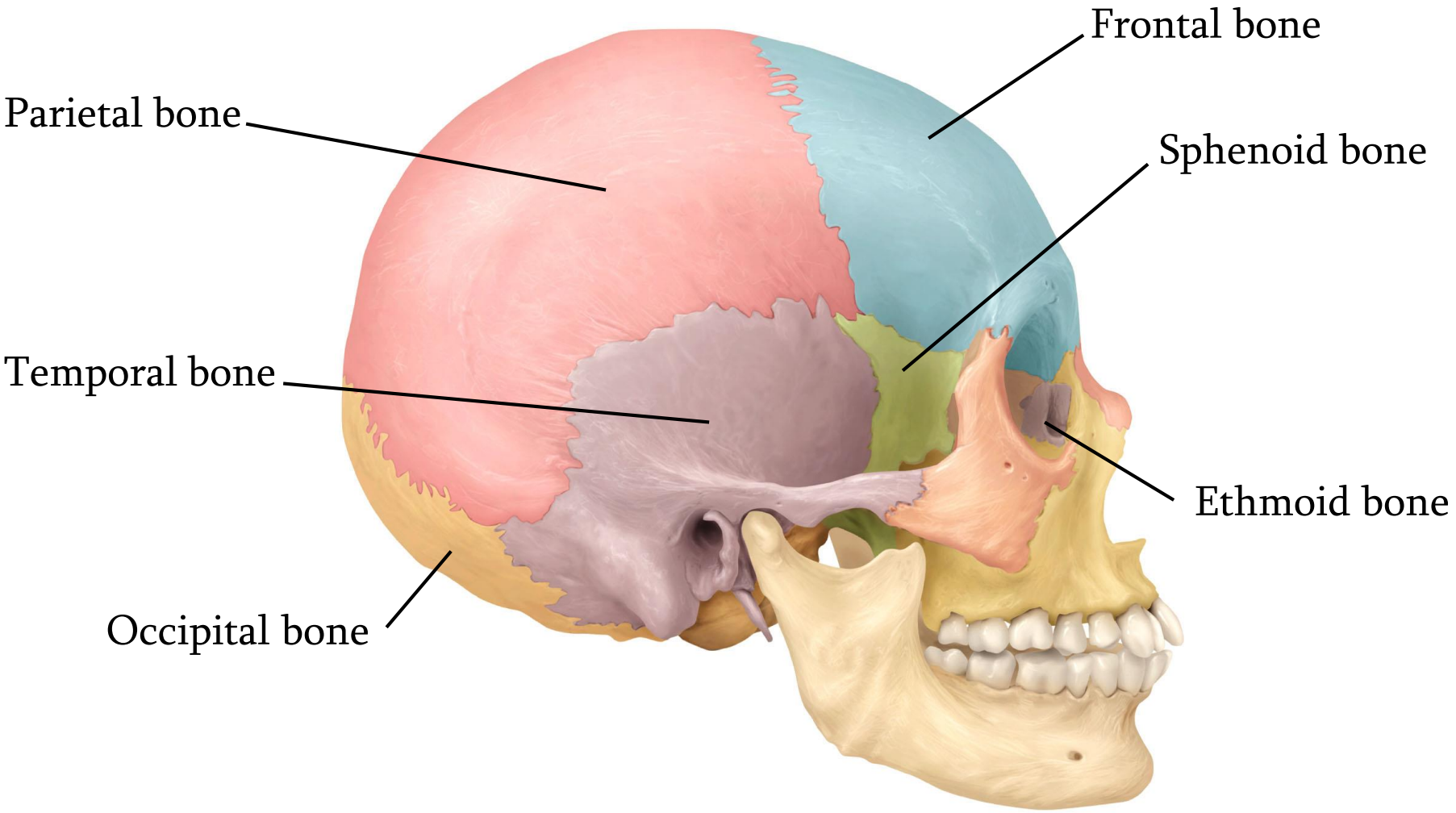
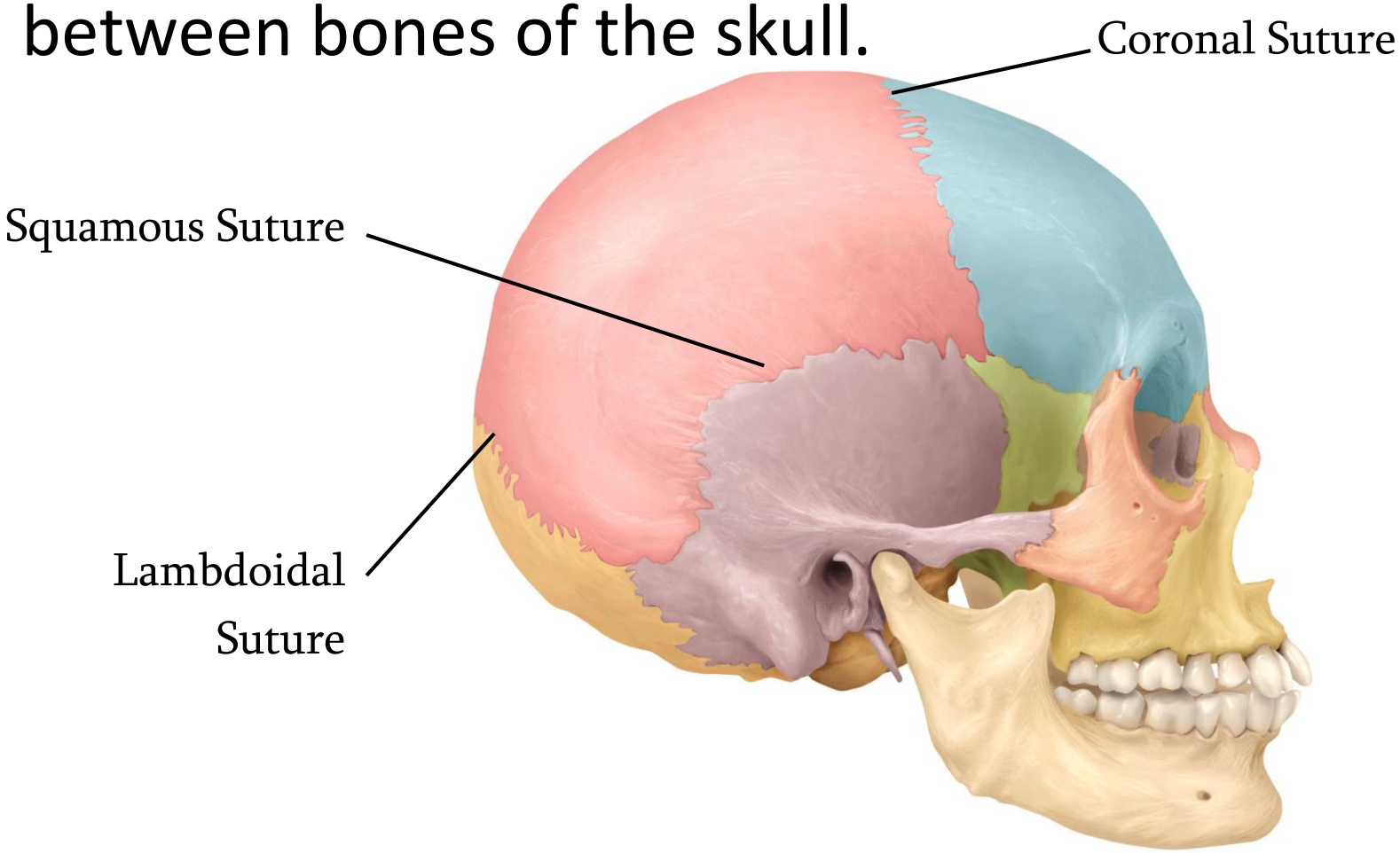
Bones of the Skull



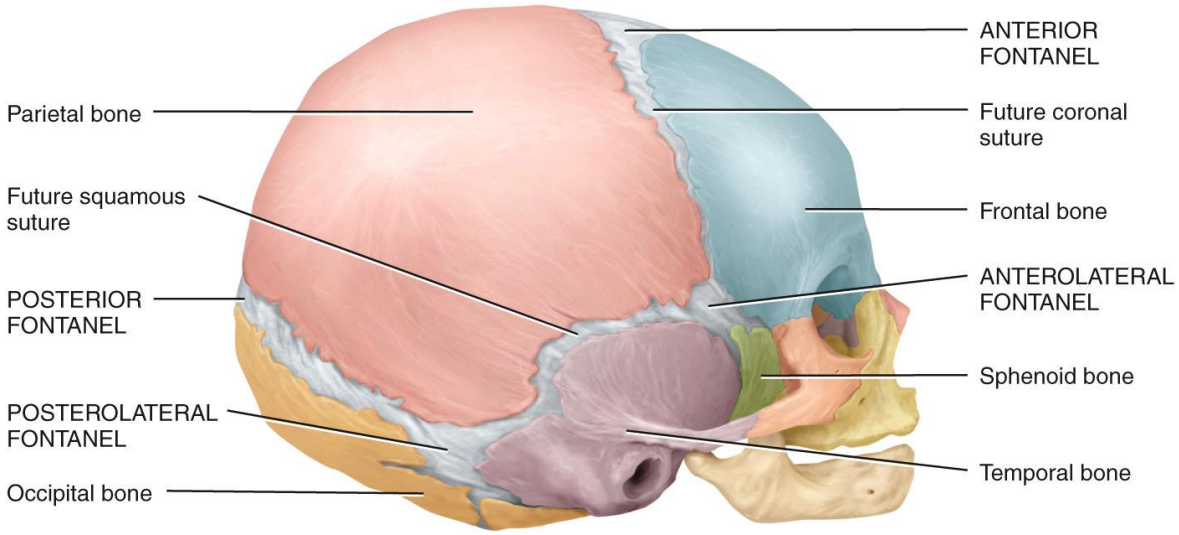
Bones of the Skull

- A suture is a “seam” – an immovable joint between bones of the skull.



Bones of the Skull

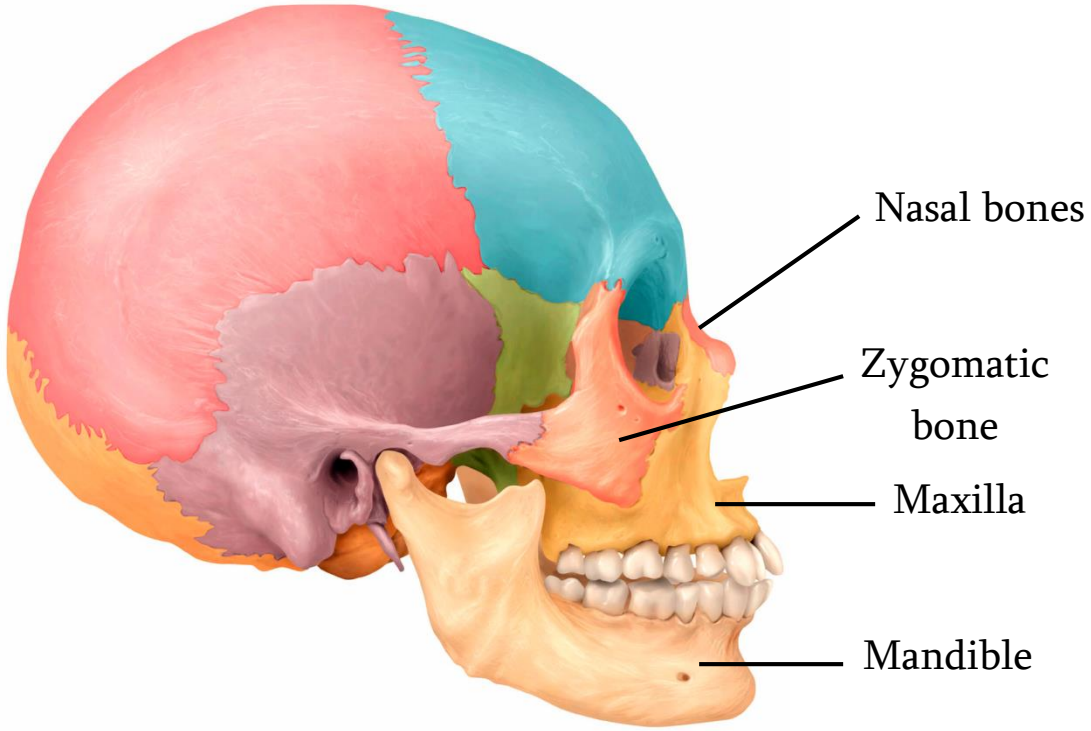
- Fontanels ("little fountains") are soft, mesenchyme-filled spaces between cranial bones in babies. They will become suture joints in adults.



(a) Right lateral view

Bones of the Skull

- 14 Facial Bones:
  - Mandible (1)
  - Maxilla (2)
  - Vomer (1)
  - Nasal bones (2)
  - Zygomatic bone
  - Lacrimal bones (2)
  - Palatine bones (2)
  - Inf. Nasal conchae (2)



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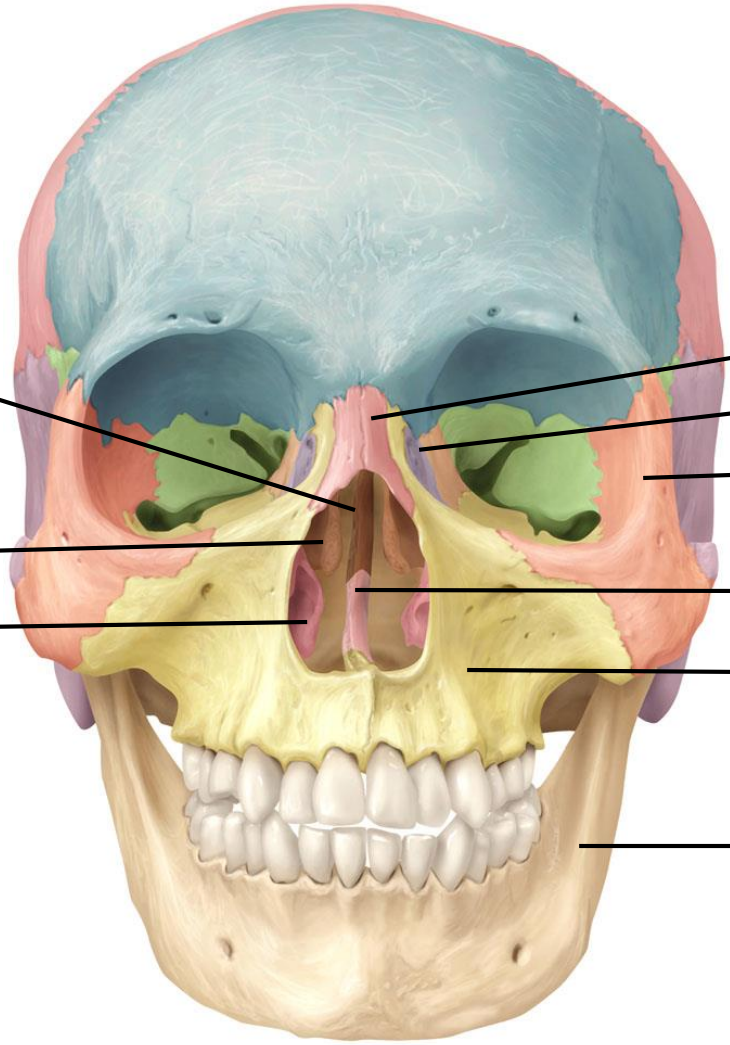
Bones of the Skull



