

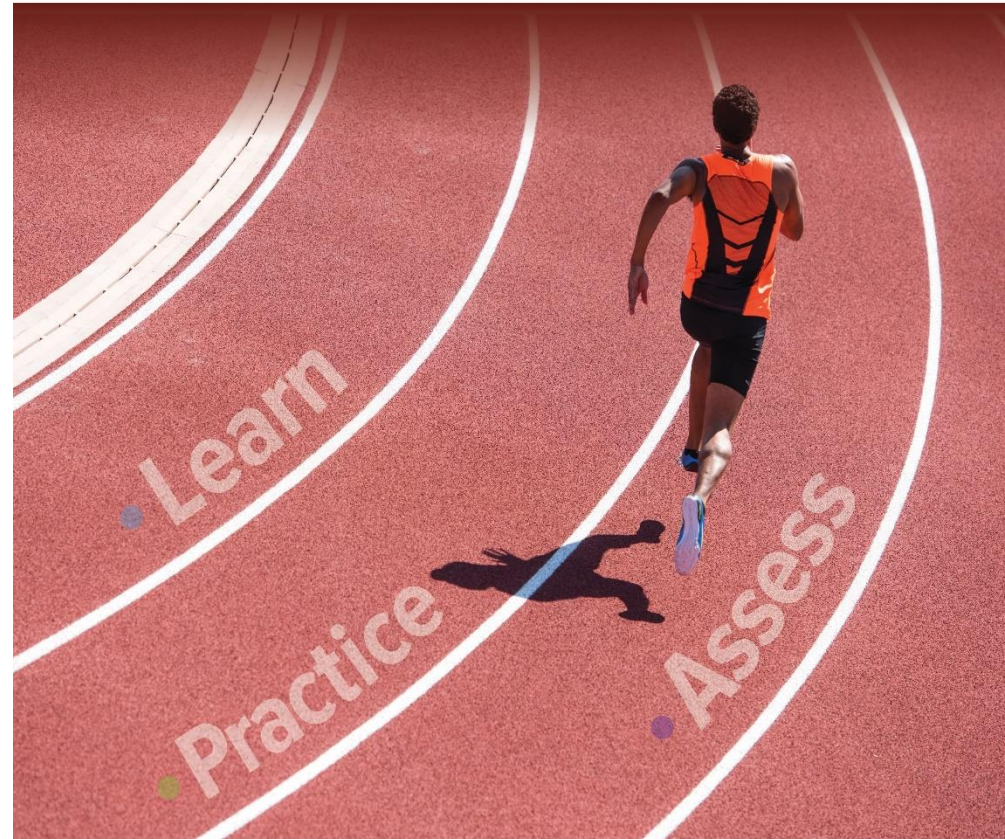
# Chapter 07

## Bone

# HOLE'S

Fifteenth Edition

## Human Anatomy & Physiology



# Bone & Osseous Tissue Part I

7.1-7.3 Interactive Notes pgs. 201-212



# Introduction

Bones are the organs of the skeletal system and are composed of many tissues: bone tissue, cartilage, dense connective tissue, blood and nervous tissue

Bones are alive and multifunctional:

- Support and protect softer tissues
- Provide points of attachment for muscles
- House blood-producing cells
- Store inorganic salts

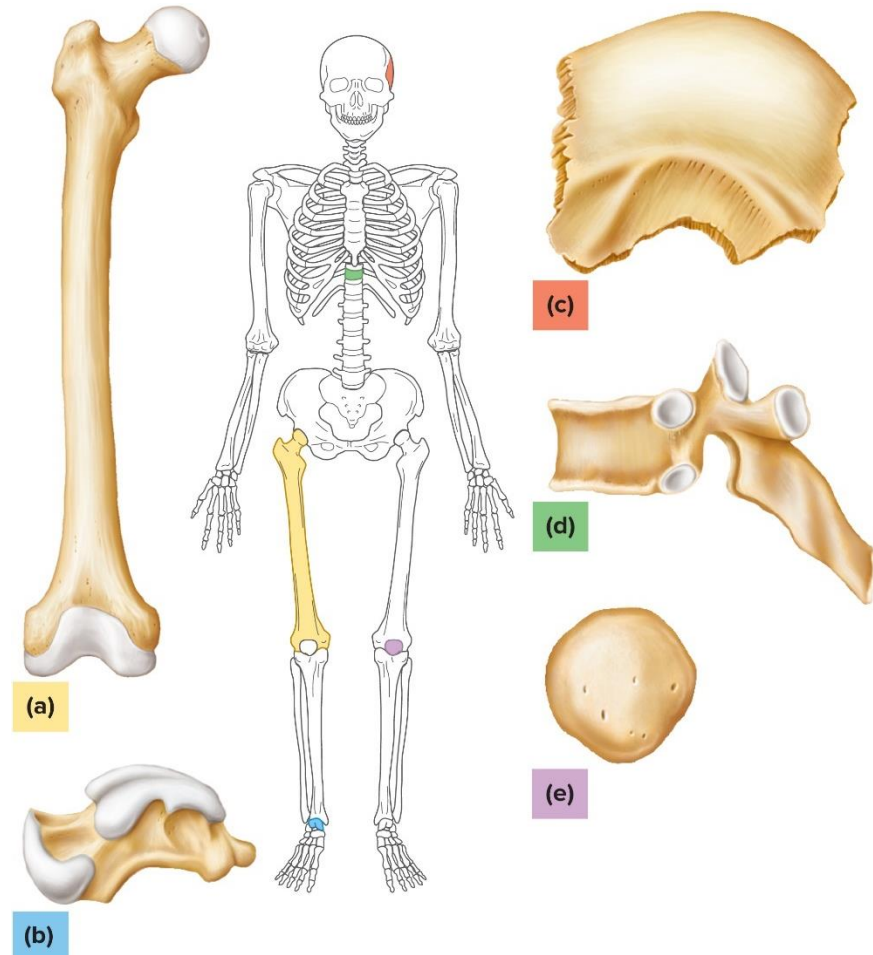
# Bone Shape and Structure

- Bones of the skeletal system vary greatly in these ways:
  - Size
  - Shape
- Bones are similar in these features:
  - Structure
  - Development
  - Function

# Figure 7.1 Bone Shapes

## Bone Classification by Shape:

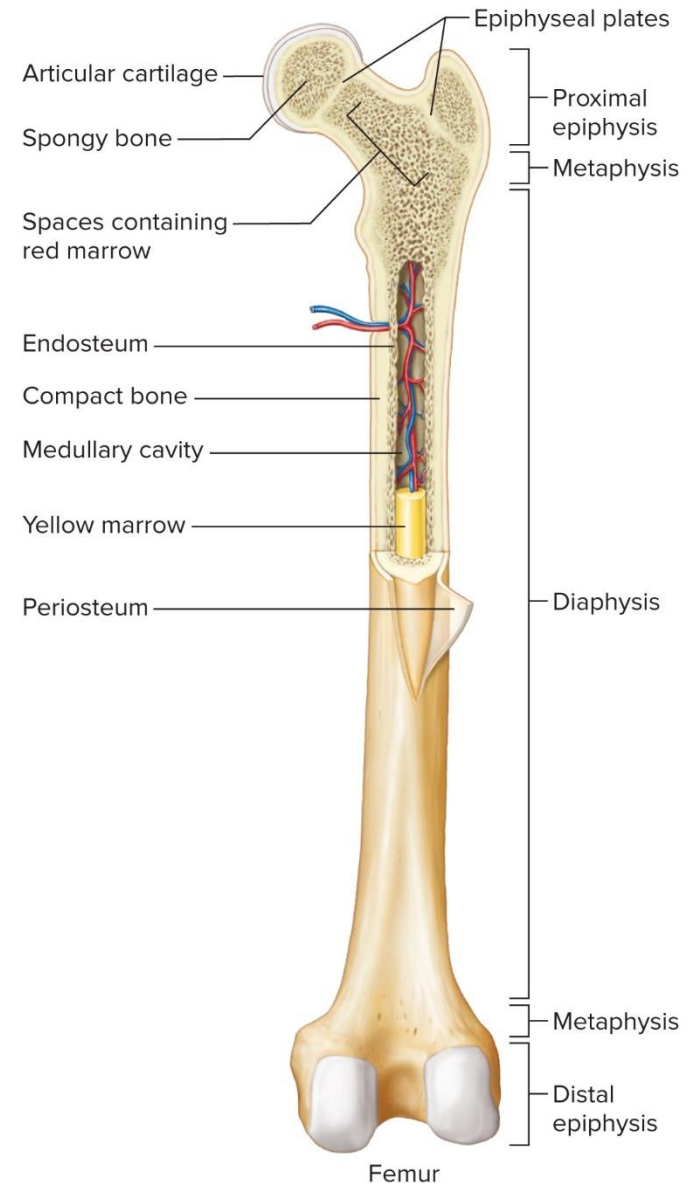
- **Long Bones:**
  - Long and narrow
  - Have expanded ends
- **Short Bones:**
  - Cube-like, length = width
  - Include sesamoid (round) bones, which are embedded in tendons
- **Flat Bones:**
  - Plate-like, with broad surfaces
- **Irregular Bones:**
  - Variety of shapes
  - Most are connected to several other bones





