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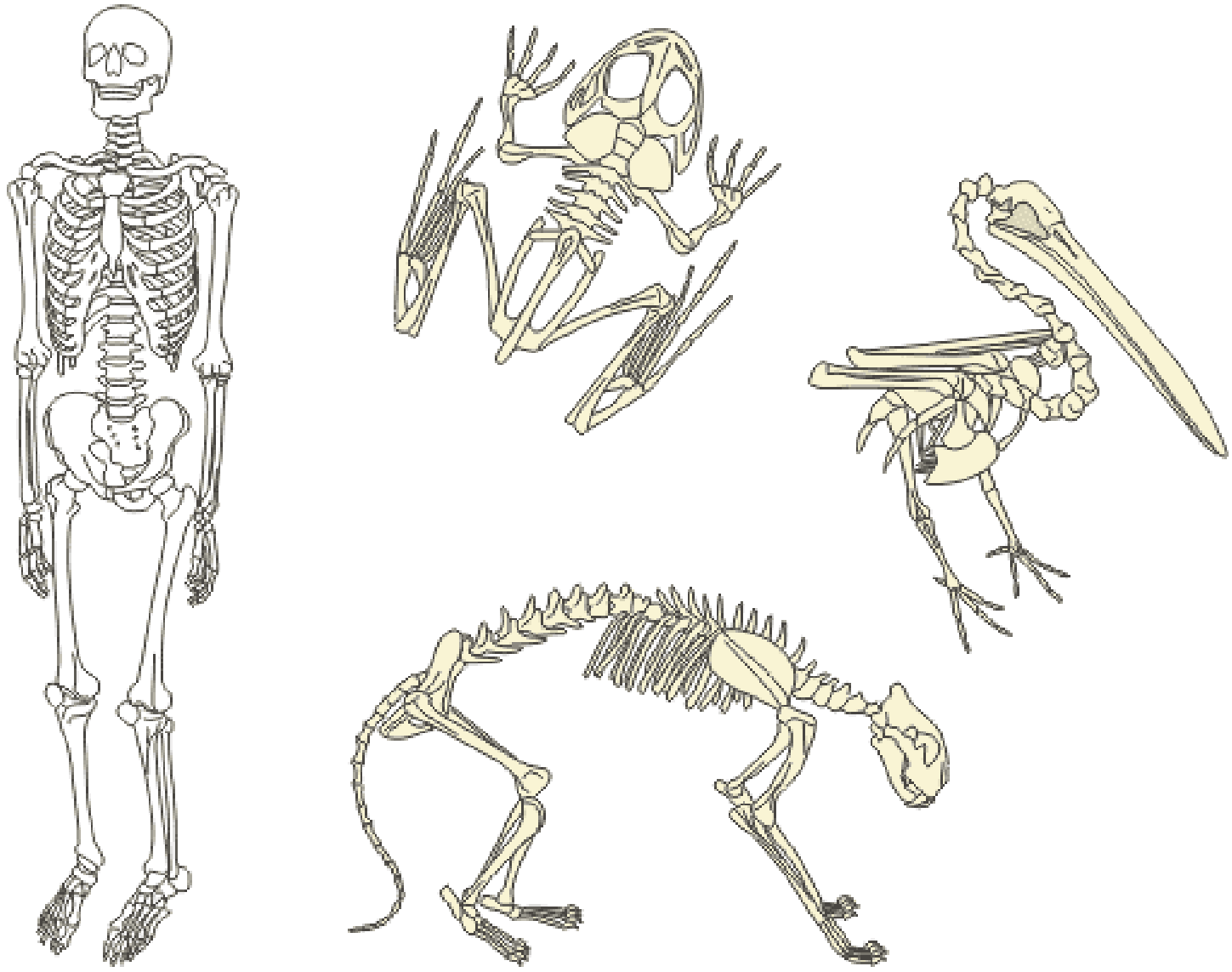
CHAPTER 6

The Skeletal System

THE SKELETAL SYSTEM



Five Functions of the Skeletal System (6-1)

1. Support
   - Provided for the entire body by the entire skeletal system
   - Bones provide attachments for soft tissues and organs
2. Storage
   - Provided by the bones for calcium salts for body fluids
   - Lipids are stored in yellow marrow for energy reserves

Five Functions of the Skeletal System (6-1)

3. Blood cell production
   - Occurs in the red marrow and results in increases in red blood cells, white blood cells, and platelets
4. Protection
   - Provided to soft tissues and organs by surrounding them with the skeleton
   - Examples:
     - The skull enclosing the brain
     - The ribs protecting the heart and lungs

Five Functions of the Skeletal System (6-1)

5. Movement

- In part a function of the skeletal system because the bones function as levers
- When the skeletal muscles pull on the bones, movement occurs

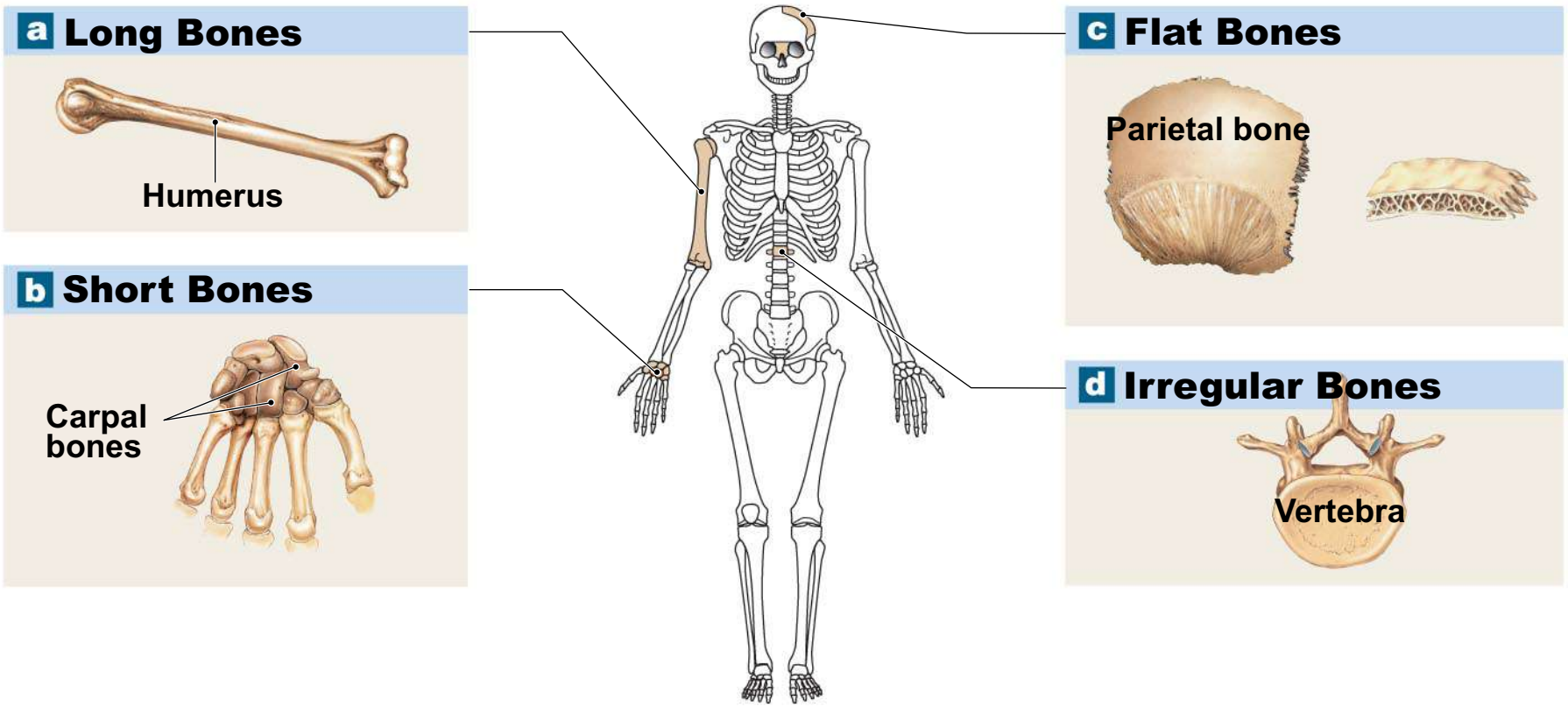
Bone Tissue Characteristics (6-2)

- **Bones** or **osseous tissue**
  - Are a supporting connective tissue; cells are called osteocytes
  - Matrix made of extracellular protein fibers and a ground substance
- Calcium phosphate – give bone its texture
  - $Ca_3(PO_4)_2$
  - A salt deposited into the matrix
    - Giving 2/3 of the weight of the 206 bones in the body
    - Remaining weight is collagen

Four General Shapes of Bones (6-2)

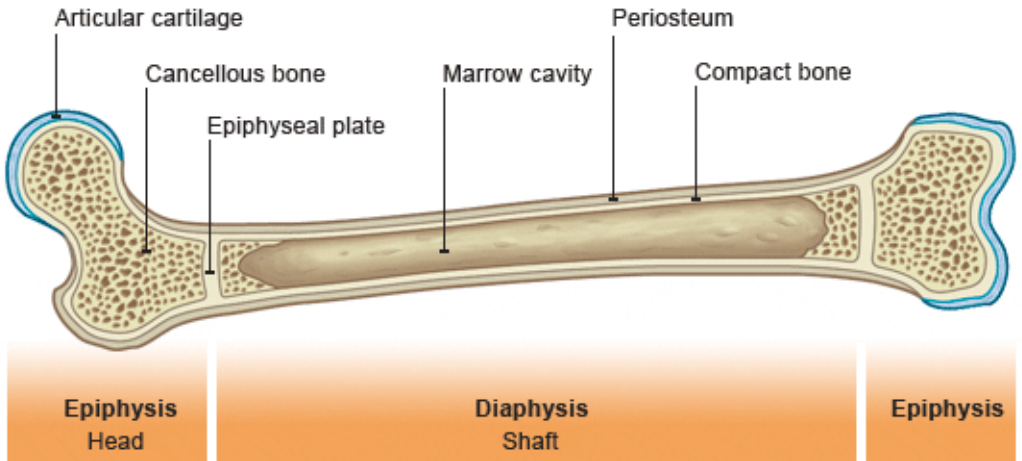
1. **Long bones**
   - Longer than they are wide
   - For example, the humerus
2. **Short bones**
   - About as wide as they are long
   - For example, the carpal bones
3. **Flat bones**
   - Are broad
   - Like the scapula, ribs
4. **Irregular bones**
   - Complex in shape
   - Like a vertebra

Figure 6-1 Shapes of Bones.



Structure of a Long Bone (6-2)

- The **diaphysis**, or central shaft
  - Has a **marrow cavity** in the center filled with **bone marrow (soft fatty tissue)**
- The **epiphyses** are the wider portions at each end
  - Covered with articular cartilage
  - Each articulates with an adjacent bone at a joint



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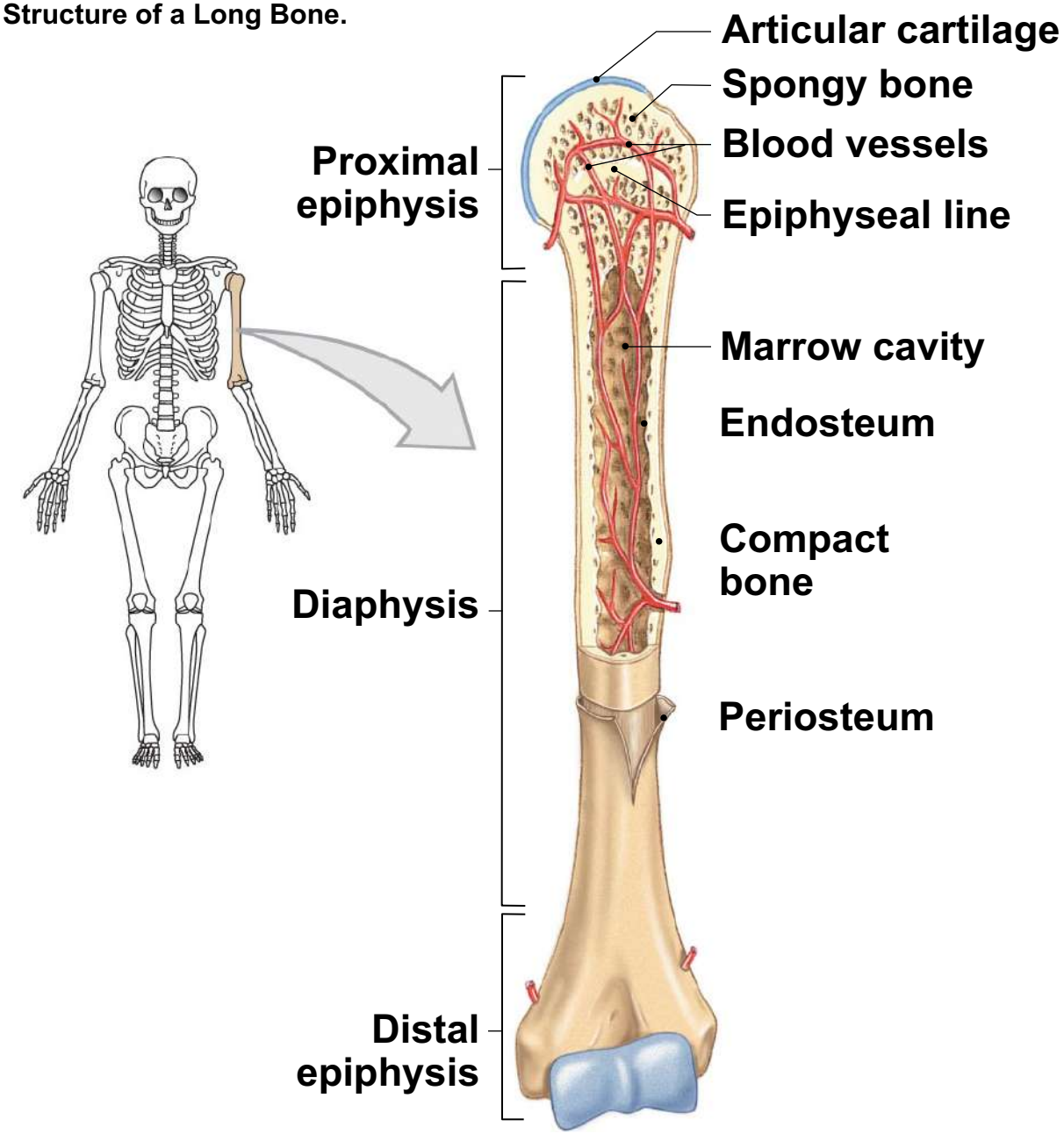
Structure of a Long Bone (6-2)

- **Compact bone**
  - Is densely packed; forms the diaphysis
- **Spongy bone**, also called cancellous bone
  - Has projections of bone separated by space
- **Periosteum**
  - Is the outer covering of bone
- **Endosteum**
  - Lines the marrow cavity and spongy bone

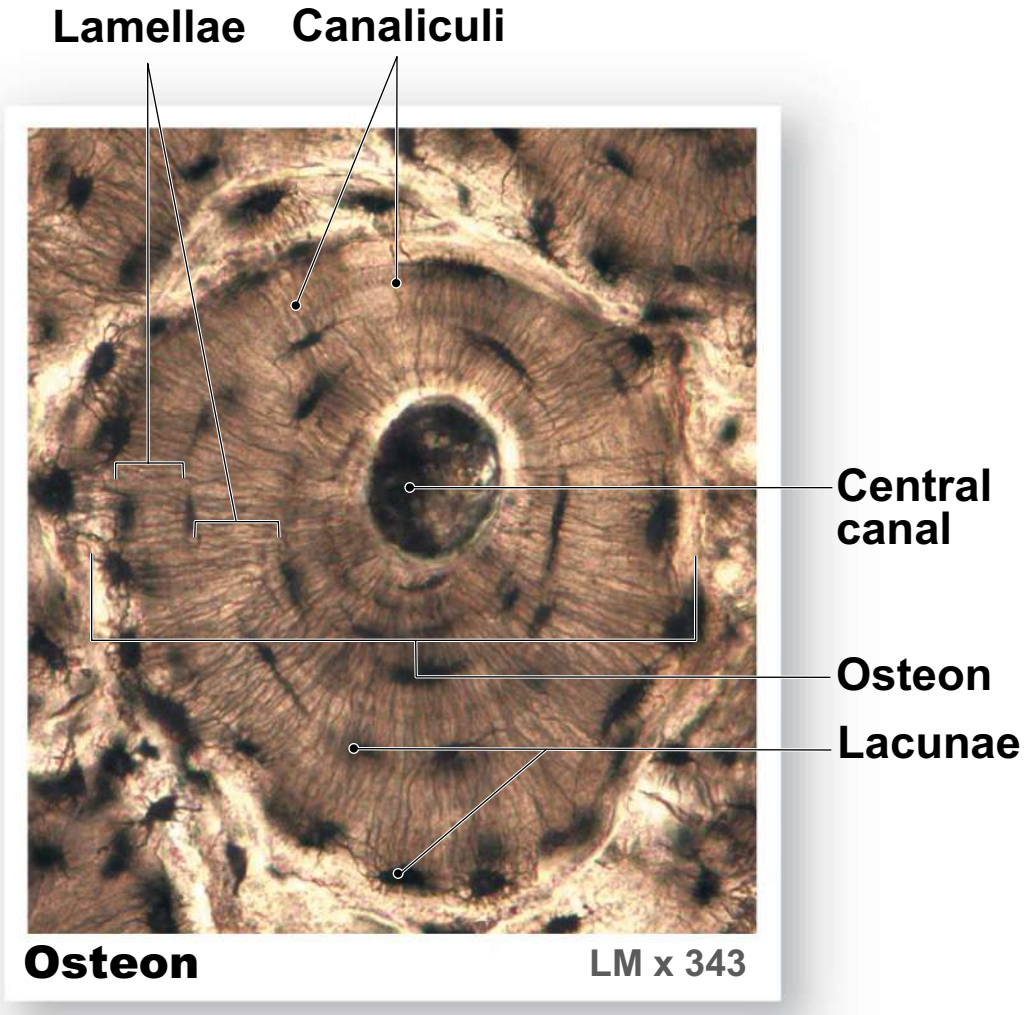
Figure 6-2 The Structure of a Long Bone.



Histology of Bone (6-2)

- Periosteum has two layers
  - A fibrous outer layer and a cellular inner layer
- Bone cells are called **osteocytes**
  - Located in pockets called **lacunae**
  - Found between sheets of matrix called **lamellae**
- **Canaliculi** are small channels
  - That run through the matrix
  - And connect the lacunae and blood vessels
  - Contain cytoplasmic extensions of the osteocytes

Figure 6-3b The Microscopic Structure of a Typical Bone.



b In this thin section through compact bone, the intact matrix making up the lamellae appears white, and the central canal, luacunae, and canaliculi appear black due to the presence of bone dust.

Histology of Compact Bone (6-2)

- Has a repeating functional unit called the **osteon,** or Haversian system
- Osteon is made of concentric circles of lamella
  - Surrounding a **central canal** that has blood vessels in it
- **Perforating canals** allow for blood vessels in the central canals:
  - To be linked to other vessels

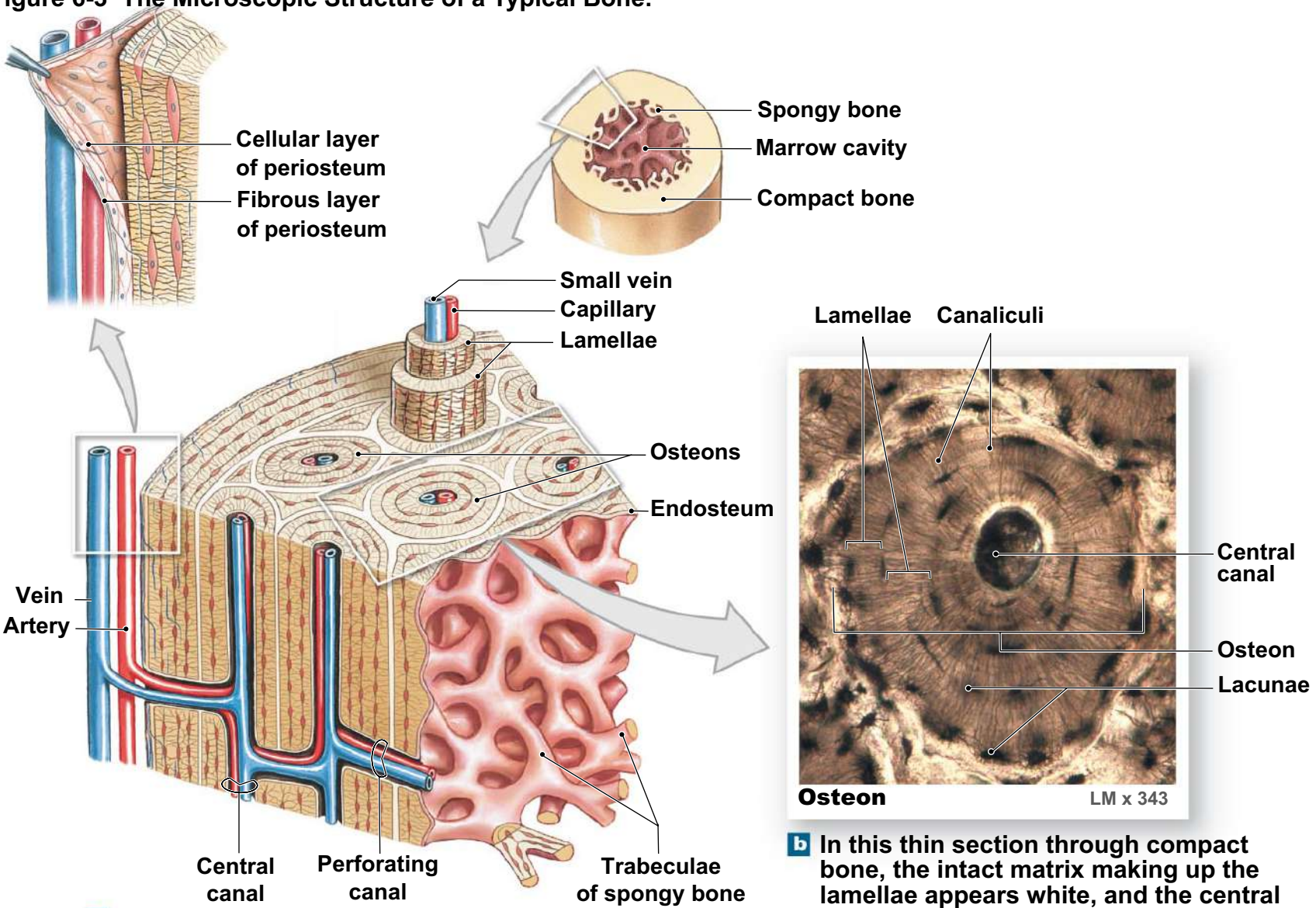
Characteristics of Compact Bone (6-2)

- Covers all bone surfaces except for the articular surfaces
- Can tolerate a lot of stress applied to either end of a long bone
  - Cannot tolerate moderate stress applied to the side of the shaft

Histology of Spongy Bone (6-2)

- Has no osteons
  - The lamellae form rods called **trabeculae**
- Found in the epiphyses
  - Where the stress is handled by the joints
- Much lighter than compact bone
  - Reducing the work of muscles to move bones

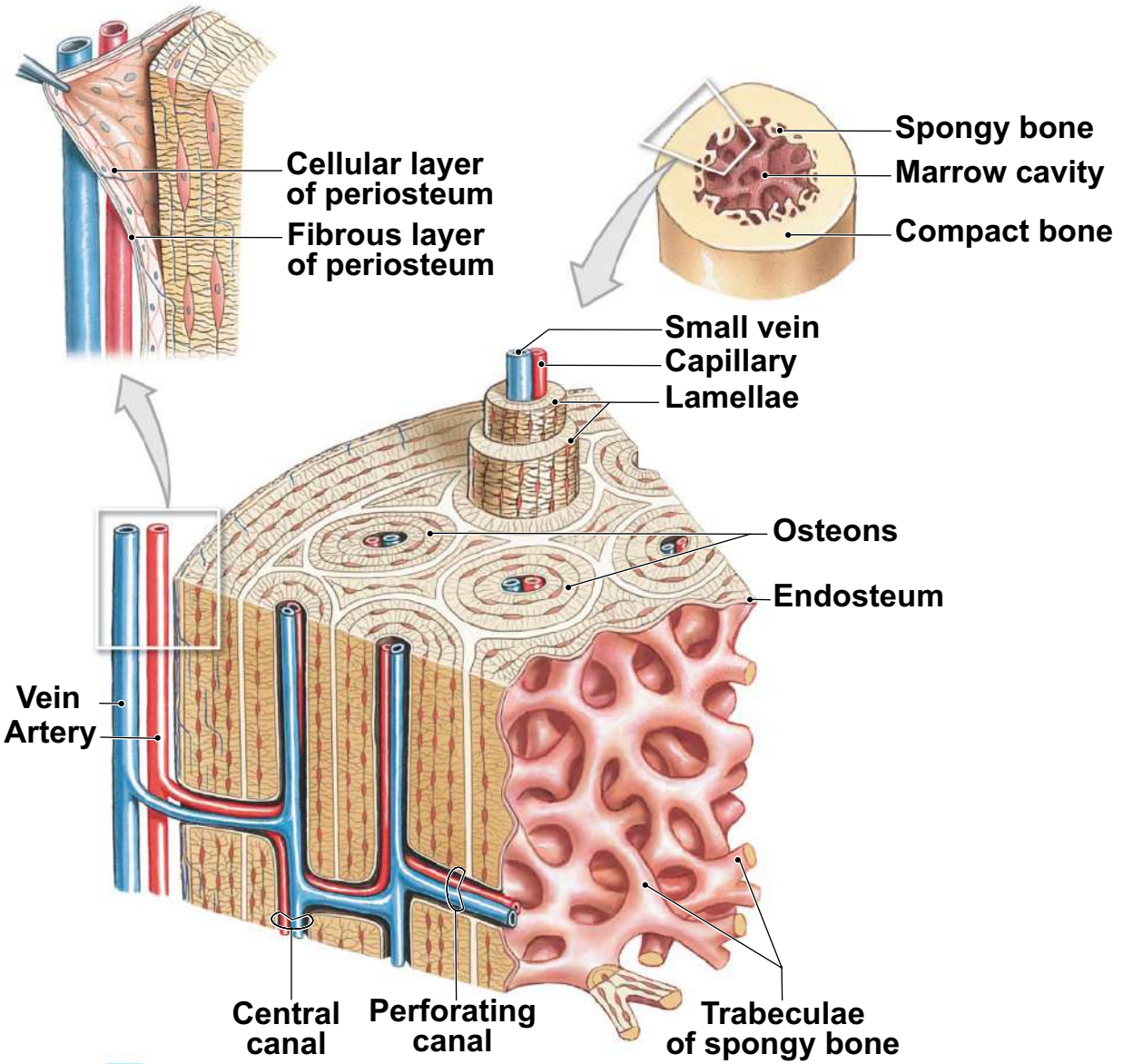
Figure 6-3 The Microscopic Structure of a Typical Bone.



a This diagrammatic view depicts the parallel osteons of compact bone and the trabecular network of spongy bone.

b In this thin section through compact bone, the intact matrix making up the lamellae appears white, and the central canal, luacunae, and canaliculi appear black due to the presence of bone dust.