Perpendicular plate of the ethmoid bone

Middle nasal concha

Inferior nasal concha

Nasal bones

Lacrimal bone

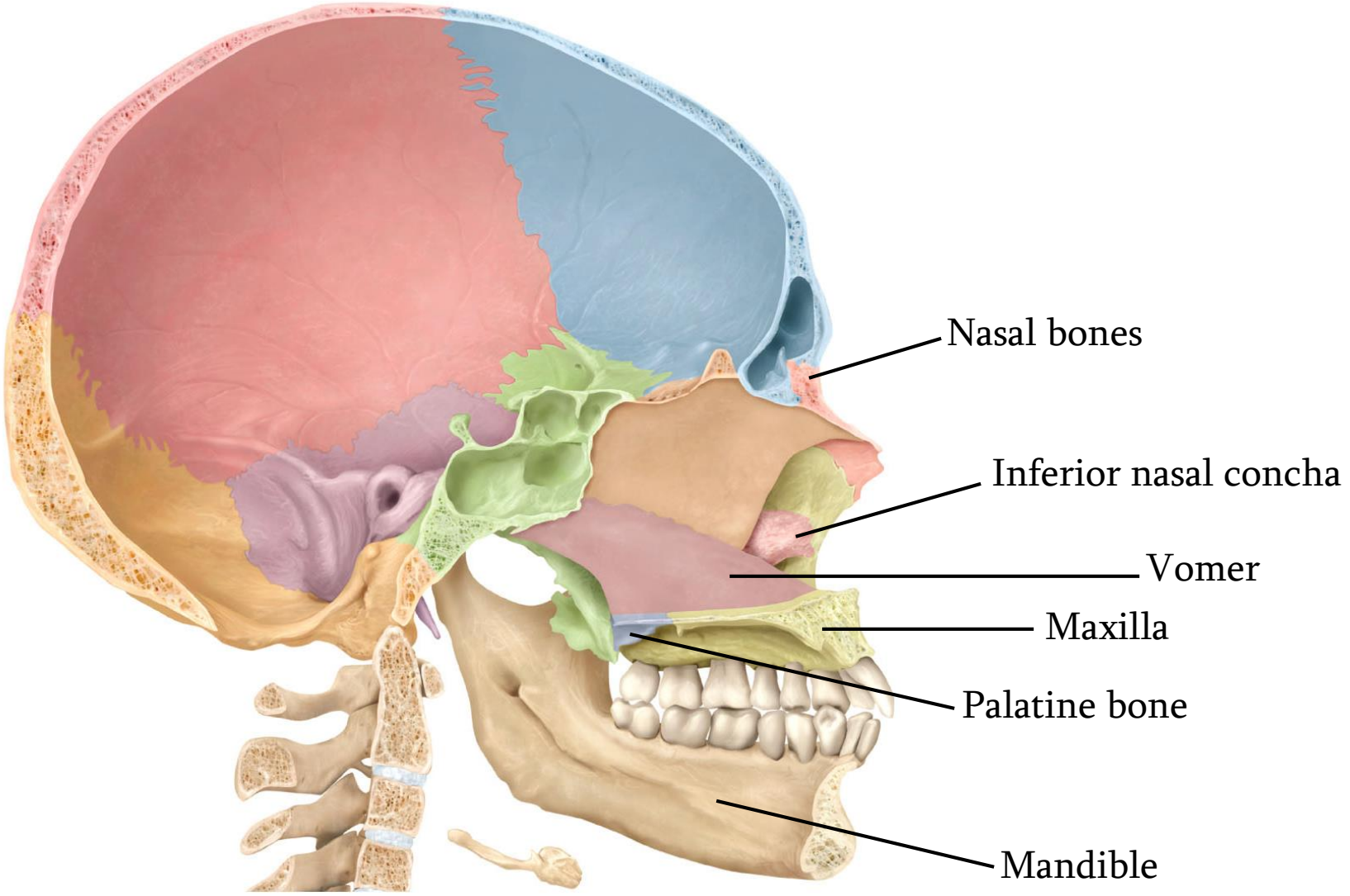
Zygomatic bone

Vomer

Maxilla (fused)

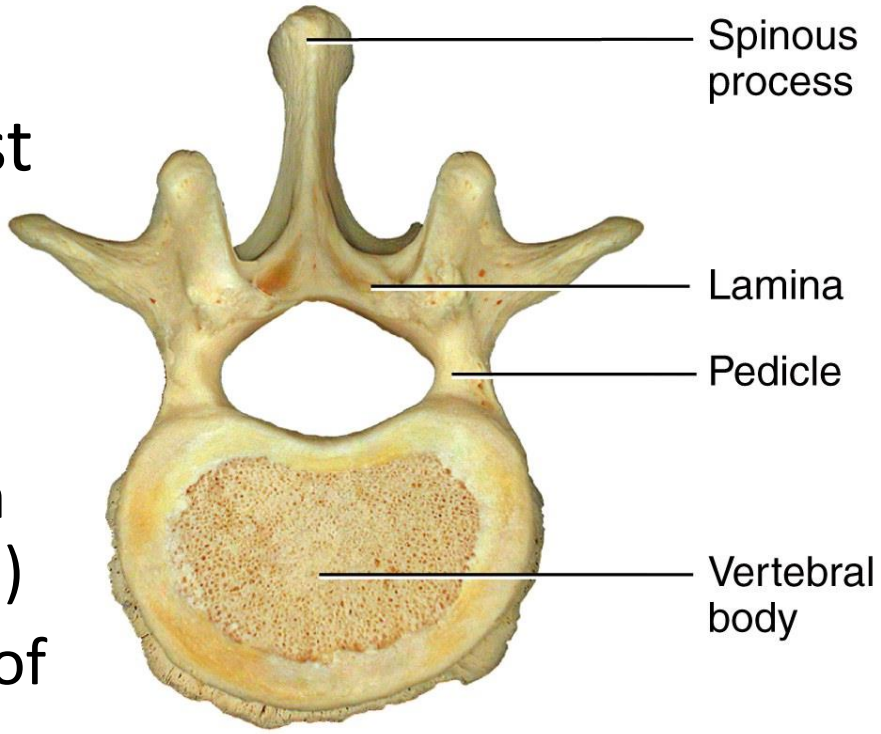
Mandible

Bones of the Skull



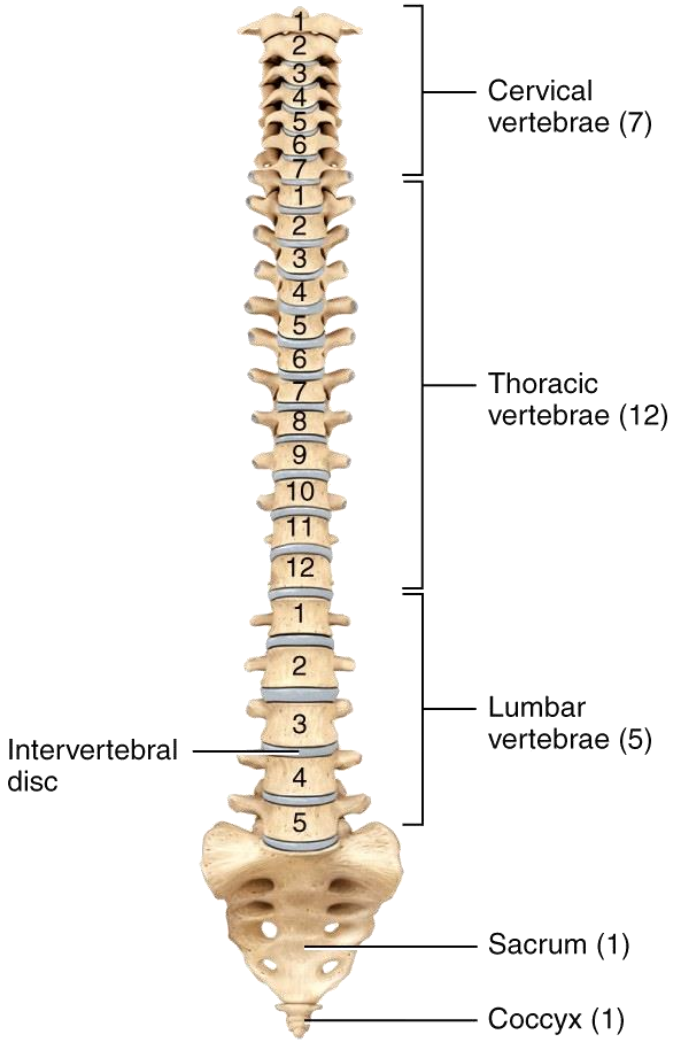
The Vertebral Column

- The spine is composed of a series of bones called vertebrae.
- Vertebrae typically consist of:
  - A body (weight bearing)
  - A pedicle and lamina forming the vertebral arch (surrounds the spinal cord)
  - Several processes (points of attachment for muscles)



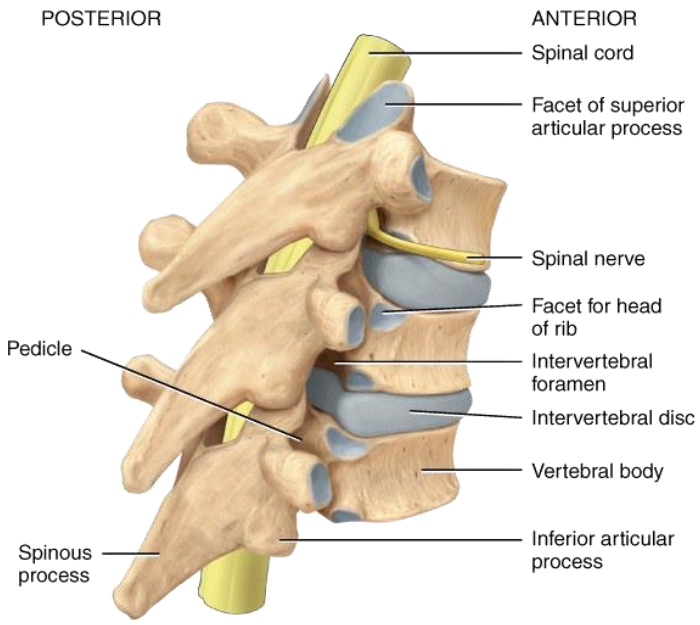
The Vertebral Column

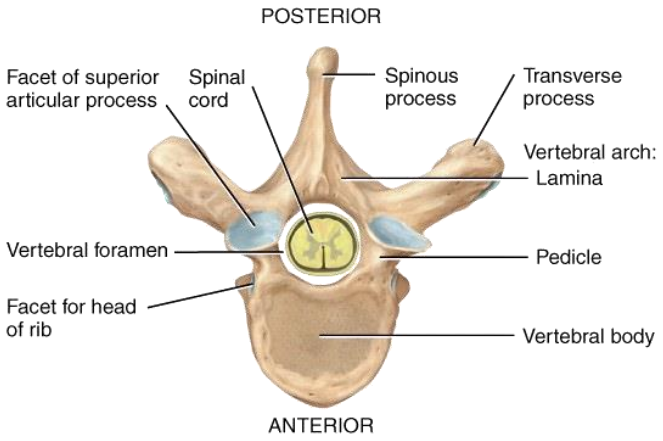
- 7 cervical vertebrae
  - Neck region labeled (C1-C7)
    - C1 (Atlas) – Yes
    - C2 (Axis) - No
- 12 thoracic vertebrae
  - Articulate with the ribs (T1-T12)
- 5 lumbar vertebrae
  - Support the lower back (L1-L5)
- 1 sacral bone
  - 5 fused vertebrae
- 1 coccygeal bone
  - 3-5 fused vertebrae



The Vertebral Column

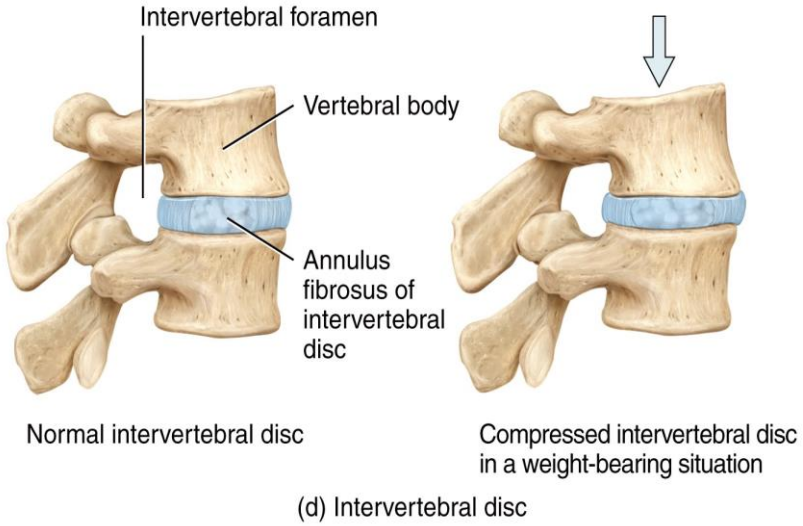
- From the cervical region to the sacrum, each vertebra has a large central hole, or vertebral foramen in which the spinal cord can travel.
- At each segmental level, on both the right and left sides, an intervertebral foremen is formed for the exiting spinal nerves.





The Vertebral Column

- A tough fibrocartilage intervertebral disc is found between the bodies of adjacent vertebrae.
  - It functions to absorb vertical shock and form joints which are strong yet still permit movement of the spine.