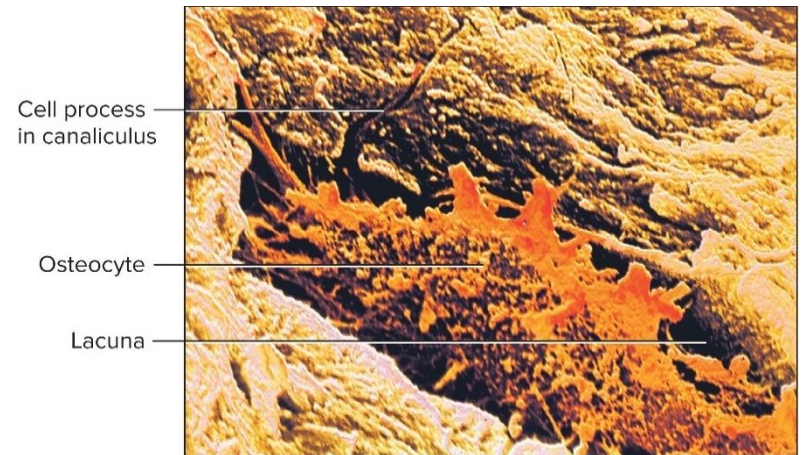
# Figure 7.2 Parts of a Long Bone

- Epiphysis: expanded end
- Diaphysis: bone shaft
- Metaphysis: between diaphysis and epiphysis, widening part
- Articular cartilage: covers epiphysis
- Periosteum: encloses bone; dense connective tissue
- Compact (cortical) bone: wall of diaphysis
- Spongy (cancellous) bone: makes up epiphyses
- Trabeculae: branching bony plates, make up spongy bone
- Medullary cavity: hollow chamber in diaphysis; contains marrow
- Endosteum: Lines spaces, cavity
- Bone marrow: Red or yellow marrow, lines medullary cavity, spongy bone spaces



# Figure 7.7 Microscopic Structure

- Mature bone cells are called osteocytes
- Osteocytes occupy chambers called lacunae
- Osteocytes exchange nutrients and wastes via cell processes within tiny passageways called canaliculi
- The extracellular matrix of bone is largely collagen fibers and inorganic salts:
  - Collagen gives bone resilience
  - Inorganic salts make bone hard



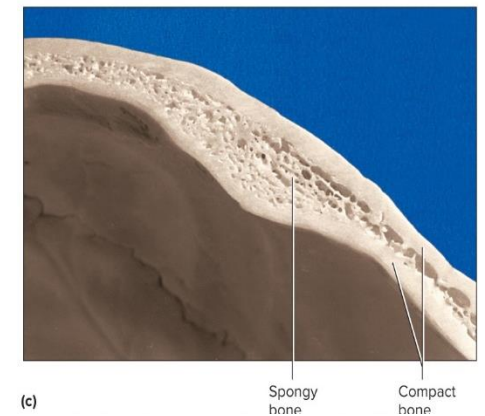
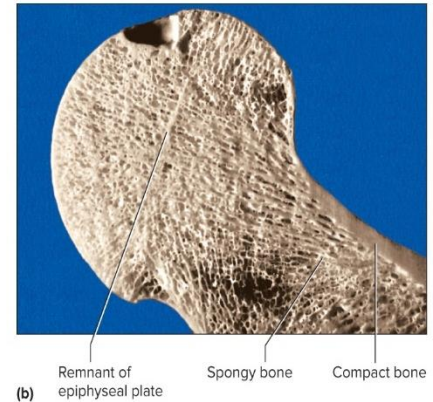
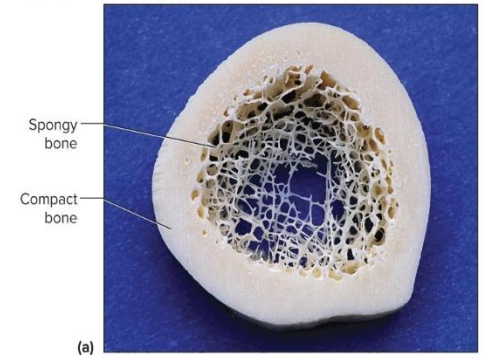
# Figure 7.3 Compact and Spongy Bone

## Compact Bone:

- Consists of cylindrical units called osteons
- Strong and solid
- Weight-bearing
- Resists compression

## Spongy Bone:

- Consists of branching plates called trabeculae
- Somewhat flexible
- Has spaces between trabeculae that reduce the bone's weight

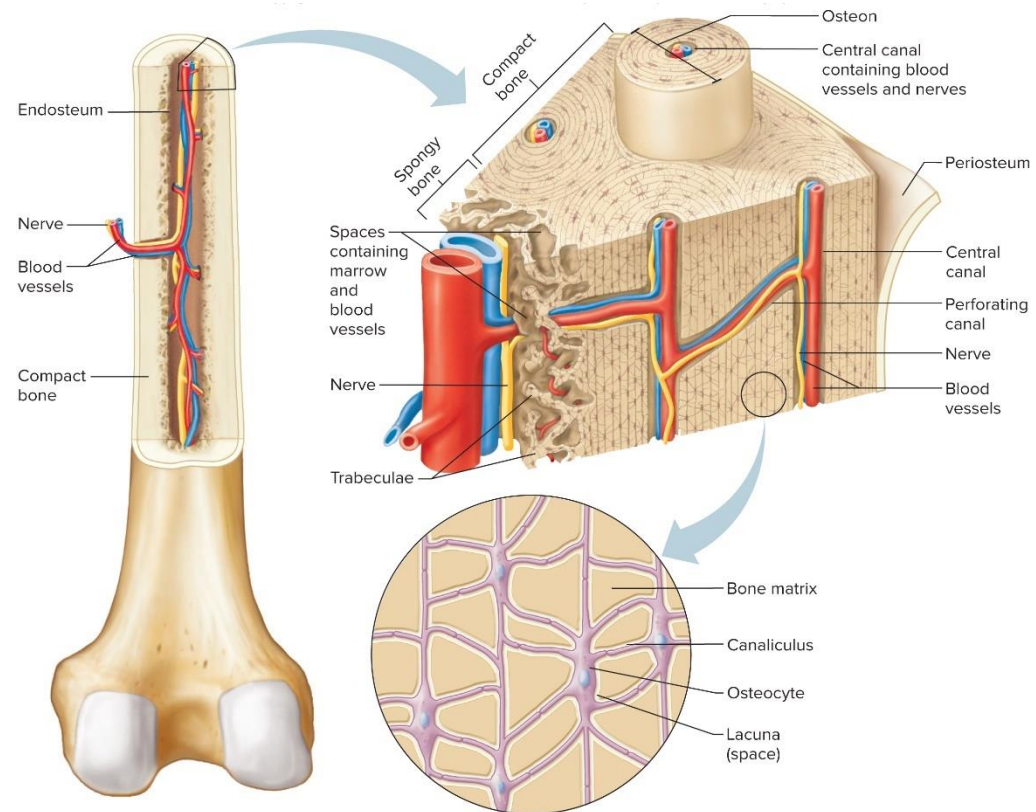




# Figure 7.4 Compact Bone

## Compact Bone:

- Consists of osteons
- Osteocytes in lacunae
- Lamellae: layers of matrix around central canal
- Osteons cemented together by bone matrix
- Perforating canals join adjacent central canals
- Blood vessels provide nutrients to bone tissue
- Osteocytes can pass nutrients through canaliculi



# Bone Development and Growth

- Parts of the skeletal system begin to develop during the first few weeks of prenatal development
- Bony structures continue to grow and develop into adulthood
- Bones form when bone tissue replaces existing connective tissue in 1 of 2 ways:
  - As intramembranous bones
  - As endochondral bones

# Figure 7.6 Bone Growth and Development

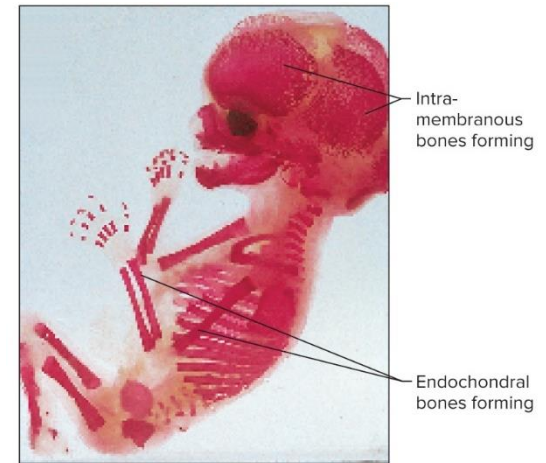
Bone development in a 14-week fetus:

## Intramembranous Ossification:

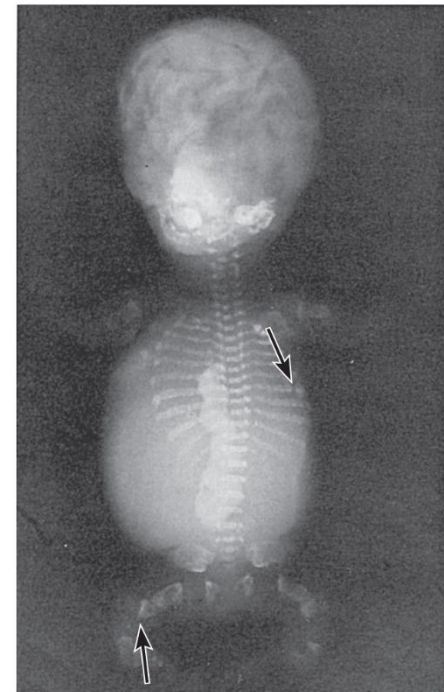
Flat skull bones, clavicles, sternum and some facial bones are forming between sheets of primitive connective tissue

## Endochondral Ossification:

Long bones and most of skeleton are forming from hyaline cartilage models



(a)



(b)