Figure 6-3a The Microscopic Structure of a Typical Bone

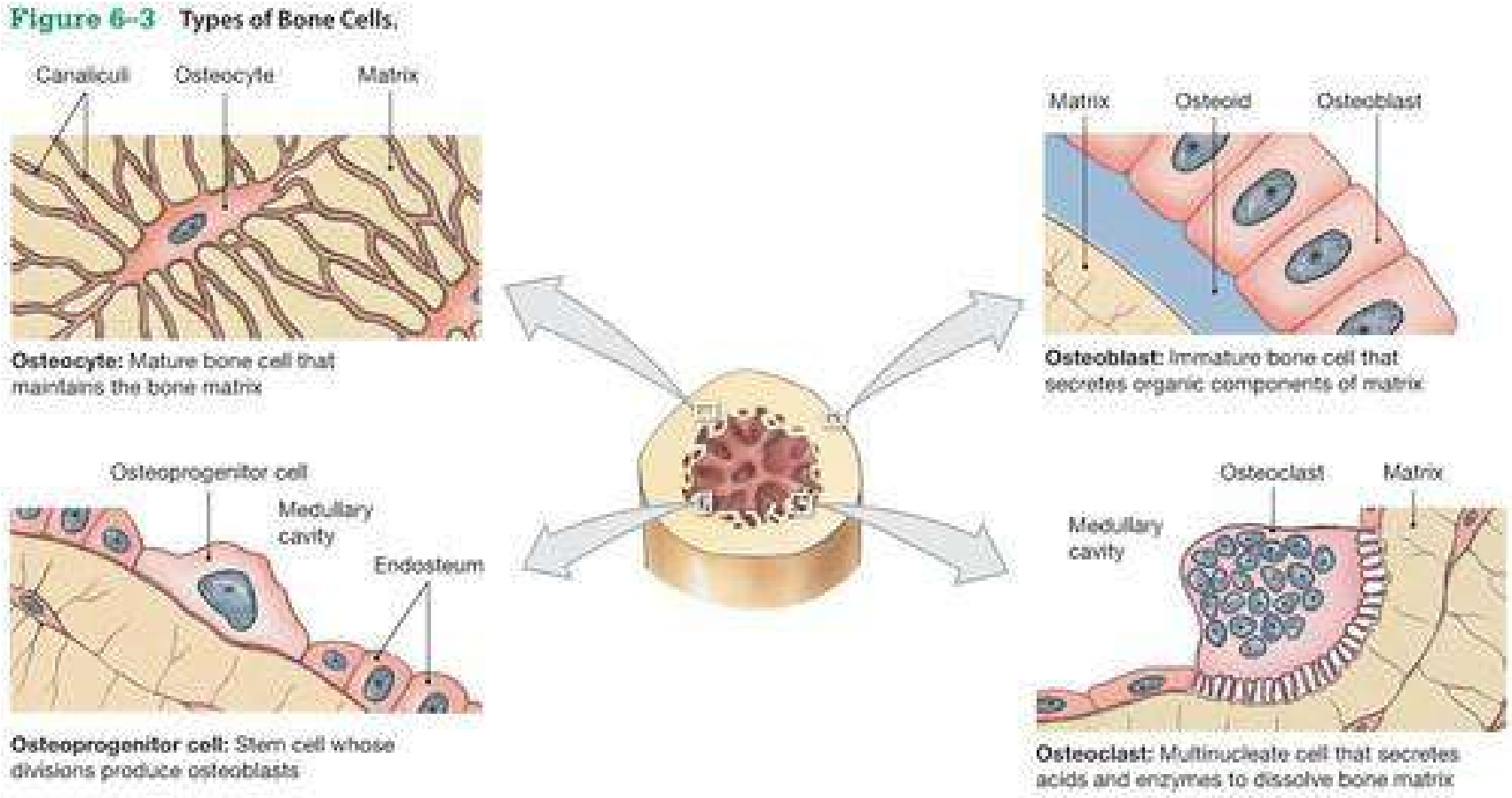


a This diagrammatic view depicts the parallel osteons of compact bone and the trabecular network of spongy bone.

Types of Bone Cells (6-2)

- **Osteocytes**
  - Mature cells that maintain bone structure by recycling calcium salts
- **Osteoclasts**
  - Large cells that secrete acid and enzymes that break down the matrix – 50 or more nuclei
    - Releasing minerals through osteolysis
- **Osteoblasts**
  - Produce new bone through a process called **ossification**

Three Bone Cells



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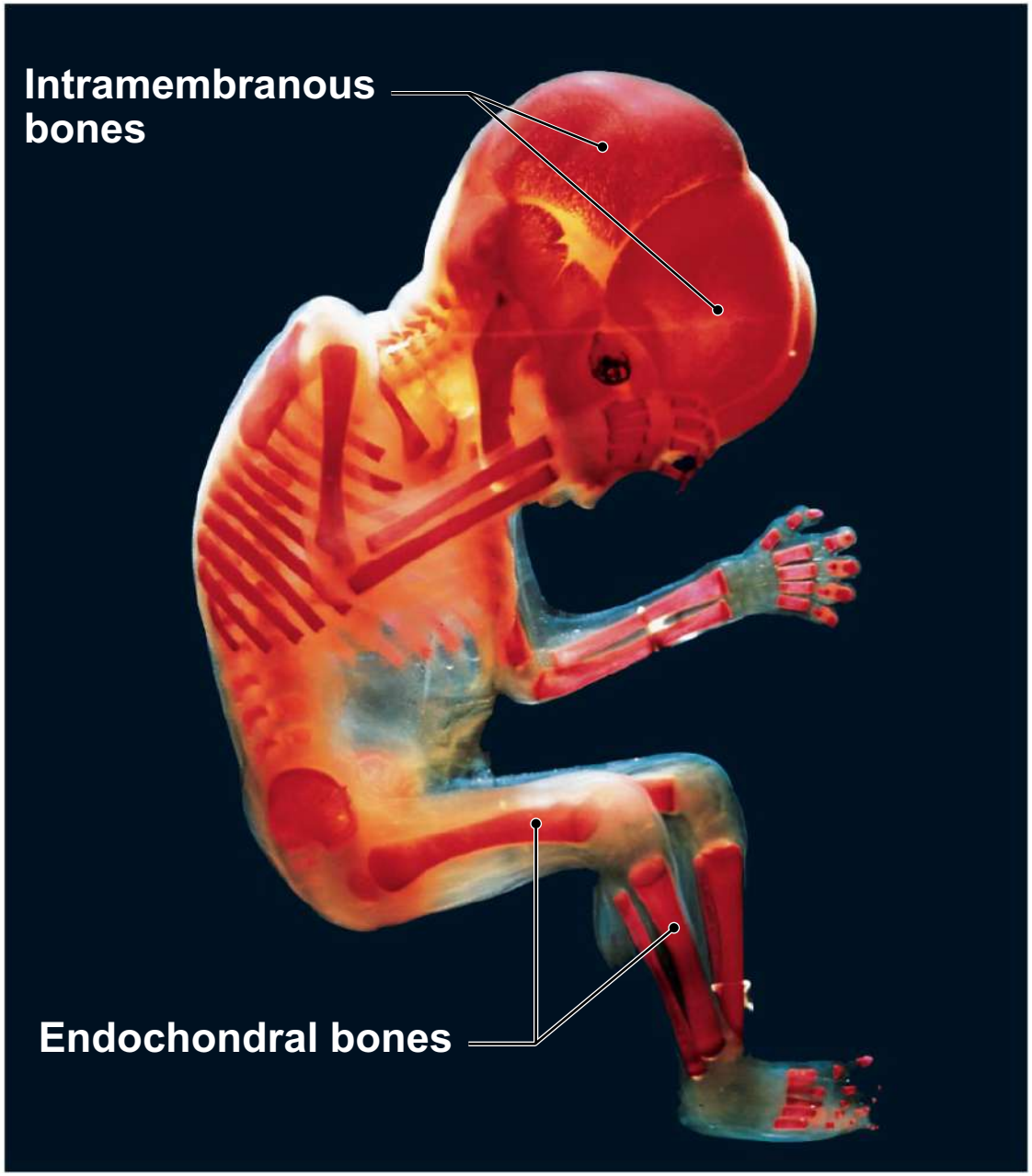
Bone Formation (6-3)

- Embryonic development of bone
  - Begins at week 6 as a cartilaginous formation
  - Bone growth continues and some do not stop until 25 yo
  - Replaced with bone, a process called **ossification**
- **Calcification** occurs during ossification – deposition of calcium salts
  - Can also occur in other tissues besides bone

Two Types of Ossification

- Two types
  1. **Intramembranous ossification**
     1. **Bone develops within sheets or membranes of connective tissue**
  2. **Endochondral ossification**
     1. **Bone replaces existing cartilage**

Figure 6-4 Bone Formation in a 16-Week-Old Fetus.



Intramembranous Ossification (6-3)

- Occurs during fetal development
  - Developing sheets of connective tissue
  - Deepest layers of the dermis
- Osteoblasts differentiate and develop calcified matrix
- Ossification begins around an **ossification center**
- New bone branches outward, develops blood supply
  - Spongy bone structures remodel into compact flat bones
    - Such as the skull bones

Five Steps of Endochondral Ossification (6-3)

- Embryonic cartilaginous skeletal structures are replaced by true bone in a series of five steps

1. Chondrocytes enlarge and matrix begins to calcify
    - Closing off the chondrocytes from nutrients
    - Causing them to die
2. Bone formation starts at the shaft surface
    - Blood vessels invade the perichondrium
    - New osteoblasts produce bone matrix

Five Steps of Endochondral Ossification (6-3)

3. Blood vessels invade inner region of cartilage
   - New osteoblasts form spongy bone at primary ossification center
   - Bone develops toward each end
   - Filling shaft with spongy bone
4. Osteoclasts begin to break down spongy bone in center
   - To form marrow cavity
   - **Epiphyseal cartilages**, or plates, on the ends of the bone continue to enlarge

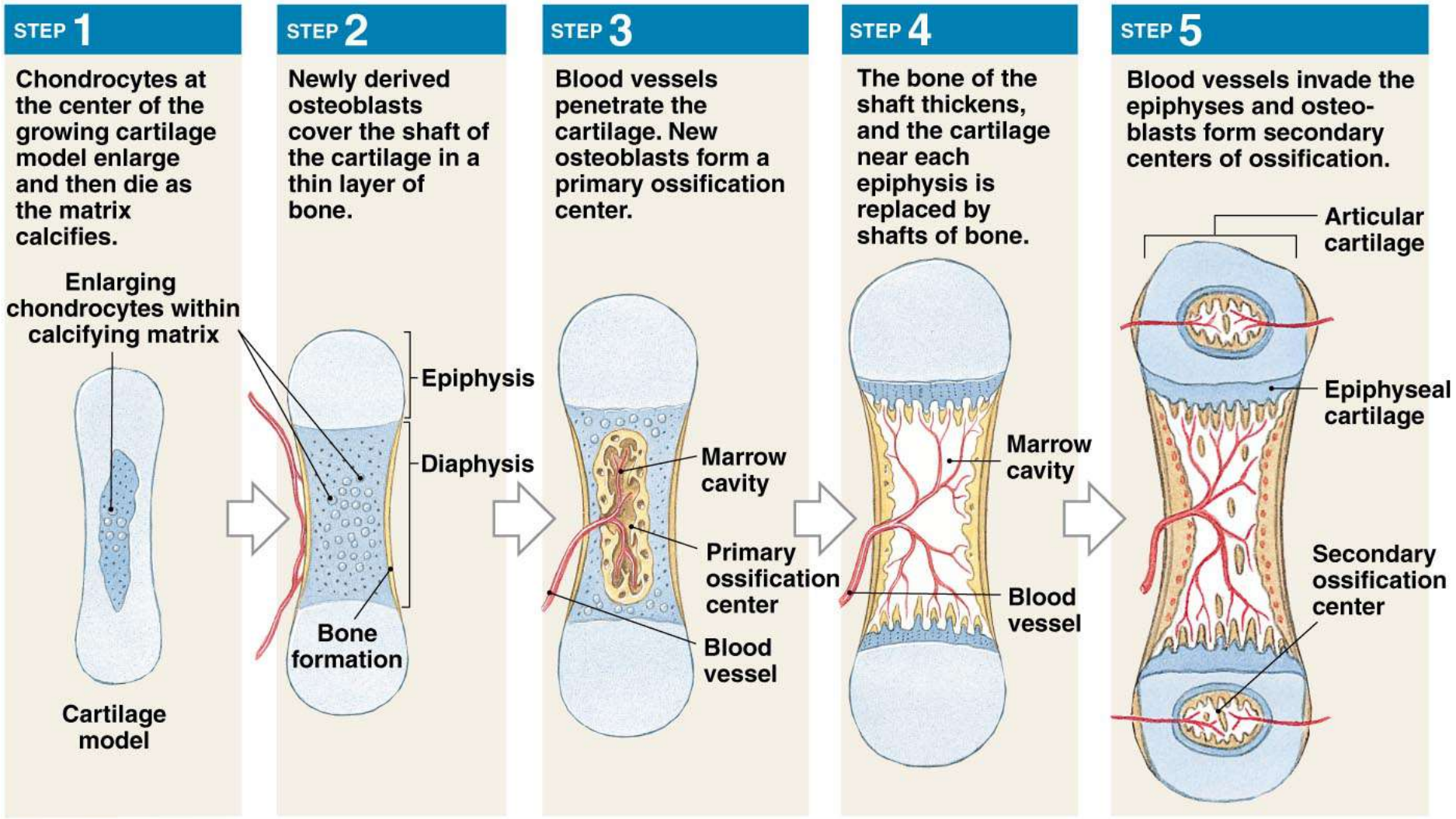
Five Steps of Endochondral Ossification (6-3)

5. Centers of the epiphyses begin to calcify

- Secondary ossification centers form
- Epiphyses fill with spongy bone
- Bone grows in length from the epiphyseal cartilages
- Joint surfaces are covered with **articular cartilage**

Endochondral Ossification (6-3)

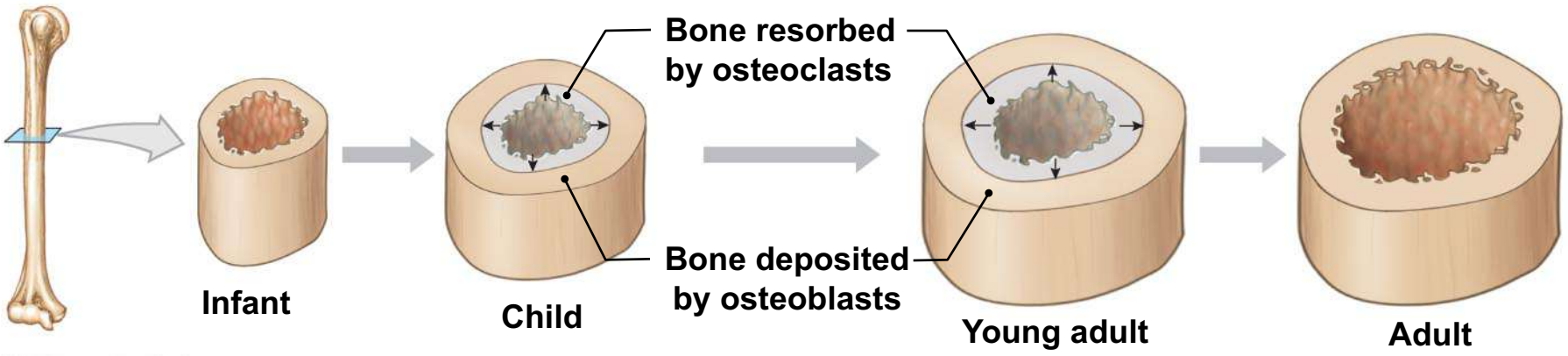
- At puberty, bone growth accelerates
  - Due to sex hormone production
- Osteoblasts produce bone faster than the epiphyseal cartilage can expand
  - Epiphyseal artilages eventually disappear or "close"
- Adult bones show evidence of the **epiphyseal line**
  - Where the cartilage once was



Appositional Growth (6-3)

- Enlargement in the diameter of bones occurs as it is growing in length
- Periosteum cells develop into osteoblasts
  - Produce more matrix on the outer surface of the bone
- Osteoclasts erode the inner surface
  - Enlarging the marrow cavity

Figure 6-6 Appositional Bone Growth.



Closing of Epiphyseal Plates (6-3)

- Vary from bone to bone
  - Digits close early
  - Arm, leg, and pelvis bones close later
- Vary from person to person
  - And between males and females
    - Mostly due to differences in sex hormones

Requirements for Bone Growth (6-3)

- Mineral supply
  - Especially calcium salts
- Vitamin D_3
  - Involved in calcium metabolism
  - Rickets is due to vitamin D_3 deficiency – softening and bending of the bones in growing kids
- Vitamin A and vitamin C
  - Provide support for osteoblasts
  - Vitamin C deficiency can cause scurvy – weak and brittle bones
- Growth hormone, sex hormones, thyroid hormone, and the calcium-balancing hormones

Bone Remodeling (6-4)

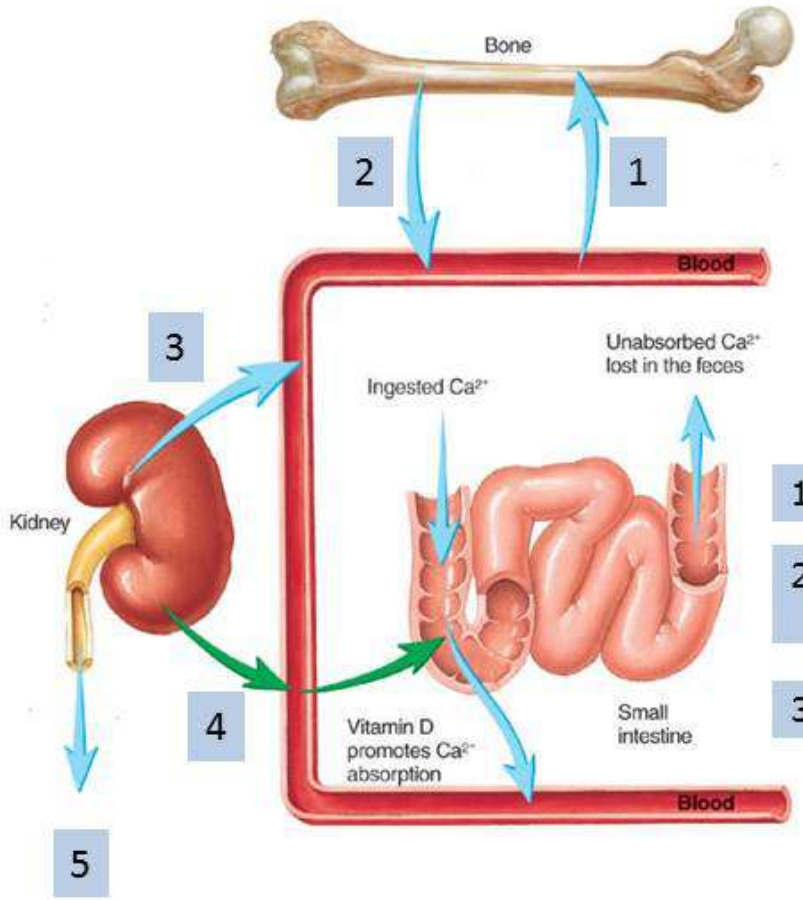
- In adults:
  - Osteocytes in lacunae continuously remove and replace surrounding calcium salts
  - Osteoblasts and osteoclasts remain active
    - Osteoblasts – forms osteon, osteoclasts –destroys osteon
  - **Remodeling** bone, especially spongy bone
- In young adults:
  - Remodeling is so rapid that about one-fifth of the skeletal mass is replaced each year

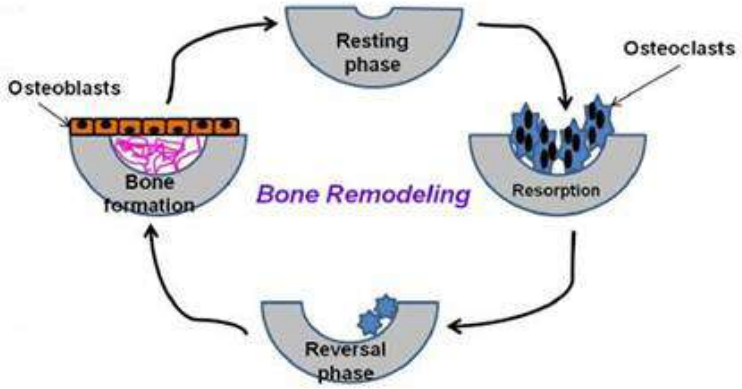
Bone Remodeling (6-4)

- Appropriate stress
  - Causes thickening and strengthening of bone
  - Little stress on bones causes them to be weak and thin
- Exercise
  - Is key to maintaining normal bone structure and strength

The Calcium Reserve (6-4)

- Calcium balance in the body fluids
  - Is essential for many physiological mechanisms
    - Especially in nerves and muscles – increase by 30%, unresponsive, decrease by 35%, can convulse, 50% death
- Calcium balance is regulated by:
  - Parathyroid hormone (PTH) and calcitriol to raise calcium levels
  - Calcitonin to lower calcium levels in body fluids





1 = osteoblast remove Ca from blood

2 = osteoclast release Ca from bone due to PTH
calcitonin inhibits Ca release

3 = reabsorption of Ca due to PTH

4 = PTH promotes calcitriol for active
Ca absorption

5 = Ca loss via urine

Types of Fractures (6-4)

- Named by external appearance
  - **Fracture – every crack or break in bone**
  - **Closed** (*simple*) **fractures**
    - Completely internal
  - **Open** (*compound*) **fractures**
    - Project through the skin

Types of Fractures (6-4)

- Named by location
  - Example: *Pott's fracture*
    - Occurs at the ankle and affects bones of the leg
  - Example: *Colles fracture*
    - Break in the distal portion of the radius

Types of Fractures (6-4)

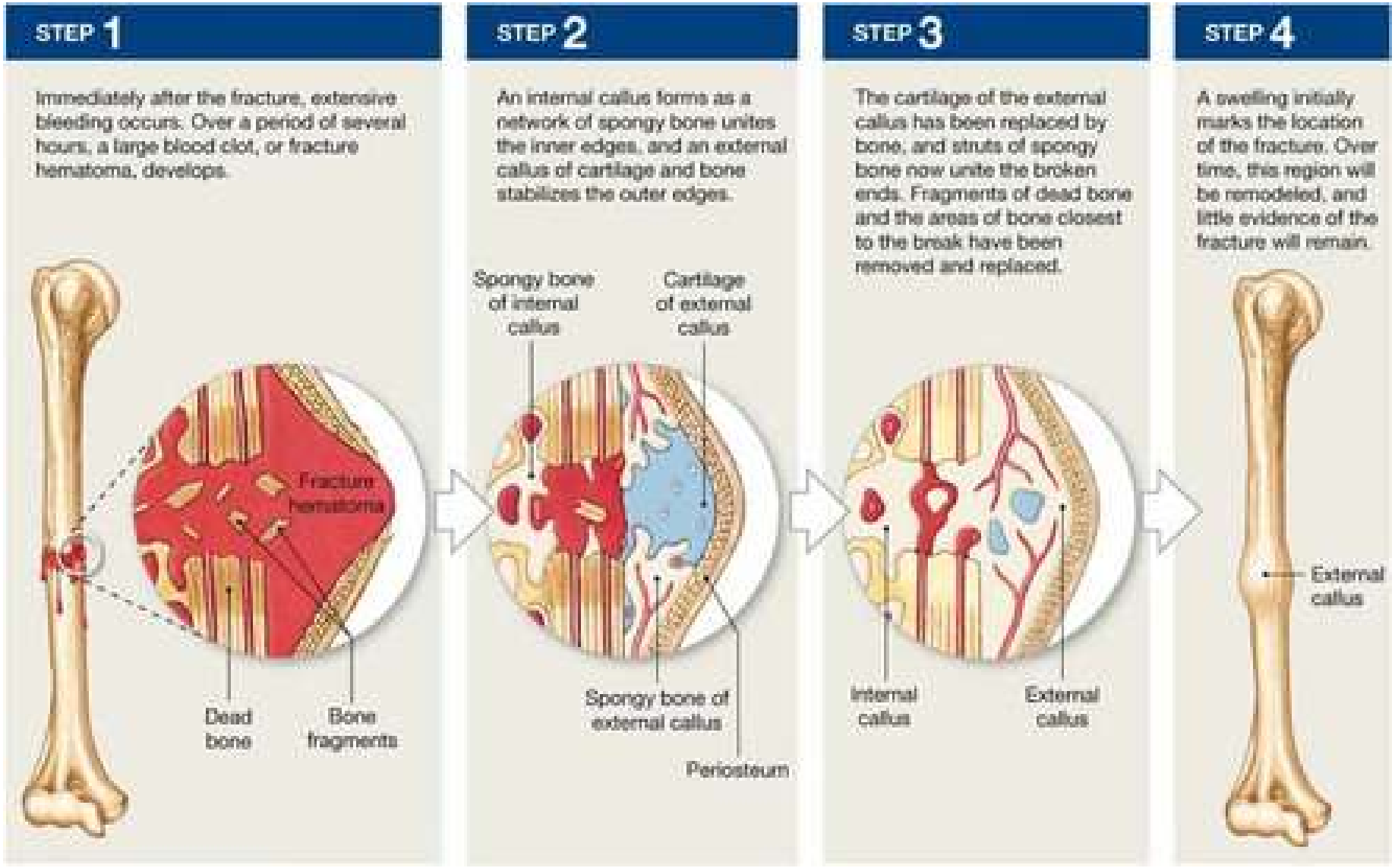
- Named by the nature of the break
  - Example: *transverse fractures*
    - Break a shaft of bone across its long axis
  - Example: *spiral fractures*
    - Produced by twisting stresses along the length of a bone
  - Example: *comminuted fractures*
    - Shatter the area into many smaller fragments

Four Steps to Repair Fractures (6-4)

1. Fractures result in broken blood vessels that cause a blood clot, called a **fracture hematoma**, to form
   - This closes off the blood supply
   - Killing osteocytes
   - Resulting in dead bone on either side of the fracture

Four Steps to Repair Fractures (6-4)

2. Cells of periosteum and endosteum collect at the fracture
   - And develop into an **external callus** (develops hyaline cartilage) and **internal callus**, respectively
3. Osteoblasts replace cartilage with spongy bone
4. Spongy bone is replaced by compact bone
   - Leaving a slightly thicker spot at the fracture site


STEP 1
Immediately after the fracture, extensive bleeding occurs. Over a period of several hours, a large blood clot, or fracture hematoma, develops.
Fracture hematoma
Dead bone
Bone fragments
STEP 2
An internal callus forms as a network of spongy bone unites the inner edges, and an external callus of cartilage and bone stabilizes the outer edges.
Spongy bone of internal callus
Cartilage of external callus
Spongy bone of external callus
Periosteum
STEP 3
The cartilage of the external callus has been replaced by bone, and struts of spongy bone now unite the broken ends. Fragments of dead bone and the areas of bone closest to the break have been removed and replaced.
Internal callus
External callus
STEP 4
A swelling initially marks the location of the fracture. Over time, this region will be remodeled, and little evidence of the fracture will remain.
External callus

Osteopenia and Aging (6-5)

- **Osteopenia**
  - Inadequate ossification that naturally occurs as part of the aging process
  - Starting between the ages of 30 and 40:
    - Osteoblastic activity slows and osteoclastic activity increases
- **Osteoporosis**
  - Loss of bone mass that impairs normal function and can lead to more fractures
  - More common in women and accelerates after menopause
    - Due to a decline in circulating estrogens

Surface Bone Markings (6-6)

- Are landmark features on the surfaces of bones
- Include projections
  - Where tendons and ligaments attach
  - Where bones articulate
- Include depressions, grooves, and openings
  - Where blood vessels and nerves pass through the bone

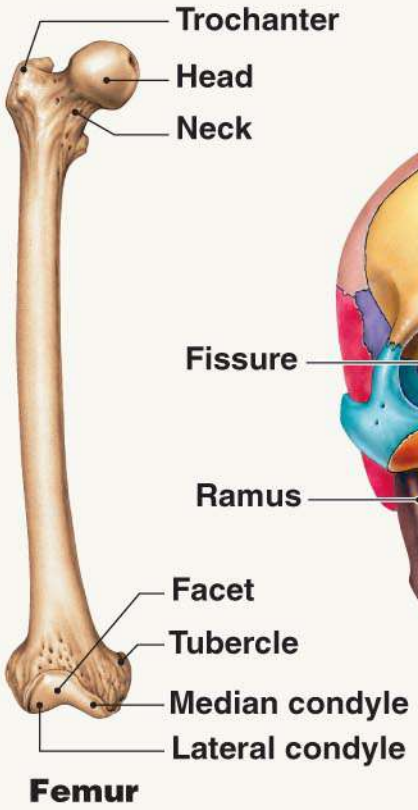
Table 6-1 An Introduction to Bone Markings

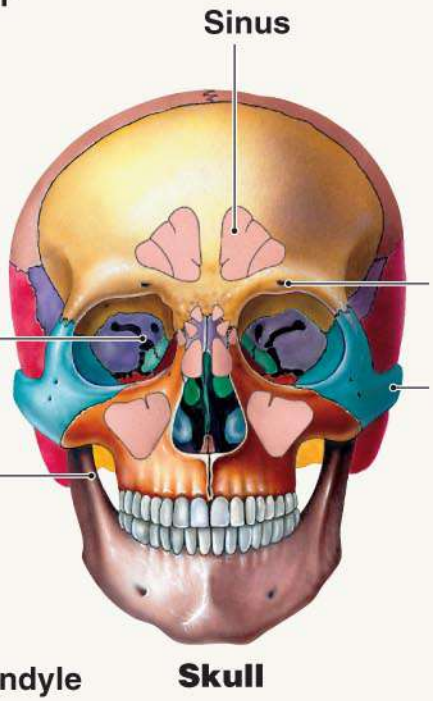
General Description	Anatomical Term	Definition
Elevations and projections (general)	Process	Any projection or bump
	Ramus	An extension of a bone making an angle with the rest of the structure
Processes formed where tendons or ligaments attach	Trochanter	A large, rough projection
	Tuberosity	A smaller, rough projection
	Tubercle	A small, rounded projection
	Crest	A prominent ridge
	Line	A low ridge
	Spine	A pointed process
Processes formed for articulation with adjacent bones	Head	The expanded articular end of an epiphysis, separated from the shaft by a neck
	Neck	A narrow connection between the epiphysis and the diaphysis
	Condyle	A smooth, rounded articular process
	Trochlea	A smooth, grooved articular process shaped like a pulley
	Facet	A small, smooth articular surface
Depressions	Fossa	A shallow depression
	Sulcus	A narrow groove

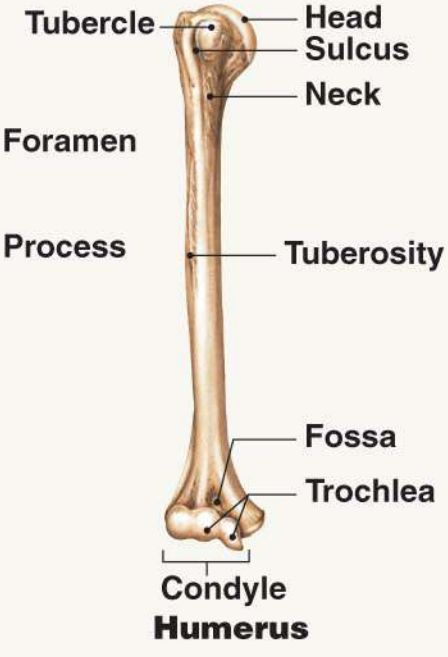
Table 6-1 An Introduction to Bone Markings (2 of 2)