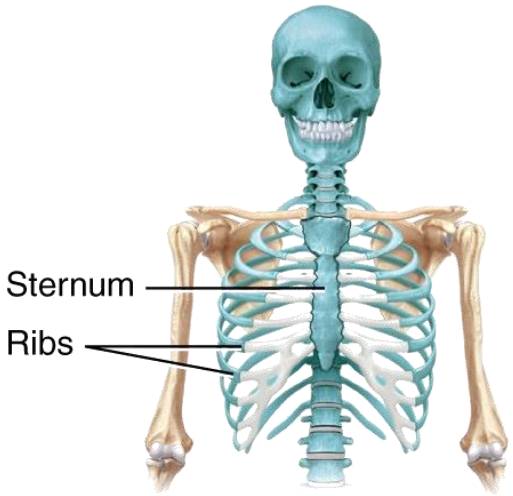
The Thorax

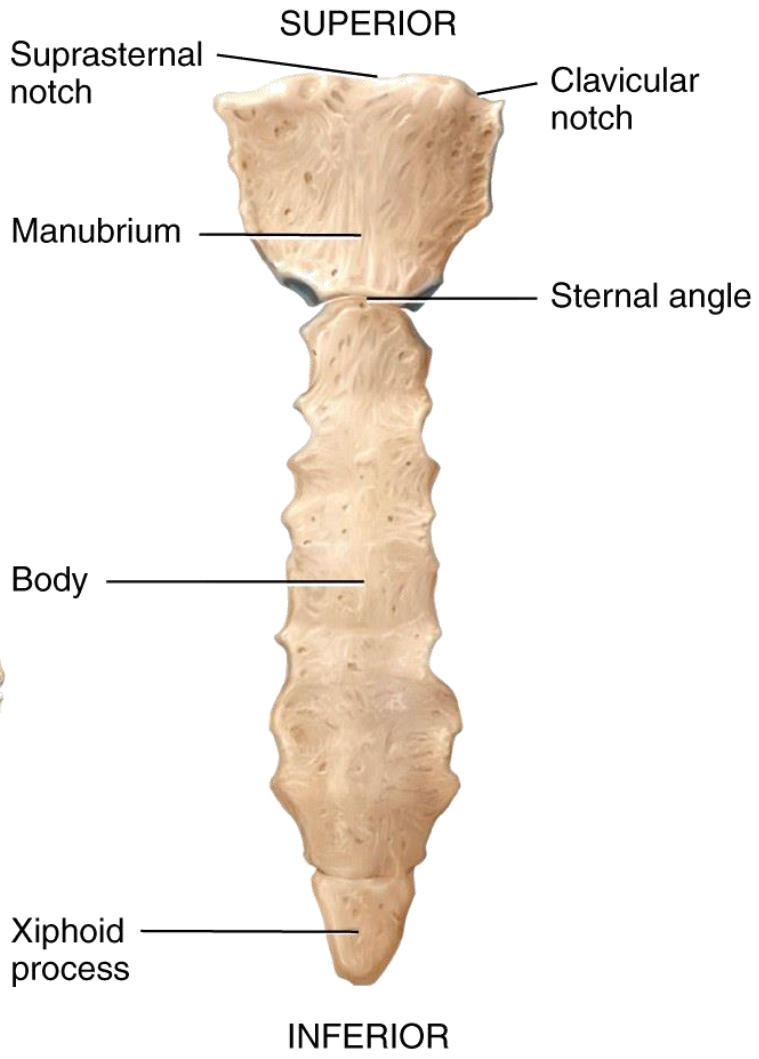
- The thoracic cage is the final part of the axial skeleton.
- In addition to the thoracic vertebrae, it is formed from:
  - The sternum
  - The ribs and costal cartilages
- Its functions are to enclose and protect the organs in the thoracic and abdominal cavities:
  - Provide support for the bones of the upper limbs
  - Play a role in breathing

The Thorax

- The sternum or “breastbone” is located anteriorly in the center of the thoracic wall.
  - Consists of the manubrium, body, xiphoid process
- The 12 pairs of ribs give structural support to the sides of the thoracic cavity.
- The costal (having to do with the ribs) cartilages are bars of hyaline cartilage connecting the sternum to the ribs.
  - Contribute to the elasticity of the thoracic cage

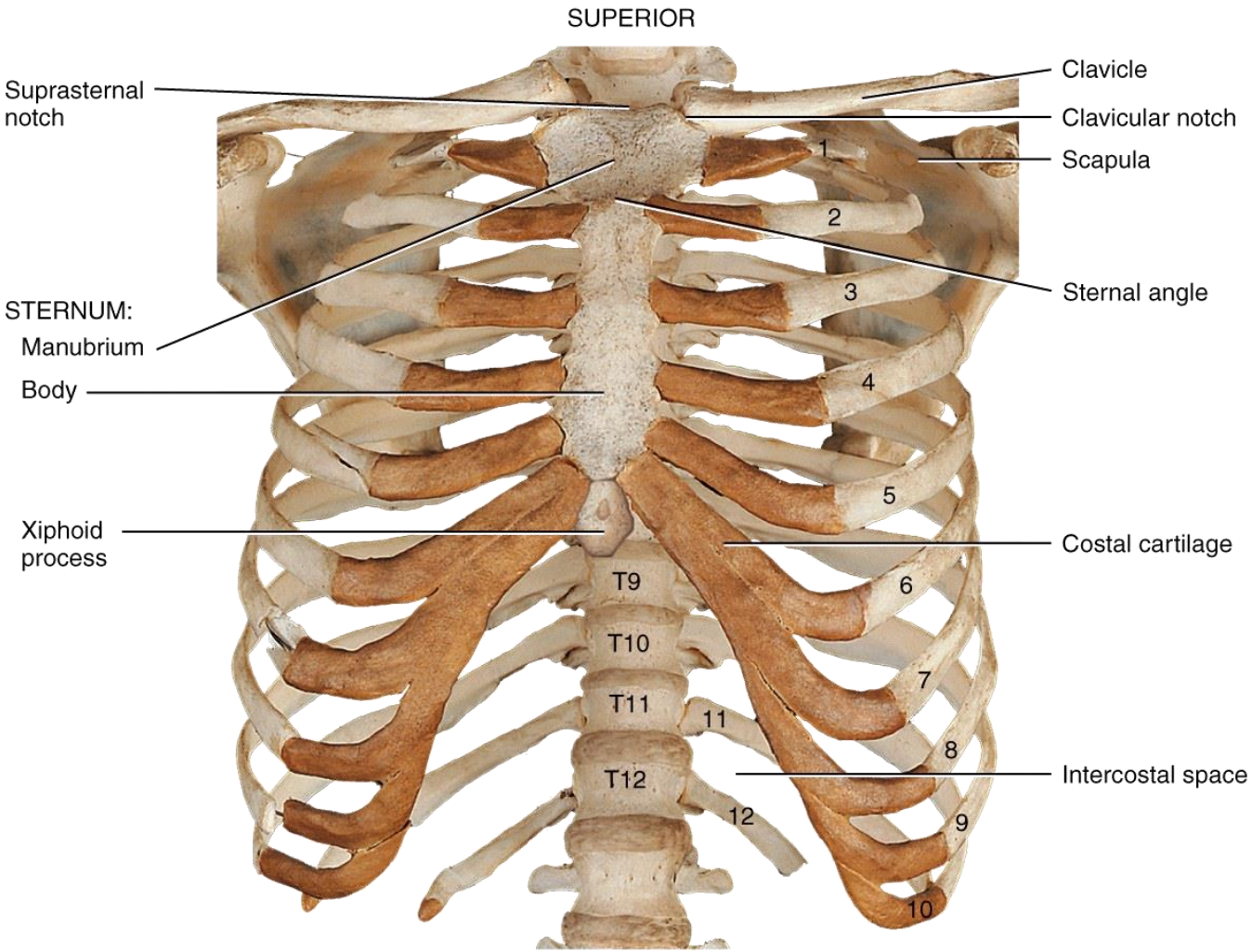
The Thorax





(a) Anterior view of sternum

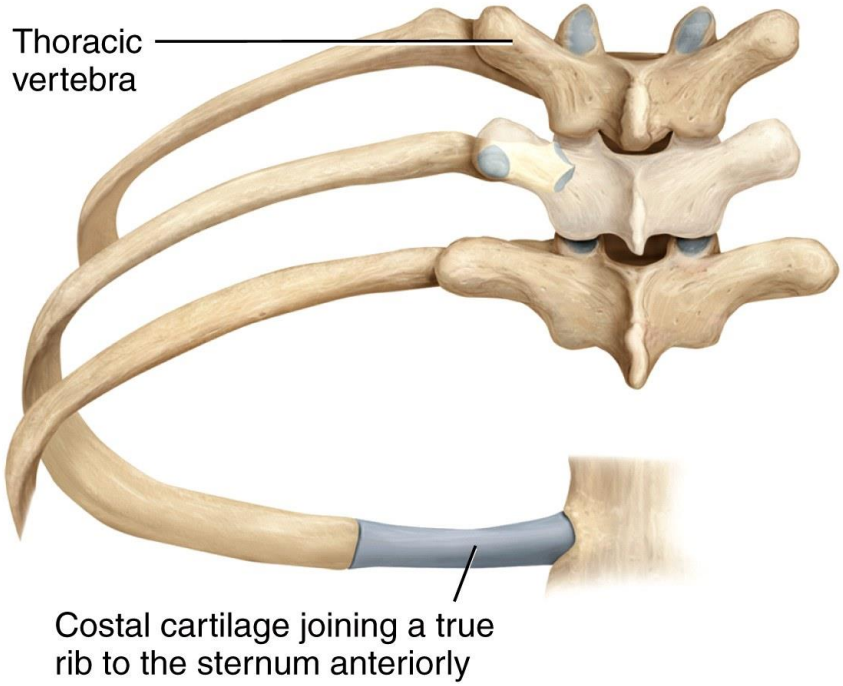
The Thorax



(b) Anterior view of skeleton of thorax

The Thorax

- The upper 7 rib pairs are called true ribs because they attach “directly” to the sternum (with just a small piece of costal cartilage).



The Thorax

- The bottom 5 pairs of ribs (and this number can vary from one individual to another) are called false ribs.
  - They attach indirectly to the sternum with an elongated piece of costal cartilage…or not at all (ribs 11 and 12 are called floating ribs.)

The Skeletal System

APPENDICULAR SKELETON

The Appendicular Skeleton

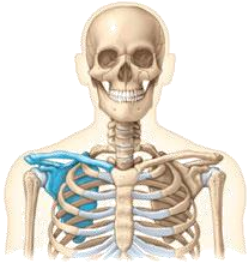
- The 126 bones of the appendicular skeleton are primarily concerned with movement.
  - As “appendages” to the central skeleton
  - These bones include those of the upper and lower limbs (including the girdles that attach them to the axial skeleton)

The Upper Limb

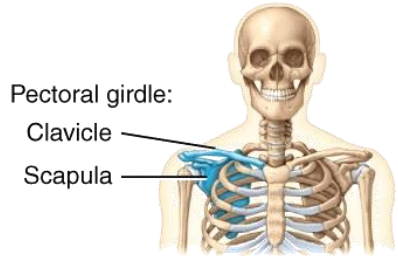
- Based on the position of its major joints and component bones, the upper limb is divided into the shoulder, arm, forearm, and hand:
  - The shoulder is the area of upper limb attachment to the trunk.
  - The arm is the part of the upper limb between the shoulder and the elbow joint.
  - The forearm is between the elbow and the wrist.
  - The hand is distal to the wrist.

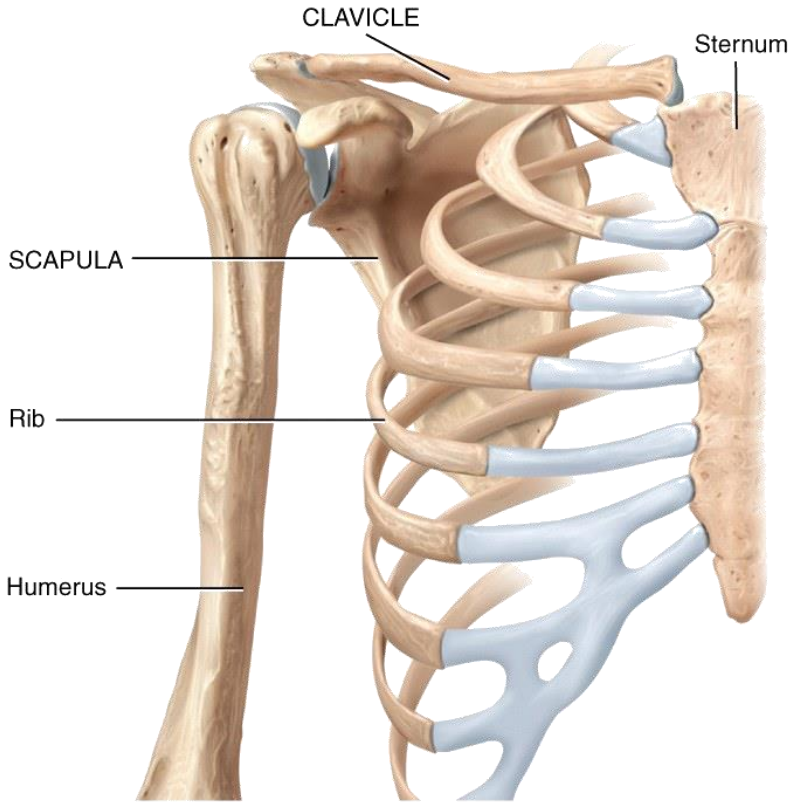
The Shoulder Girdle

- The bones of the shoulder (pectoral) girdle include the scapula and the clavicle.
  - The shoulder joint also incorporates the upper part of the humerus.