# Intramembranous Bones

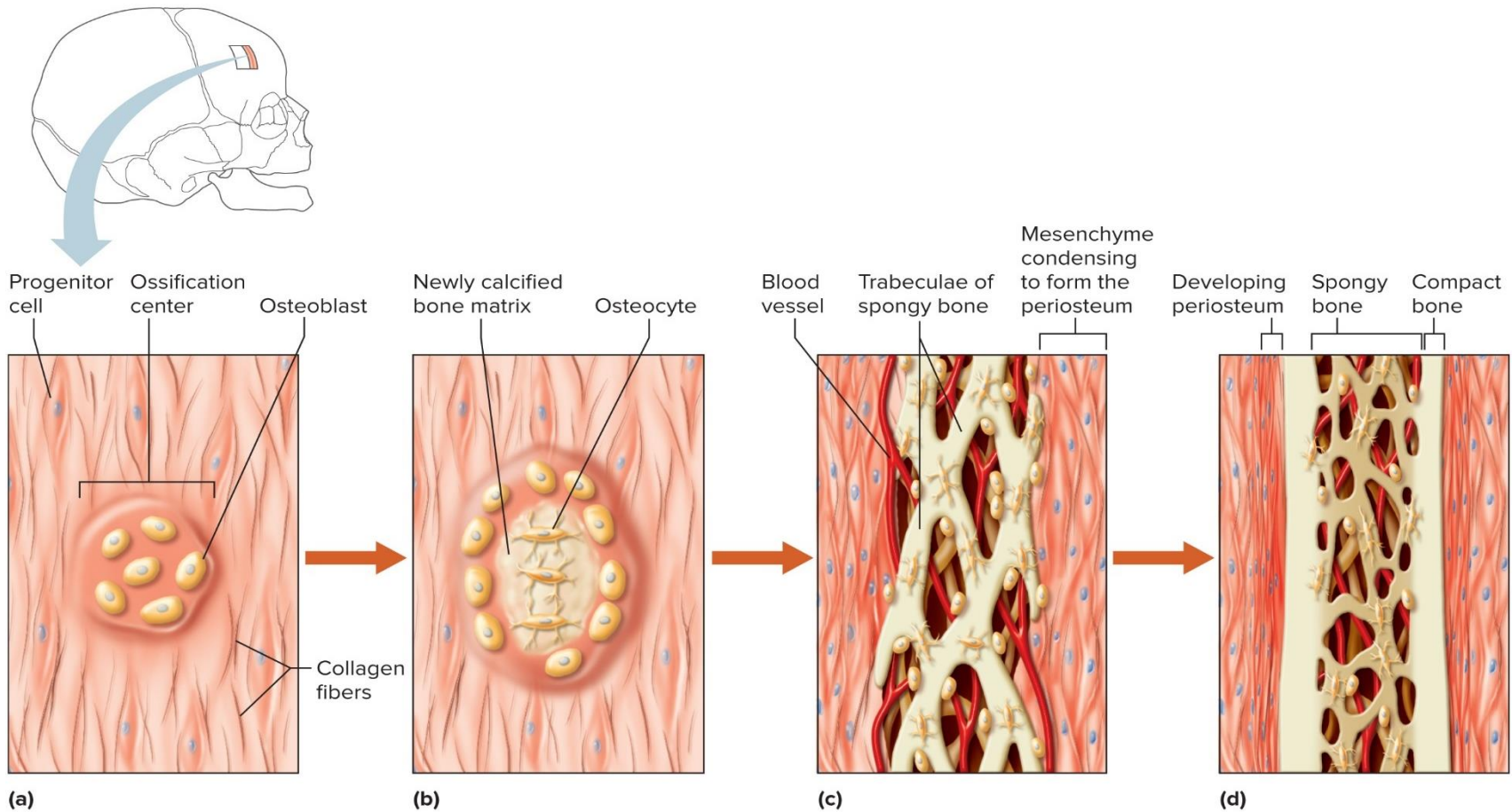
## Intramembranous Bones:

- Originate within sheet-like layers of connective tissue
- Broad, flat bones
- Examples: Flat bones of the skull, clavicles, sternum, and some facial bones (mandible, maxilla, zygomatic)

## Intramembranous Ossification:

- Process of replacing embryonic connective tissue to form intramembranous bone:
- Mesenchymal cells in primitive tissue differentiate into osteoblasts
- Osteoblasts: bone-forming cells that deposit bone matrix around themselves
- When osteoblasts are completely surrounded by matrix, they are now osteocytes in lacunae
- Mesenchyme on outside forms periosteum

# Figure 7.8 Development of Intramembranous Bone





# Endochondral Bones

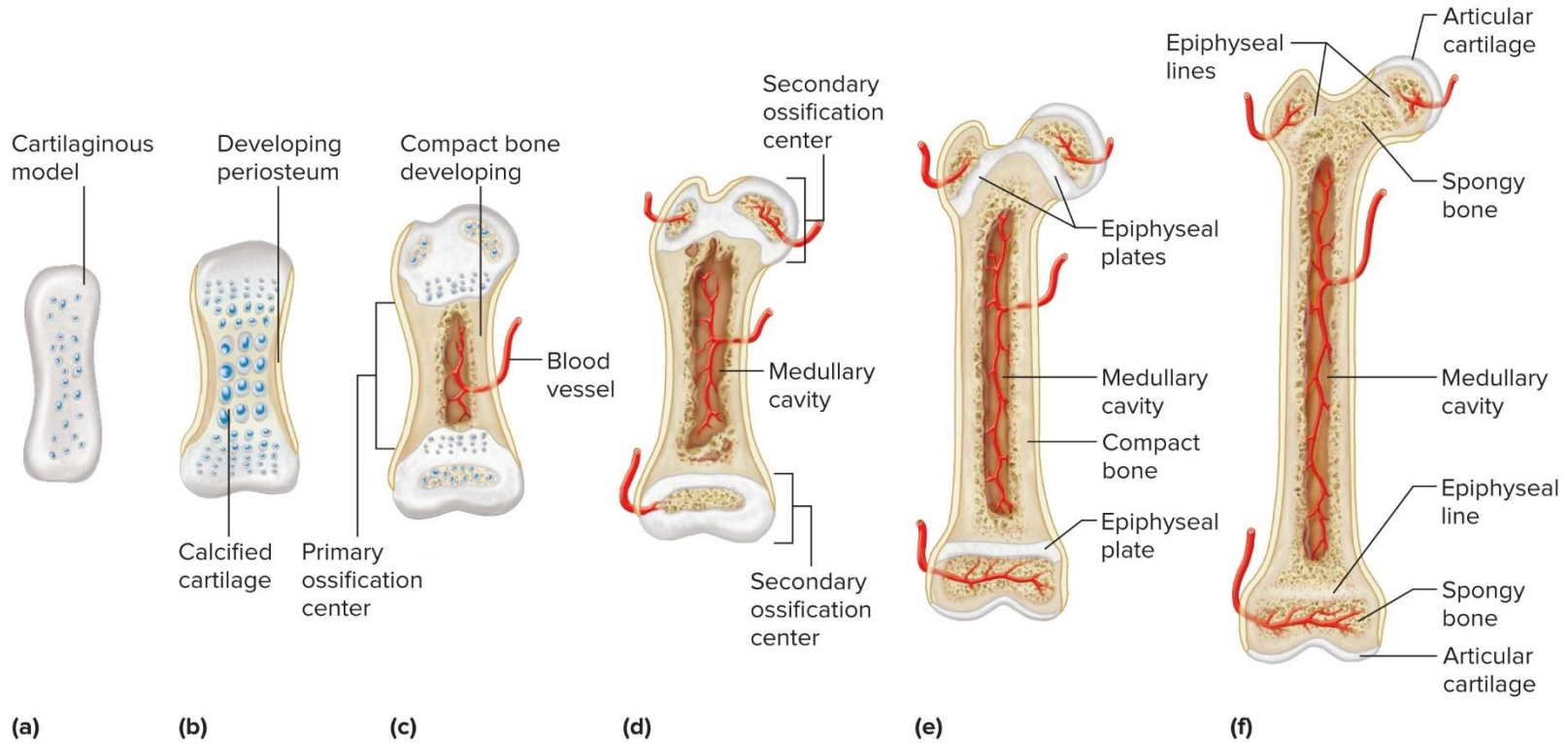
## Endochondral Bones:

- Begin as masses of hyaline cartilage
- Most bones of the skeleton
- Examples: Femur, humerus, radius, tibia, phalanges, vertebrae

## Endochondral Ossification:

- Process of replacing hyaline cartilage to form an endochondral bone:
- Begin as hyaline cartilage models
- Chondrocytes (cartilage cells) enlarge, lacunae grow
- Matrix breaks down, chondrocytes die
- Osteoblasts invade area, deposit bone matrix
- Osteoblasts form spongy and then compact bone
- Once encased by matrix, osteoblasts are now osteocytes

# Figure 7.9 Development of Endochondral Bones



- Hyaline cartilage model
- Primary ossification center
- Secondary ossification centers
- Epiphyseal plate
- Osteoblasts vs. osteoclasts

# Table 7.1 Major Steps in Bone Development

Intramembranous Ossification	Endochondral Ossification
1. Sheets of embryonic connective tissue (mesenchyme) appear at the sites of future bones.	1. Masses of hyaline cartilage form models of future bones.
2. Mesenchymal cells differentiate into osteoblasts, which deposit bone matrix.	2. Cartilage tissue breaks down. Periosteum develops.
3. Dense networks of blood vessels supply the developing spongy bone.	3. Blood vessels and differentiating osteoblasts from the periosteum invade the disintegrating tissue.
4. Osteoblasts become osteocytes when bony matrix completely surrounds them.	4. Osteoblasts form spongy bone in the space occupied by cartilage.
5. Mesenchyme on the surface of each developing structure condenses to form periosteum.	5. Osteoblasts beneath the periosteum deposit compact bone.
6. Osteoblasts on the inside of the periosteum deposit compact bone over the spongy bone.	6. Osteoblasts become osteocytes when bony matrix completely surrounds them.

# Growth at the Epiphyseal Plate

In a growing long bone, diaphysis is separated from epiphysis by Epiphyseal Plate. Region at which bone grows in length.