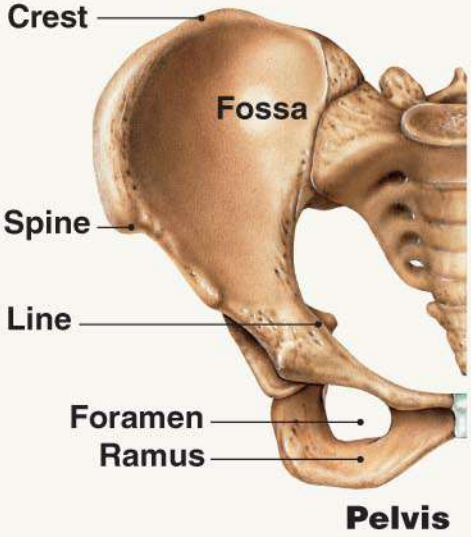
Table 6-1 An Introduction to Bone Markings *(continued)*

General Description	Anatomical Term	Definition
Openings	Foramen	A rounded passageway for blood vessels or nerves
	Canal	A duct or channel
	Meatus	A passageway through a bone
	Fissure	An elongated cleft or slit
	Sinus	A chamber within a bone, normally filled with air









Skeletal Divisions (6-6)

- **Axial skeleton** includes:
  - The **skull** and associated bones
  - The **thoracic cage** with the **ribs** and **sternum**
  - The **vertebral column**
- **Appendicular skeleton** includes:
  - The **pectoral girdle** and the upper limbs
  - The **pelvic girdle** and the lower limbs

Figure 6-8 The Skeletc

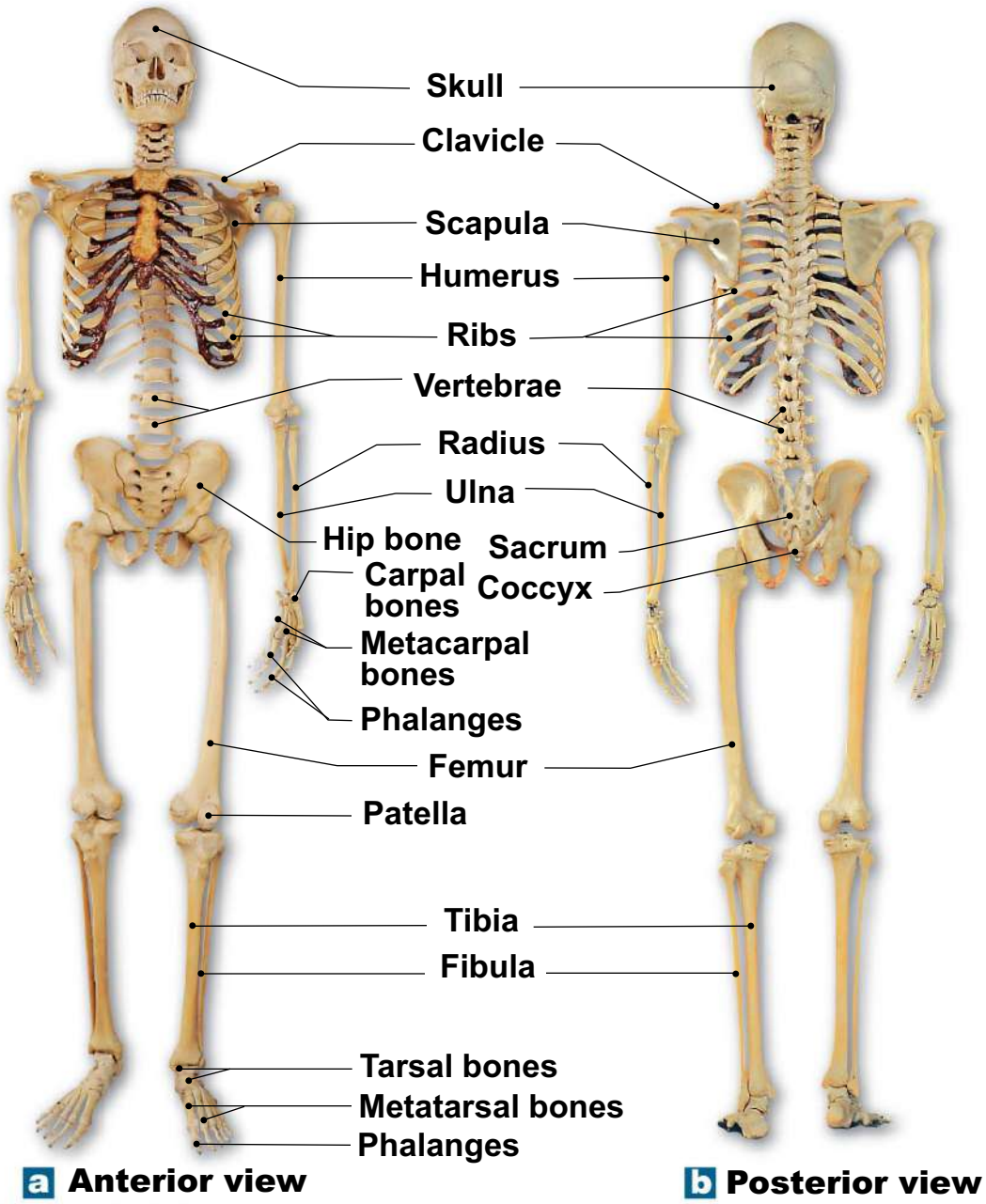
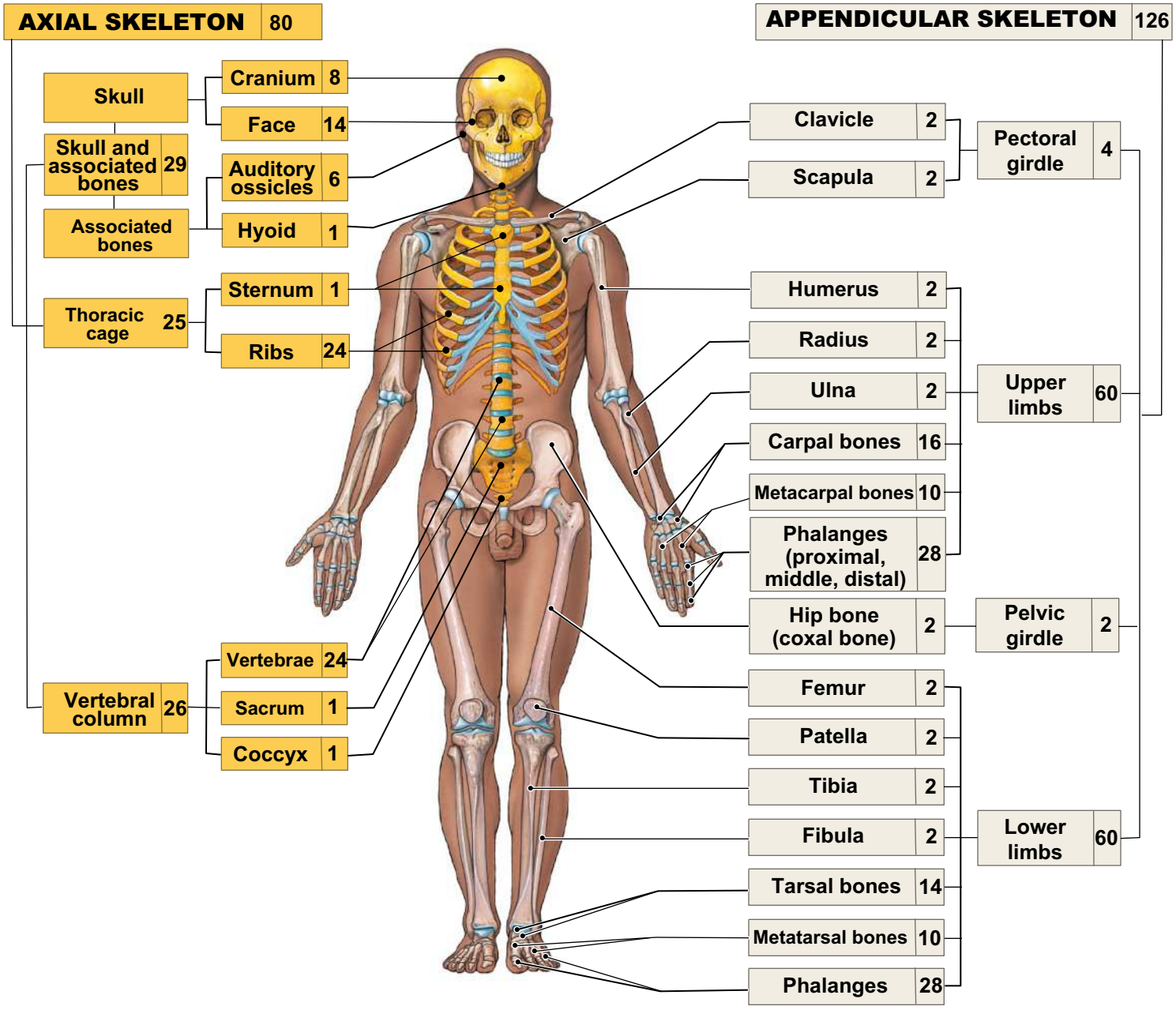


Figure 6-9 The Axial and Appendicular Divisions of the Skeleton.



The Axial Skeleton (6-7)

- Framework for support and protection of the brain, spinal cord, and organs in the ventral body cavity
- Provides surface area for attachment of muscles that:
  1. Move the head, neck, and trunk
  2. Perform respiration
  3. Stabilize elements of the appendicular skeleton

The Skull (6-7)

- Houses brain and sense organs for sight, smell, taste, and balance
- Total of 22 bones
  - 8 form the **cranium**
    - Forming **cranial cavity**, which houses brain
  - 14 are **facial bones**
    - Also includes associated bones, 6 auditory ossicles, and one hyoid bone

The Frontal Bone (6-7)

- Forms the forehead and the roof of the **orbits**, or eye sockets
- **Supra-orbital foramen**
  - Forms a passageway above each orbit for blood vessels and nerves
- **Frontal sinuses**
  - Are air-filled cavities above the orbit
    - Lined with mucus membrane
    - Connect with the nasal cavity

The Parietal Bones (6-7)

- Are posterior to frontal bones and form the roof of the cranium
- **Coronal suture**
  - Where the parietal and frontal bones interlock
- **Sagittal suture**
  - Where the parietal bones interlock at the midline of the cranium

The Occipital Bone (6-7)

- Forms the posterior, inferior part of the cranium
- **Lambdoid suture**
  - Where the occipital and parietal bones interlock
- **Foramen magnum**
  - Surrounds the connection between the brain and the spinal cord
- **Occipital condyles**
  - The articular surfaces that sit on the first vertebra

The Temporal Bones (6-7)

- On either side of the cranium and zygomatic arches, housing the ossicles in middle ear
- **Squamous sutures**
  - Where the temporal and parietal bones interlock
- Key bone markings
  - **External auditory meatus**
  - **Mandibular fossa**
  - **Mastoid process**
  - **Styloid process**

The Sphenoid Bone (6-7)

- Forms part of the floor of the cranium
  - The bridge between the cranial bones and the facial bones
- Contains a pair of sinuses, the **sphenoidal sinuses**
- "Wings" of the bone extend laterally from a central depression, the **sella turcica**
  - Which houses and protects the pituitary gland

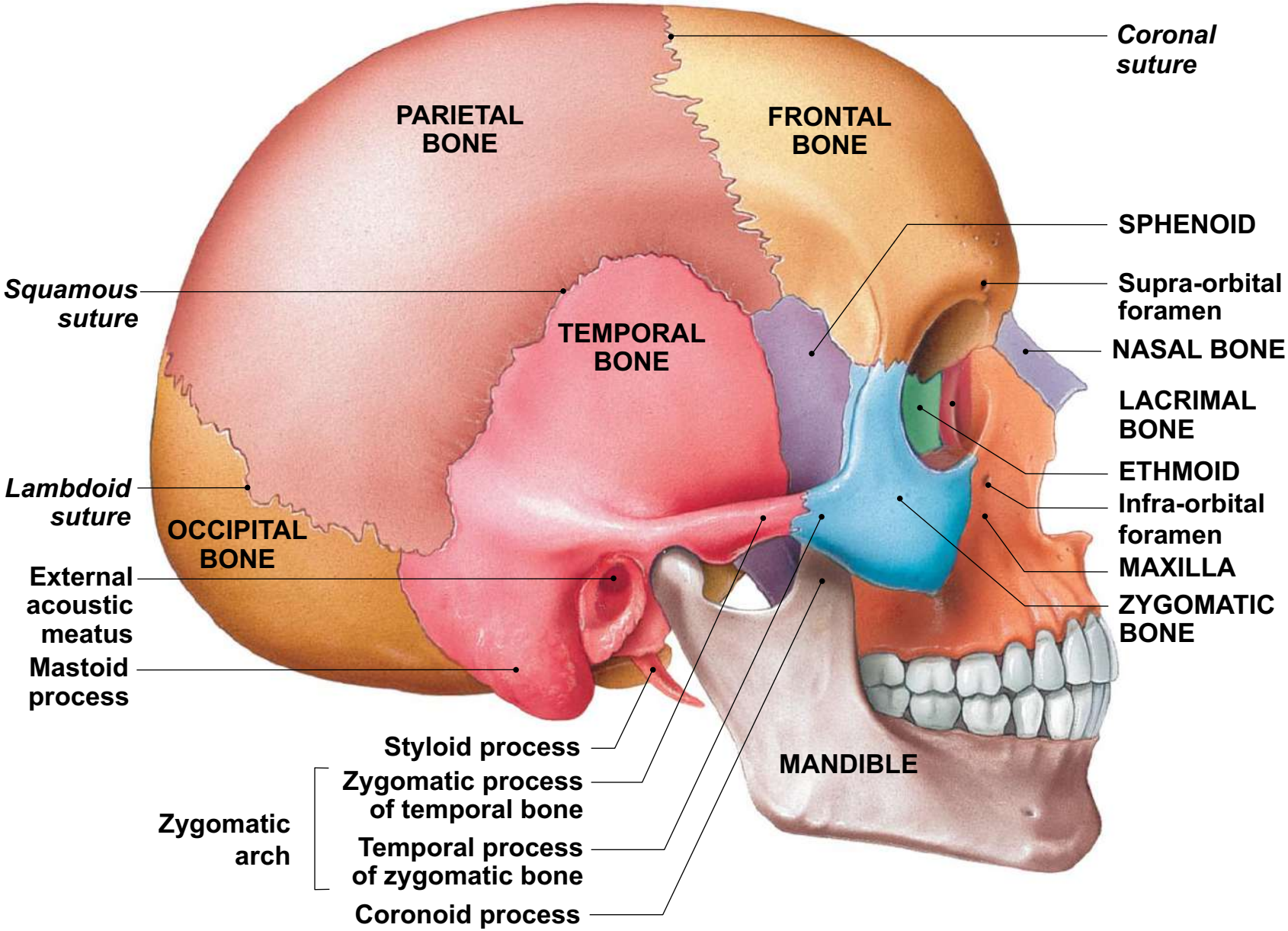
The Ethmoid Bone (6-7)

- Anterior to the sphenoid, forms part of the cranial floor
  - Forms the medial surfaces of the orbits and is the roof and sides of the nasal cavity
- **Crista galli** projects upward toward the brain and the inferior **cribriform plate**
  - Has holes in it allowing for olfactory nerves to pass into the nasal cavity

The Ethmoid Bone (6-7)

- Contains **ethmoidal sinuses**
- Projections into the nasal cavity toward the nasal septum
  - Called the **superior** and **middle nasal conchae**
- **Perpendicular plate** extends down from the crista galli between the conchae
  - To form part of the nasal septum

Figure 6-10 The Adult Skull, Part I.



The Maxillae (6-7)

- Also called the maxillary bones
- Articulate with all other facial bones except for the mandible
- Forms the floor and medial sides of the rim of the orbits, the walls of the nasal cavity, and the anterior roof of the mouth (bony palate)
- **Maxillary sinuses**
  - Drain into nasal cavity
  - Lighten the weight of the bones

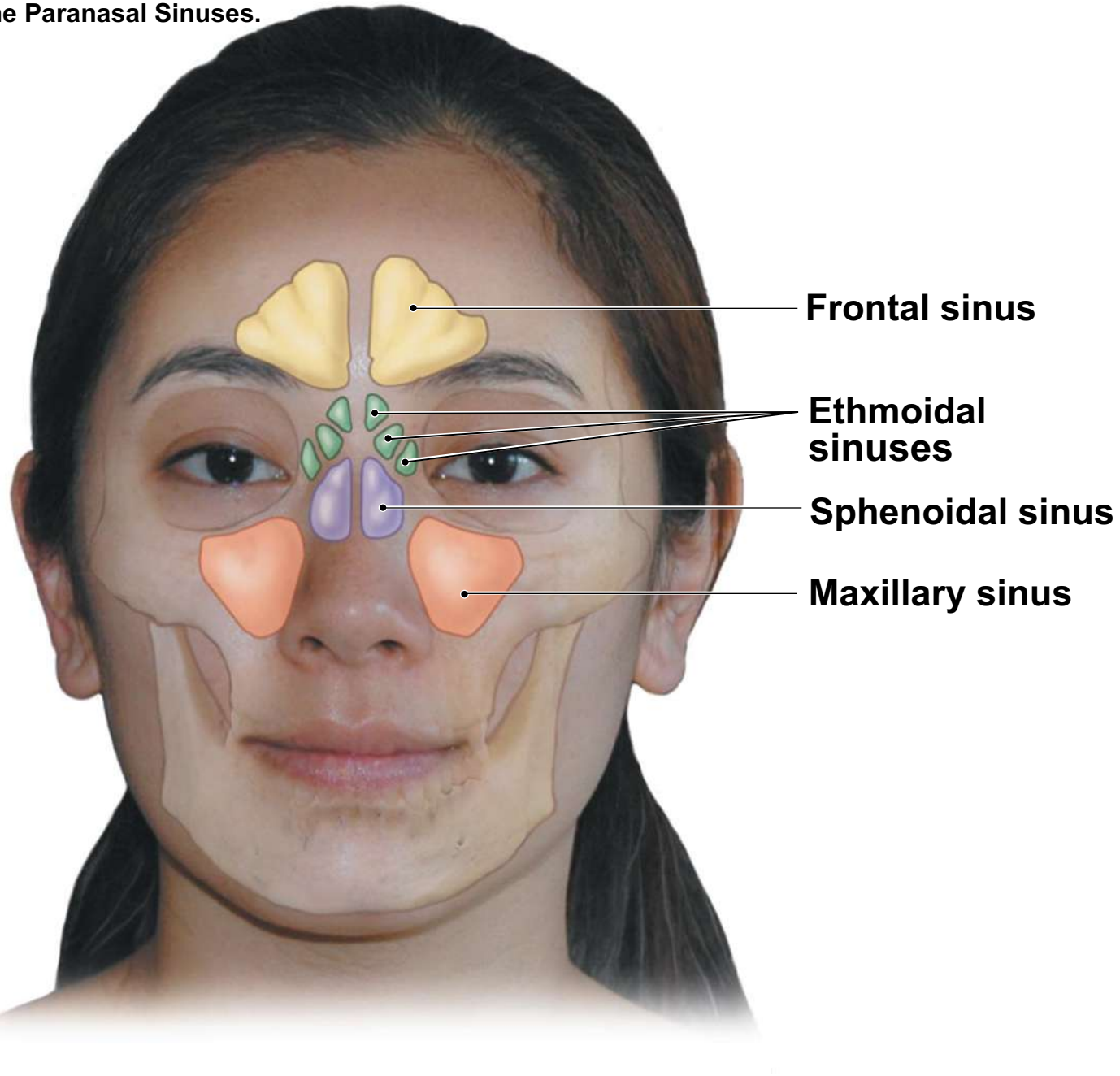
The Zygomatic Bones (6-7)

- Articulate with the frontal bone and the maxillae, forming the lateral wall of the orbit
- Temporal process of the zygomatic
  - Curves laterally and posteriorly to articulate with the zygomatic process of the temporal bone
  - Forming the **zygomatic arch**

The Nasal and Lacrimal Bones (6-7)

- Nasal bones form the bridge of the nose between the orbits
  - Articulating with the frontal and maxillary bones
- Lacrimal bones are found within the orbit on the medial surfaces
  - Articulating with the frontal, ethmoid, and maxillary bones

Figure 6-13 The Paranasal Sinuses.



The Mandible (6-7)

- The lower jaw
  - Vertical process on either side
  - The **ramus** extends up toward the temporal bone
- Posterior process of the ramus, the **condylar process**
  - Articulates with the mandibular fossa of the temporal bone
- Anterior **coronoid process** is the attachment point:
  - For the temporalis muscle that closes the jaw

Figure 6-11a The Adult Skull, Part II.

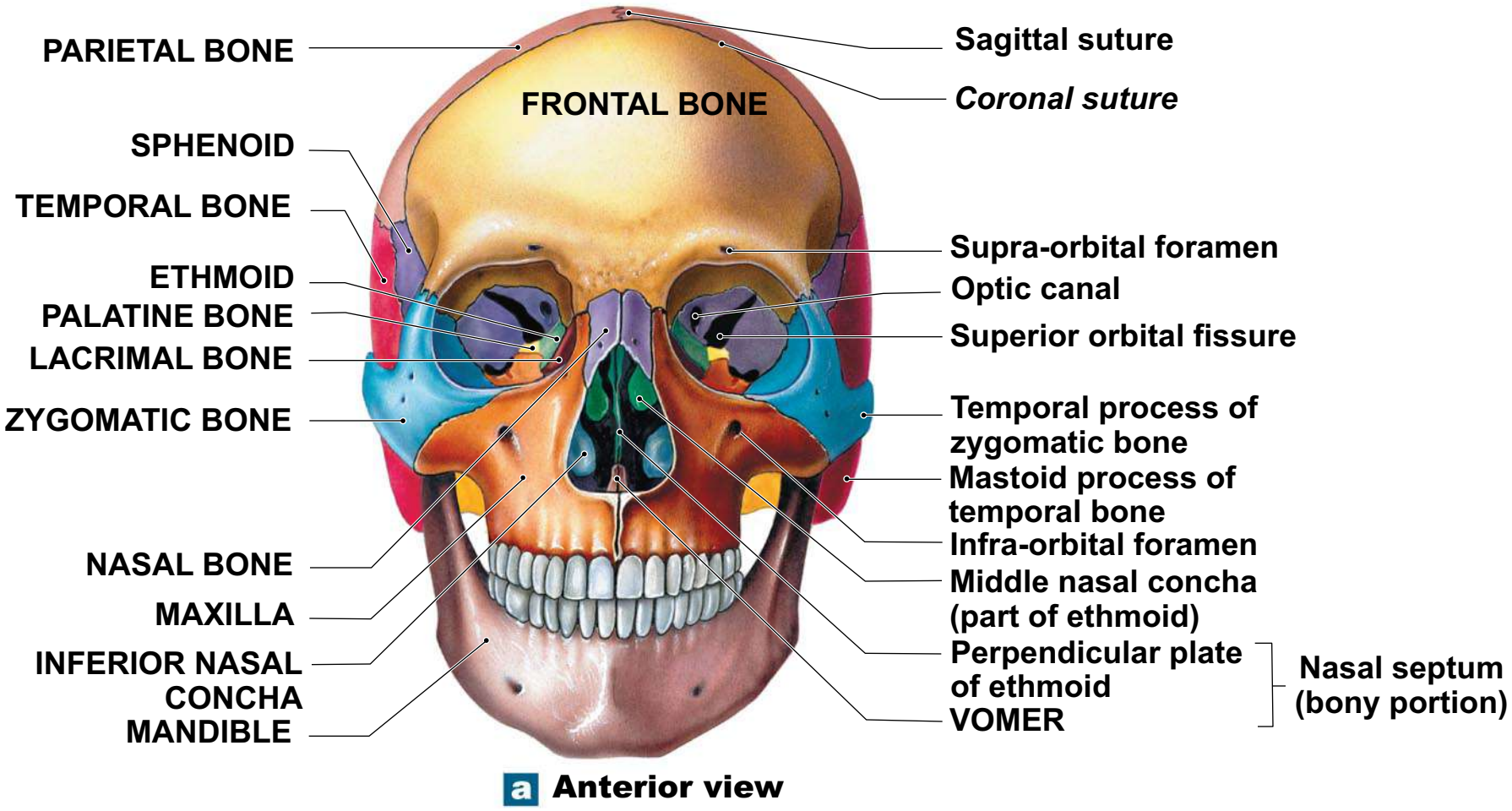
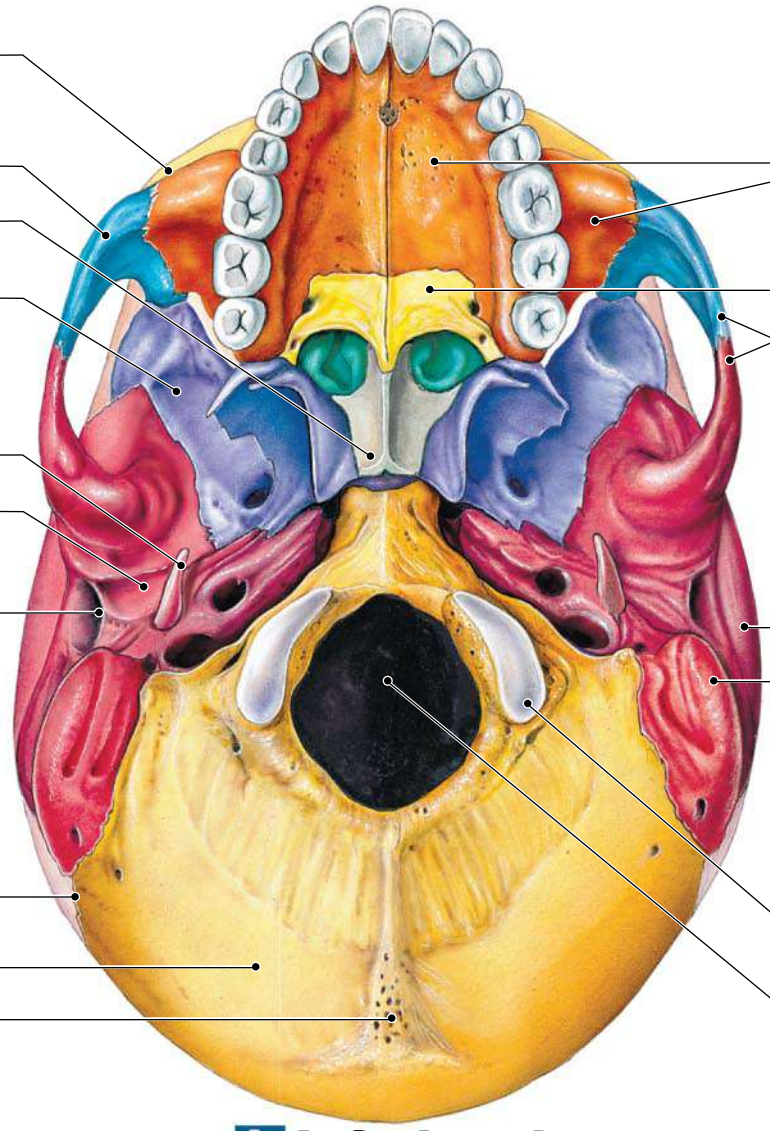
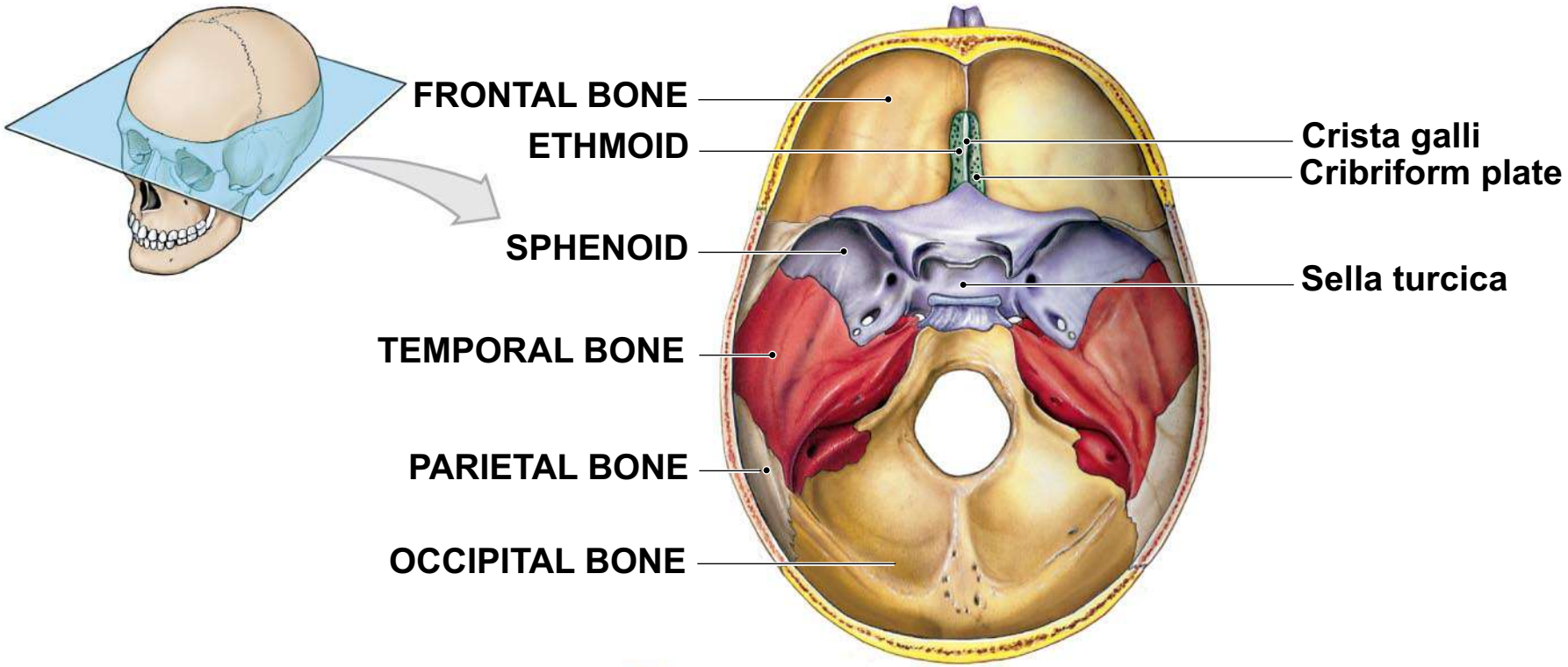


Figure 6-11b The Adult Skull, Part II.



b Inferior view

Figure 6-12a Sectional Anatomy of the Skull.



a Superior view of a horizontal section through the skull, showing the floor of the cranial cavity

Figure 6-12b Sectional Anatomy of the Skull.