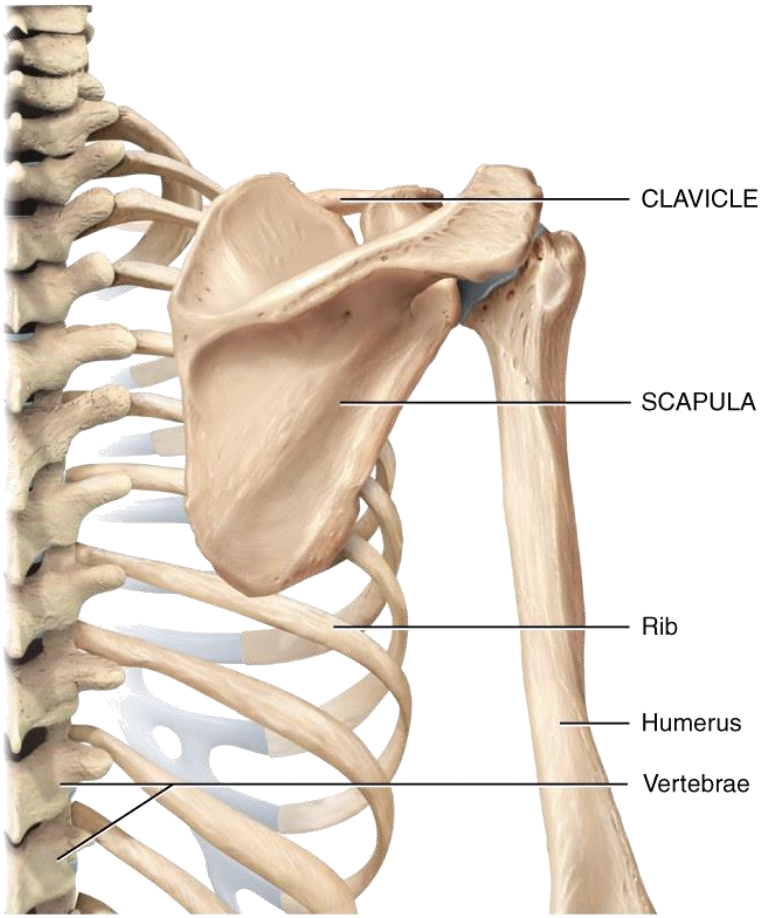


The Shoulder Girdle





(a) Anterior view of pectoral girdle

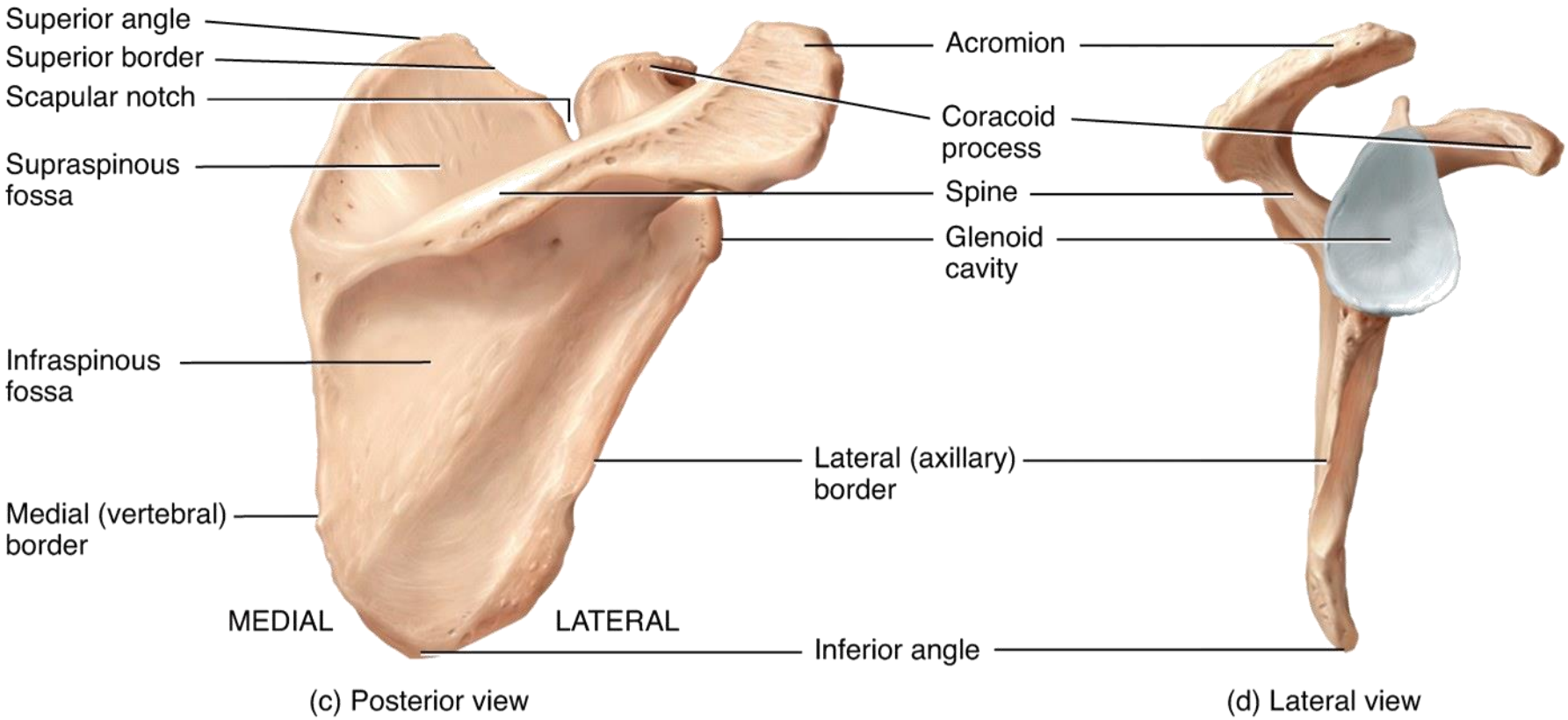


(b) Posterior view of pectoral girdle

The Shoulder Girdle

- The triangular shaped scapula is also called the shoulder blade.
  - Spine - a large process on the posterior of the scapula
  - Acromion - the flattened lateral portion of the spine
  - Coracoid process - a protruding projection on the anterior surface just inferior to the lateral aspect of the clavicle
  - Glenoid cavity - shallow concavity that articulates with the head of the humerus

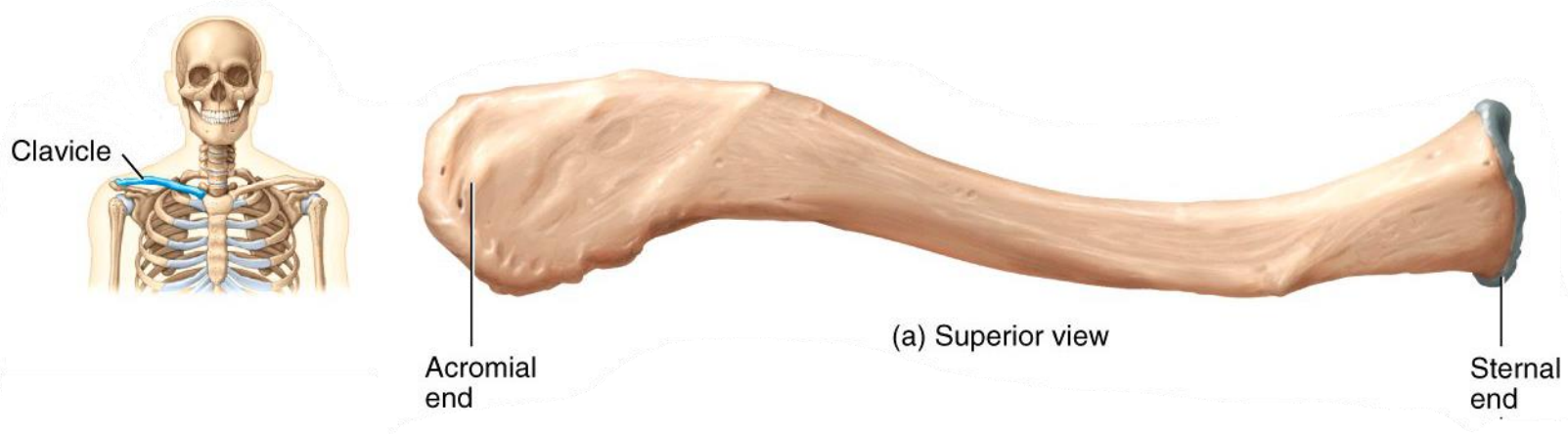
The Shoulder Girdle



Right scapula (shoulder blade), posterior and lateral view

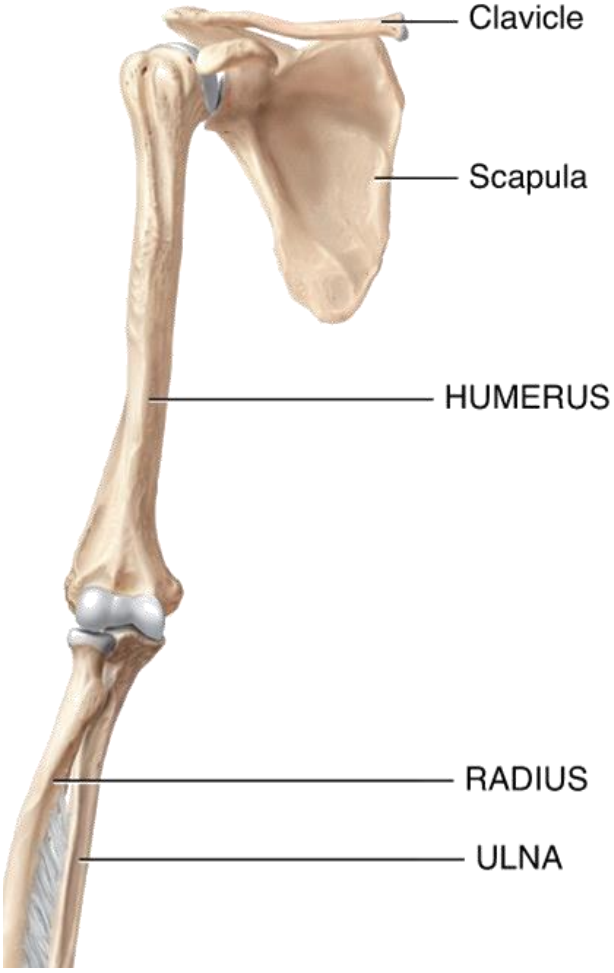
The Shoulder Girdle

- The clavicle is “S” shaped:
  - The medial end articulates with the manubrium of the sternum forming the sternoclavicular joint.
  - The lateral end articulates with the acromion forming the acromioclavicular joint.



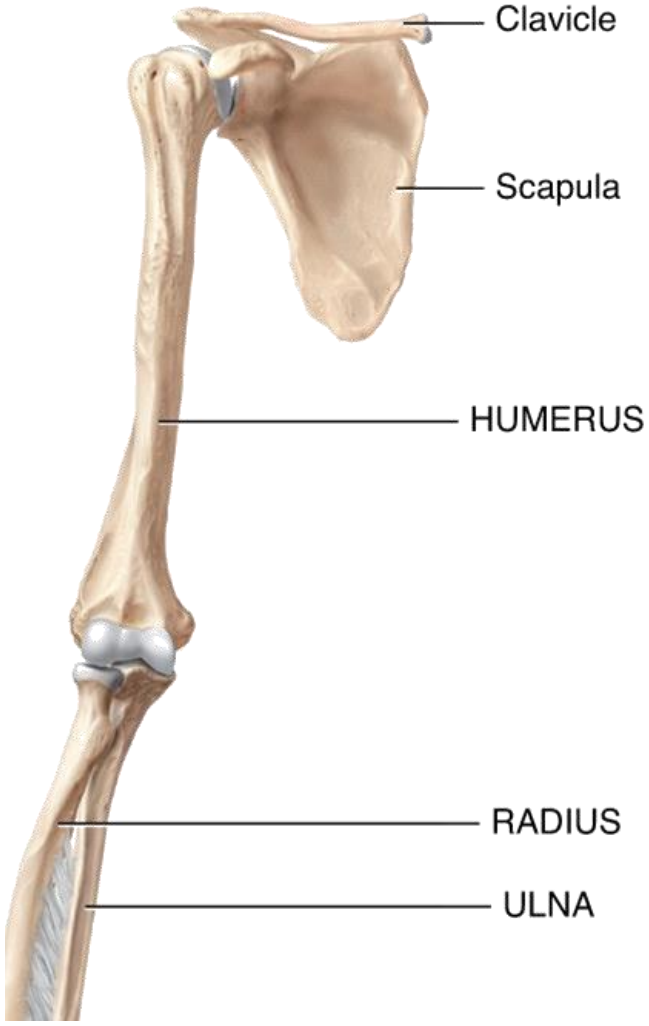
The Arm

- The only bone in the arm is the humerus. The head of the humerus has two projections:
  - The greater tubercle lies more laterally.
  - The lesser tubercle lies more anteriorly.
  - Between the tubercles lies the intertubercular groove or sulcus (bicipital groove) where the long head of the biceps brachii tendon is located.



The Forearm

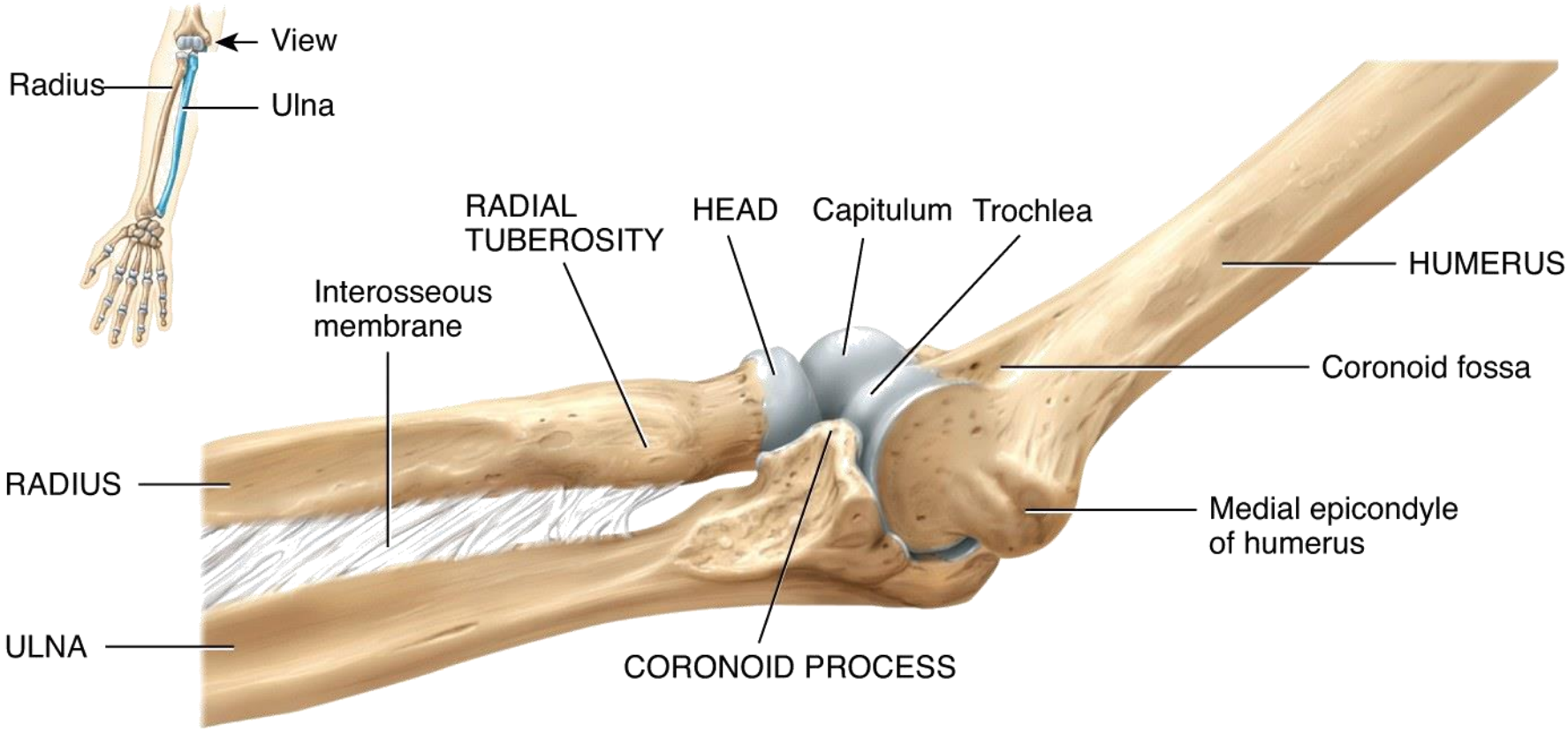
- The two bones of the forearm are the radius and ulna:
  - The radius is lateral (in anatomic position) and widens distally.
  - The more medial ulna widens proximally into the Olecranon process, a large prominence we feel as the tip of the elbow.