Cartilaginous cells of epiphyseal plate form 4 layers:

1. Zone of resting cartilage:

- Layer closest to end of epiphysis
- Resting cells; anchor epiphyseal plate to epiphysis

2. Zone of proliferating cartilage:

- Rows of young cells, undergoing mitosis

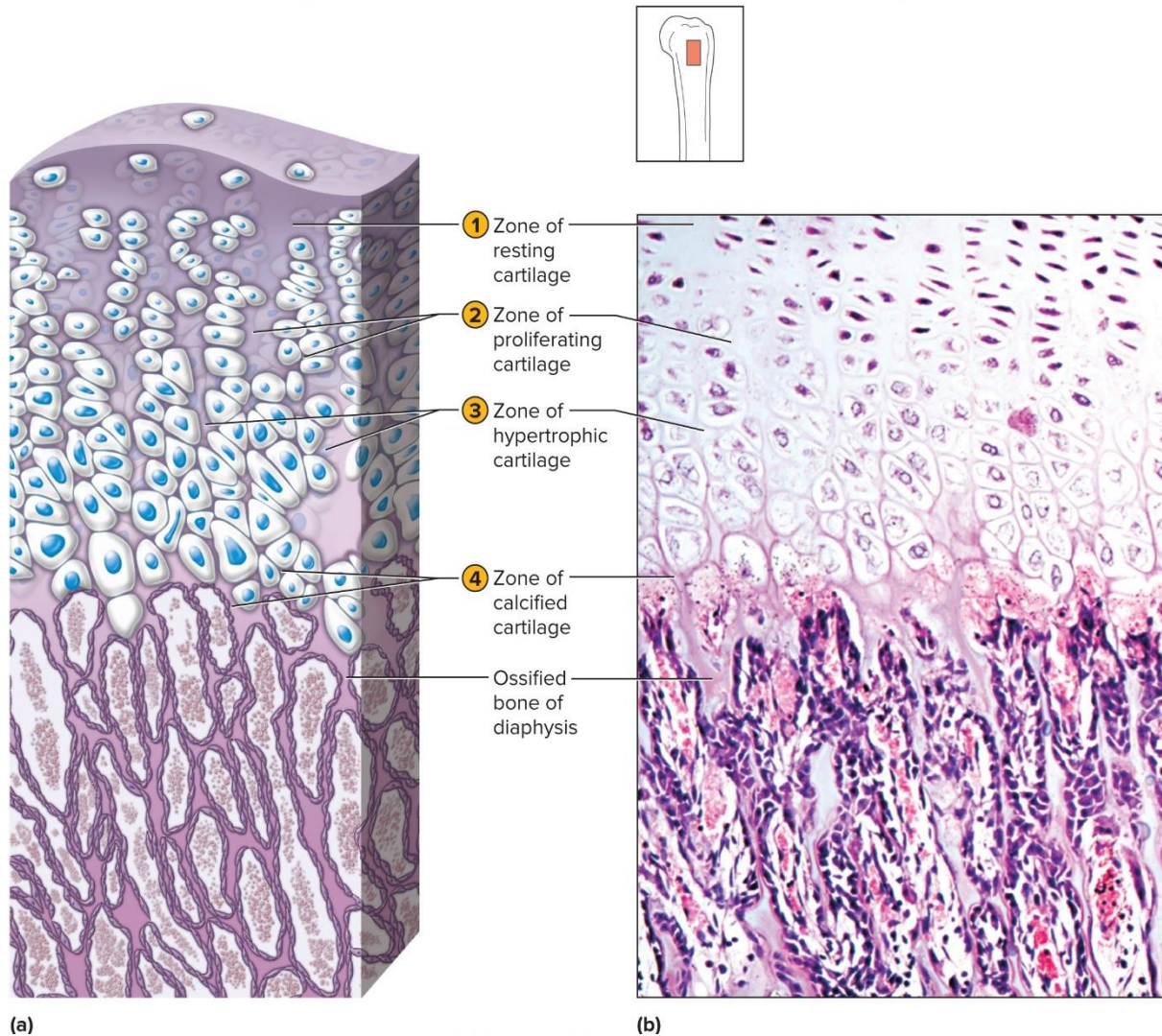
3. Zone of hypertrophic cartilage:

- Rows of older cells left behind when new cells appear
  - Thicken epiphyseal plate, lengthening the bone
- Matrix calcifies, cartilage cells (chondrocytes die)

4. Zone of calcified cartilage:

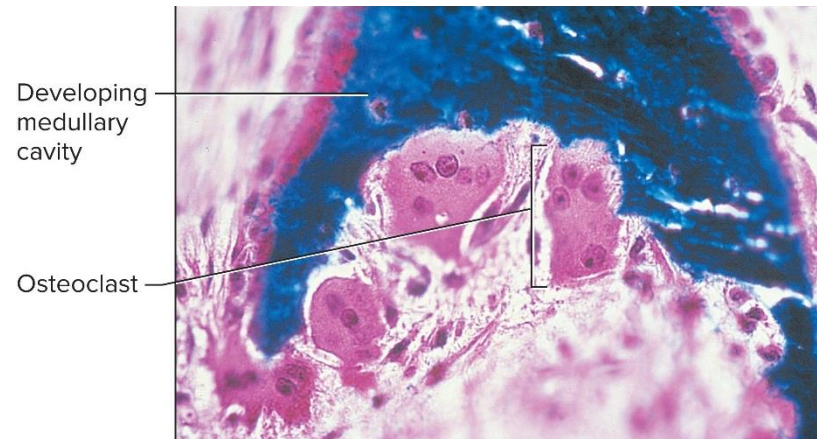
- Thin layer of dead cartilage cells and calcified matrix

# Figure 7.11 Growth at the Epiphyseal Plate





# Figure 7.12 Growth at the Epiphyseal Plate



Osteoclasts break down calcified matrix

Osteoblasts then invade, replacing cartilage with bone tissue

**Bone can continue to grow in length, as long as cartilage cells of epiphyseal plate remain active**

When ossification centers meet, and epiphyseal plate ossifies, bone can no longer grow in length

Bone can thicken by depositing compact bone on outside, under periosteum

# Table 7.2 Ossification Timetable

Age	Occurrence	Age	Occurrence
Third month of prenatal development	Ossification in long bones begins.	15 to 18 years (females) 17 to 20 years (males)	Bones of the upper limbs and scapulae completely ossified.
Fourth month of prenatal development	Most primary ossification centers have appeared in the diaphyses of long bones	16 to 21 years (females) 18 to 23 years (males)	Bones of the lower limbs and hip bones completely ossified.
Birth to 5 years	Secondary ossification centers appear in the epiphyses of long bones.	21 to 23 years (females) 23 to 25 years (males)	Bones of the sternum, clavicles, and vertebrae completely ossified.
5 to 12 years (females) 5 to 14 years (males)	Ossification rapidly spreads from the ossification centers.	By 23 years (females) By 25 years (males)	Nearly all bones completely ossified.

# Homeostasis of Bone Tissue

- Bone remodeling occurs throughout life
- Opposing processes of deposition and resorption occur on surfaces of endosteum and periosteum
- Bone Resorption: removal of bone, action of osteoclasts
- Bone Deposition: formation of bone, action of osteoblasts
- 10% - 20% of skeleton is replaced each year

# Factors Affecting Bone Development, Growth and Repair

Nutrition, sunlight exposure, hormone levels, and physical exercise all affect bone development, growth and repair:

- Vitamin D: calcium absorption; deficiency causes rickets, osteomalacia
- Vitamin A: osteoblast & osteoclast activity; deficiency retards bone development
- Vitamin C: collagen synthesis; deficiency results in slender, fragile bones
- Growth Hormone: stimulates cartilage cell division
  - Insufficiency in a child can result in pituitary dwarfism
  - Excess causes gigantism in child, acromegaly in adult
- Thyroid Hormone: causes replacement of cartilage with bone in epiphyseal plate, osteoblast activity
- Parathyroid Hormone (PTH): stimulates osteoclasts, bone breakdown
- Sex Hormones (estrogen, testosterone): promote bone formation; stimulate ossification of epiphyseal plates
- Physical Stress: stimulates bone growth

# Clinical Application 7.1

## Fractures

Fractures are classified by cause and nature of break

### Simple (closed) fracture:

Fracture protected by uninjured skin (or mucous membrane)

### Compound (open) fracture:

Fracture in which the bone is exposed to the outside through opening in skin (or mucous membrane)



# Clinical Application 7.1

## Types of Fractures



A *greenstick* fracture is incomplete, and the break occurs on the convex surface of the bend in the bone.



A *fissured* fracture is an incomplete longitudinal break.



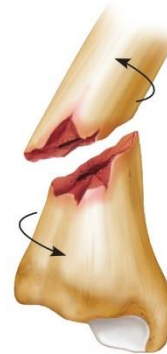
A *comminuted* fracture is complete and fragments the bone.



A *transverse* fracture is complete, and the break occurs at a right angle to the axis of the bone.



An *oblique* fracture occurs at an angle other than a right angle to the axis of the bone.

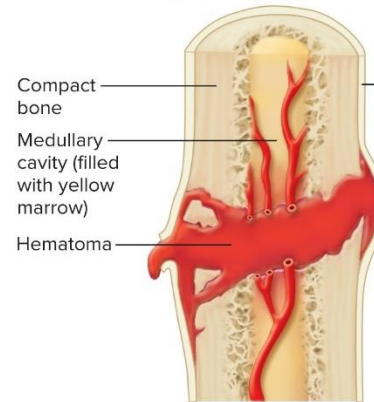


A *spiral* fracture is caused by excessive twisting of a bone.

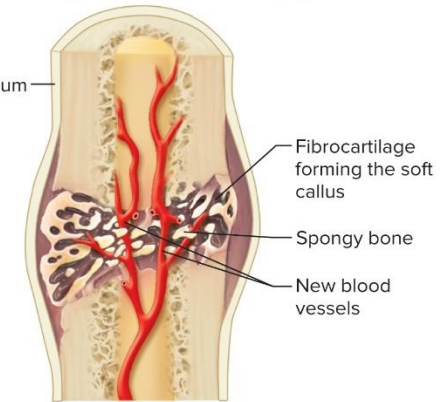
# Clinical Application 7.1

## Steps in Fracture Repair

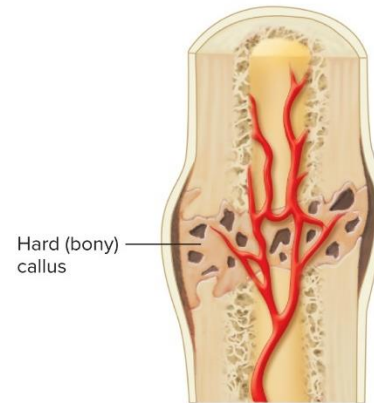
- Hematoma:**  
Large blood clot
- Cartilaginous callus:**  
Phagocytes remove debris, fibrocartilage invades
- Bony callus:**  
Osteoblasts invade, hard callus fills space
- Remodeling:**  
Bone restored close to original shape



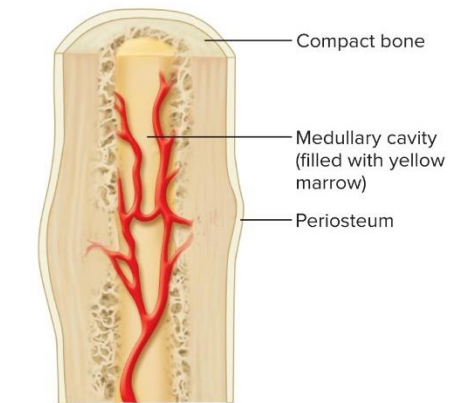
(a) Blood escapes from ruptured blood vessels and forms a hematoma.