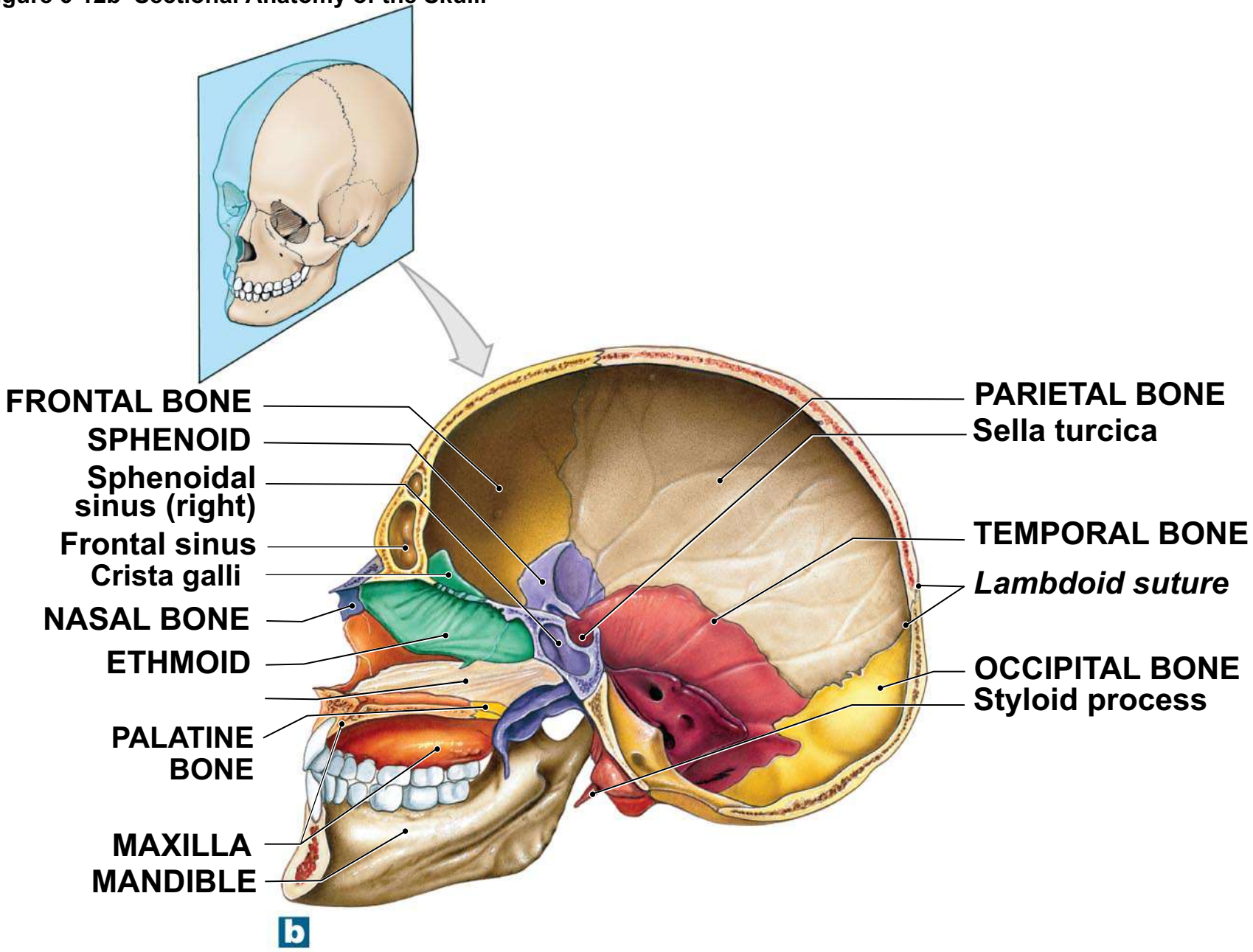
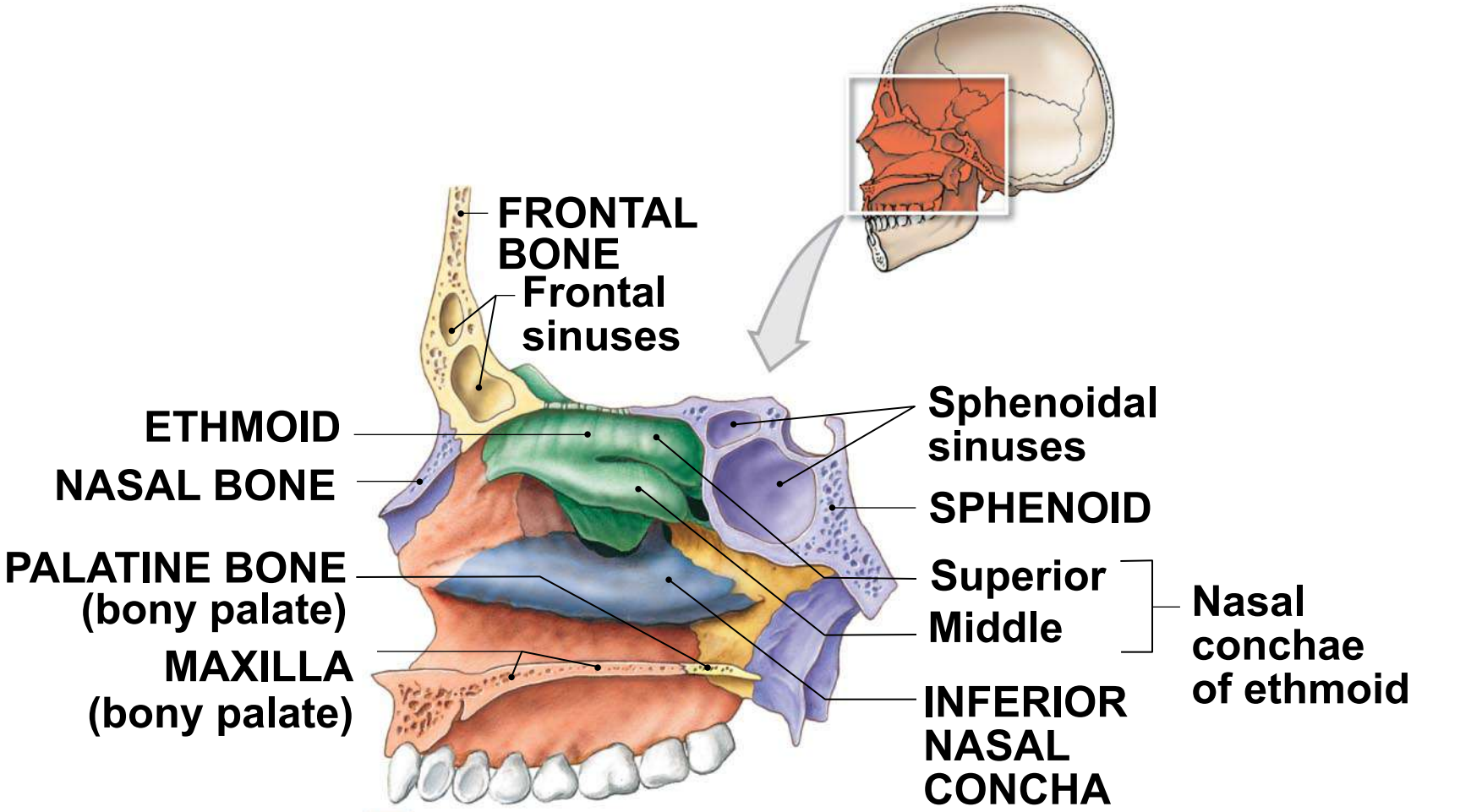


Figure 6-12c Sectional Anatomy of the Skull.

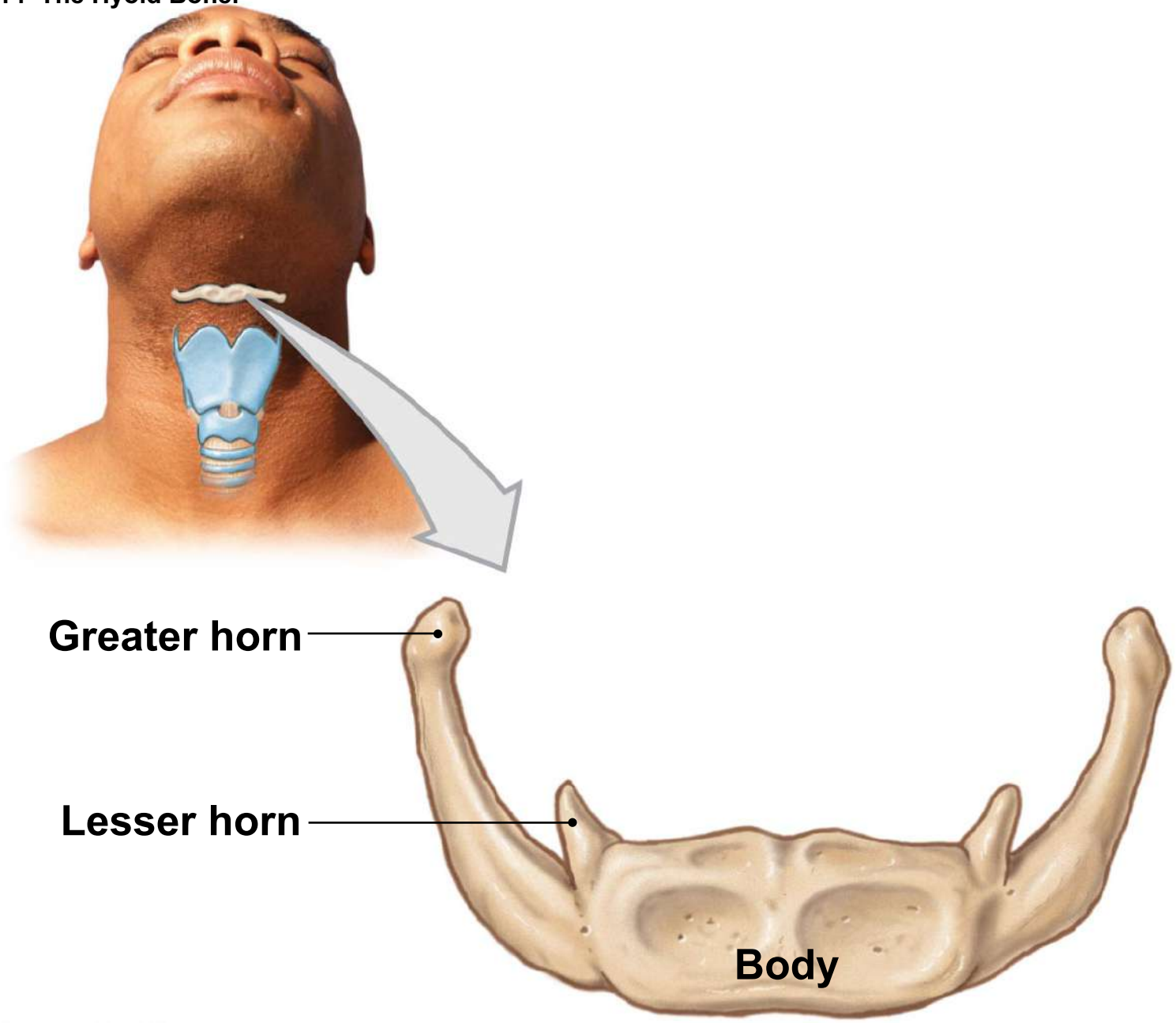


C A sagittal section through the skull, with the nasal septum removed to show major features of the wall of the right nasal cavity

The Hyoid Bone (6-7)

- Small and U-shaped
- The only bone in the body not directly articulated with another bone
- Is suspended from the styloid processes of the temporal bones
- Serves as attachment for muscles of the larynx, the tongue, and the pharynx

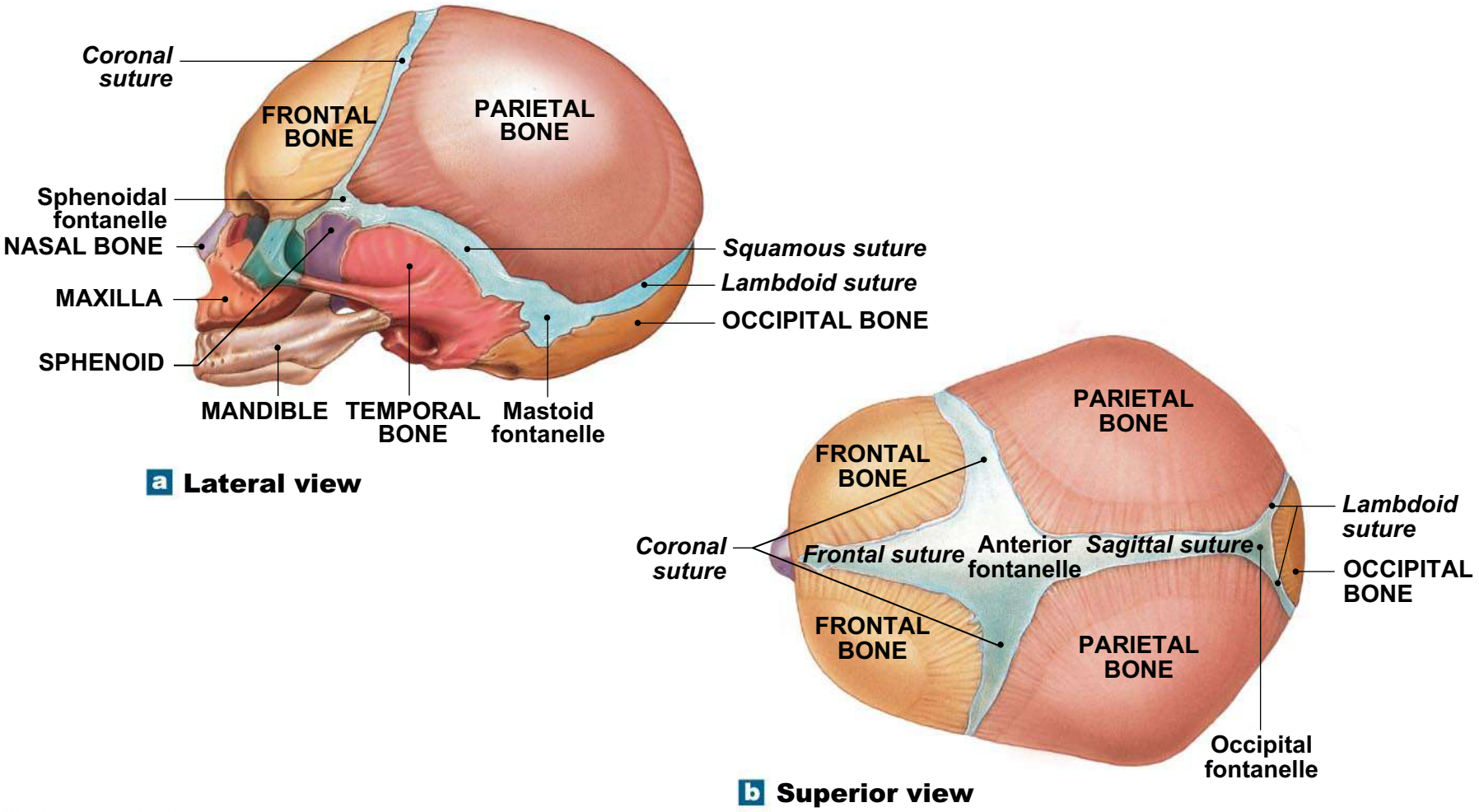
Figure 6-14 The Hyoid Bone.



The Skulls of Infants and Children (6-7)

- Fetal development of skull bones occurs around the developing brain
- At birth:
  - The cranial bones are connected with connective tissue called **fontanelles**
    - Flexible soft spots that allow for easier delivery of the head
- By age 4:
  - The fontanelles disappear and skull growth is finished

Figure 6-15 The Skull of a Newborn.



The Vertebral Column (6-7)

- Also called the **spine**
- Has 24 **vertebrae**
- A fused **sacrum**
- A fused **coccyx**
- Provides weight-bearing column of support and protection of spinal cord

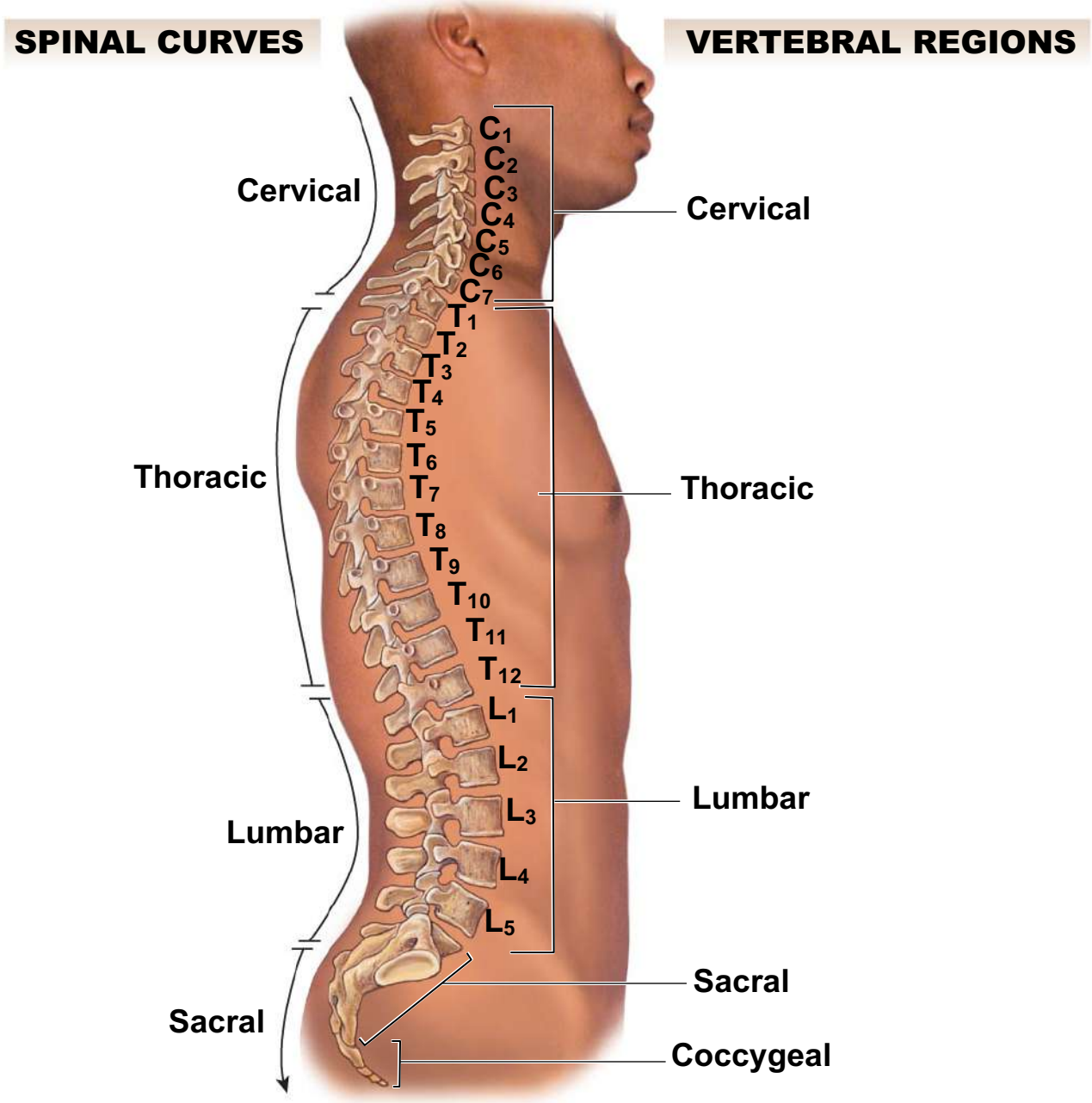
The Vertebral Column (6-7)

- **Cervical region** (neck) has 7 **cervical vertebrae**
- **Thoracic region** has 12 **thoracic vertebrae**
- **Lumbar region** has 5 **lumbar vertebrae**
- **Sacral region** has 5 fused vertebrae in the sacrum
- **Coccygeal region** also made of 3–5 fused vertebrae in the **coccyx**

Spinal Curvature (6-7)

- **Primary curves**
  - Project posteriorly and include the **thoracic** and **sacral curves**
  - Are present at birth
- **Secondary curves**
  - Project anteriorly and include the **cervical** and **lumbar curves**
  - Develop several months after birth

Figure 6-16 The Vertebral Column.



General Vertebral Anatomy (6-7)

- **Vertebral bodies**
  - Bear weight and are separated from each other by **intervertebral discs**
- **Vertebral arches**
  - Form posterior margin of **vertebral foramina**, which form the **vertebral canal**
  - Have walls called pedicles and roofs called laminae

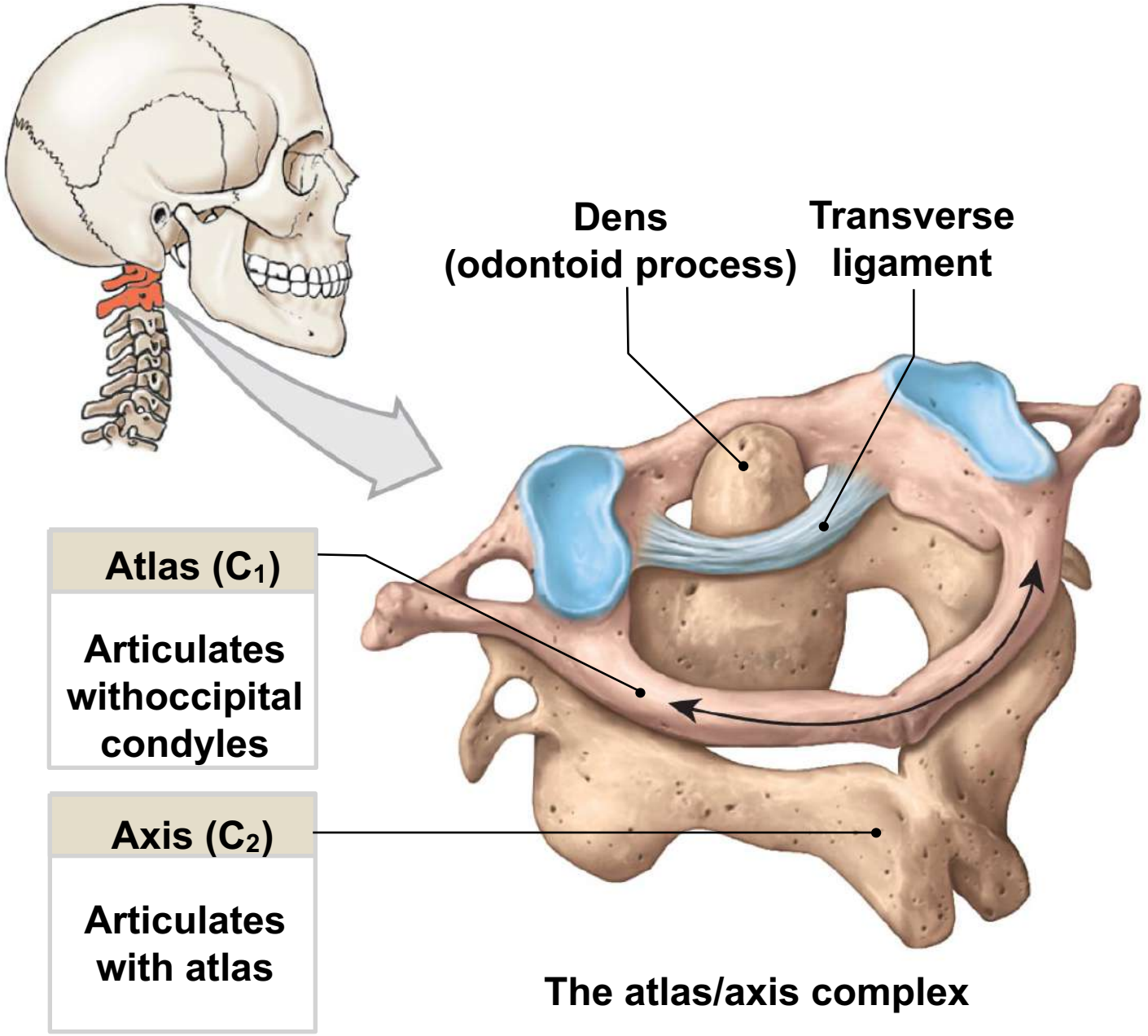
The Cervical Vertebrae (6-7)

- C_1–C_7
- Body relatively small, and is oval and concave in shape
- Vertebral foramina gradually decrease in diameter, but are relatively large
- Spinous process is stumpy, with notched tip
- Transverse processes have **transverse foramina**
  - That protect blood vessels to and from the brain

The Cervical Vertebrae (6-7)

- C_1 is the **atlas**
  - Holds up the head
  - Articulates with the occipital condyles
  - Allows for a specific "nodding yes" movement
- C_2 is the **axis**
  - Has a projection up toward the atlas, called the **dens**, or odontoid process
  - Allows for rotational "shaking the head no" movement

Figure 6-18 The Atlas and Axis.



The Thoracic Vertebrae (6-7)

- T_1–T_{12}
- Has heart-shaped body
- Has a long, slender spinous process that points inferiorly
- Has costal facets that articulate with the ribs

The Lumbar Vertebrae (7-6)

- L_1–L_5
- Vertebral body is significantly larger, thicker, and more oval
- Has a massive, stumpy spinous process
- Has a bladelike transverse process

Figure 6-17 Typical Vertebrae of the Cervical, Thoracic, and Lumbar Regions.