The Forearm

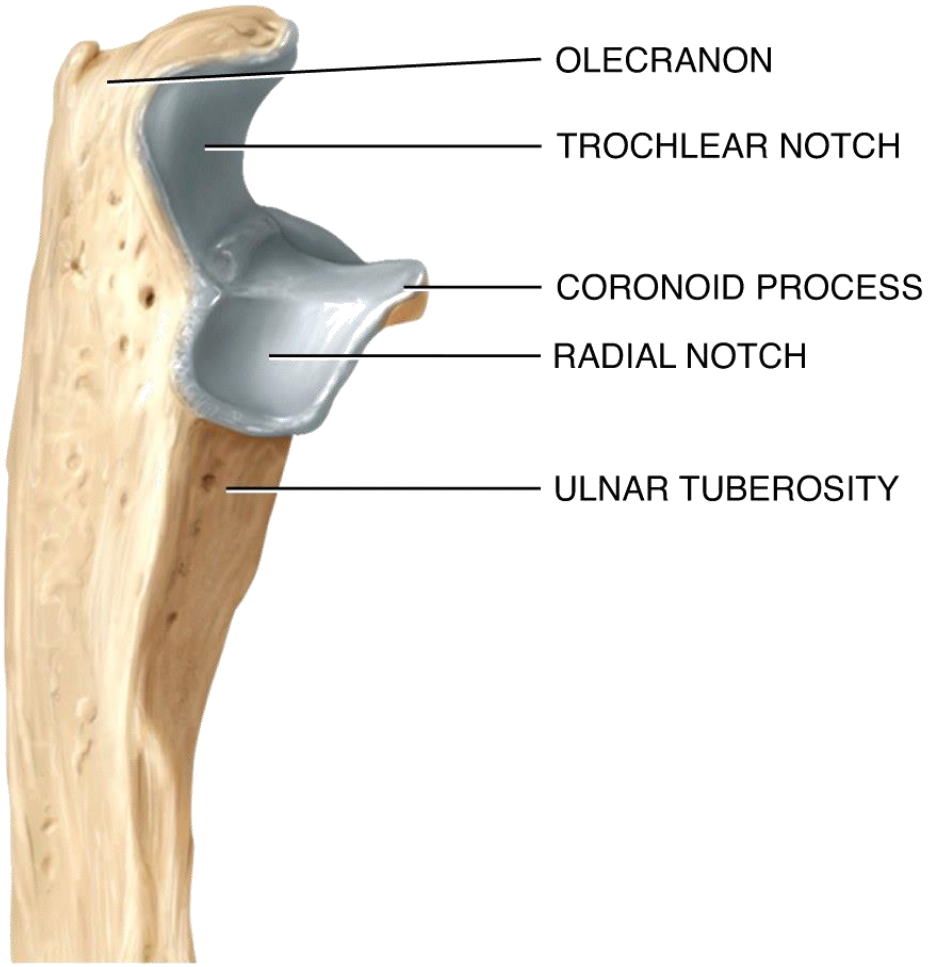
- The diaphysis (shaft) of the radius and ulna are connected by an interosseous membrane.
- There is a proximal radioulnar joint and a distal radioulnar joint.
  - Proximally, the head of the radius articulates with the radial notch of the ulna.
  - Distally, the head of the ulna articulates with the ulnar notch of the radius.

The Forearm



(a) Medial view in relation to humerus

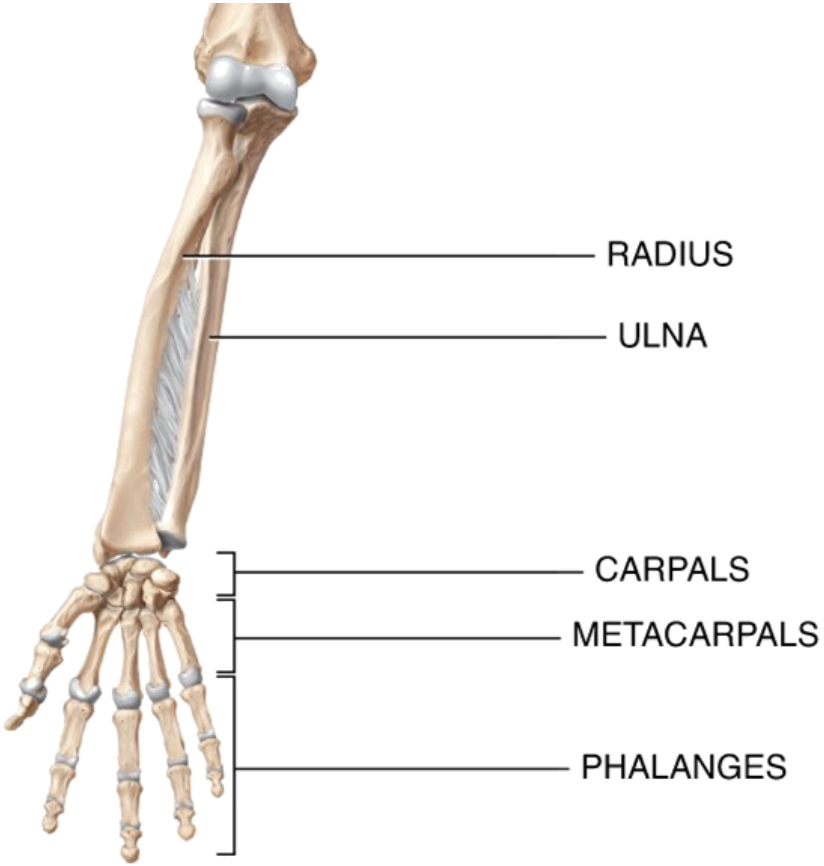
The Forearm



(b) Lateral view of proximal end of ulna

The Hand

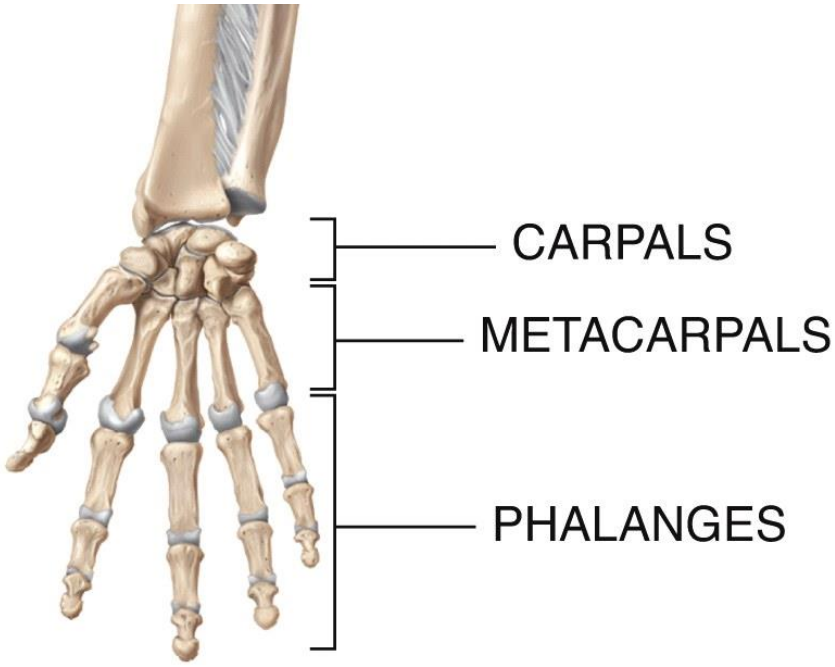
- The hand is composed of the wrist, the palm, and the fingers.
  - The wrist, or carpus, is made up of 8 carpal bones arranged in two rows.
  - The palm of the hand has 5 metacarpal bones .



Anterior view of free upper limb

The Hand

- Each finger, with the exception of the thumb or 1st digit, is composed of 3 phalanges:
  - proximal phalanx
  - middle phalanx
  - distal phalanx
- The joints of the hand include the carpometacarpal, metacarpophalangeal, and interphalangeal joints.



Anterior view

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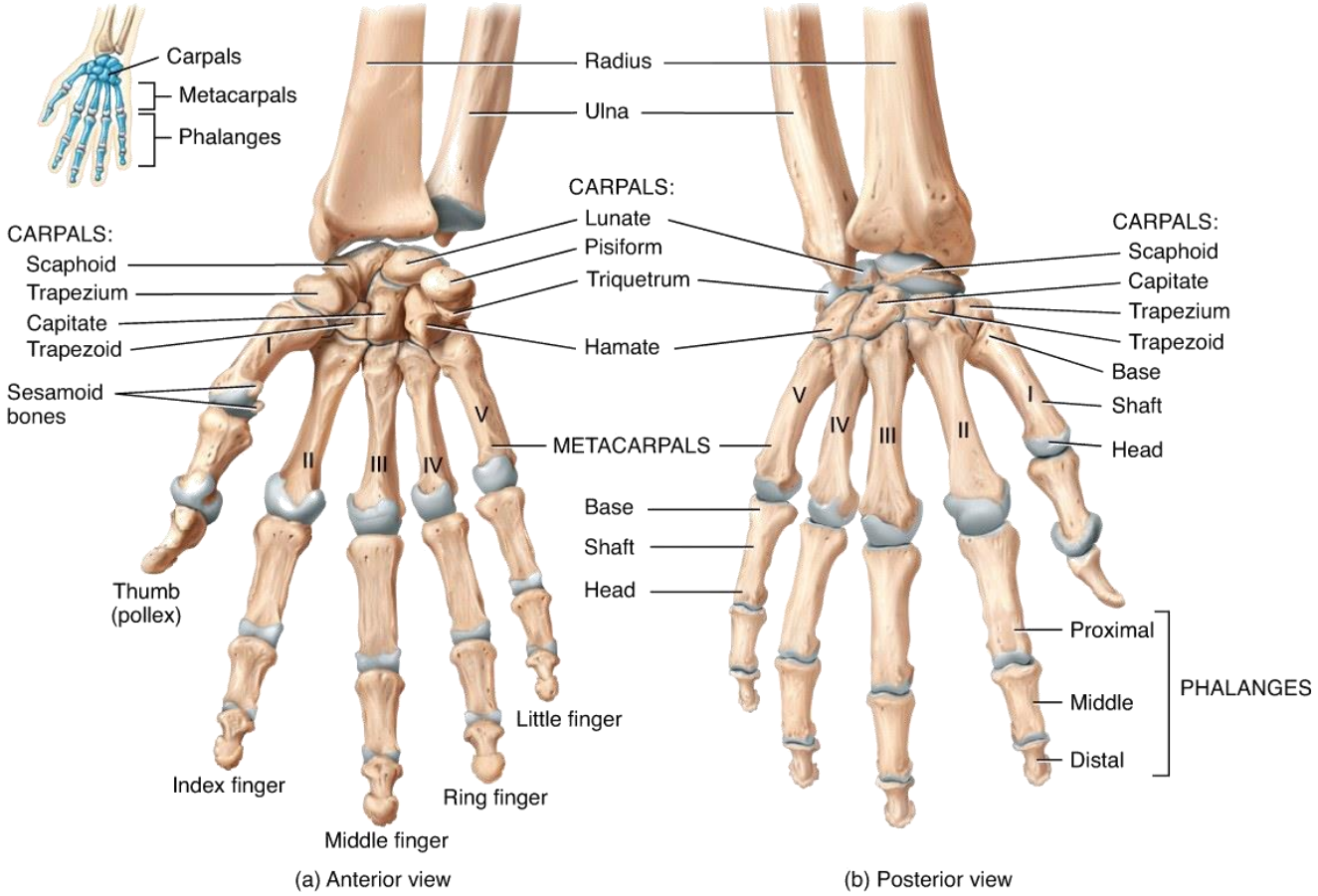
The Hand



MNEMONIC for carpal bones*:

Stop **L**etting **T**hose **P**eople **T**ouch **T**he **C**adaver's **H**and.

Scaphoid	**L**unate	**T**riquetrum	**P**isiform	**T**rapezium	**T**rapezoid	**C**apitate	**H**amate
Proximal row				Distal row			
Lateral → Medial				Lateral → Medial			

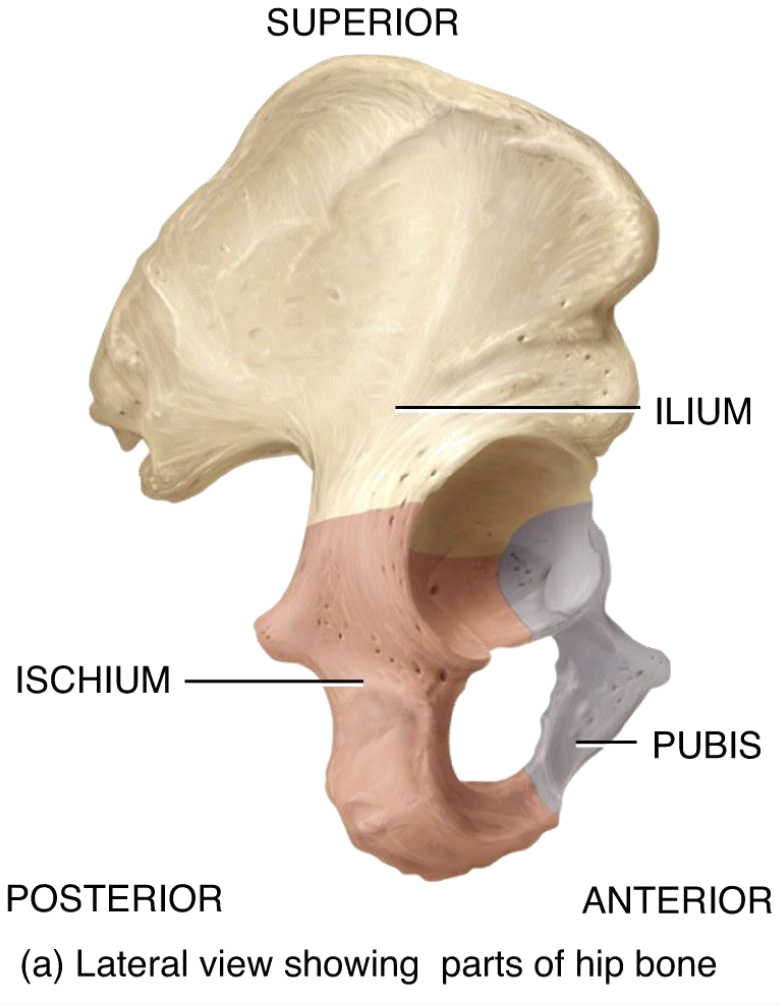
* *Edward Tanner, University of Alabama, SOM*

The Lower Limb

- The lower limb is directly anchored to the axial skeleton by a sacroiliac joint which links the pelvic bone to the sacrum.
- Based on the position of its major joints and component bones, the lower limb is divided into the gluteal region (the major bones forming the hip girdle), thigh, leg, and foot.
  - The gluteal region is between the iliac crest and hip joint.
  - The thigh is between the hip and the knee joint.
  - The leg is between the knee and the ankle.
  - The foot is distal to the ankle.