(b) Spongy bone forms in regions close to developing blood vessels, and fibrocartilage forms in more distant regions.



(c) A hard (bony) callus replaces the fibrocartilage.



(d) Osteoclasts remove excess bony tissue, restoring new bone structure much like the original.

# Bone Function

## Major functions of bones:

- Provide shape to body
- Support body structures
- Protect body structures
- Aid body movements
- Contain tissue that produces blood cells
- Store inorganic salts

# Support, Protection, and Movement

- Bones provide shape for head, face, thorax, limbs
- Bones support body weight (bones of lower limbs, pelvis, vertebral column)
- Skull bones protect brain, ears, eyes
- Bones of rib cage, shoulder girdle protect heart, lungs
- Bones of pelvic girdle protect internal reproductive organs, lower abdominal organs
- Bones + muscles provide movement

# Blood Cell Formation

- Hematopoiesis: Blood cell formation
- Blood cell production occurs in red bone marrow
- Red blood cells, white blood cells, and platelets are produced in red bone marrow
- With age, some red bone marrow is replaced by yellow bone marrow, which stores fat, but does not produce blood cells

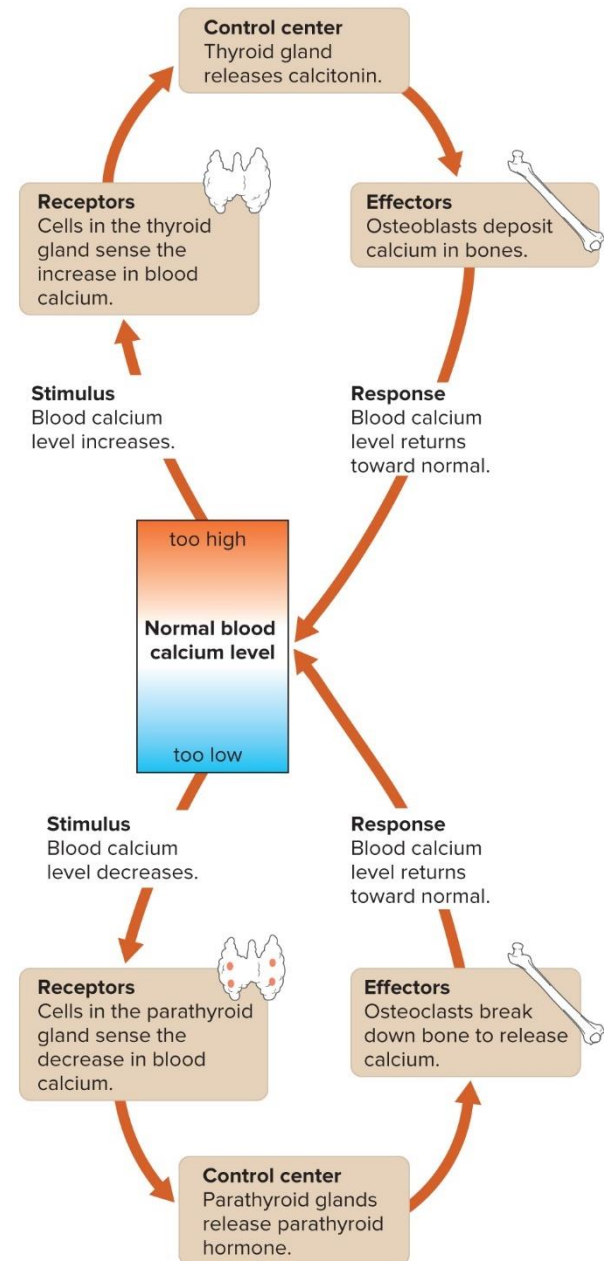
# Inorganic Salt Storage

- About 70% of bone matrix consists of inorganic mineral salts
- Inorganic Salt Storage
  - Most abundant salt is crystals of [hydroxyapatite \(calcium phosphate\)](#)
  - Other salts include:
    - Magnesium ions
    - Sodium ions
    - Potassium ions
    - Carbonate ions
- Osteoporosis is a condition that results from loss of bone mineralization
- Since calcium is vital in nerve impulse conduction and muscle contraction, blood calcium level is regulated by Parathyroid hormone and Calcitonin



# Figure 7.14

## Hormonal Control of Blood Calcium



# Clinical Application 7.2

## Preventing Fragility Fractures

Fragility Fracture: Fracture that occurs after a fall from less than standing height; a sign of low bone density

- Bone remodeling occurs throughout life, but with age, osteoclasts remove more bone tissue than osteoblasts deposit
- Can result in osteopenia (bone loss) or progress to osteoporosis (severe bone loss that leaves spaces and canals in bone, and weakens them)
- Estimated that half of people over 50 have one of the bone loss conditions; common in postmenopausal women, due to hormone changes

To prevent fragility fractures:

- Get 30 minutes of exercise per day; should include weight-bearing exercise
- Get enough calcium and vitamin D
- Do not smoke



**END OF PART 1**  
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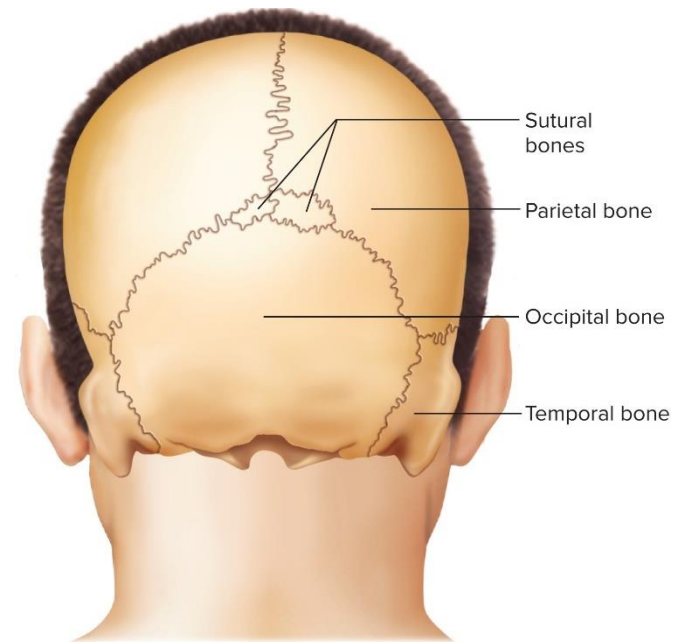
# Figure 7.15 Skeletal Organization

Number of bones in the adult skeleton is about 206

Some people have extra bones, while others lack certain bones

Examples of extra bones that some people have:

- Sutural (wormian) bones in sutures between major skull bones
- Small sesamoid bones in tendons; reduce friction



# Table 7.3 Bones of the Adult Skeleton

1. Axial Skeleton		2. Appendicular Skeleton	
<b>a. Skull</b>	22 bones	<b>a. Pectoral girdle</b>	4 bones
8 cranial bones	14 facial bones	scapula 2	
frontal 1	maxilla 2	clavicle 2	
parietal 2	palatine 2	<b>b. Upper limbs</b>	60 bones
occipital 1	zygomatic 2	humerus 2	
temporal 2	lacrimal 2	radius 2	
sphenoid 1	nasal 2	ulna 2	
ethmoid 1	vomer 1	carpal 16	
	inferior nasal concha 2	metacarpal 10	
	mandible 1	phalanx 28	
<b>b. Middle ear bones</b>	6 bones	<b>c. Pelvic girdle</b>	2 bones
malleus 2		hip bone 2	
incus 2		<b>d. Lower limbs</b>	60 bones
stapes 2		femur 2	
<b>c. Hyoid</b>	1 bone	tibia 2	
hyoid bone 1		fibula 2	
<b>d. Vertebral column</b>	26 bones	patella 2	
cervical vertebra 7		tarsal 14	
thoracic vertebra 12		metatarsal 10	
lumbar vertebra 5		phalanx 28	
sacrum 1		<b>Total</b>	<u>206 bones</u>
coccyx 1			
<b>e. Thoracic cage</b>	25 bones		
rib 24			
sternum 1			