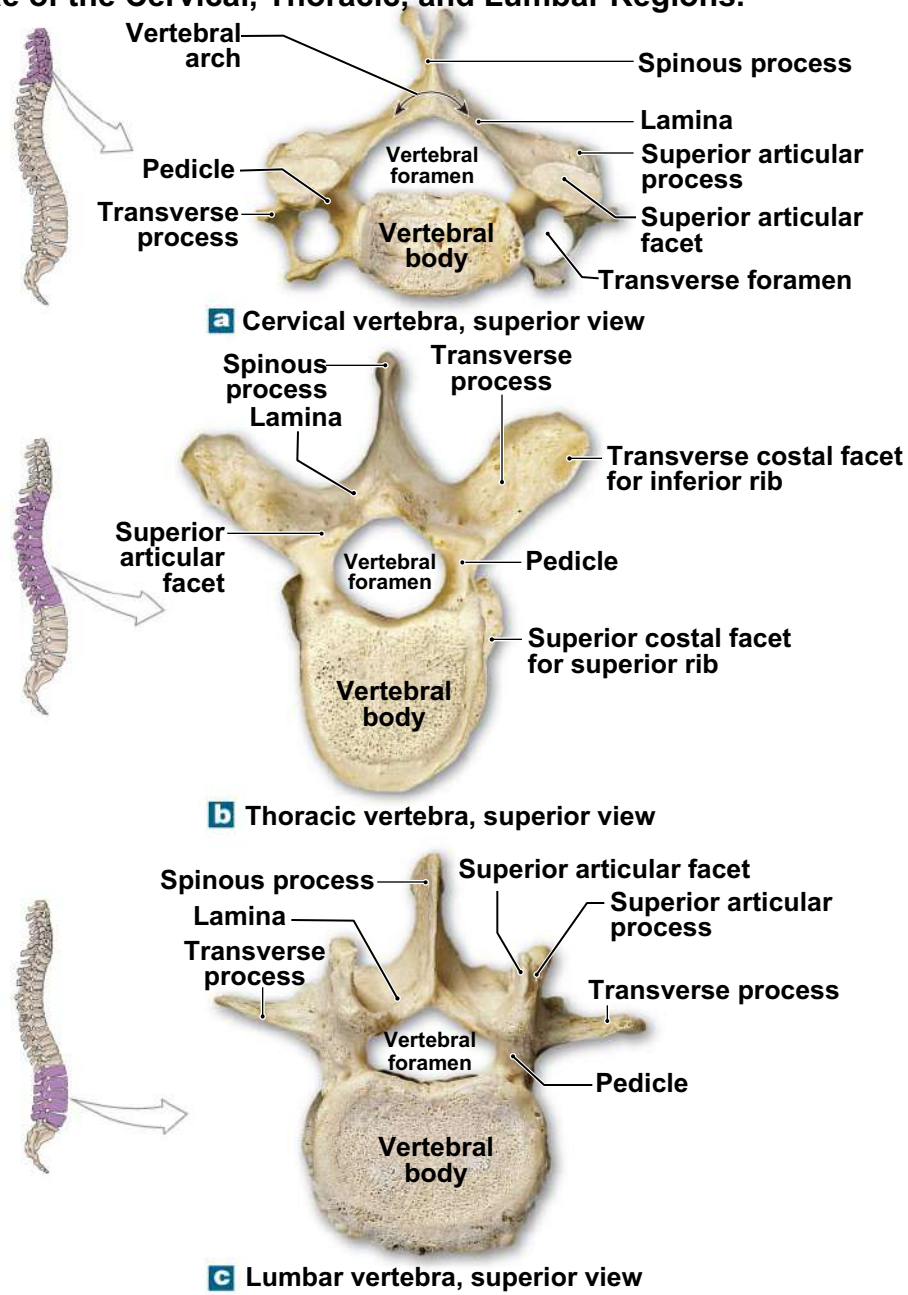


Figure 6-17a Typical Vertebrae of the Cervical, Thoracic, and Lumbar Regions.

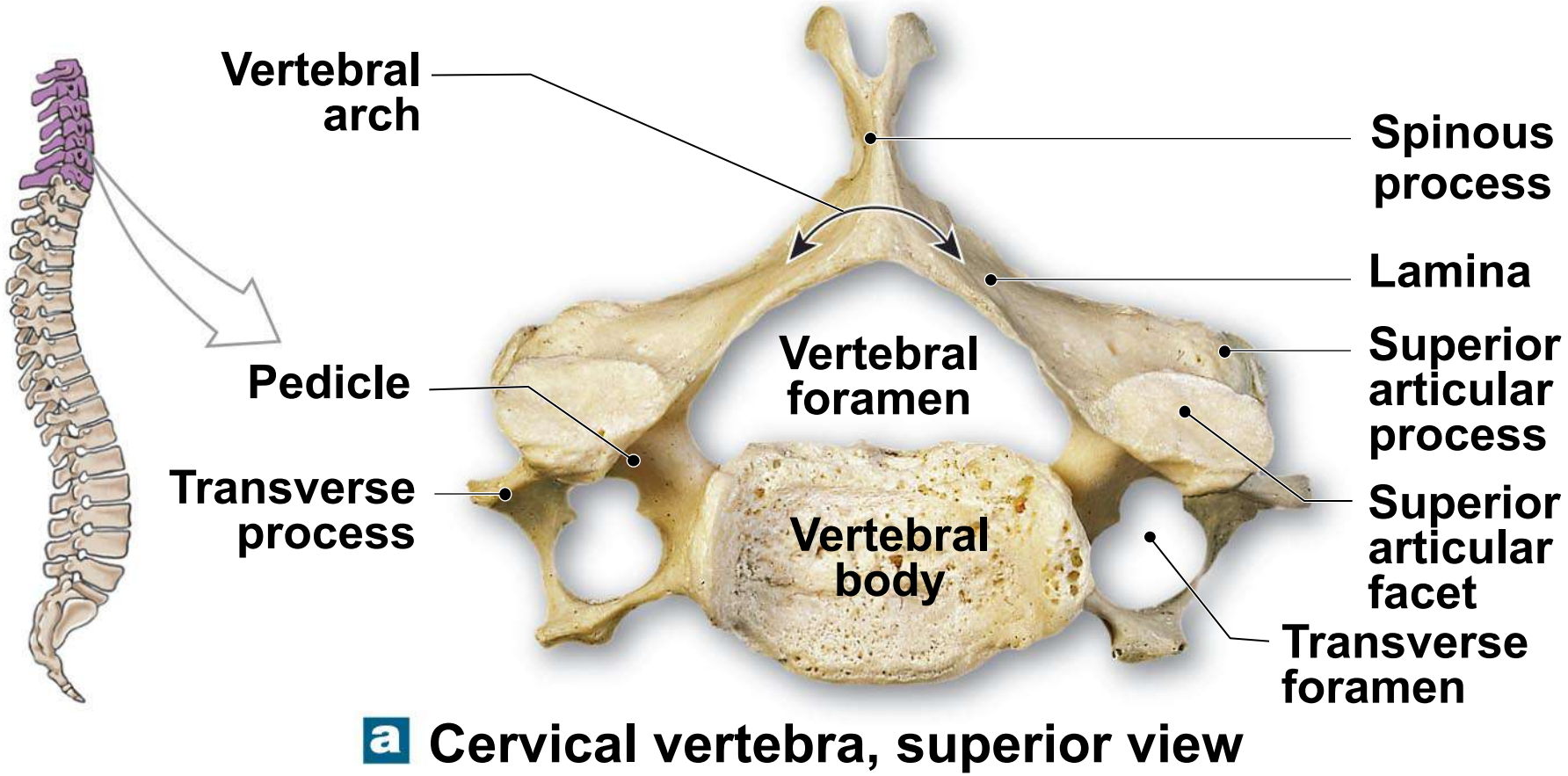


Figure 6-17b Typical Vertebrae of the Cervical, Thoracic, and Lumbar Regions

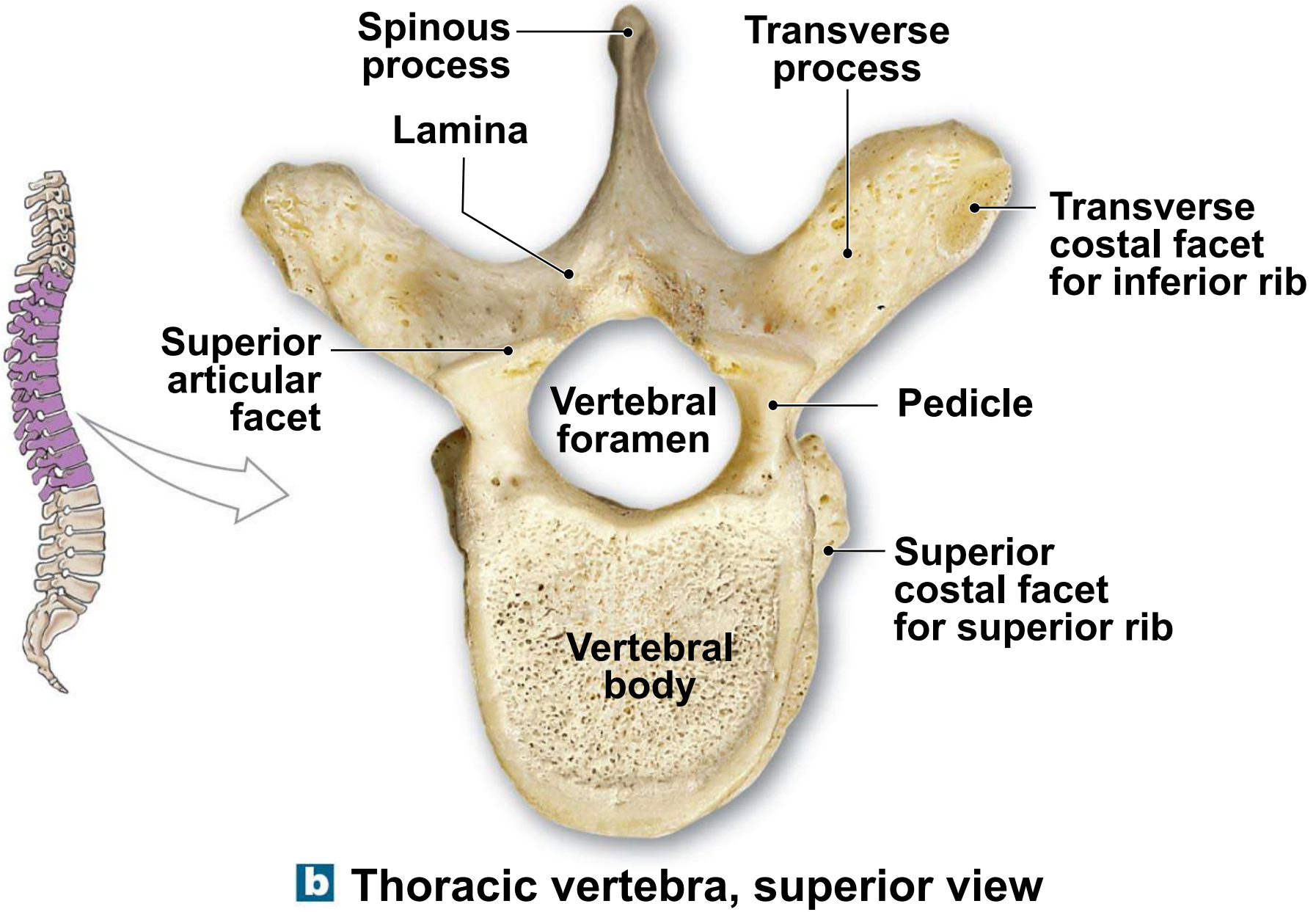
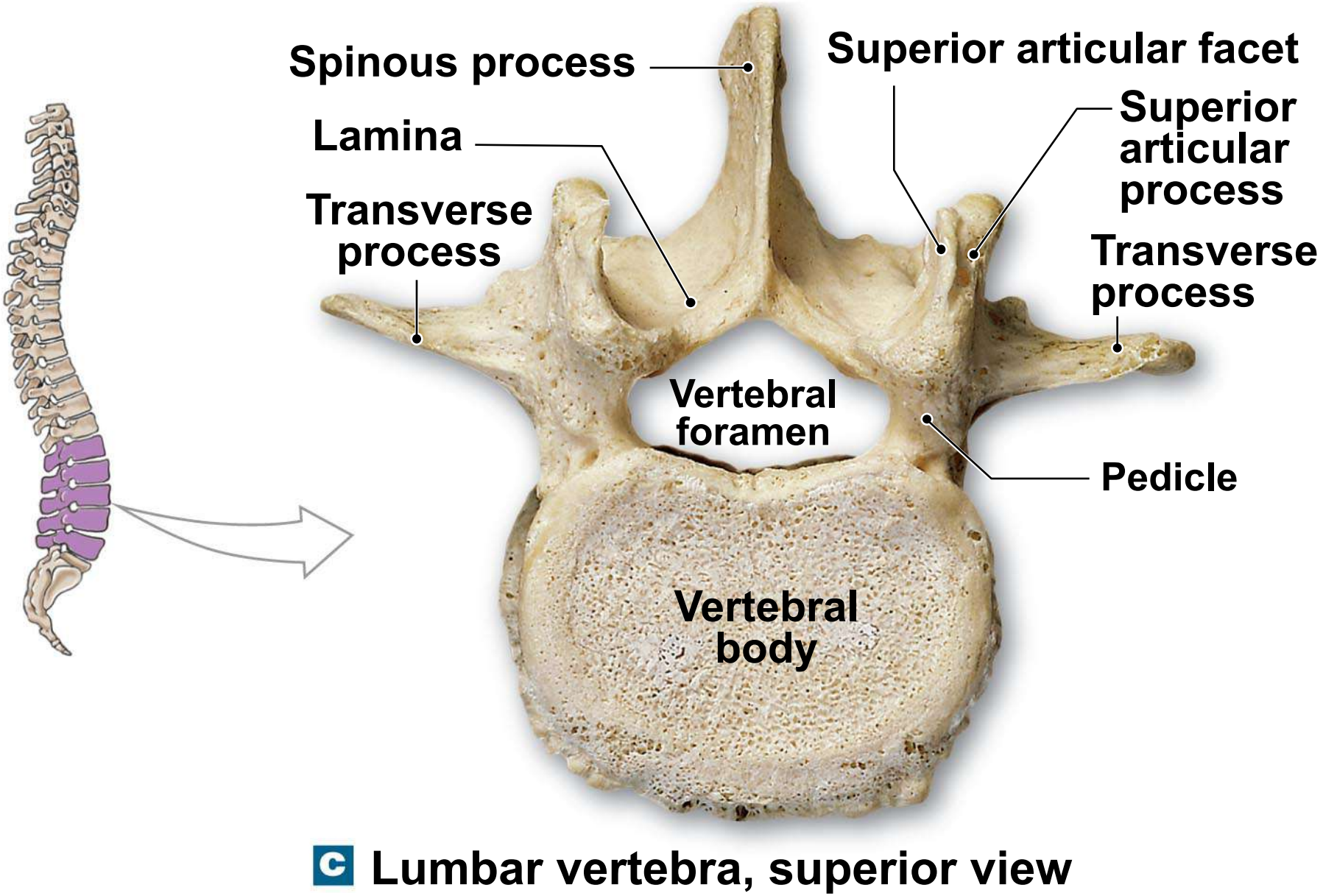


Figure 6-17c Typical Vertebrae of the Cervical, Thoracic, and Lumbar Regions.



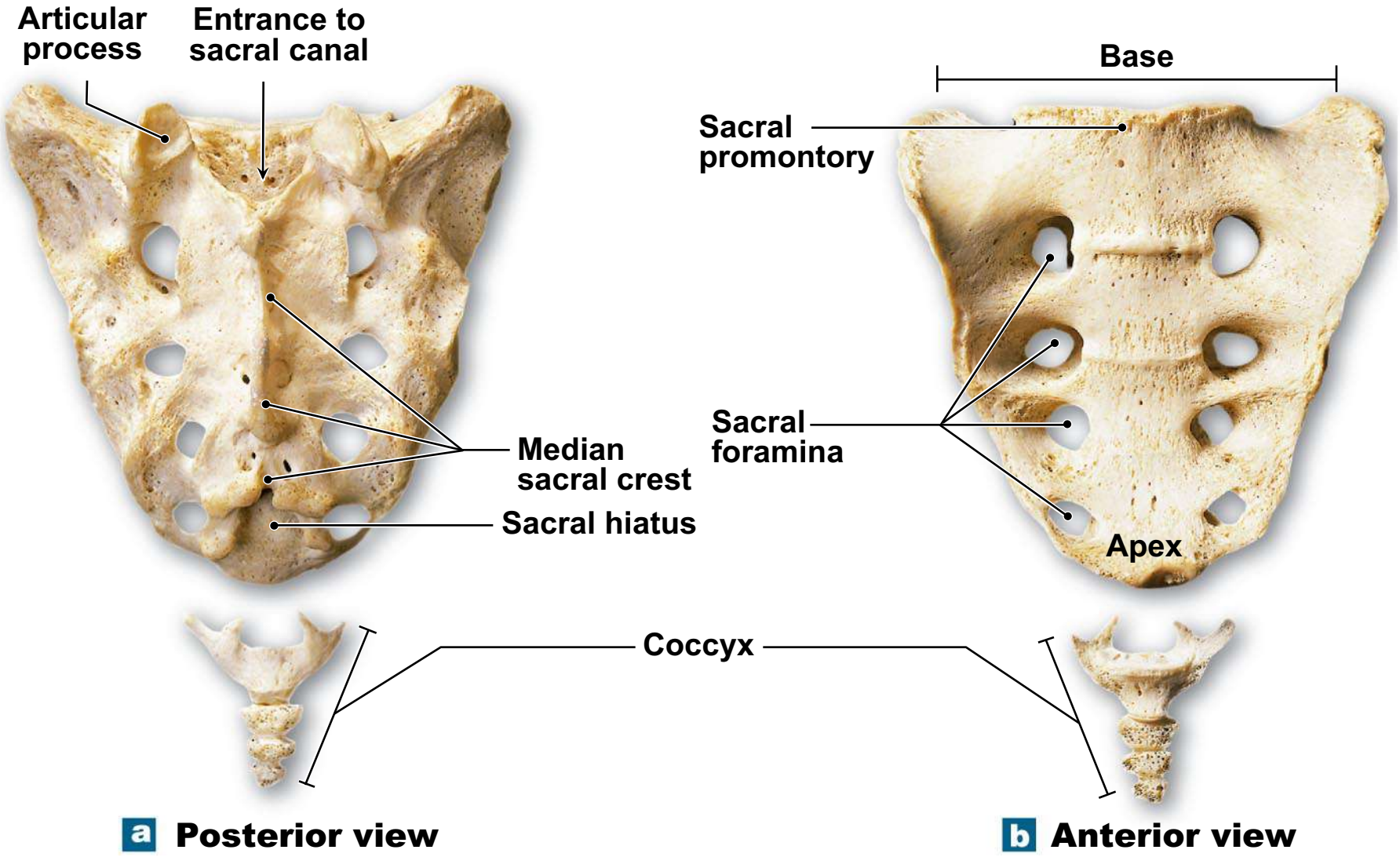
The Sacrum (6-7)

- Has five fused vertebrae
- Protects organs in pelvic cavity
- Has lateral articulations with pelvic girdle
- Narrow caudal area is the **apex**; superior surface is the **base**
  - Which has the **sacral promontory**
- **Sacral canal** runs down posterior surface
- **Sacral foramina** on either side of median sacral crest

The Coccyx (6-7)

- Three to five fused vertebrae
- Provides attachment for muscles of the anal opening

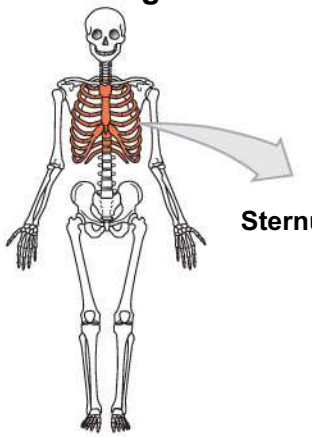
Figure 6-19 The Sacrum and Coccyx.

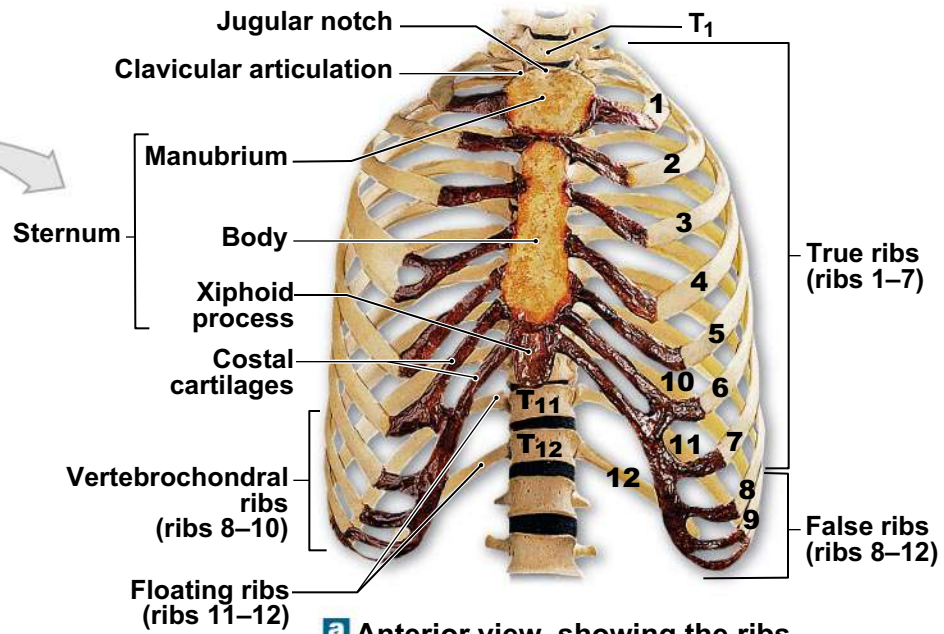


The Thoracic Cage (6-7)

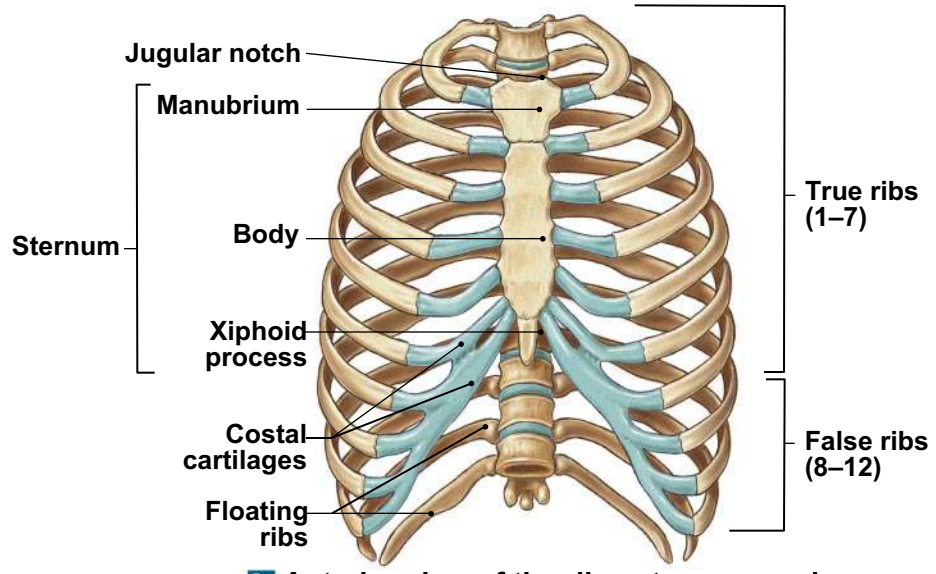
- Made of thoracic vertebrae, the ribs, and the sternum
  - Forming the walls of the thoracic cavity
- Seven pairs of **true ribs**, called *vertebrosternal ribs*
  - Connect to sternum with **costal cartilages**
- Five pairs of **false ribs**, pairs 8–10, are *vertebrochondral ribs*
- Last two pairs are **floating ribs**, or vertebral ribs

Figure 6-20 The Thoracic Cage.





a Anterior view, showing the ribs, costal cartilages, and the sternum



b Anterior view of the ribs, sternum, and costal cartilages, shown diagrammatically

The Pectoral Girdle (6-8)

- Connects the upper limbs to the trunk
- Includes the **clavicle** and the **scapula**
- **Clavicle**
  - S-shaped bone articulates with manubrium at sternal end and with the acromion process of the scapula

The Scapula (6-8)

- A broad triangular bone with **superior, medial**, and **lateral borders**
- The three tips are the superior, inferior, and lateral angles
  - Lateral angle, or head of the scapula, has the **glenoid cavity**
    - Which articulates with the humerus to form the shoulder joint

Figure 6-21 The Clavicle.

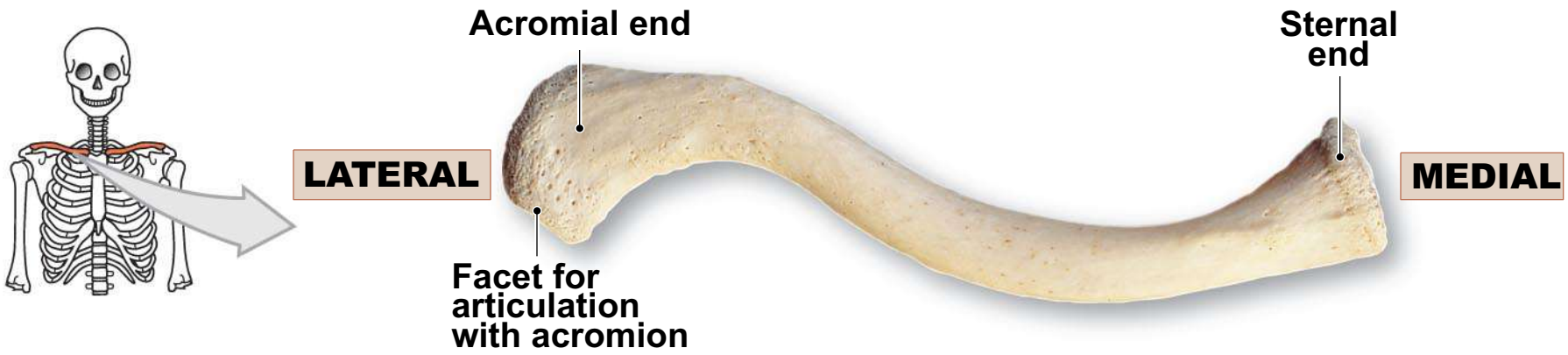
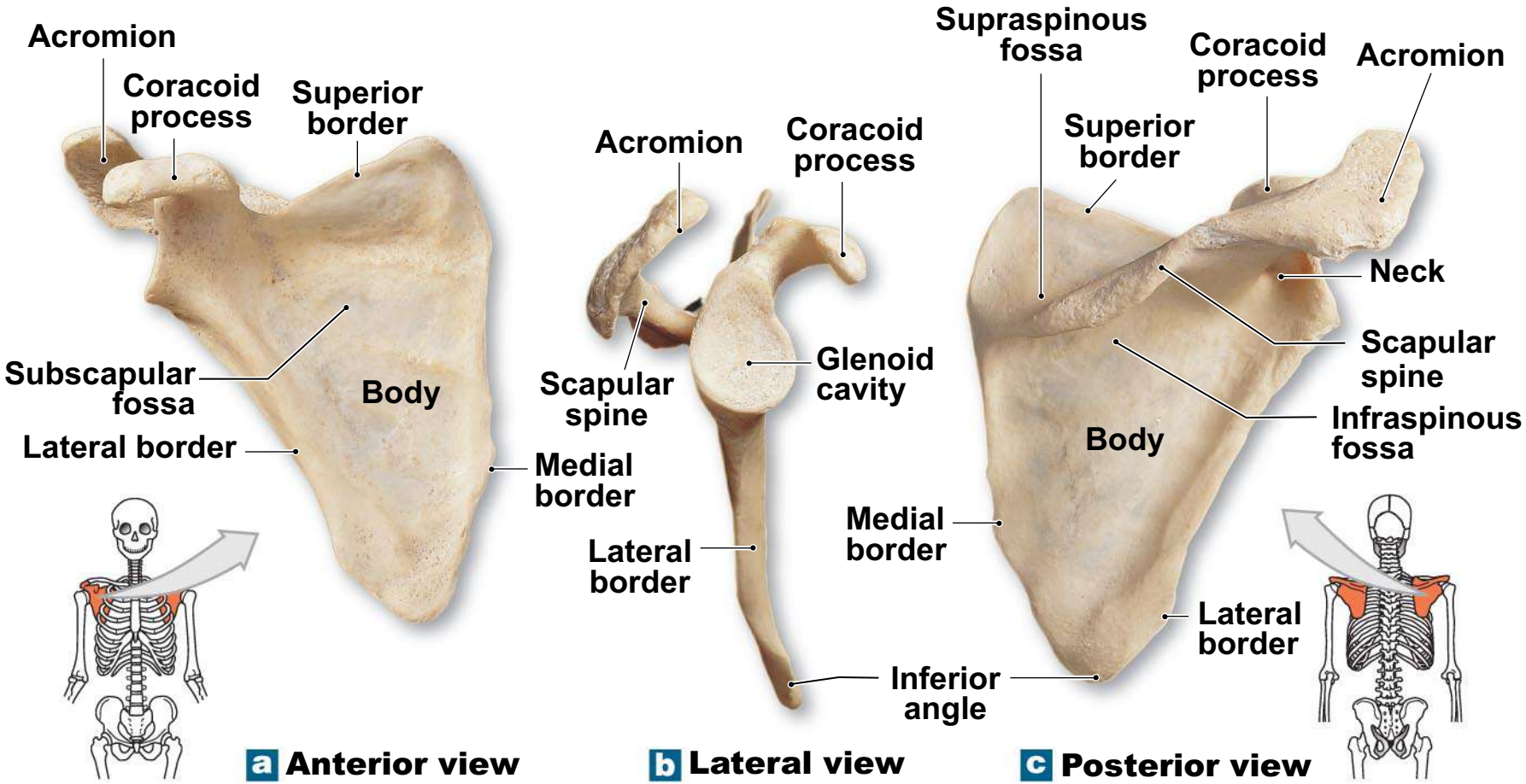


Figure 6-22 The Scapula.