The Pelvic Girdle

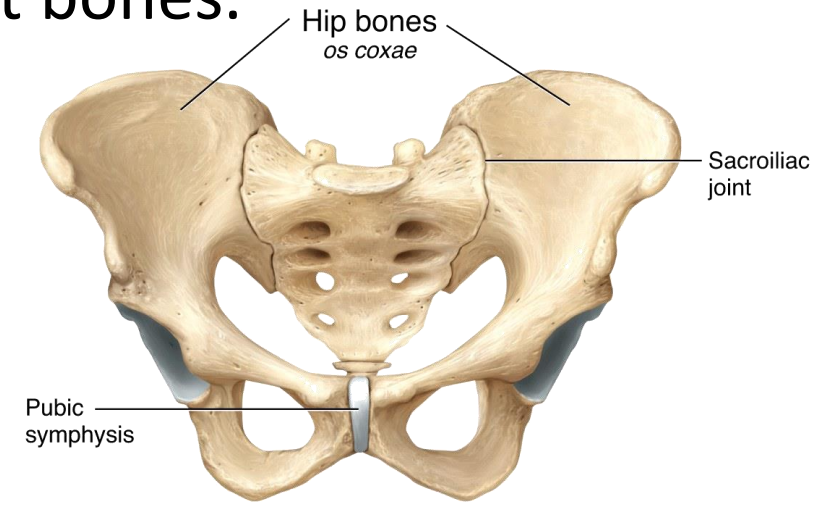
- In the gluteal region, the pelvic girdle is made up of two os coxae, or hip bones.
  - Each coxal (hip) bone consists of 3 bones that fuse together:
    - Ileum
    - Ischium
    - Pubis



(a) Lateral view showing parts of hip bone

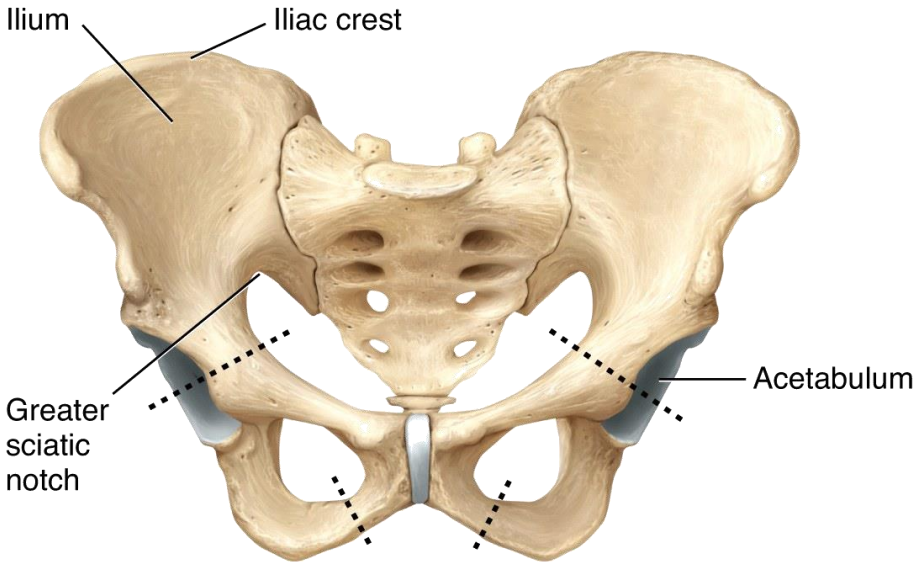
The Pelvic Girdle

- On the right and left sides, the os coxae are joined posteriorly to the sacrum, and anteriorly to one another at the pubic symphysis (made of fibrocartilage).
  - The free part of the lower limb below the hip joint is composed of 30 different bones.



The Pelvic Girdle

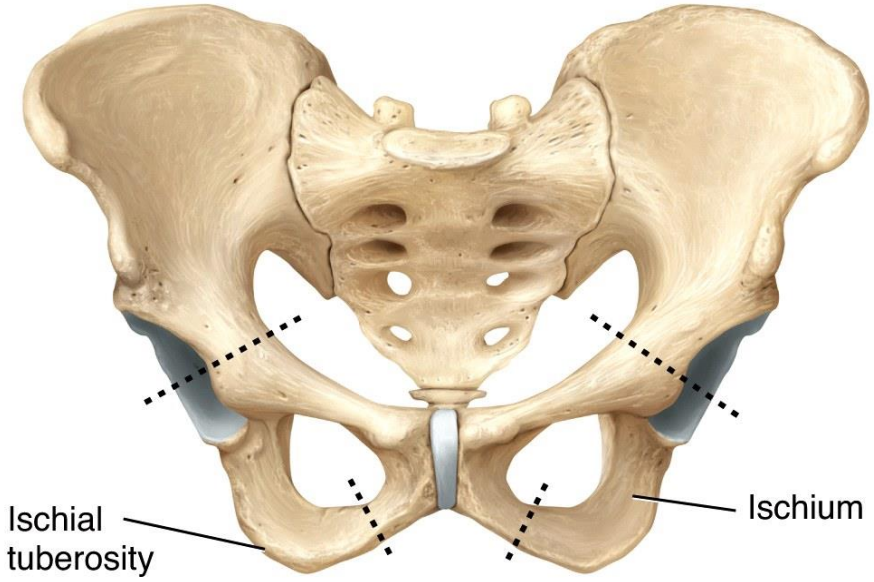
- The ilium is the largest of the three hip bones - it forms the superior lateral prominence of the pelvis (iliac crest):
  - Consists of a superior ala and inferior body which forms the acetabulum (the socket for the head of the femur)
  - Greater sciatic notch allows passage of the sciatic nerve.



Dotted lines show approximate locations of the three bones

The Pelvic Girdle

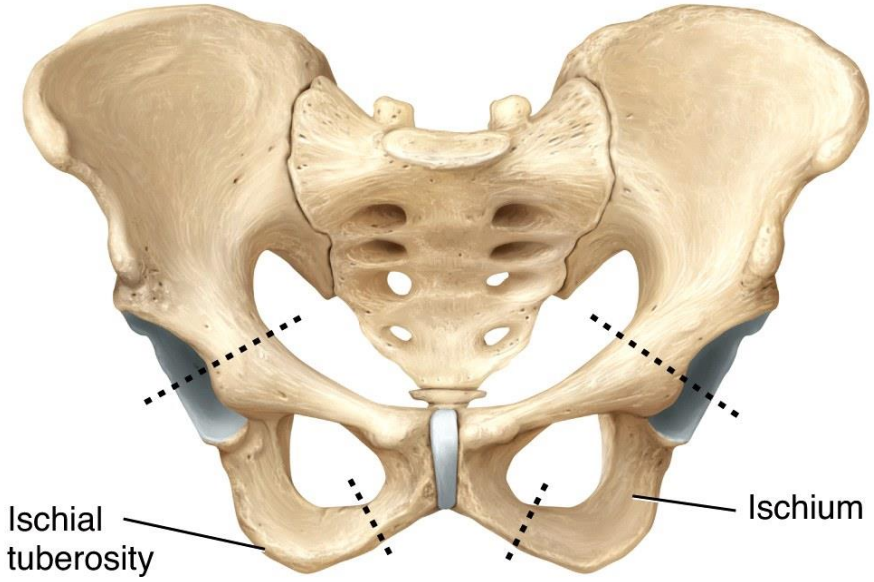
- The ischium constitutes the inferior and posterior part of the hip bone.
  - Its most prominent feature is the ischial tuberosity



Dotted lines show approximate locations of the three bones

The Pelvic Girdle

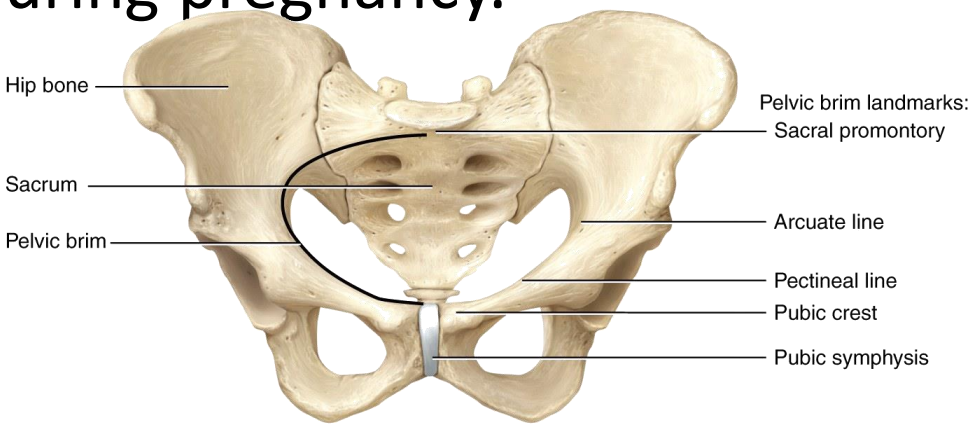
- The pubis is the anterior and inferior part of the hip bone.
  - It has superior and inferior rami and a body.



Dotted lines show approximate locations of the three bones

The Pelvic Girdle

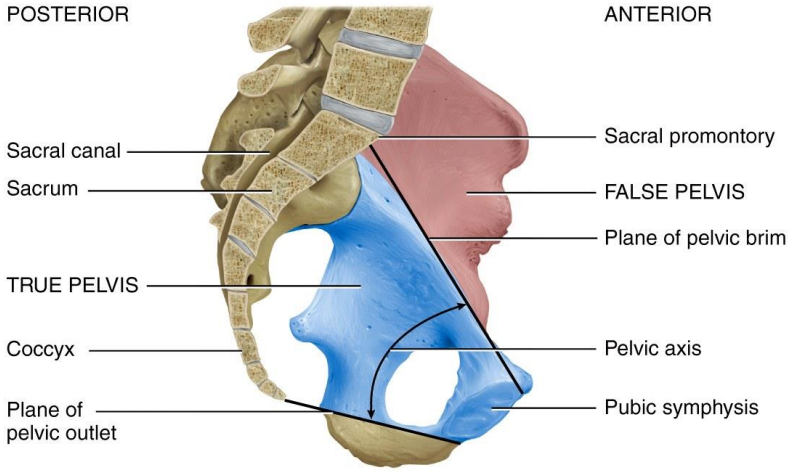
- The pelvic brim is a line from the sacral promontory to the upper part of the pubic symphysis.
  - The false pelvis lies above this line. It contains no pelvic organs except the urinary bladder (when full) and the uterus during pregnancy.



(a) Anterior view of pelvic girdle

The Pelvic Girdle

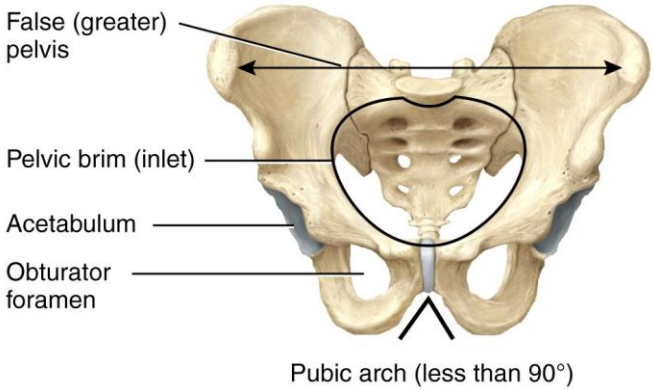
- The true pelvis is the bony pelvis inferior to the pelvic brim. It has an inlet, an outlet and a cavity.
  - The pelvic axis is the path of childbirth during the first and second stages of labor.



Midsagittal section indicating locations of true and false pelves

The Male/Female Pelvis

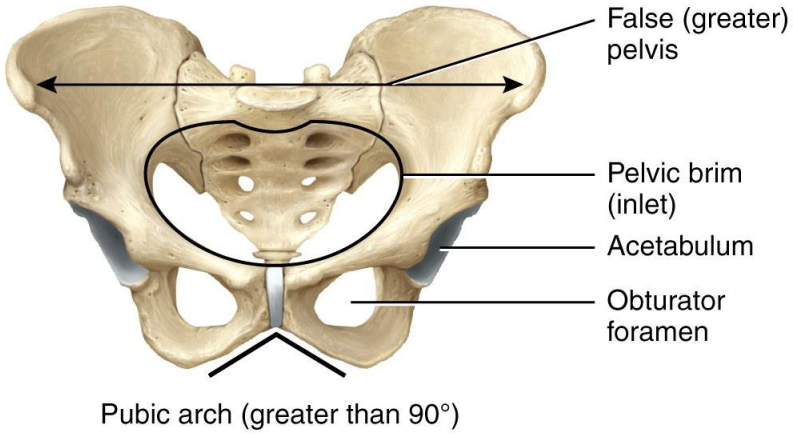
- Compared to the female pelvis, the male pelvis:
  - Is larger, heavier, and more narrow
  - Has a smaller inlet and outlet
  - Has a pubic arch angle of < 90°



Male Pelvis

The Male/Female Pelvis

- Compared to the male pelvis, the female pelvis:
  - Is rounder, has a flared iliac crest, and a wider pelvic opening to assist childbirth. It also has a pubic arch angle of > 90^{o} and a more moveable pubic symphysis.
  - Has a more flexible coccyx



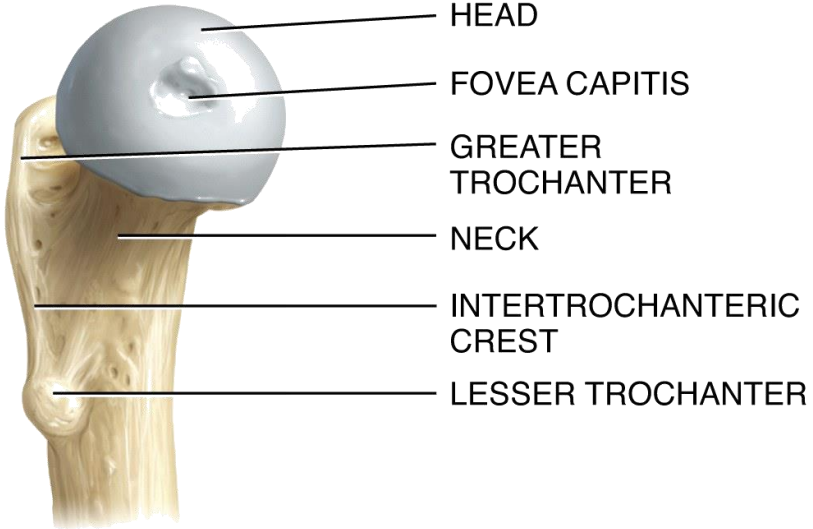
Female Pelvis

The Thigh

- The femur is the longest, heaviest, and strongest bone in the thigh, and in the entire body.
  - Proximally, the head articulates with the acetabulum of the hip bone forming the hip (coxal) joint.
  - The neck (distal to head) is a common site of fracture.
  - Distally, the medial and lateral femoral condyles articulate with the tibia to form the knee joint.
    - The femur also articulates with patella.