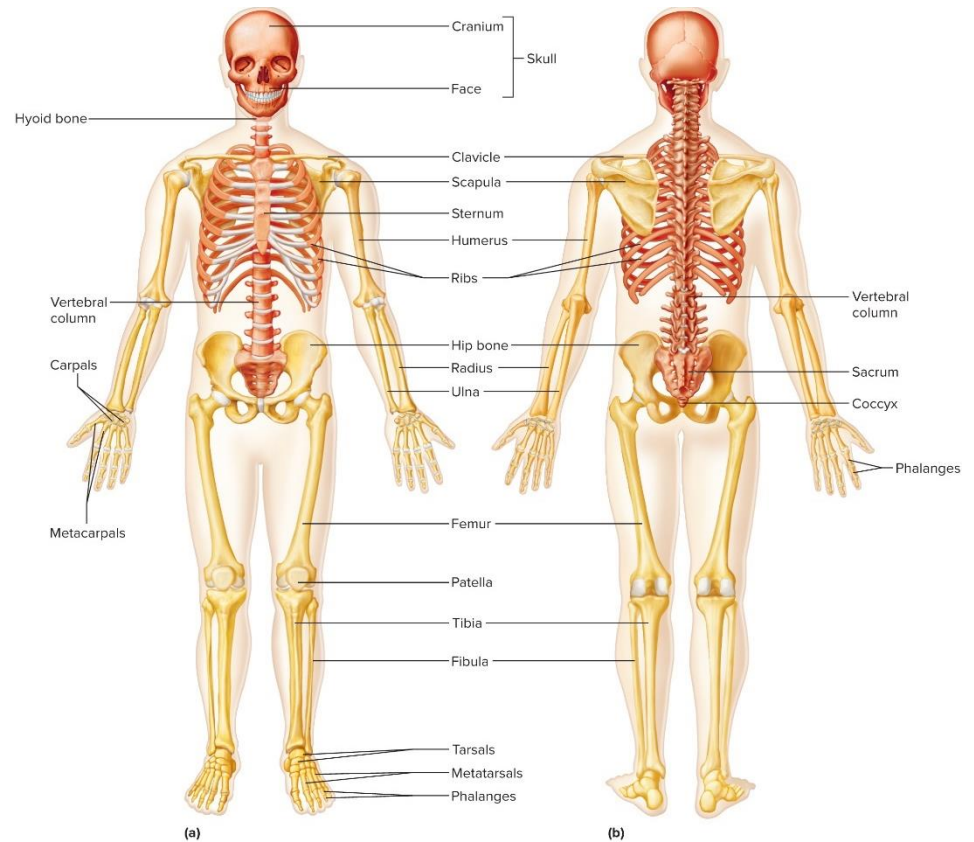
# Figure 7.16 Divisions of the Skeleton

## Axial Skeleton (80 bones):

- Skull
- Middle ear bones
- Hyoid bone
- Vertebral column
- Thoracic cage

## Appendicular Skeleton (126 bones):

- Pectoral girdle
- Upper limbs
- Pelvic girdle
- Lower limbs





# Table 7.4 Terms Used to Describe Skeletal Structures

Term	Definition	Example
Condyle (kon'dīl)	Rounded process that usually articulates with another bone	Occipital condyle of the occipital bone (Fig. 7.22)
Crest (krest)	Narrow, ridge-like projection	Iliac crest of the ilium (Fig. 7.49)
Epicondyle (ep'i-kon'dīl)	Projection situated above a condyle	Medial epicondyle of the humerus (Fig. 7.44)
Facet (fas'et)	Small, nearly flat surface	Costal facet of a thoracic vertebra (Fig. 7.37b)
Fissure (fish'ūr)	Cleft or groove	Inferior orbital fissure in the orbit of the eye (Fig. 7.19)
Fontanel (fon'tah-nel')	Soft spot in the skull where membranes cover the space between bones	Anterior fontanel between the frontal and parietal bones (Fig. 7.32)
Foramen (fo-ra'men)	Opening through a bone that usually serves as a passageway for blood vessels, nerves, or ligaments	Foramen magnum of the occipital bone (Fig. 7.22)
Fossa (fos'ah)	Relatively deep pit or depression	Olecranon fossa of the humerus (Fig. 7.44b)
Fovea (fo've-ah)	Tiny pit or depression	Fovea capitis of the femur (Fig. 7.52b)
Head (hed)	Enlargement on the end of a bone	Head of the humerus (Fig. 7.44)

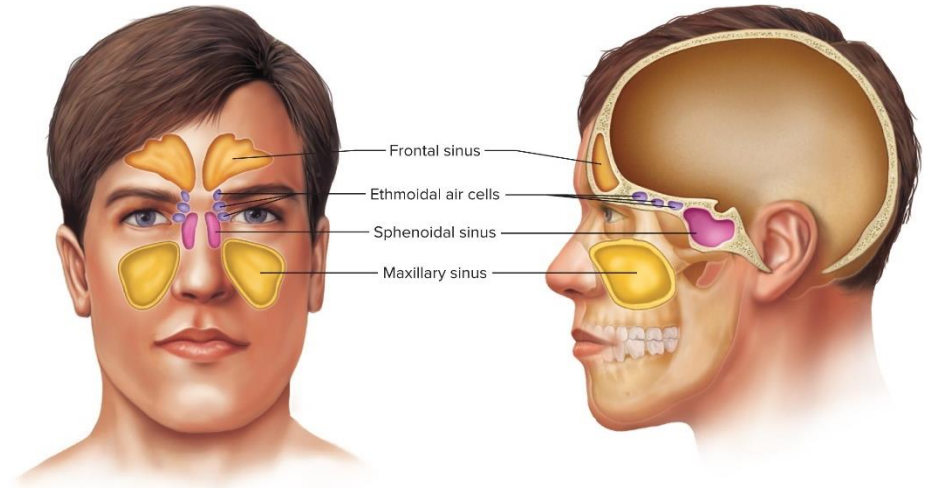
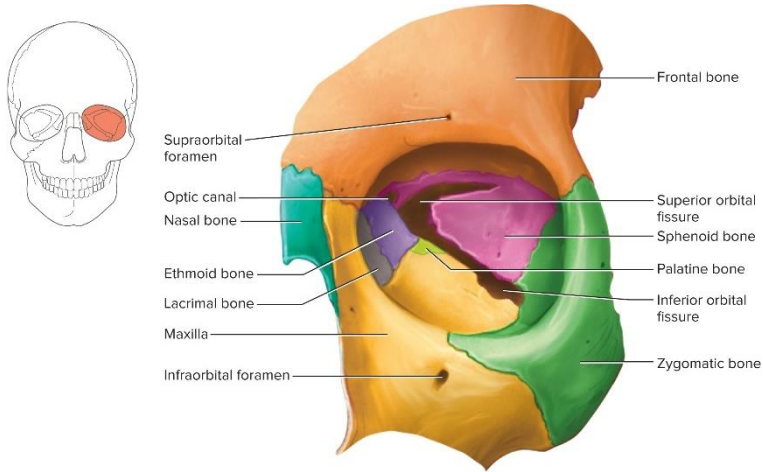
## Table 7.4 Terms Used to Describe Skeletal Structures (continued)

Term	Definition	Example
Linea (lin'e-ah)	Narrow ridge	Linea aspera of the femur (Fig. 7.52b)
Meatus (me-a'tus)	Tube-like passageway within a bone	External acoustic meatus of the temporal bone (Fig. 7.19)
Process (pros'es)	Prominent projection on a bone	Mastoid process of the temporal bone (Fig. 7.19)
Ramus (ra'mus)	Branch or similar extension	Ramus of the mandible (Fig. 7.30a)
Sinus (si'nus)	Cavity within a bone	Frontal sinus of the frontal bone (Fig. 7.21)
Spine (spīn)	Thorn-like projection	Spine of the scapula (Fig. 7.42a, b)
Sulcus (sul'kus)	Furrow or groove	Intertubercular sulcus of the humerus (Fig. 7.44)
Suture (soo'cher)	Interlocking line of union between bones	Lambdoid suture between the occipital and parietal bones (Fig. 7.19)
Trochanter (tro-kan'ter)	Relatively large process	Greater trochanter of the femur (Fig. 7.52a)
Tubercle (tu'ber-kl)	Knob-like process	Tubercle of a rib (Fig. 7.40)
Tuberosity (tu''bĕ-ros'ĭ-te)	Knob-like process usually larger than a tubercle	Radial tuberosity of the radius (Fig. 7.45a)

# The Skull

- The skull is composed of 22 bones typically
- All skull bones are interlocked along sutures, except the lower jaw (mandible)
- The skull = cranium + facial skeleton
- Cranium contains 8 bones; encloses and protects brain
- Facial skeleton contains 14 bones; forms shape of face

# Figure 7.20 and Figure 7.21 The Skull



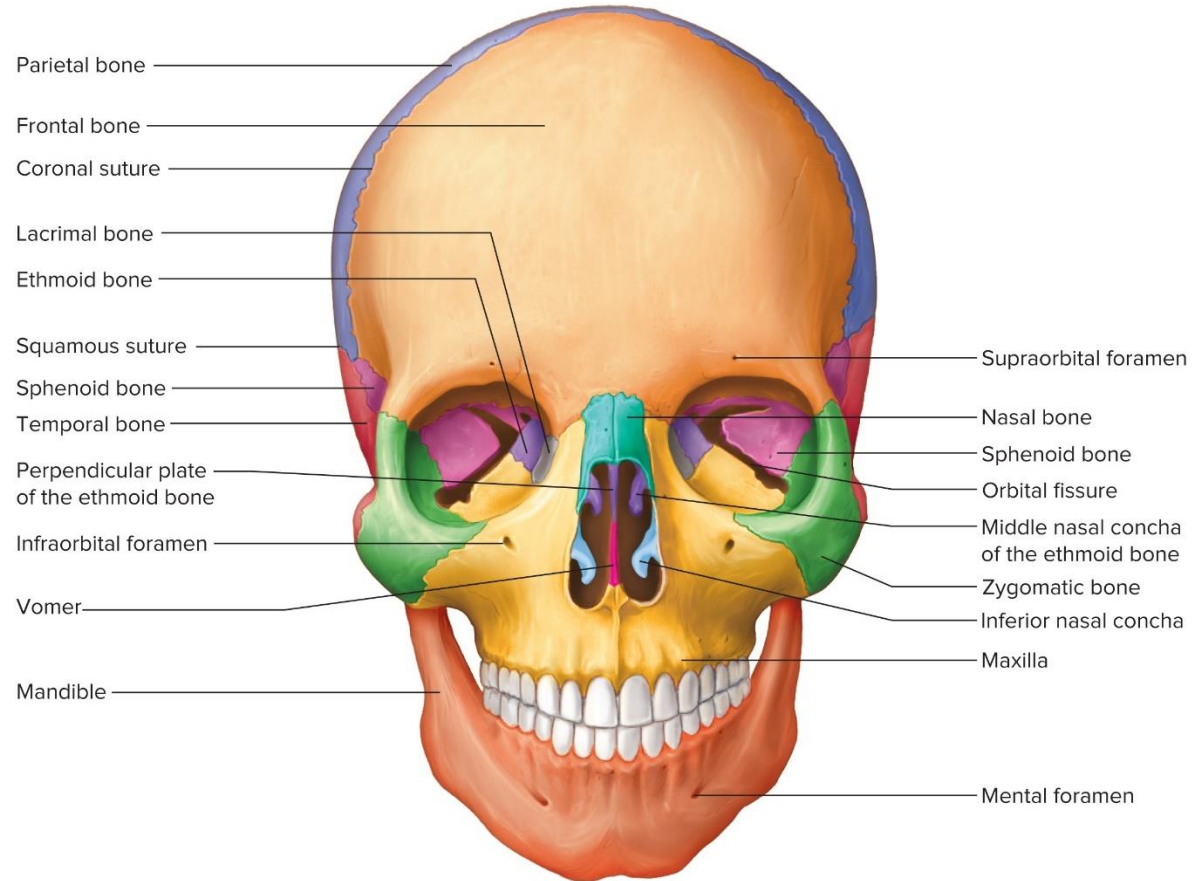
The orbit of the eye contains both cranial and facial bones.