The Upper Limb (6-8)

- Contains the bones of the arm
  - The **humerus**
  - Proximal area of the limb from the scapula to the elbow
- Contains the bones of the forearm
  - The radius and ulna
- Contains the bones of the wrist and hand
  - The carpals, metacarpals, and phalanges

Figure 6-23 The Right Humerus

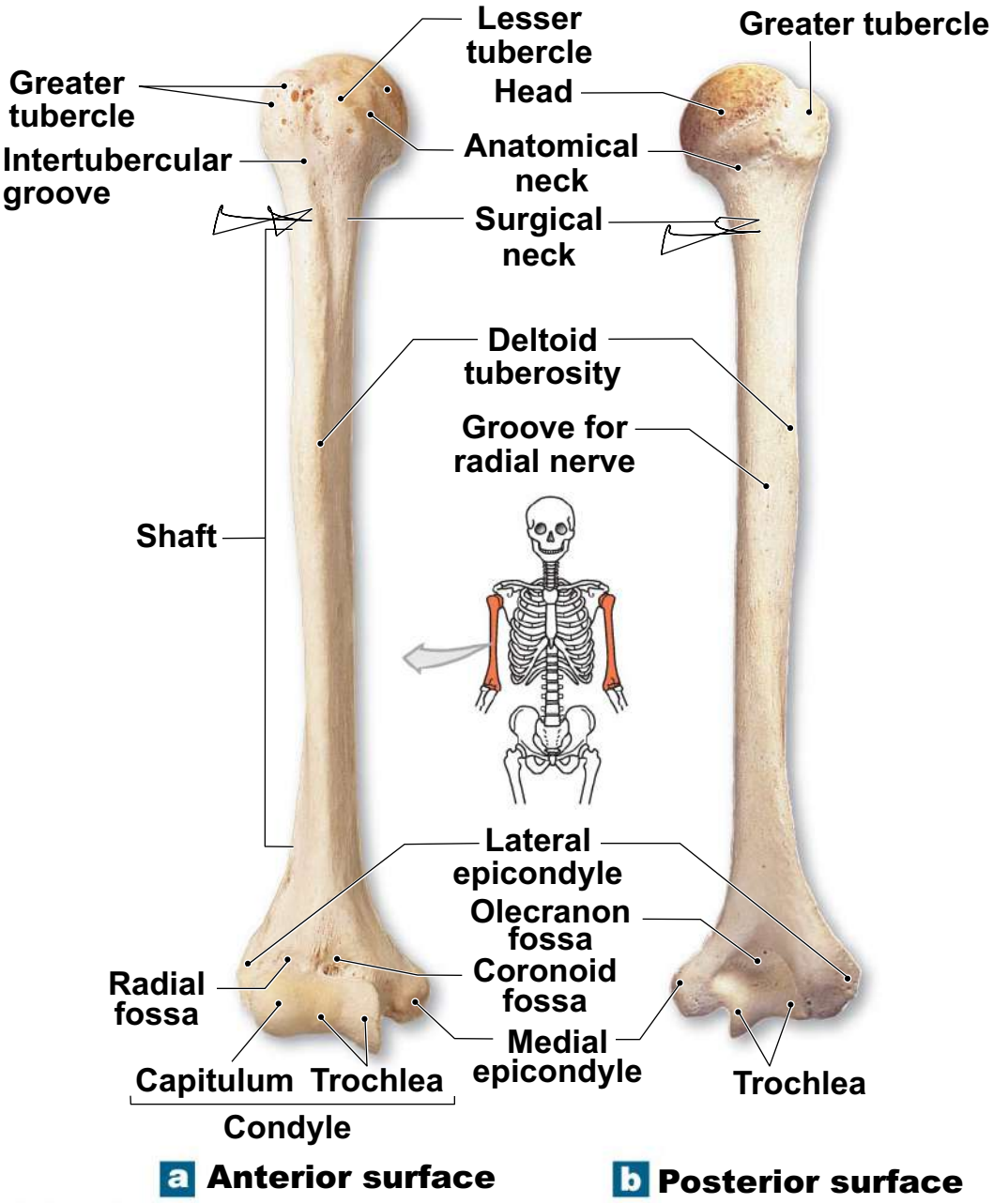
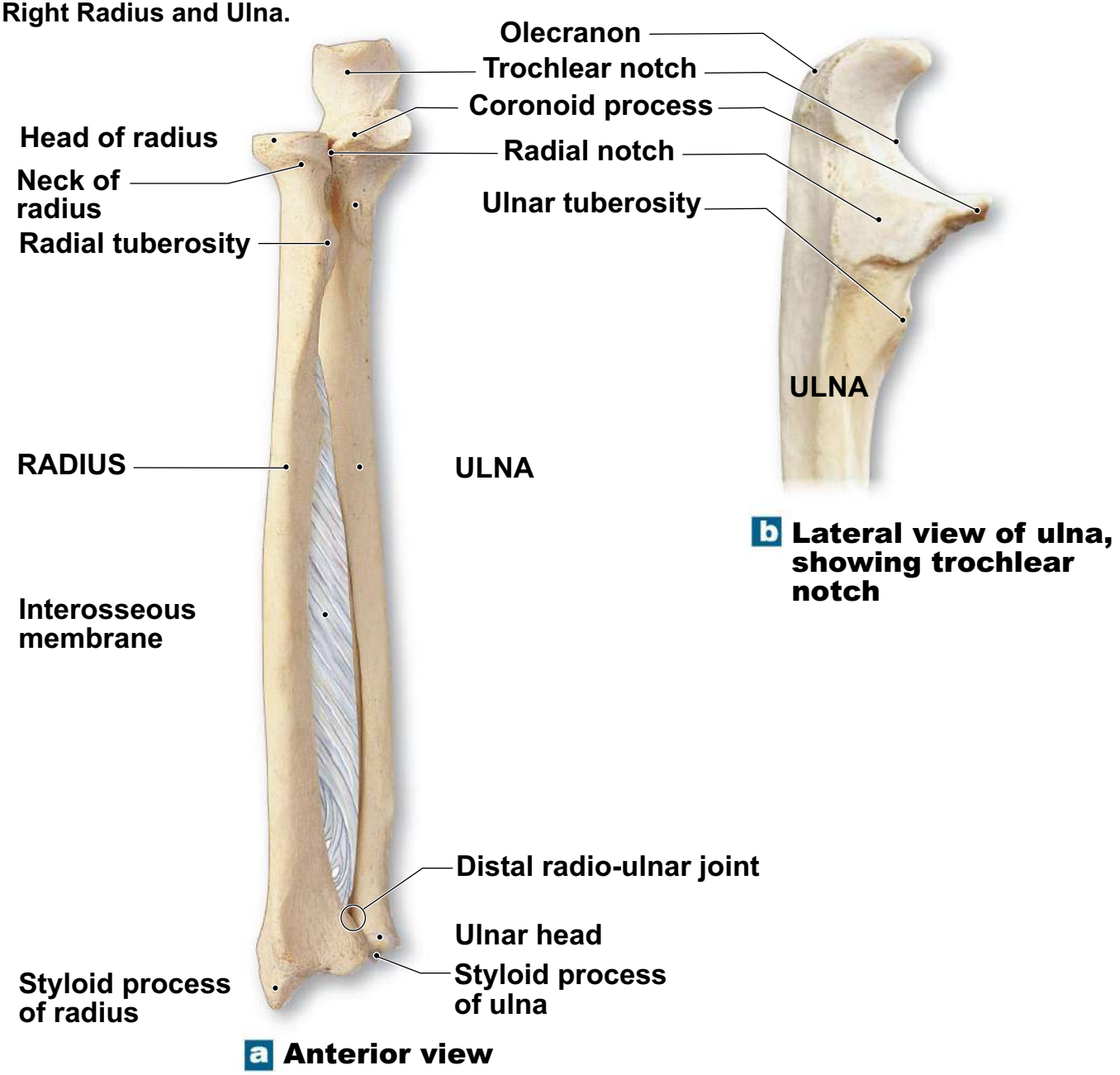


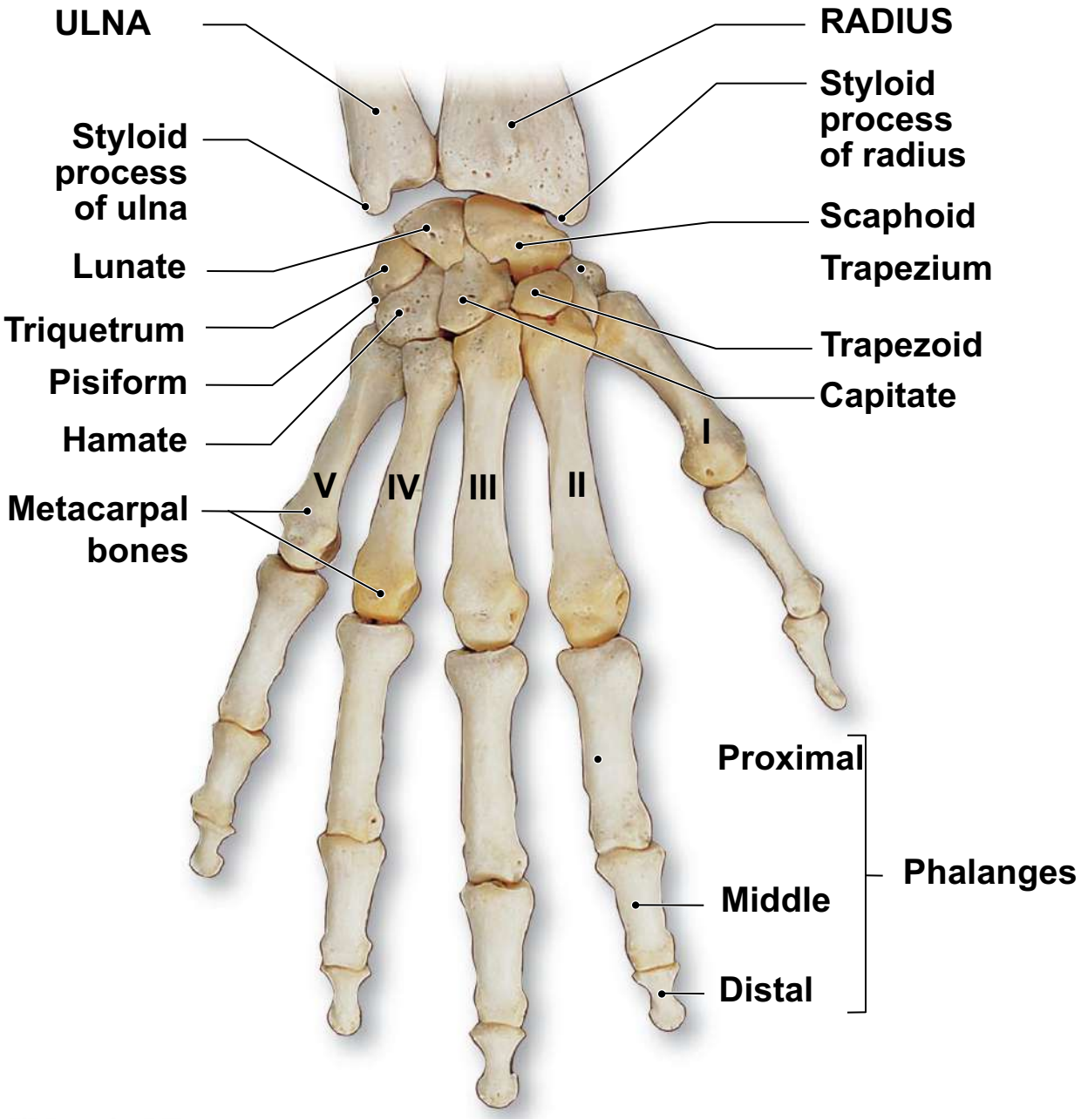
Figure 6-24 The Right Radius and Ulna.



The Bones of the Wrists and Hands (6-8)

- **Carpal bones**
  - The proximal row includes:
    - The scaphoid, lunate, triquetrum, and pisiform bones
  - The distal row includes:
    - The trapezium, trapezoid, capitate, and hamate bones
- **Five metacarpal bones**
  - Form the palm of the hand and articulate with the **phalanges**
  - The **pollex** is the thumb

Figure 6-25 Bones of the Right Wrist and Hand



The Pelvic Girdle (6-8)

- Articulates with the thigh bones
  - More massive than the pectoral girdle
  - Firmly attached to the axial skeleton
  - Consists of two large **hip bones** or **coxal bones**
  - Each a fusion of three bones
    - The **ilium**, the **ischium**, and the **pubis**
  - Hips articulate with the sacrum at the **sacroiliac joints**, with the femur at the **acetabulum**

The Hip Bone (6-8)

- The **ilium** is superior and the largest component
  - Superior margin forms the **iliac crest**
- The **ischium** has a rough projection
  - Called the *ischial tuberosity* or seat bone
- The ischium branches over to the **pubis**
  - Creating the circle of the **obturator foramen**
- Pubic bones articulate at the **pubic symphysis**

The Pelvis (6-8)

- Consists of the hip bones, the sacrum, and the coccyx
  - Stabilized by a network of ligaments
- Differences in the characteristics of the male versus female pelvis
  - In females, the pelvis is better suited for pregnancy and delivery
  - Females have a broader lower pelvis, a larger pelvic outlet, and a broader pubic angle

Figure 6-26 The Pelvis.

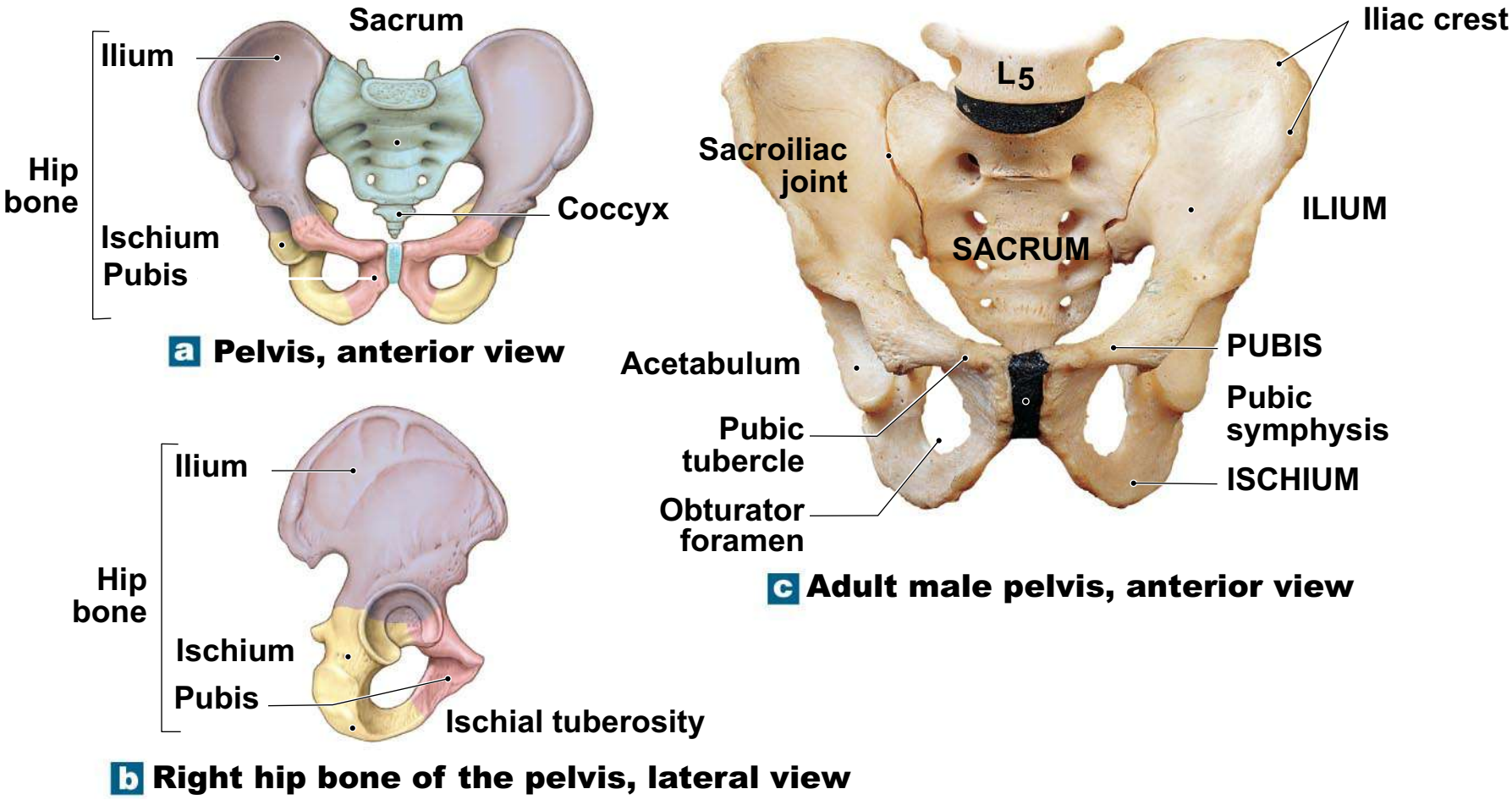
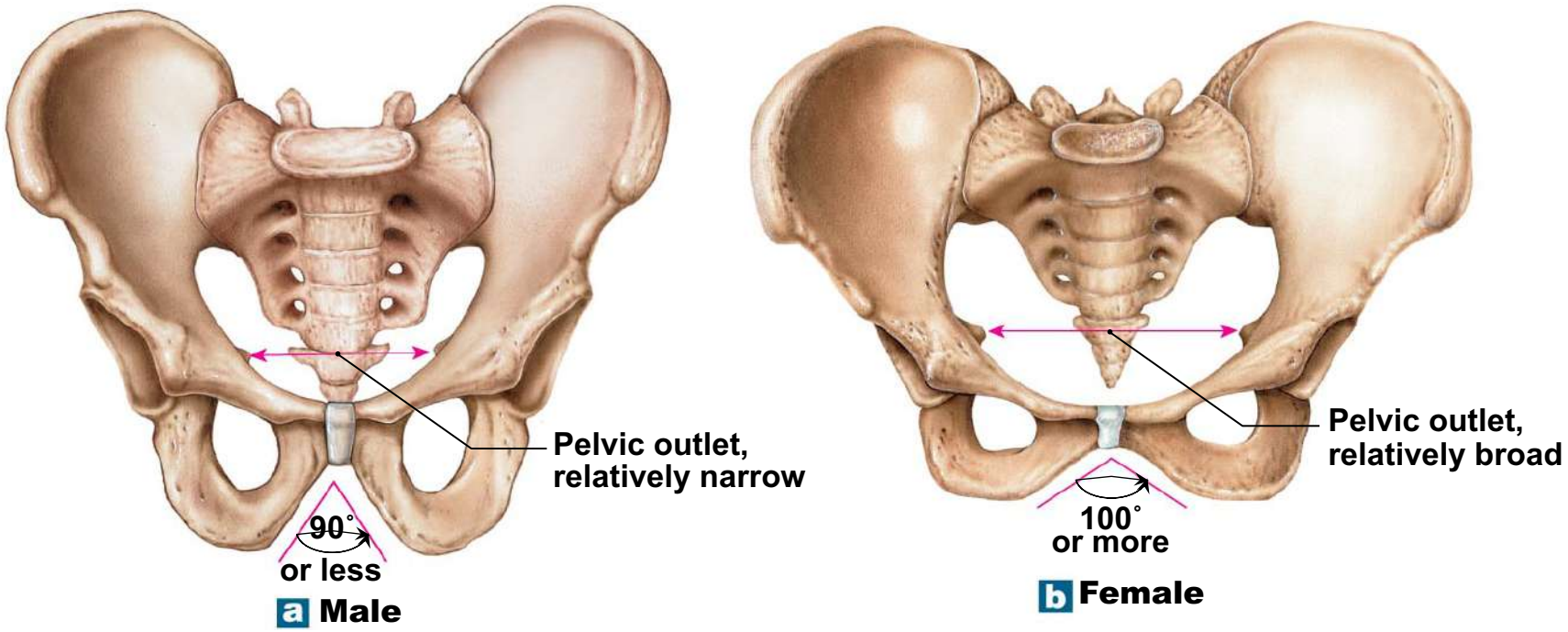


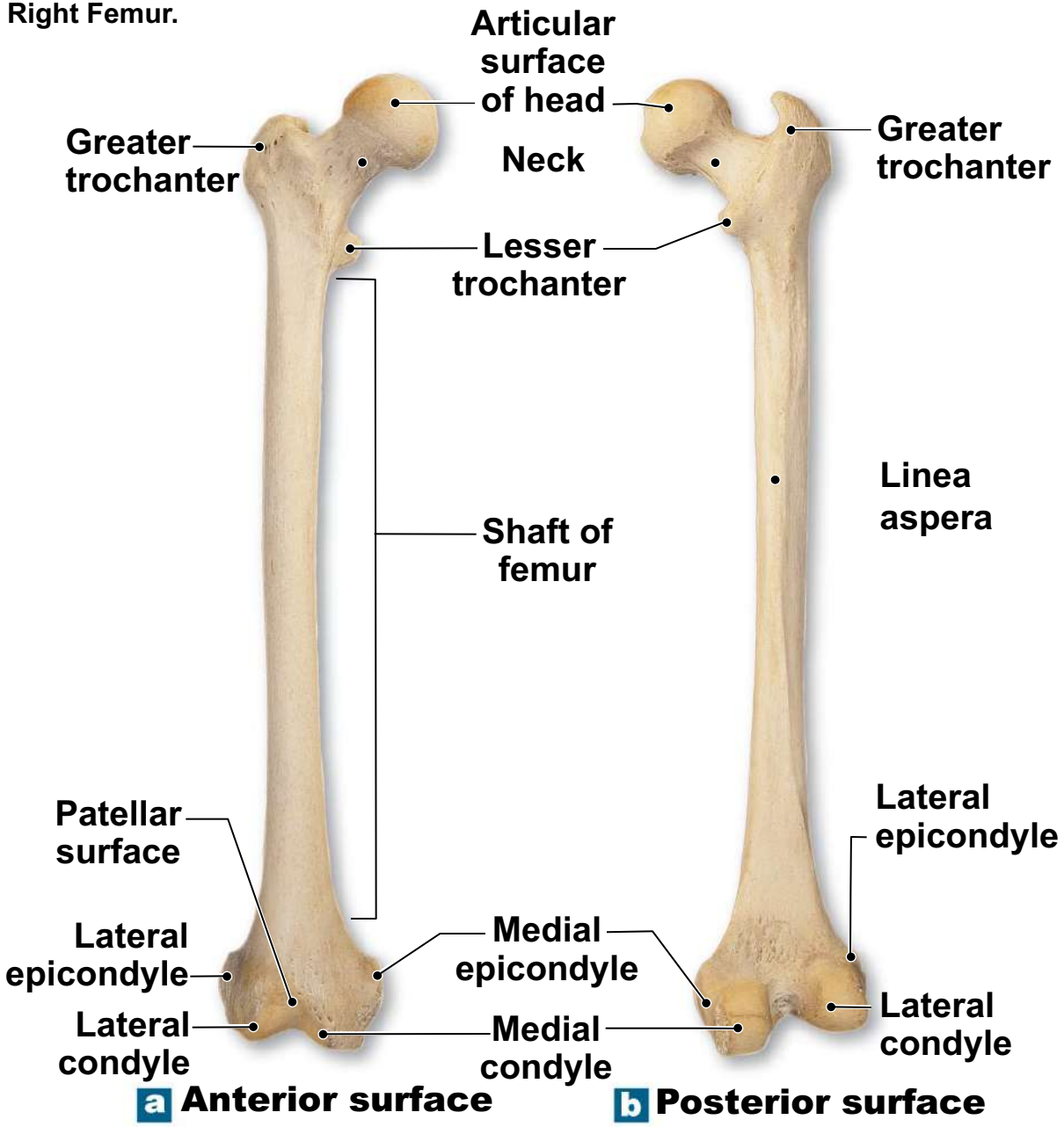
Figure 6-27 Differences in the Anatomy of the Pelvis in Males and Females.



The Lower Limb (6-8)

- Contains the bones of the thigh
  - The *femur* is the longest bone in the body
- Contains the *patella* or kneecap
- Contains the bones of the leg
  - The *tibia* and *fibula*
- Contains the bones of the ankle and foot

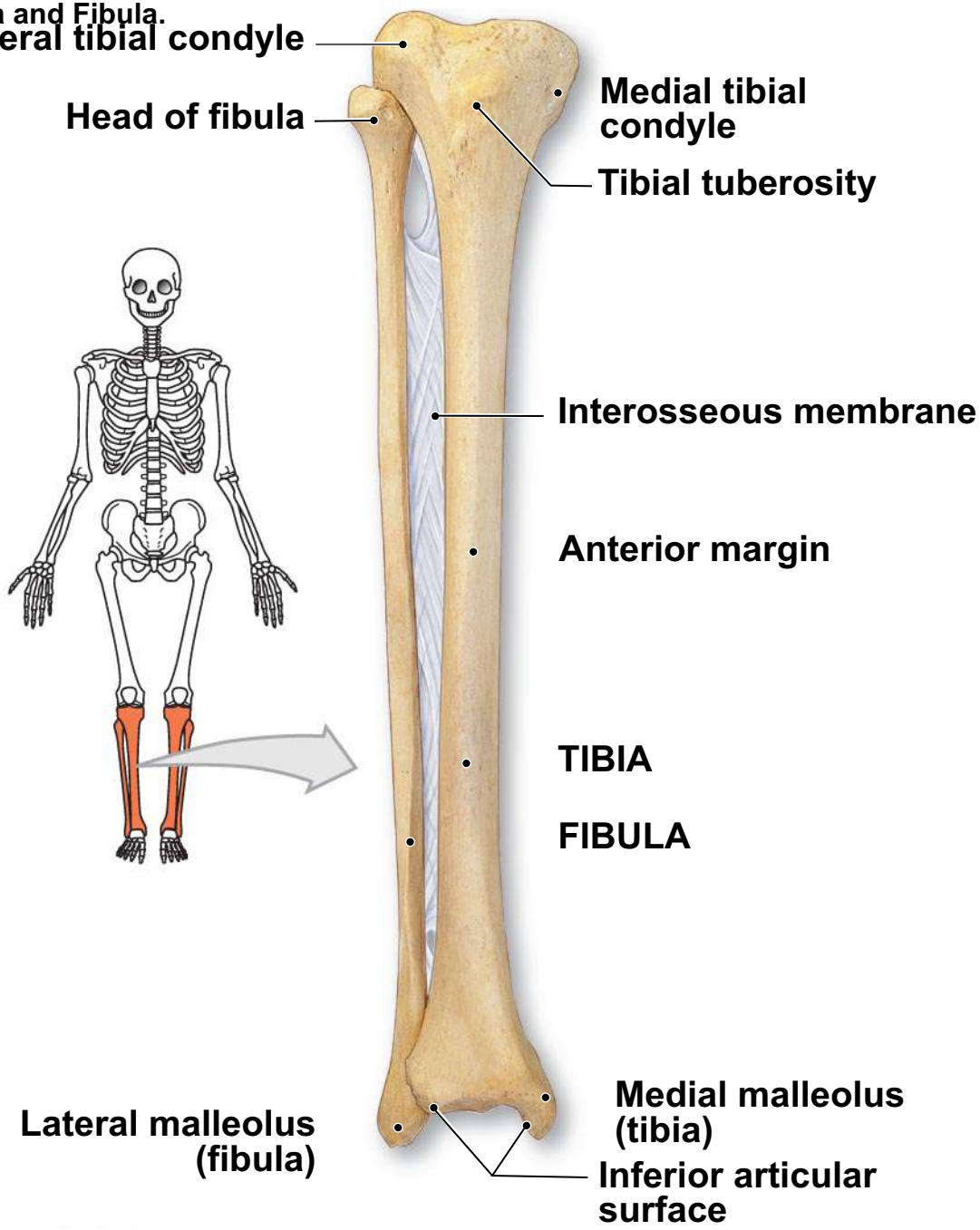
Figure 6-28 The Right Femur.



The Fibula (6-8)

- Runs parallel and lateral to tibia
- Articulates with tibia inferior to the lateral tibial condyle
- Does not articulate with the ankle
- **Lateral malleolus** is distal end of fibula
- Interosseus membrane connects tibia and fibula

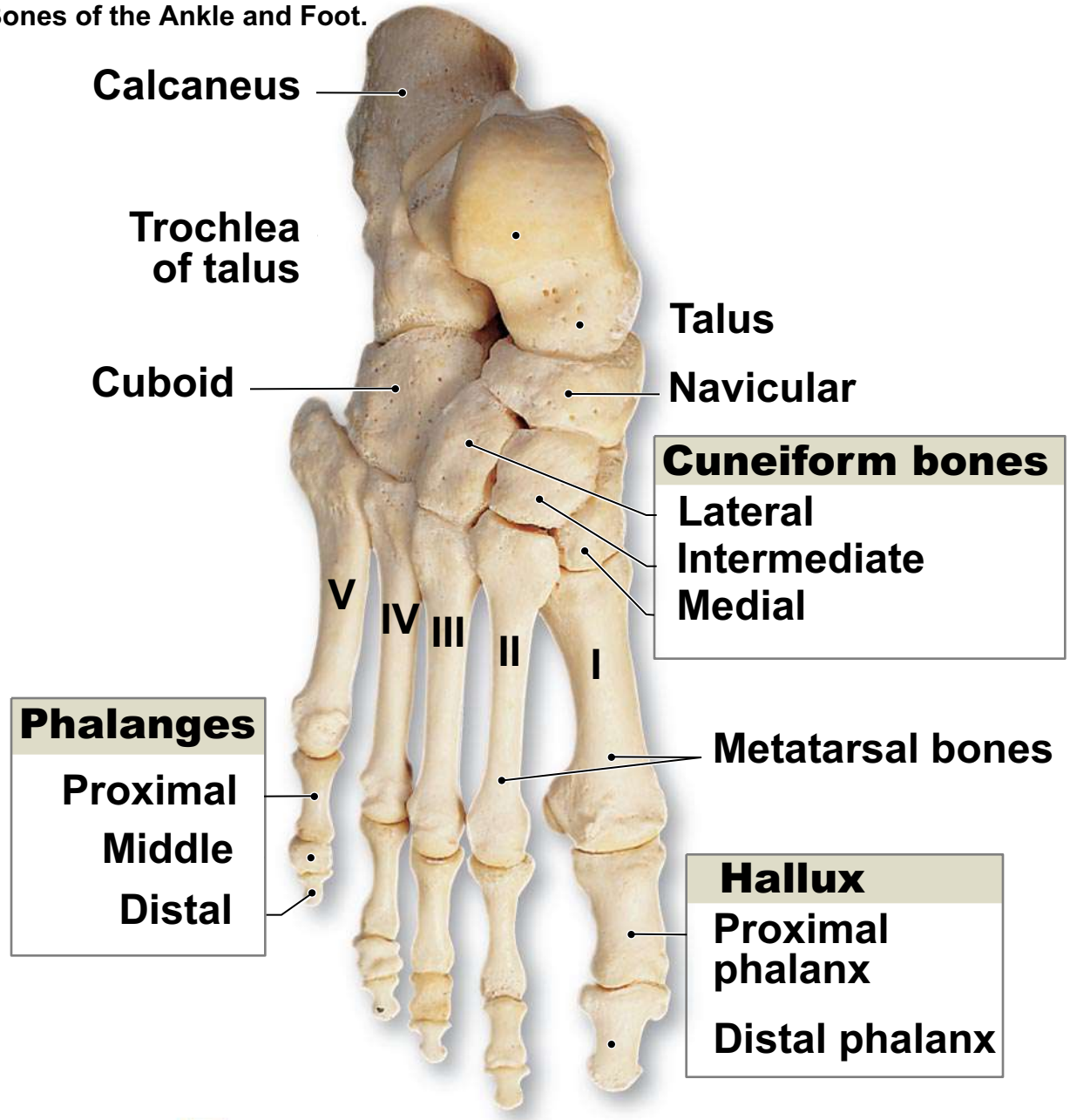
Figure 6-29 The Right Tibia and Fibula.