The Thigh

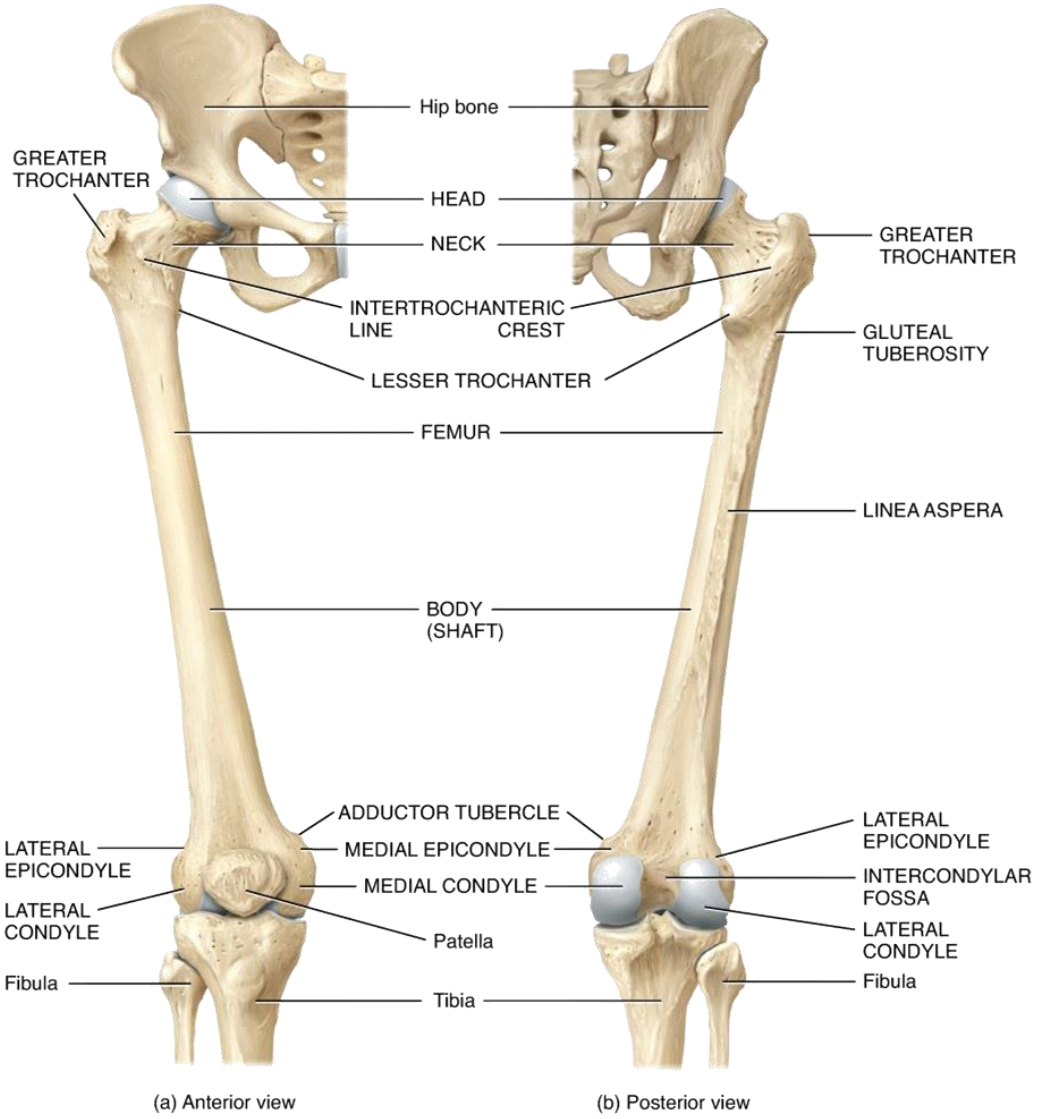
- The greater and lesser trochanters are projections where large muscles attach.
- The gluteal tuberosity and linea aspera are attachment sites for the large hip muscles.



Medial view of proximal end of femur

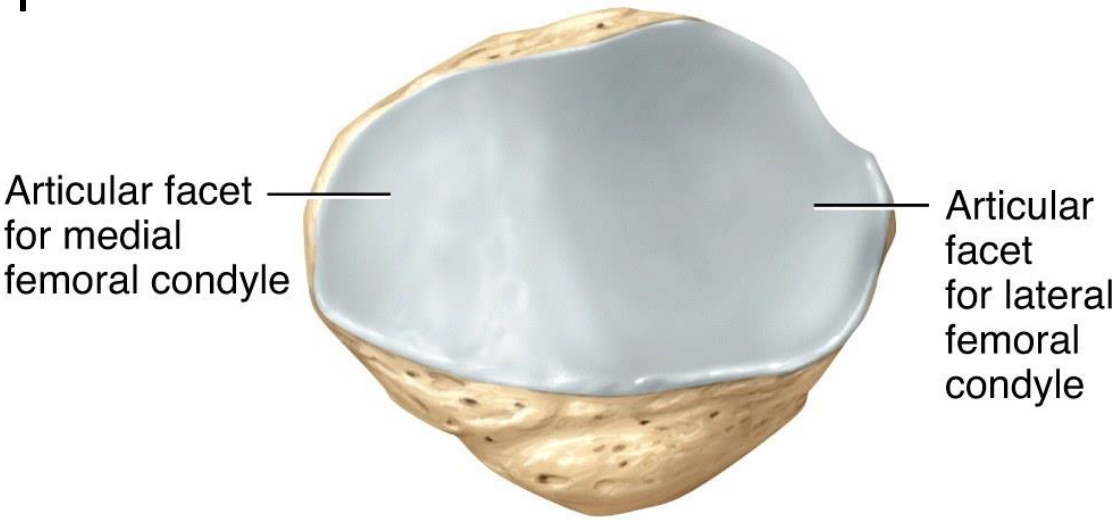
The Thigh

- The femur has sites for attachment of the knee muscles at the medial and lateral epicondyles (above the femoral condyles).



The Thigh

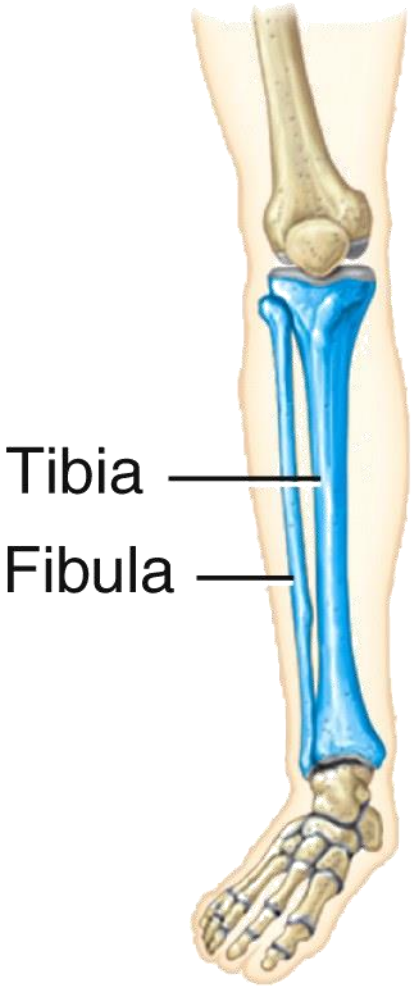
- The patella (knee cap) is the largest and only named sesamoid bone in the body.
  - A thick articular cartilage lines the posterior surface.



Posterior view

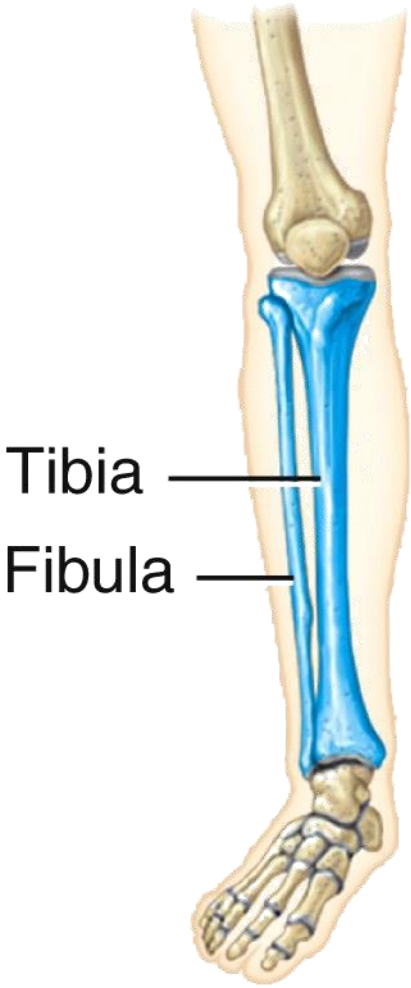
The Leg

- Of the two bones in the leg, the tibia (always medial) is the largest and bears all the weight.
  - The lateral and medial condyles at the proximal end articulate with the femur.
  - It articulates distally with the talus of the ankle and the fibula.



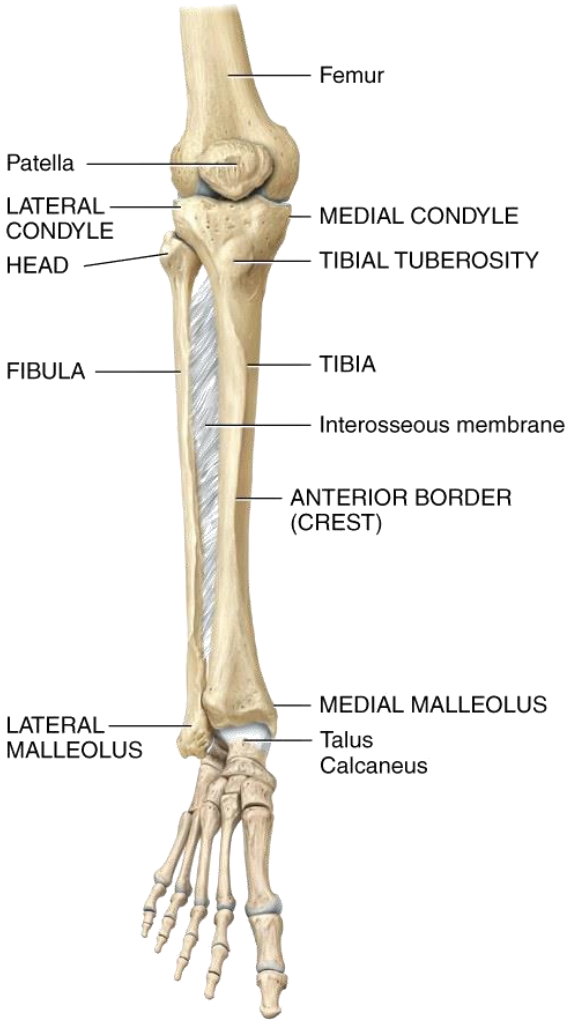
The Leg

- The fibula is the smaller, laterally placed bone of the leg:
  - It is non-weight bearing.
  - The head forms the proximal tibiofibular joint.
  - At the distal end, the lateral malleolus articulates with the tibia and the talus at the ankle.



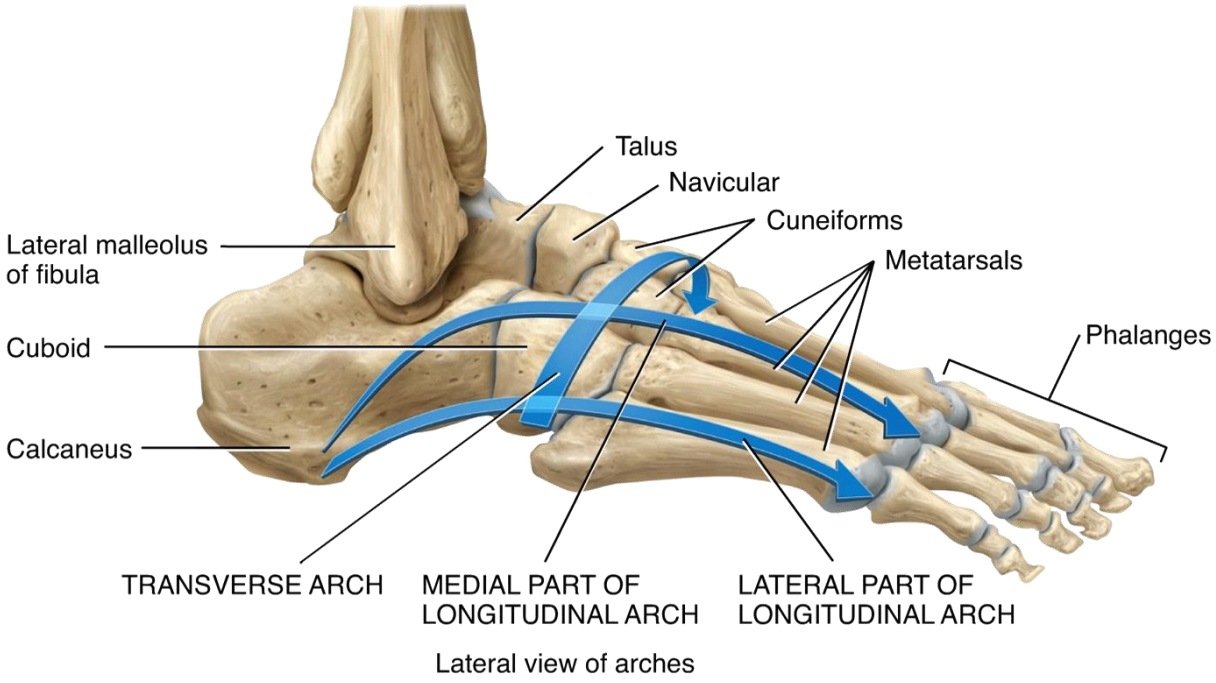
The Leg

- Much like the forearm bones, the tibia and fibula are joined by an interosseous membrane.
- The distal end of the leg bones form the medial and lateral malleoli of the ankle.



The Foot

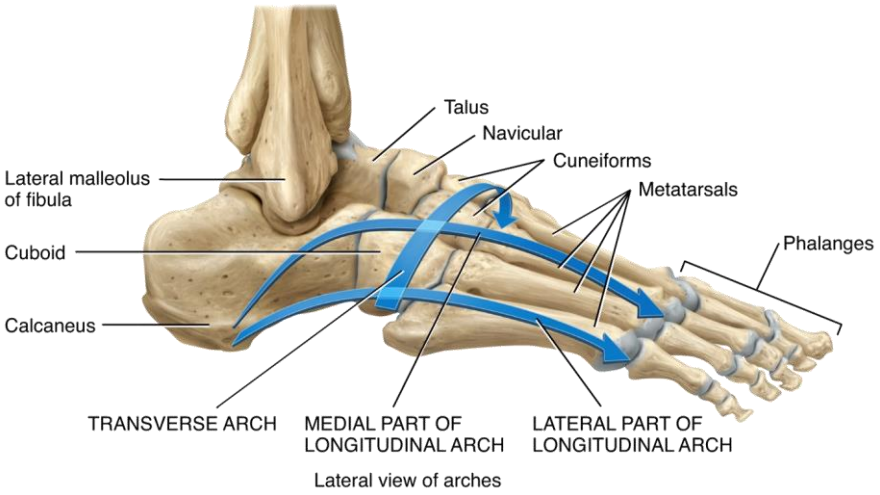
- The tibia and fibula articulate with the talus bone of the ankle to form the ankle “mortise” (ankle joint).