There are paranasal sinuses in both cranial and facial bones.

# Figure 7.18 Cranium

## Frontal Bone (1):

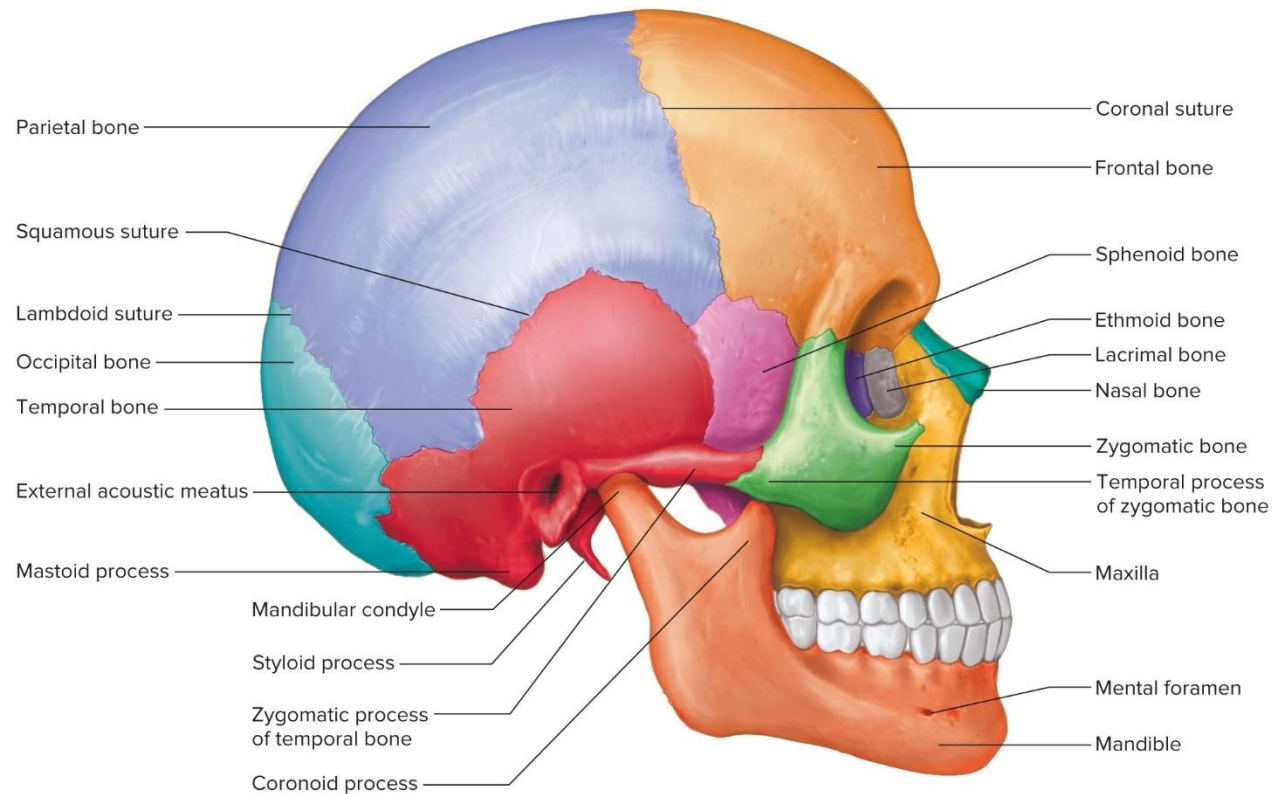
- Forehead
- Roof of nasal cavity
- Roofs of orbits
- Frontal sinuses
- Supraorbital foramen



# Figure 7.19 Cranium

## Parietal Bones (2):

- Sides & roof of cranium
- Sagittal suture
- Coronal suture

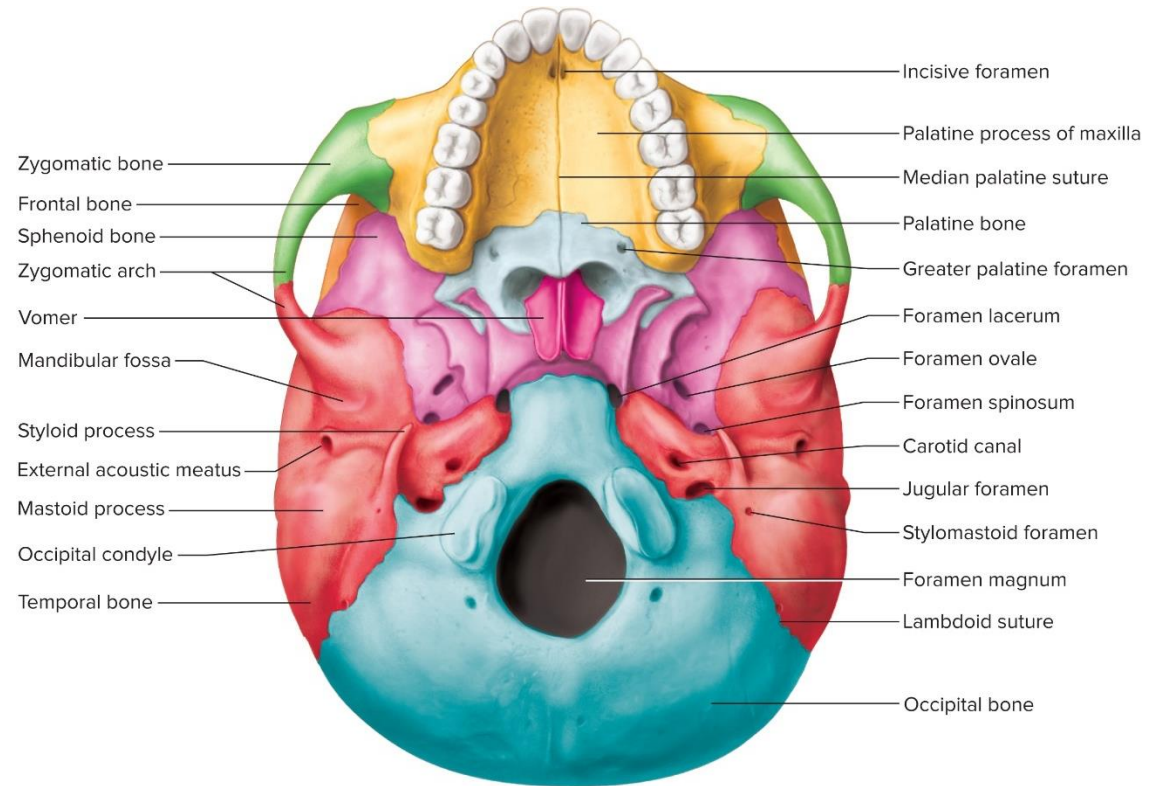




# Figure 7.22 Cranium

## Occipital Bone (1):

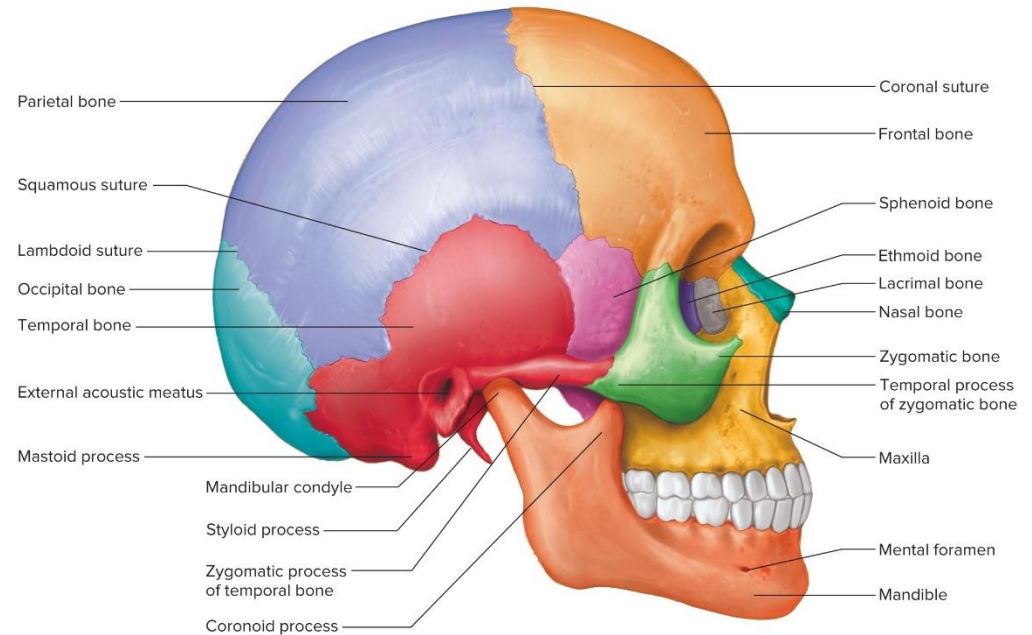
- Back of skull
- Base of cranium
- Foramen magnum
- Occipital condyles
- Lambdoid suture