The Bones of the Ankle and Foot (6-8)

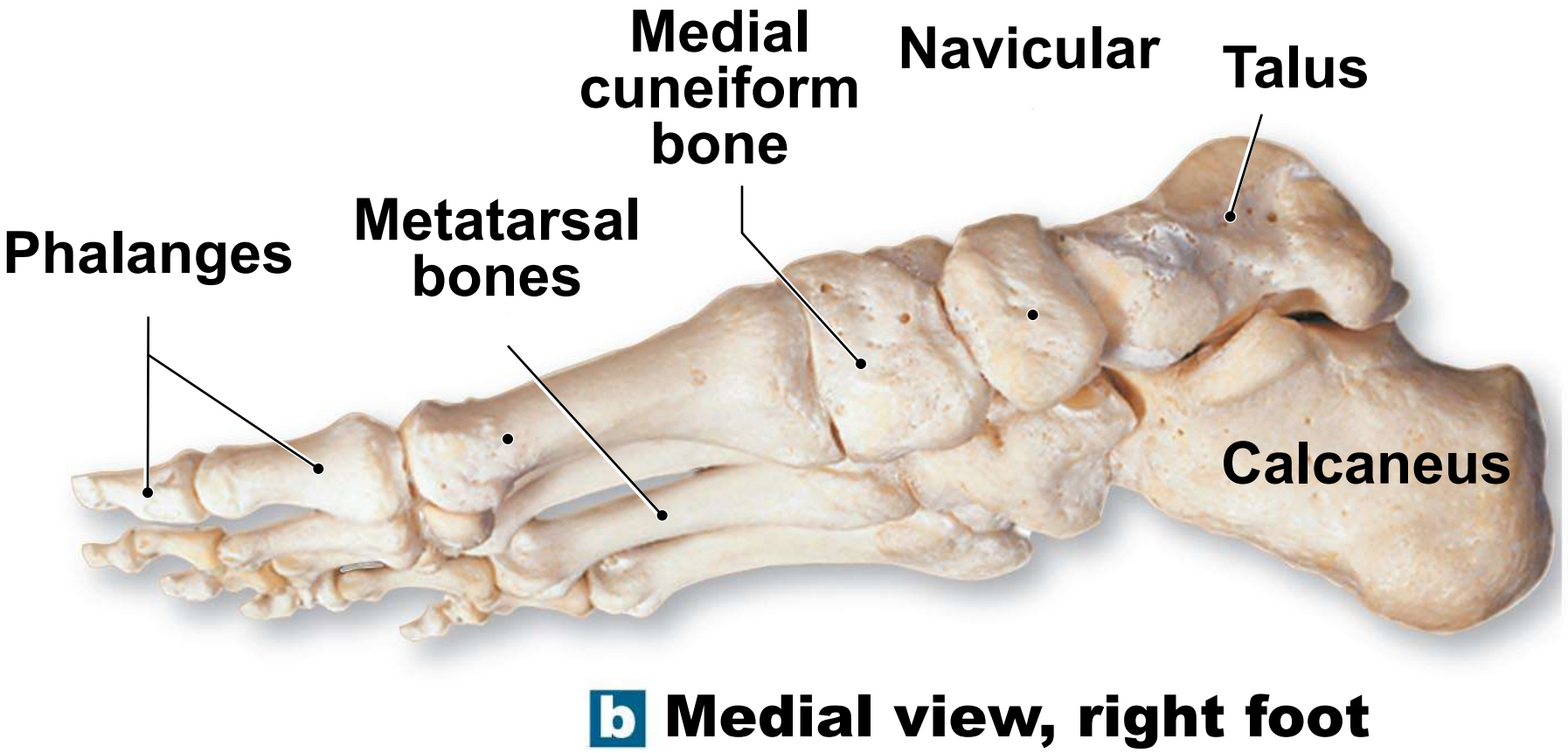
- Seven ankle or **tarsal** bones include:
  - The talus, calcaneus, navicular, and cuboid, and the medial, intermediate, and lateral cuneiforms
- Only the **talus** articulates with the tibia and fibula
- The largest is the **calcaneus**, or heel bone
- The metatarsals and phalanges are in the same pattern as in the hand
  - Big toe is **hallux**

Figure 6-30a The Bones of the Ankle and Foot.



a Superior view, right foot

Figure 6-30b The Bones of the Ankle and Foot.



Categories of Joints (6-9)

- Classified by structure
  - Based on anatomy of joints
  - Includes **fibrous, cartilaginous** (both with limited movement), and **synovial** (freely movable)
- Classified by function
  - Based on range of motion
  - Includes **synarthrosis** (immovable), **amphiarthrosis** (slightly movable), and **diarthrosis** (freely movable)

Table 6-2 A Functional and Structural Classifi cation of Articulations

Table 6-2 A Functional and Structural Classification of Articulations

Functional Category	Structural Category and Type		Description	Example
SYNARTHROSIS (NO MOVEMENT)				
	Fibrous	**Suture**	Fibrous connections plus interlocked surfaces	Between the bones of the skull
	Fibrous	**Gomphosis**	Fibrous connections plus insertion in bony socket (alveolus)	Between the teeth and jaws
	Cartilaginous	**Synchondrosis**	Interposition of cartilage plate	Epiphyseal cartilages; between the first pair of ribs and the sternum
AMPHIARTHROSIS (LITTLE MOVEMENT)				
	Fibrous	**Syndesmosis**	Ligamentous connection	Between the tibia and fibula
	Cartilaginous	**Symphysis**	Connection by a fibrocartilage pad	Between right and left halves of pelvis; between adjacent vertebrae of spinal column
DIARTHROSIS (FREE MOVEMENT)				
	Synovial		Complex joint bounded by joint capsule and containing synovial fluid	Numerous; subdivided by range of motion (Spotlight Figure 6-35)

Immovable Joints or Synarthroses (6-9)

- Can be fibrous or cartilaginous
- **Sutures** of the skull connected with dense connective tissue
- **Gomphosis**
  - A ligament binding each tooth in the socket
- **Synchondrosis**
  - A rigid cartilaginous connection
  - For example, between the first pair of ribs and the sternum

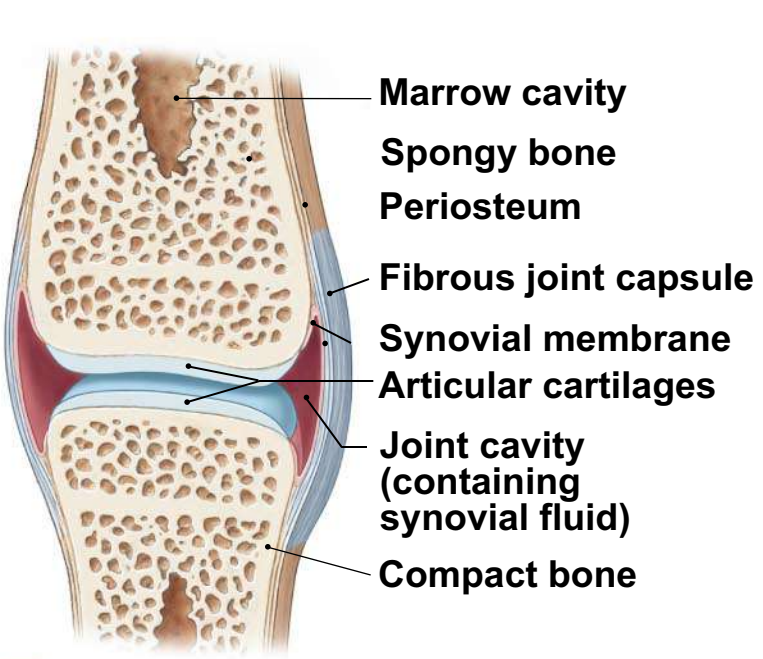
Freely Movable Joints or Diarthroses (6-9)

- **Synovial joints** with a wide range of motion
  - Usually found at the ends of long bones
- Ends of bones covered with **articular cartilages**
- Surrounded with a fibrous **joint capsule**
  - Inner surfaces are lined with the synovial membrane
- **Synovial fluid** in the joint reduces friction

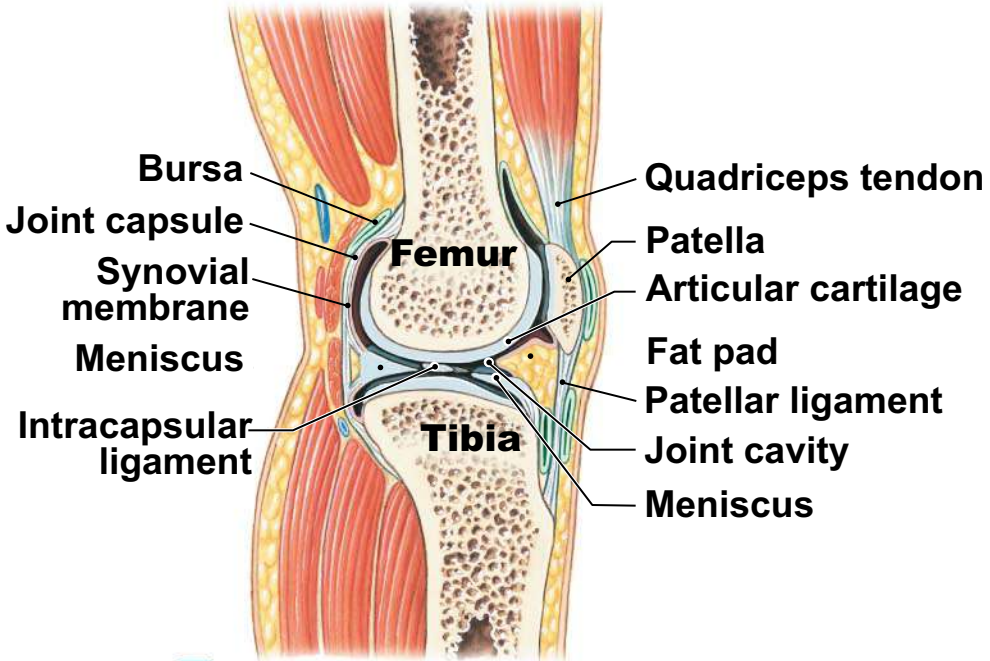
Freely Movable Joints or Diarthroses (6-9)

- Some synovial joints have additional padding
  - In the form of **menisci**
  - For example, in the knee
- **Fat pads** can also act as cushions
- **Ligaments** join bone to bone
  - May be found inside and/or outside the joint capsule
- **Bursae** are packets of connective tissue containing synovial fluid
  - They reduce friction and absorb shock

Figure 6-31 The Structure of Synovial Joints.



a Synovial joint, sagittal section



b Knee joint, sagittal section

Types of Synovial Joint Movement (6-10)

- **Gliding**
  - When two opposing surfaces slide past each other
  - For example, the carpal bones
- **Angular movement** includes:
  - **Flexion** which decreases the angle of two long bones
    - **Extension** increases the angle
  - Hip and shoulder flex by moving anteriorly
    - Extend by moving posteriorly
  - **Hyperextension** is extension beyond anatomical position

Angular Movement (6-10)

- **Abduction**
  - Moves a limb away from the midline
  - For example, separating the fingers
- **Adduction**
  - Moves a limb toward the midline
  - For example, bringing the fingers together
- **Circumduction**
  - Moves the limbs in a loop

Figure 6-32 Angular Movements.

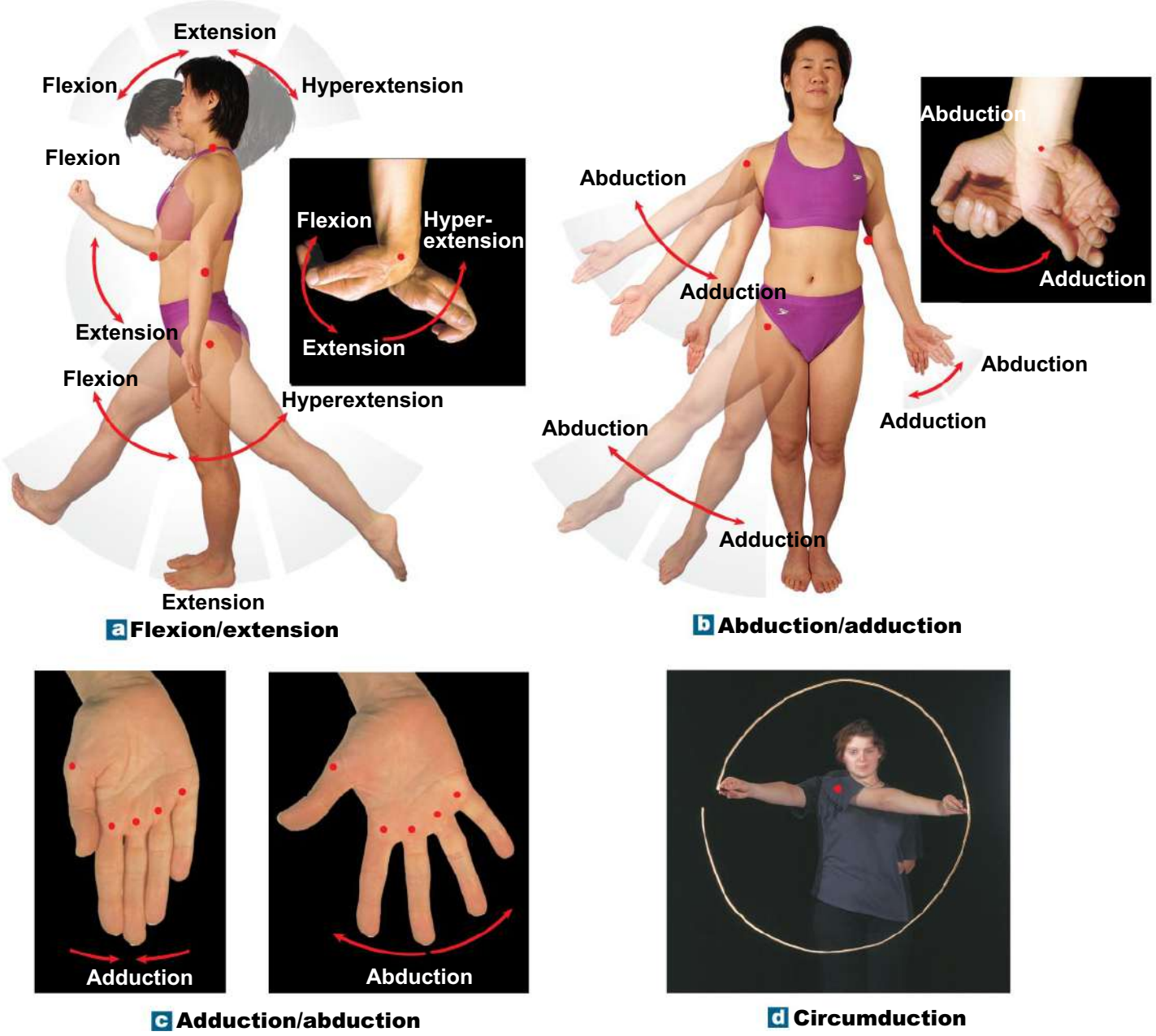


Figure 6-32a Angular Movements.

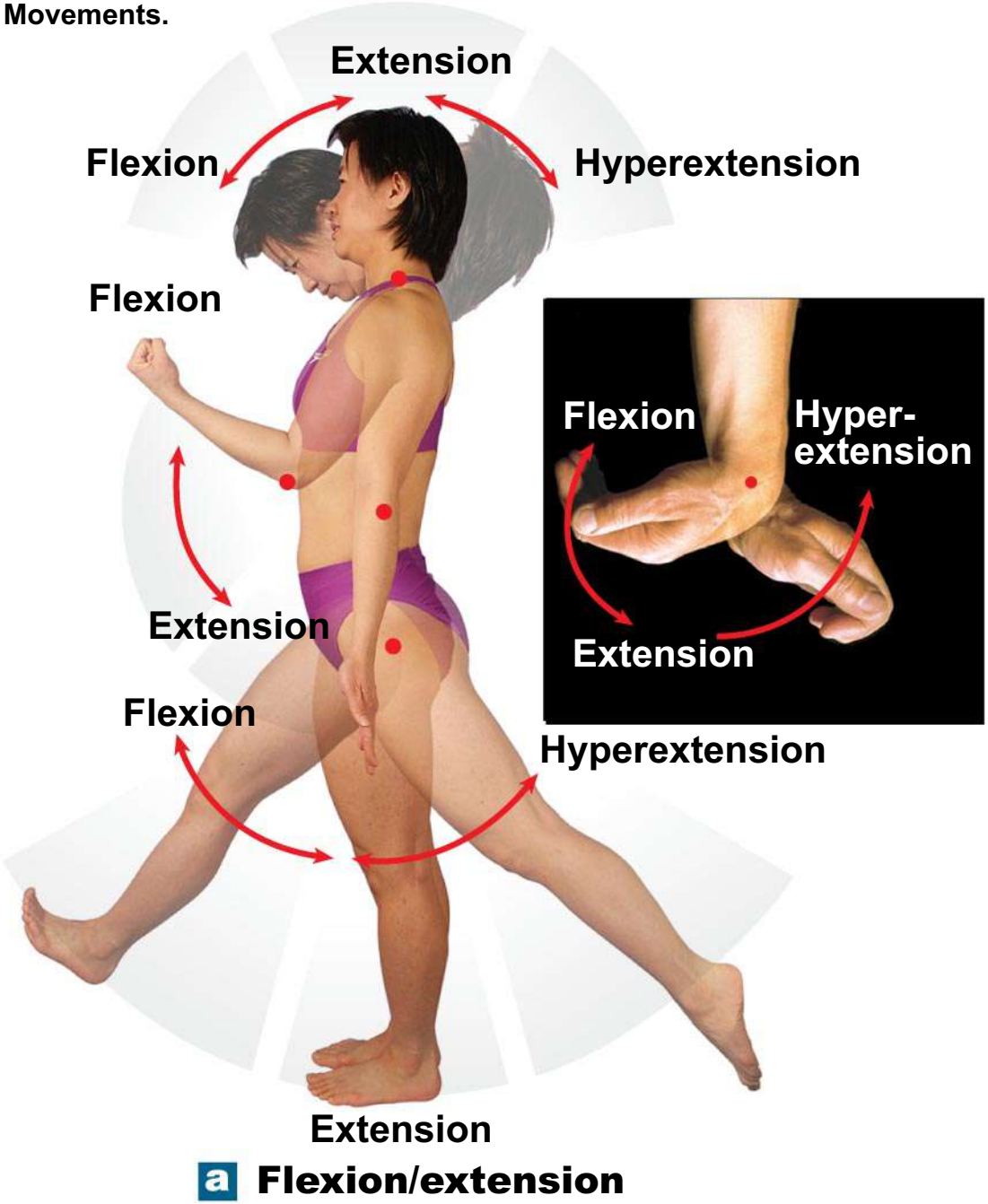
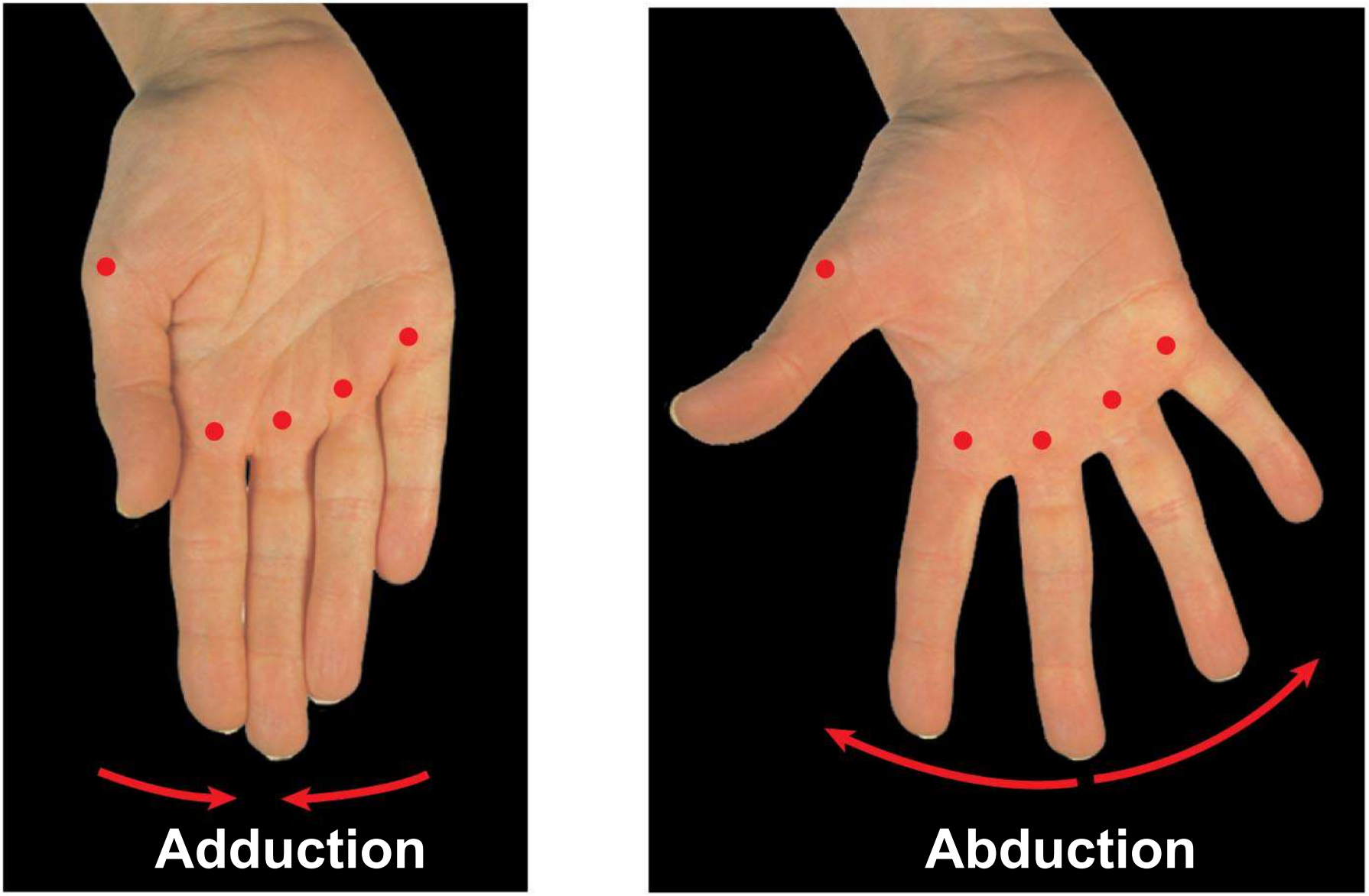
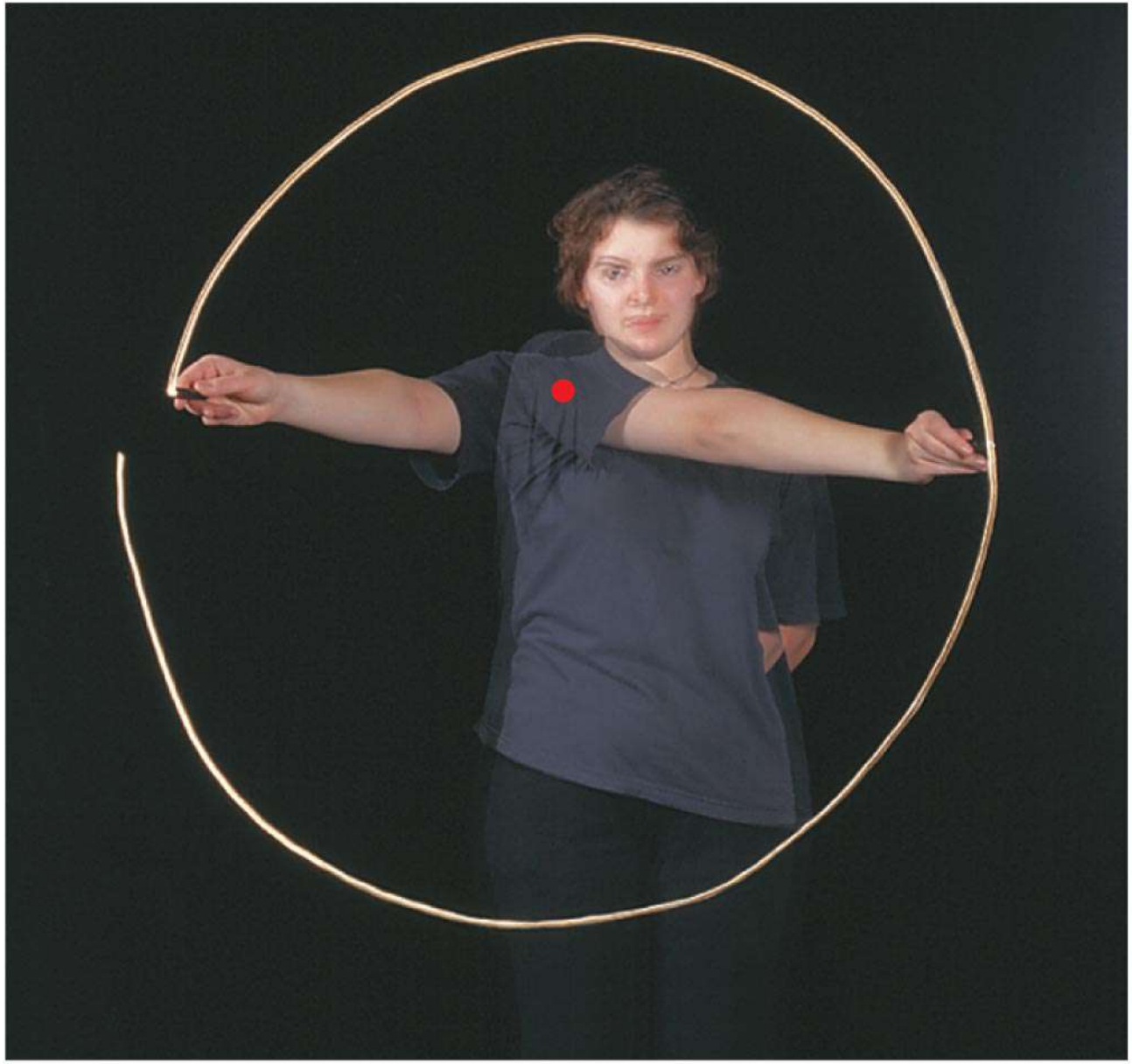


Figure 6-32b Angular Movements.