Lateral view of arches

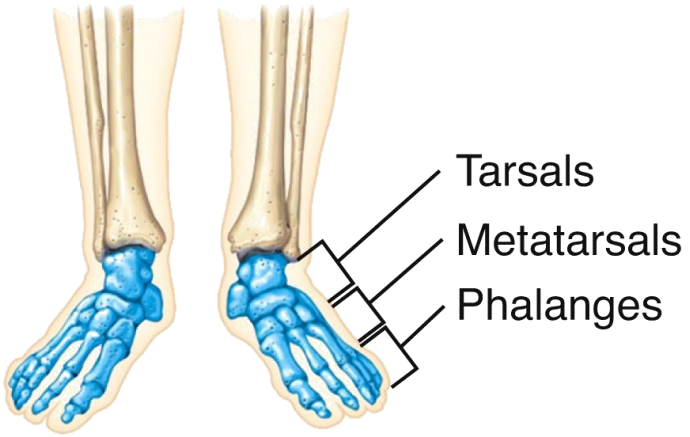
The Foot

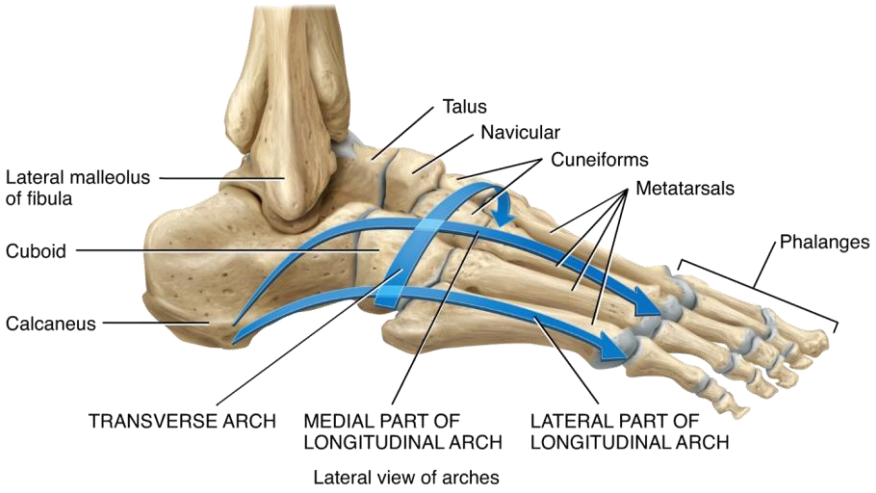
- There are many similarities between the hand of the upper limb and the foot of the lower limb:
  - The ankle, or tarsus, is made up of 7 tarsal bones arranged to form the ankle mortise, heel, and arches.
  - The largest and strongest tarsal bone, the calcaneus, forms the heel.



The Foot

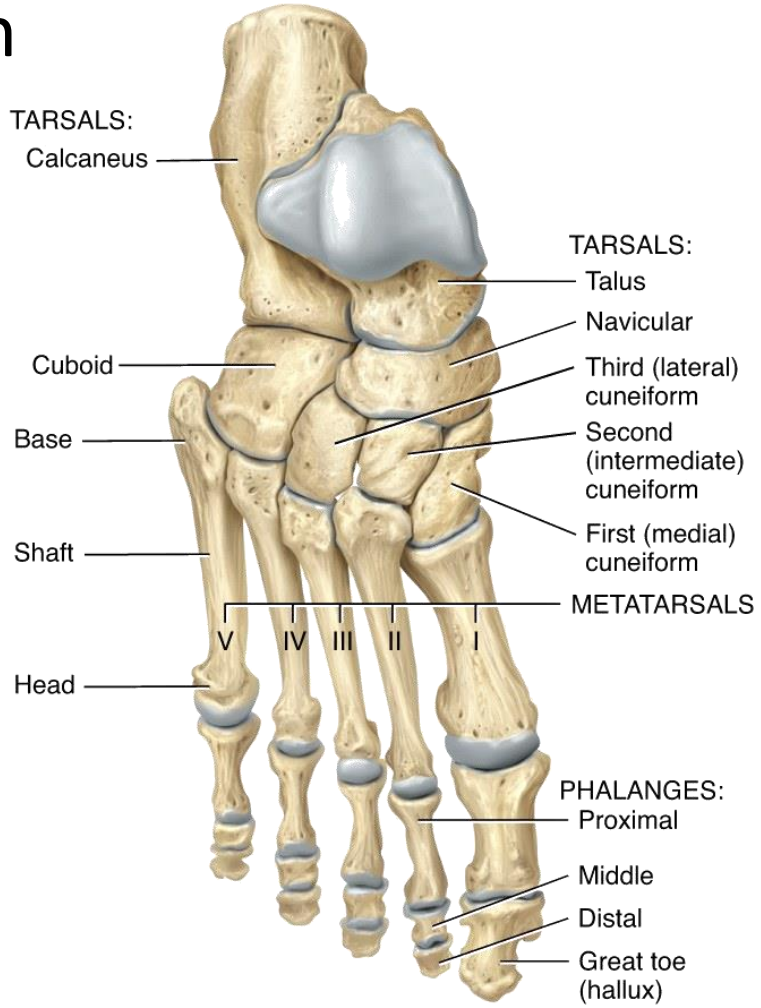
- Like the palm of the hand, the sole of the foot has 5 bones – in this case called metatarsals.
  - The metatarsals also participate in forming the arches of the foot.





The Foot

- Each toe with the exception of the hallux (big toe) is composed of 3 phalanges:
  - proximal phalanx
  - middle phalanx
  - distal phalanx
- The joints of the foot include
  - Tarsometatarsal joint
  - Metatarsophalangeal joint
  - Interphalangeal joint

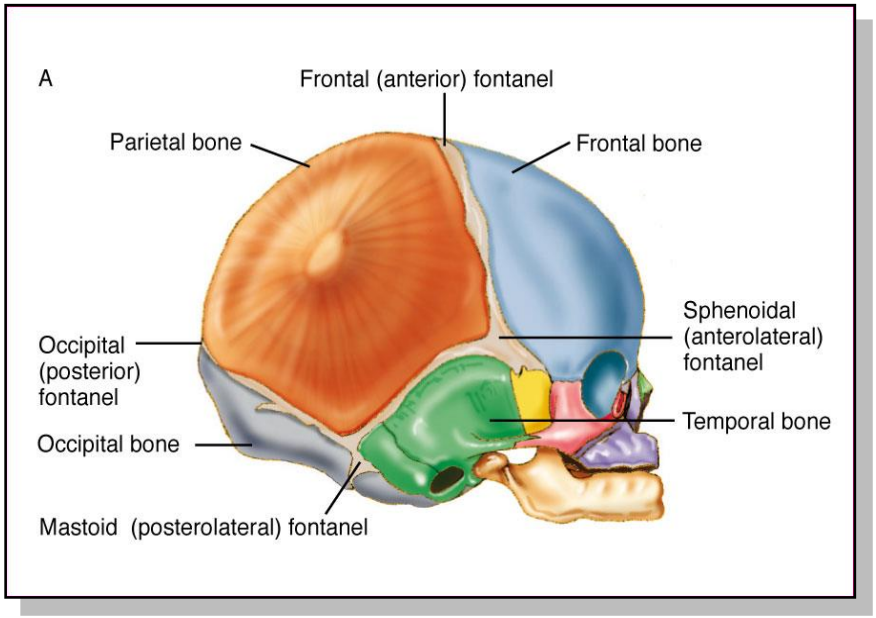


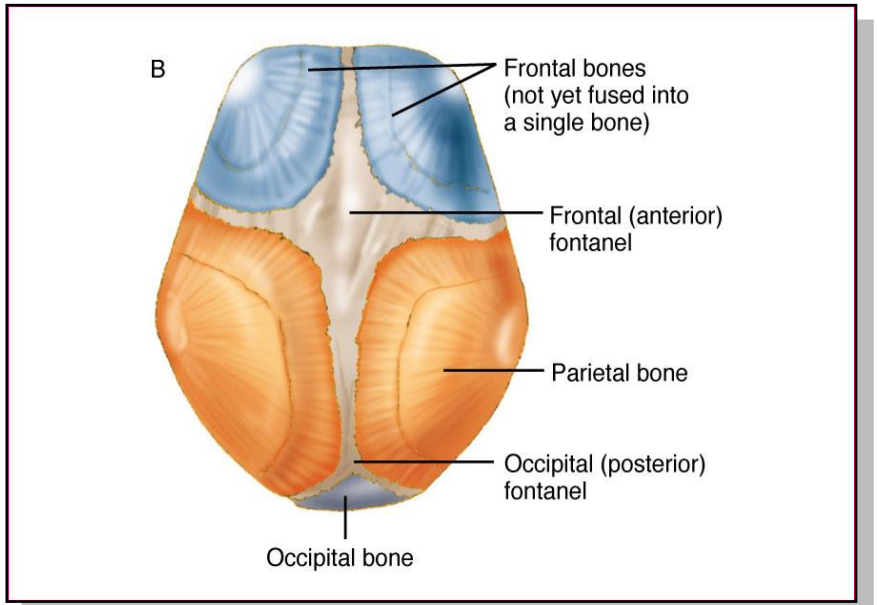
Biomechanics of Body Movement

- Every bone (except the hyoid bone) connects to at least one other bone
- Three major classifications of joints
  - Fibrous joints
  - Cartilaginous joints
  - Synovial joints

Fibrous Joints

- Consist of two bones--united by fibrous tissue—that have little or no movement
- Sutures (seams between flat bones)



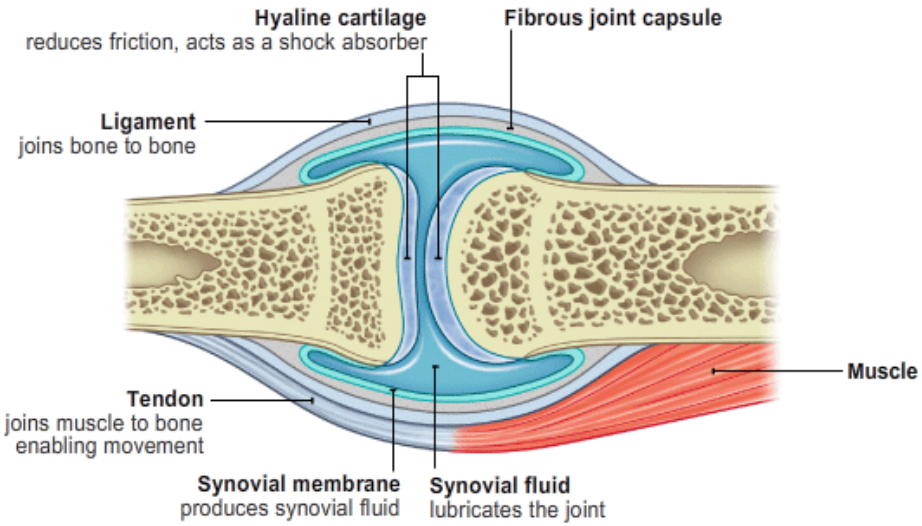


Cartilaginous Joints

- Unite two bones by means of hyaline cartilage (synchondroses) or fibrocartilage (symphyses)
- Synchondroses
  - Slight motion (between ribs and sternum)
- Symphysis
  - Slight motion, flexible (symphysis pubis)

Synovial Joints

- Contain synovial fluid
  - Allow movement between articulating bones
  - Account for most joints of appendicular skeleton



- Types
  - Plane or gliding joints
  - Saddle joints
  - Hinge joints
  - Pivot joints
  - Ball-and-socket joints
  - Ellipsoid joints

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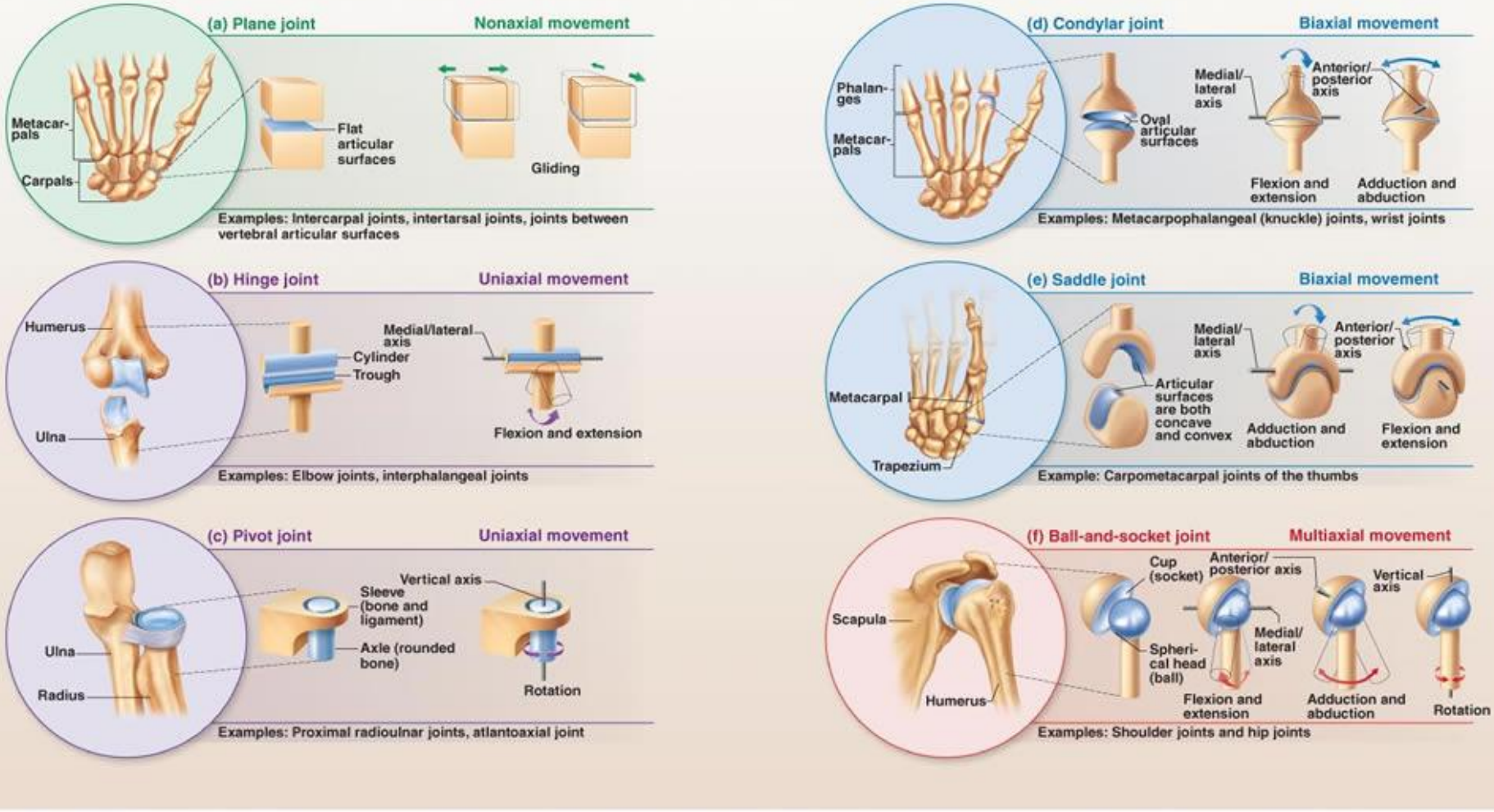
Synovial Joints



Synovial Joints