C **Adduction/abduction**

Figure 6-32d Angular Movements

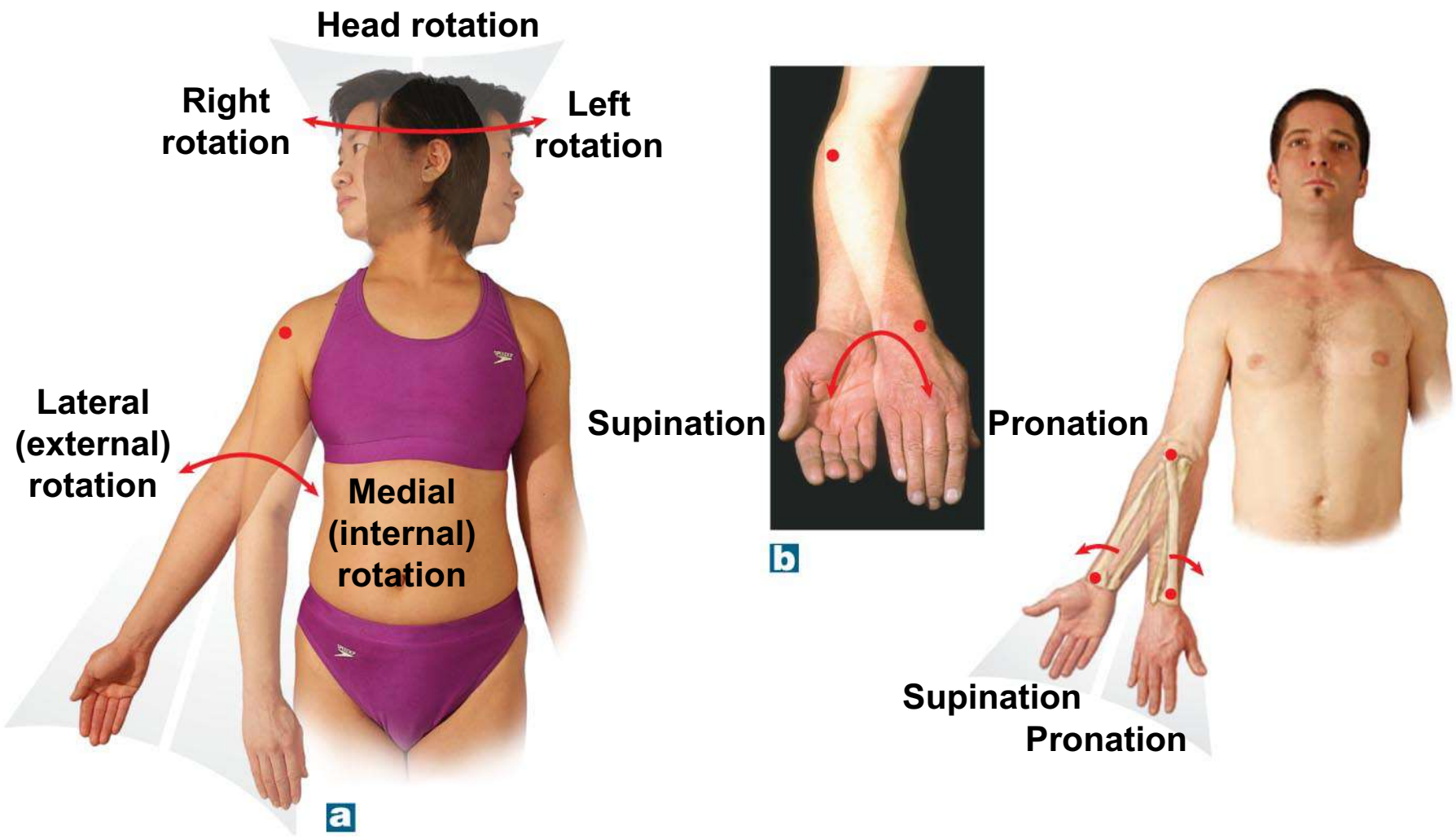


d **Circumduction**

Rotational Joint Movements (6-10)

- Involves turning around the longitudinal axis of the body or limb
  - For example, turning the head
- Rotation of the distal end of the radius across the ulna is a form of rotation
  - **Pronation**
    - The palm is facing the front and is then rotated to the back
  - **Supination**
    - Is the opposite, turning the palm forward

Figure 6-33 Rotational Movements.



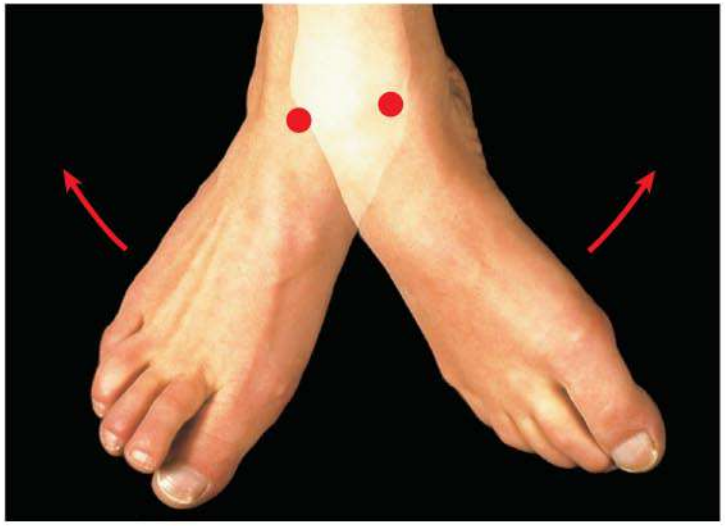
Special Joint Movements (6-10)

- **Inversion** twists the sole of the foot inward
- **Eversion** twists it outward
- **Dorsiflexion** elevates the sole at the ankle, putting the heel down
- **Plantar flexion** is to point the toes
- **Opposition** is moving the thumb toward the palm to grasp
- **Reposition** returns it from opposition

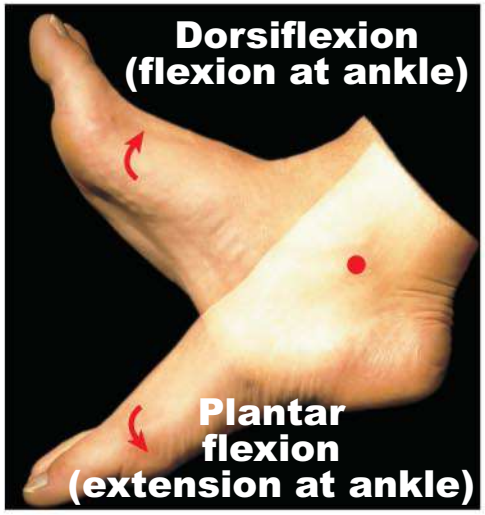
Special Joint Movements (6-10)

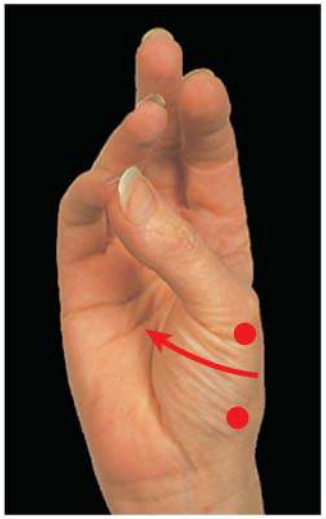
- **Elevation** and **depression**
  - Occurs when a structure moves superiorly and inferiorly
  - For example, closing and opening your mandible
- **Lateral flexion**
  - Is a bending of the vertebral column to the side

Figure 6-34 Special Movements.

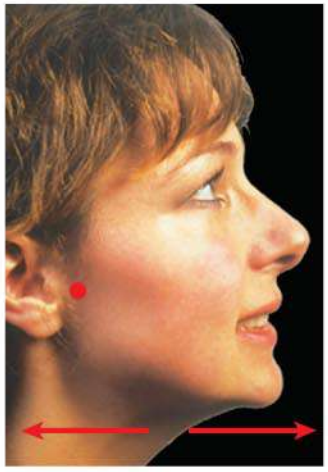


Eversion Inversion

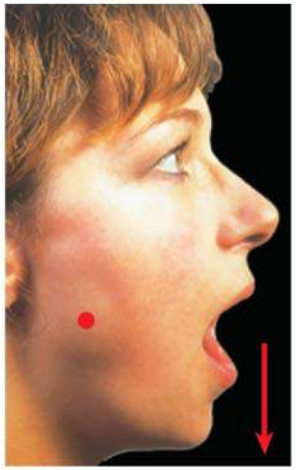




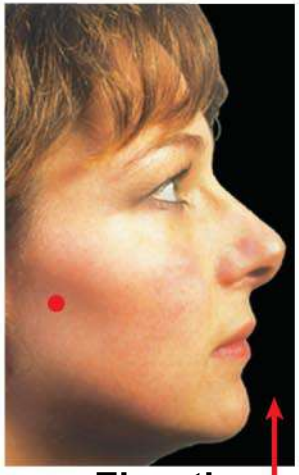
Opposition



Retraction Protraction



Depression



Elevation

Lateral flexion

Types of Synovial Joints (6-10)

- **Gliding joints**
  - Have flat or slightly curved faces
  - Movement is slight
- **Hinge joints**
  - Permit angular movement in one plane
  - Like opening and closing a door
- **Pivot joints**
  - Permit rotation only
  - Like turning the head or supinating and pronating the palm

Types of Synovial Joints (6-10)

- **Condylar joints**
  - Occur where an oval surface nests with a depression on the other bone
    - Allowing for angular motion in two planes, along or across the length of the oval
- **Saddle joints**
  - Have two bones that each have a concave face on one axis and convex on the other
    - Allowing for circumduction, but not rotation

Types of Synovial Joints (6-10)

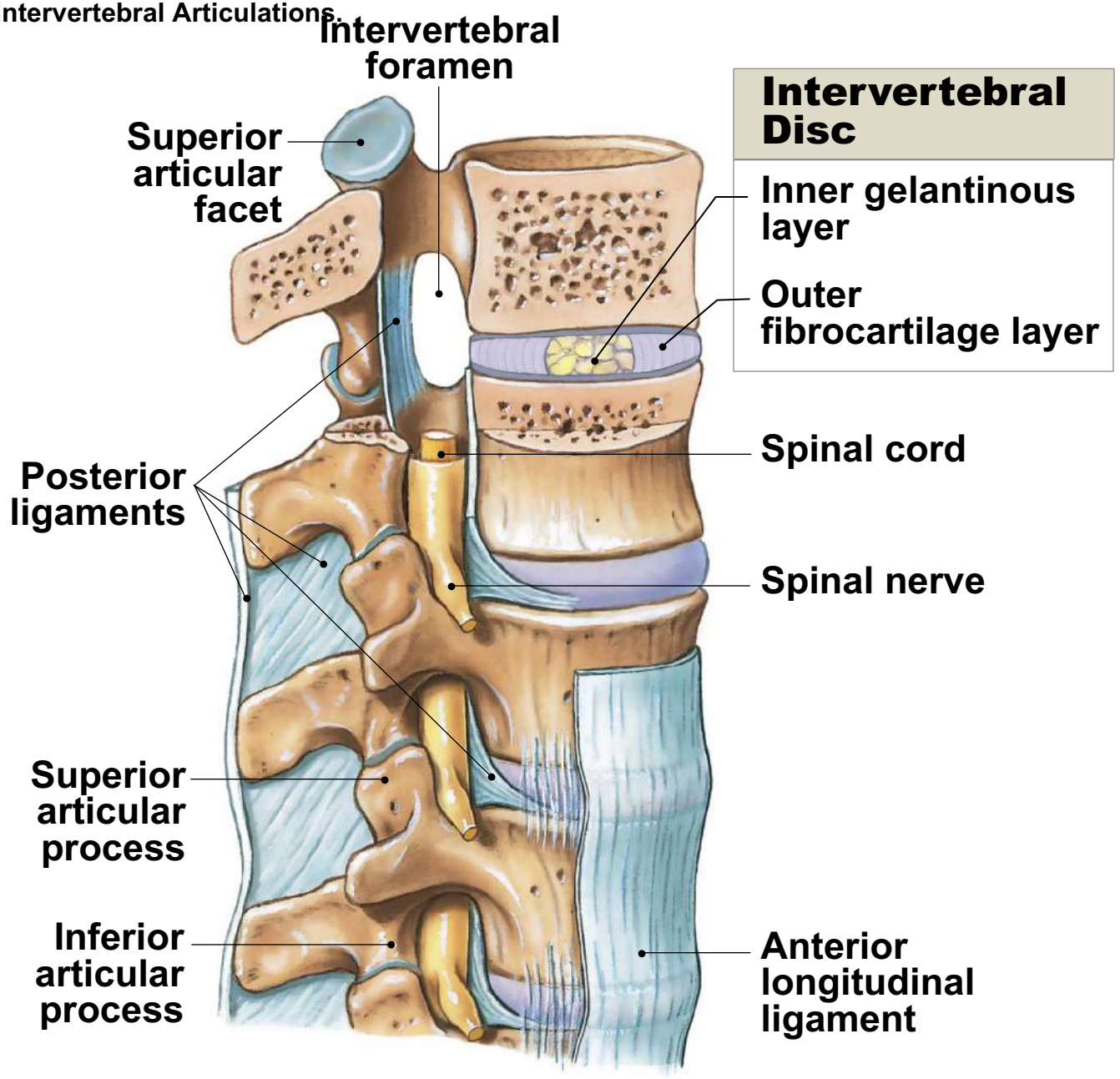
- **Ball-and-socket joints**
  - Occur where the end of one bone is a round head that nests within the cup-shaped depression in the other bone
  - Allow for a wide range of motion
  - For example, the hip and shoulder joints

Figure 6-35 Synovial Joints

Intervertebral Articulations (6-11)

- From the axis to the sacrum
- Include gliding joints between the *superior* and *inferior articular processes*
  - And *symphyseal joints* between the vertebral bodies
- Separated and padded by **intervertebral discs**
  - Made of a tough outer fibrocartilage surrounding a gelatinous core

Figure 6-36 Intervertebral Articulations

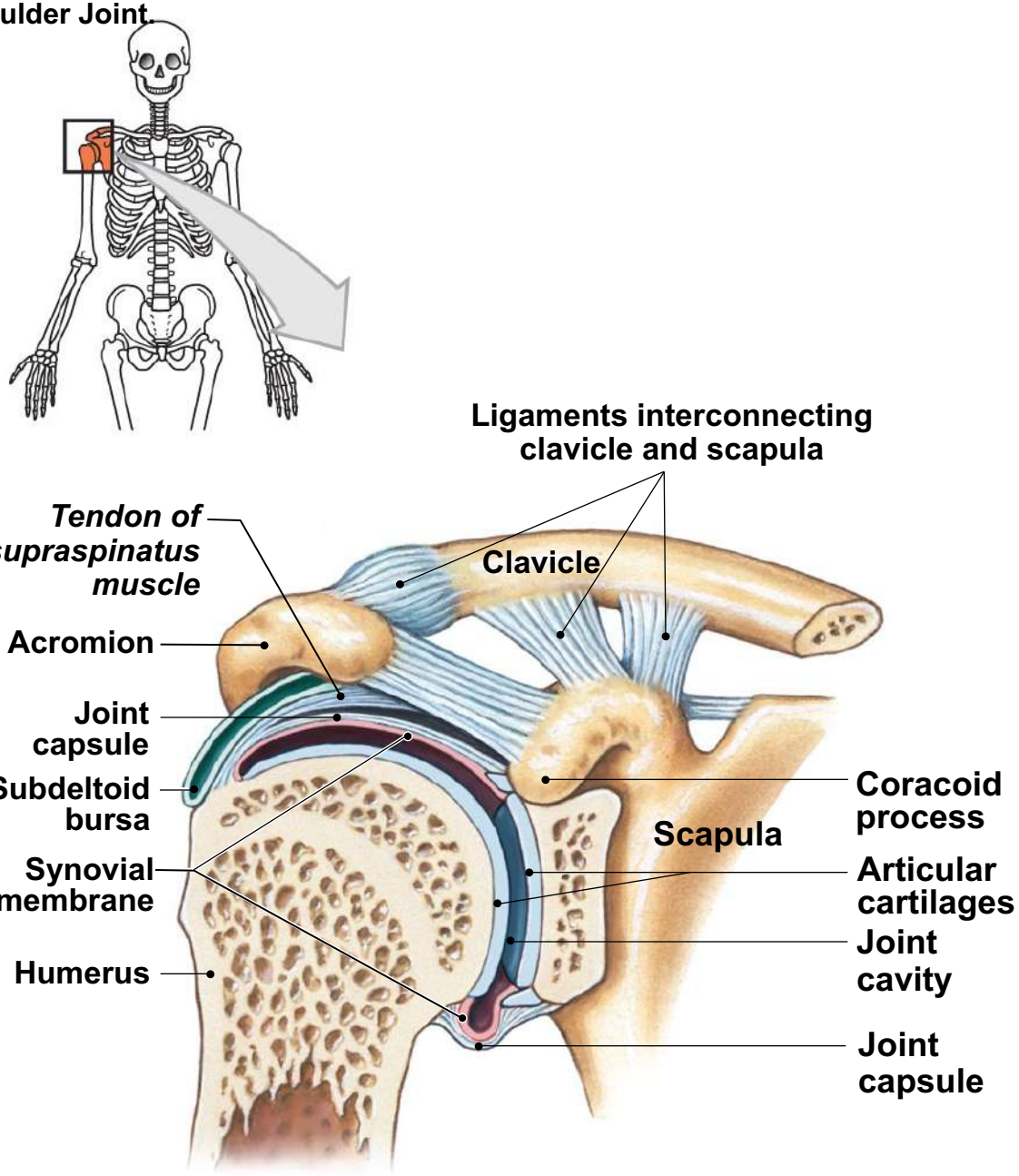


The Shoulder Joint (6-11)

- Most range of motion of any joint
  - Therefore, more likely to dislocate
- Ball-and-socket structure with many bursae
- Muscles that surround and move the shoulder joint form the rotator cuff

***ANIMATION* Humerus Circumduction**

Figure 6-37 The Shoulder Joint.

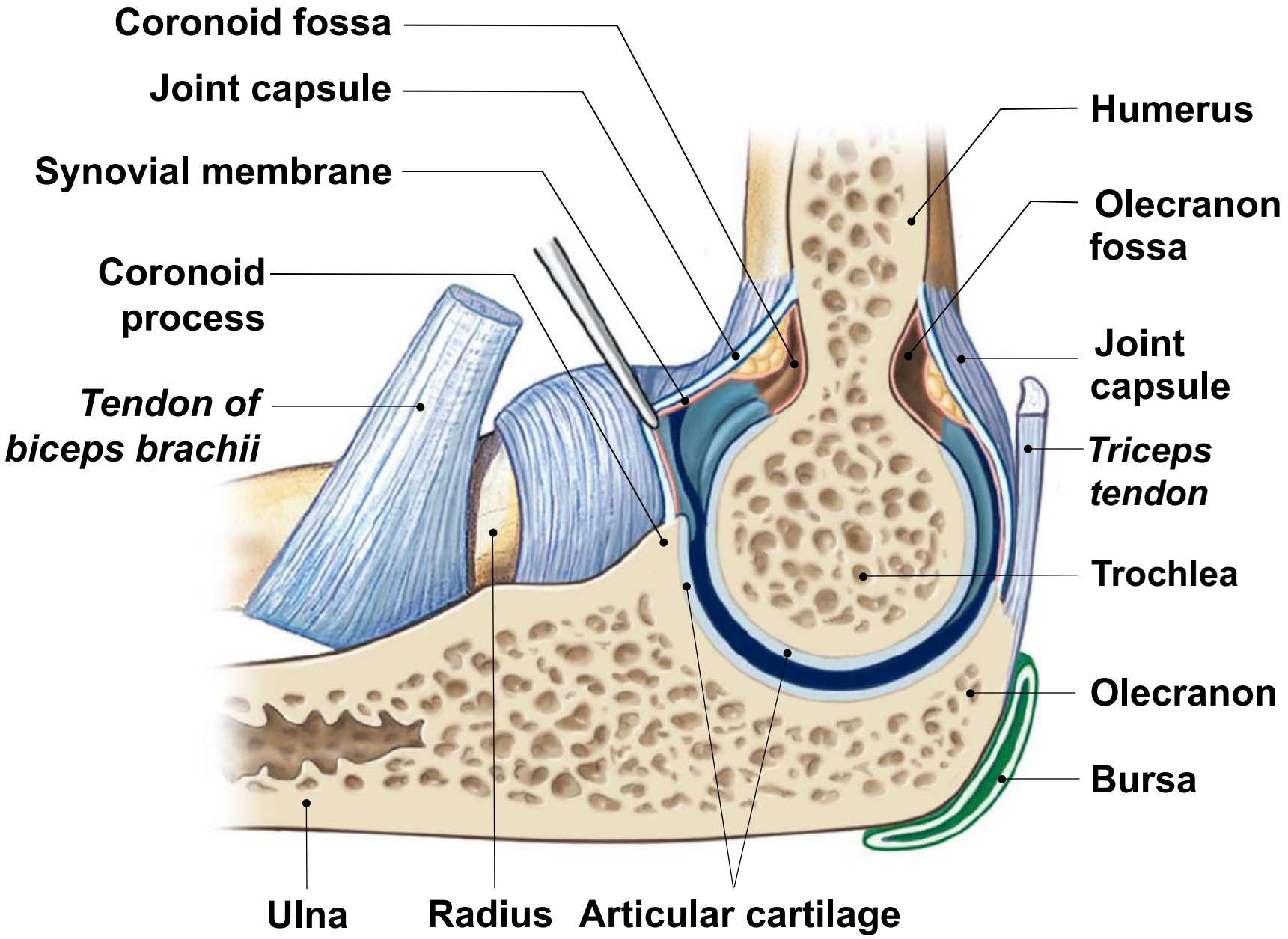


The Elbow Joint (6-11)

- Hinge joint is found between the humerus and ulna
- A weak joint is between the humerus and radius
- Very stable due to interlocking of humerus and ulna
- Very thick joint capsule and very strong ligaments

PLAY ***ANIMATION*** **Elbow Flexion/Extension**

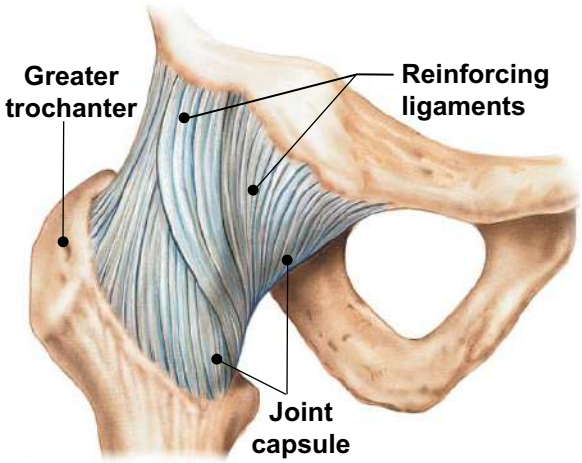
Figure 6-38 The Elbow Joint



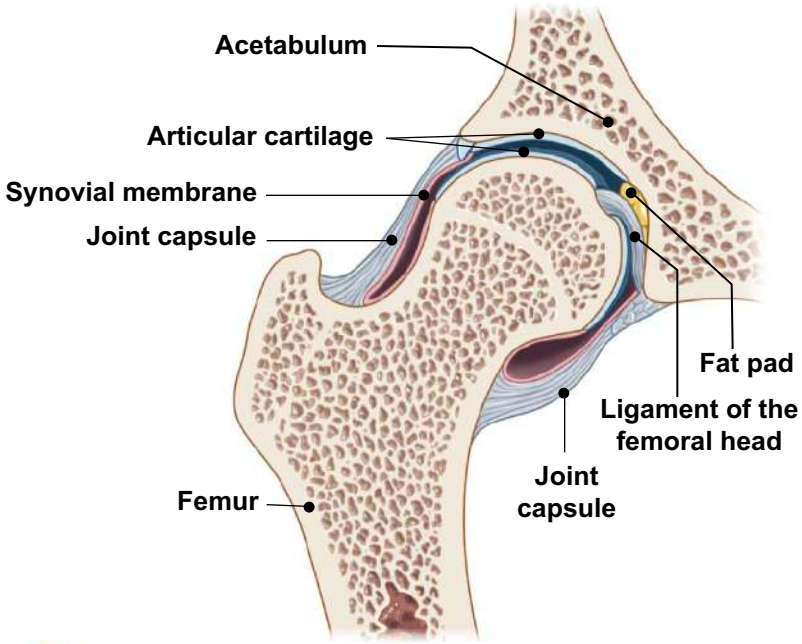
The Hip Joint (6-11)

- Ball-and-socket joint between the head of the femur and the acetabulum of the coxal bone
- Is very dense and strong
  - Due to extensive joint capsule, supporting ligaments, and strong surrounding muscles

Figure 6-39 The Hip Joint



a The hip joint is extremely strong and stable, in part because of the massive joint capsule and surrounding ligaments.

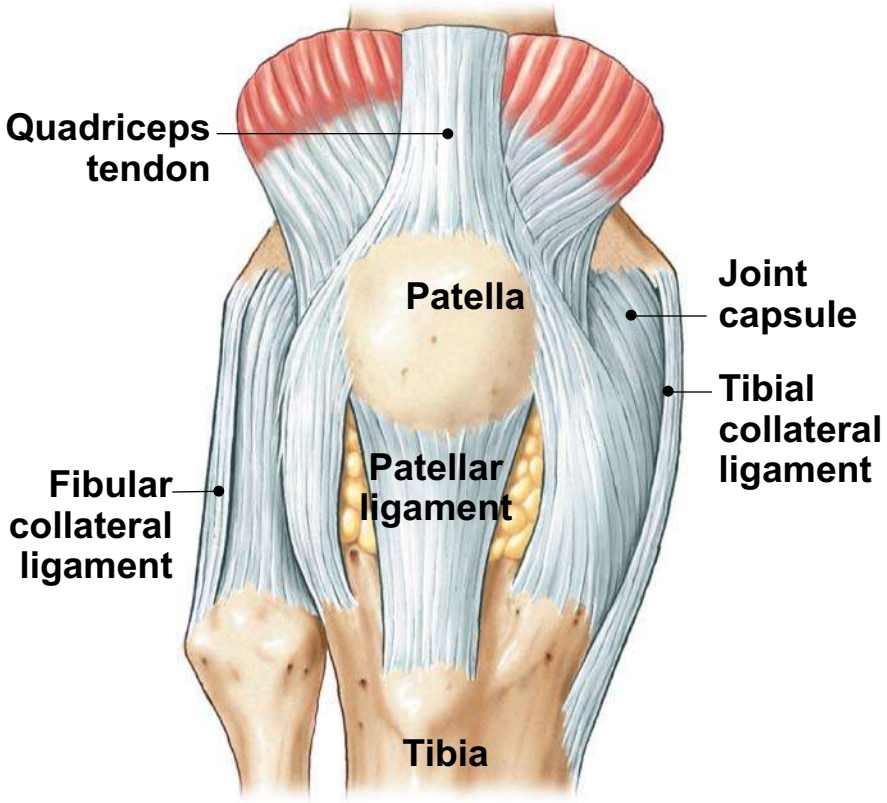


b This sectional view of the right hip shows the structure of the joint and the position of the ligament of the fermoral head.

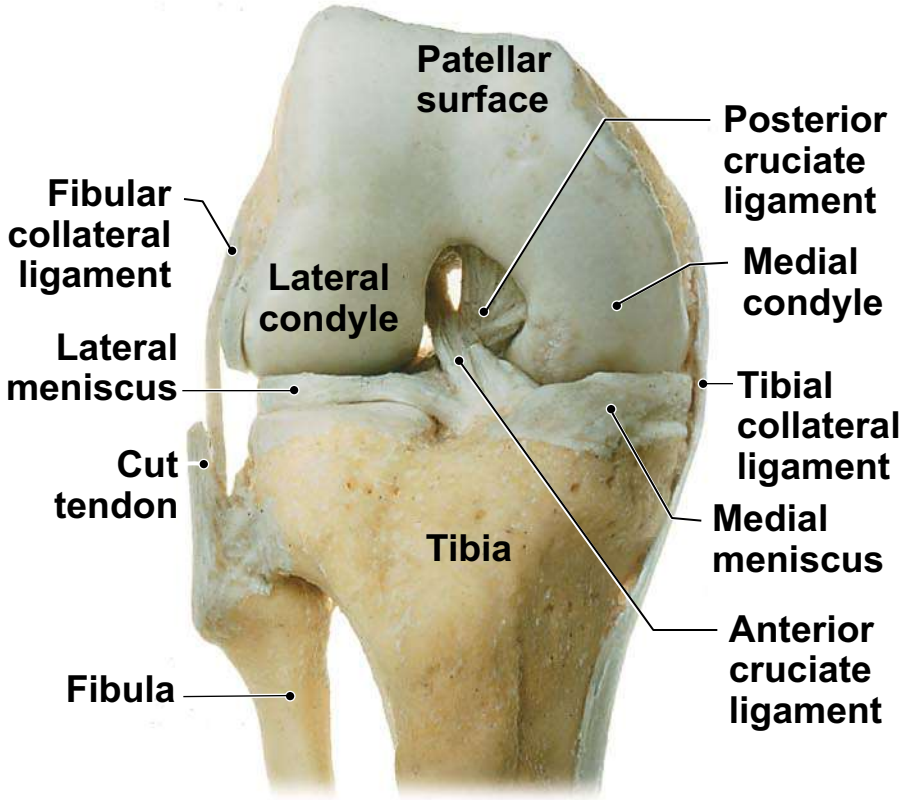
The Knee Joint (6-11)

- Complex joint between distal femoral and proximal tibial condyles
  - And between the patella and femur
- Has multiple joint capsules
  - And condyles are cushioned by the **medial** and **lateral menisci**
- Multiple ligaments from different angles support the knee
  - Patella is within quadriceps tendon
- **Patellar ligament** links to tibial anterior surface

Figure 6-40 The Knee Joint.



a Anterior view of the right knee joint, superficial layer



b Deep anterior view of the right knee when flexed

Skeletal Support of Other Body Systems (6-12)

- Balance between bone formation and recycling creates dynamic interactions with other systems
  - For example, bones:
    - Provide attachments for muscles
    - Interact with cardiovascular and lymphatic systems
    - Are under the control of the endocrine system
  - Digestive and urinary systems play a role in calcium and phosphate balance

Figure 6-41