# Figure 7.19 Cranium

## Temporal Bones (2):

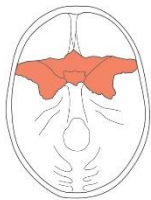
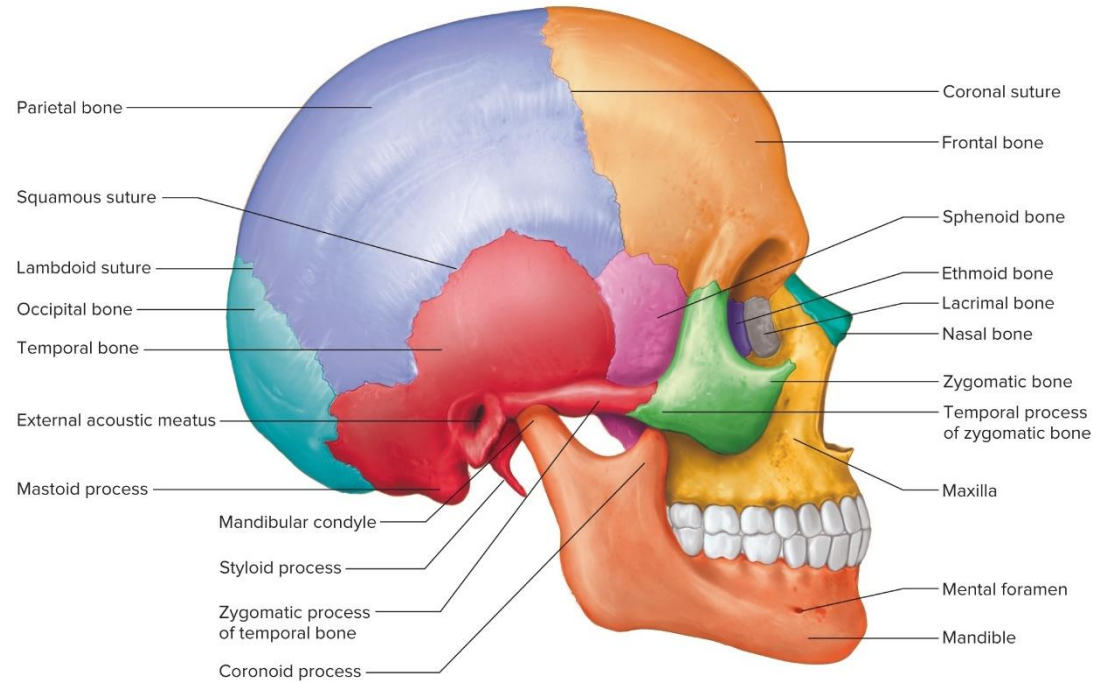
- Sides & base of cranium
- Floors and sides of orbits
- Squamous suture
- External acoustic meatus
- Mandibular fossa
- Mastoid process
- Styloid process
- Zygomatic process
- Zygomatic arch



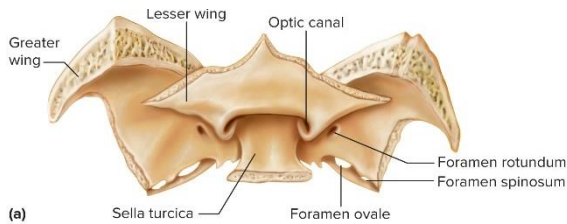
# Figure 7.23 and Figure 7.19 Cranium

## Sphenoid Bone (1):

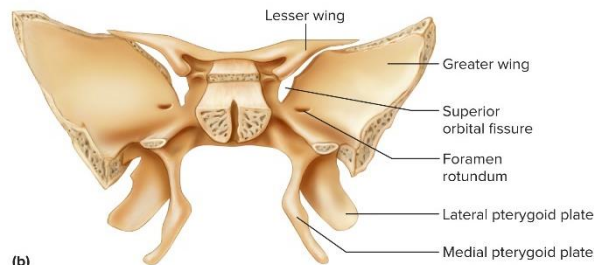
- Base of cranium
- Sides of skull
- Floors and sides of orbits
- Sella turcica
- Sphenoid sinuses



Transverse section



(a)

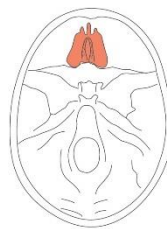
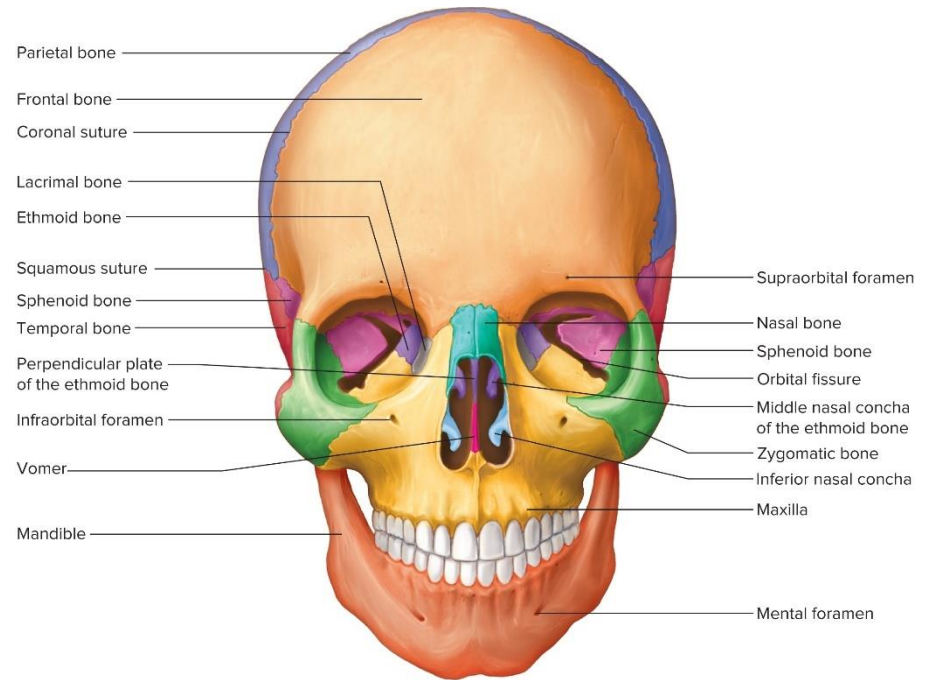


(b)

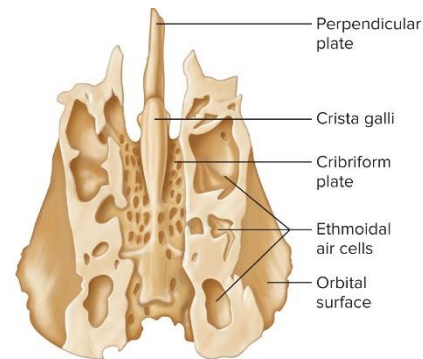
# Figure 7.18 and Figure 7.24 Cranium

## Ethmoid Bone (1):

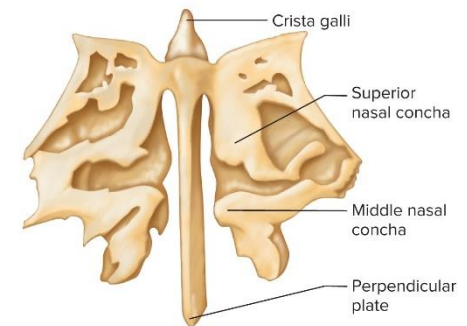
- In front of sphenoid
- Roof and walls of nasal cavity
- Floor of cranium
- Wall of orbits
- Cribriform plates
- Perpendicular plate
- Superior and middle nasal conchae
- Ethmoidal air cells
- Crista galli



Transverse section



(a)

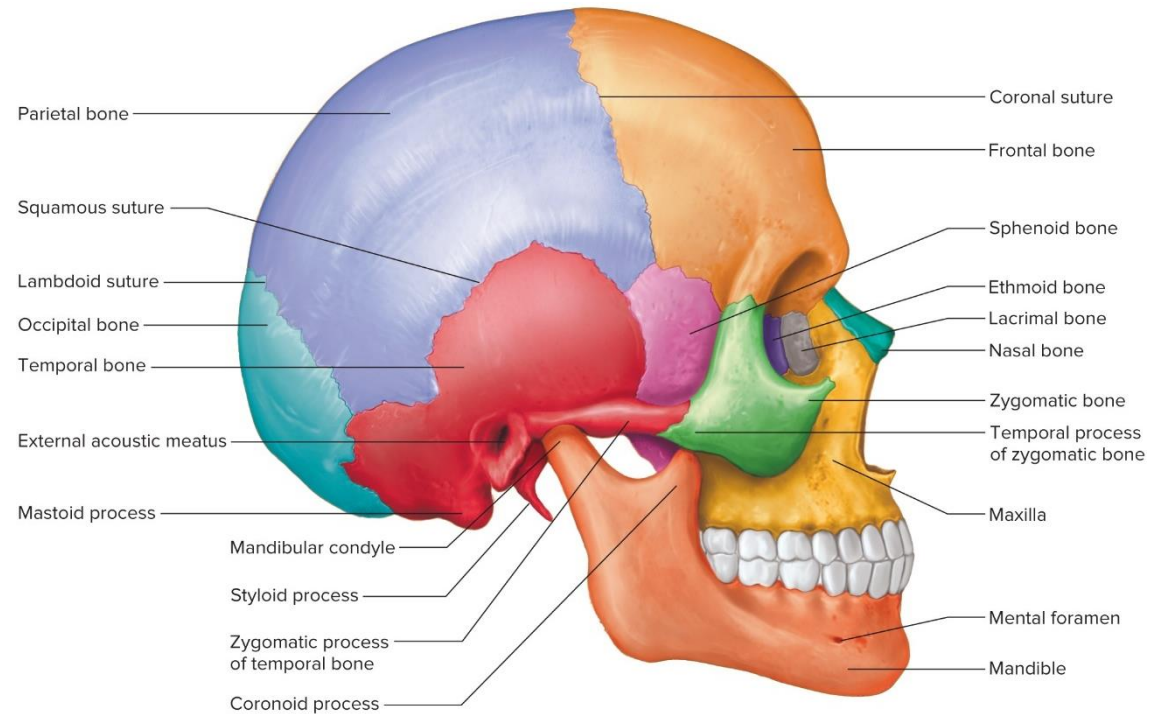


(b)

# Figure 7.19 Cranial Sutures

## Major Sutures of the Cranium:

- Coronal
- Sagittal
- Squamous
- Lambdoid

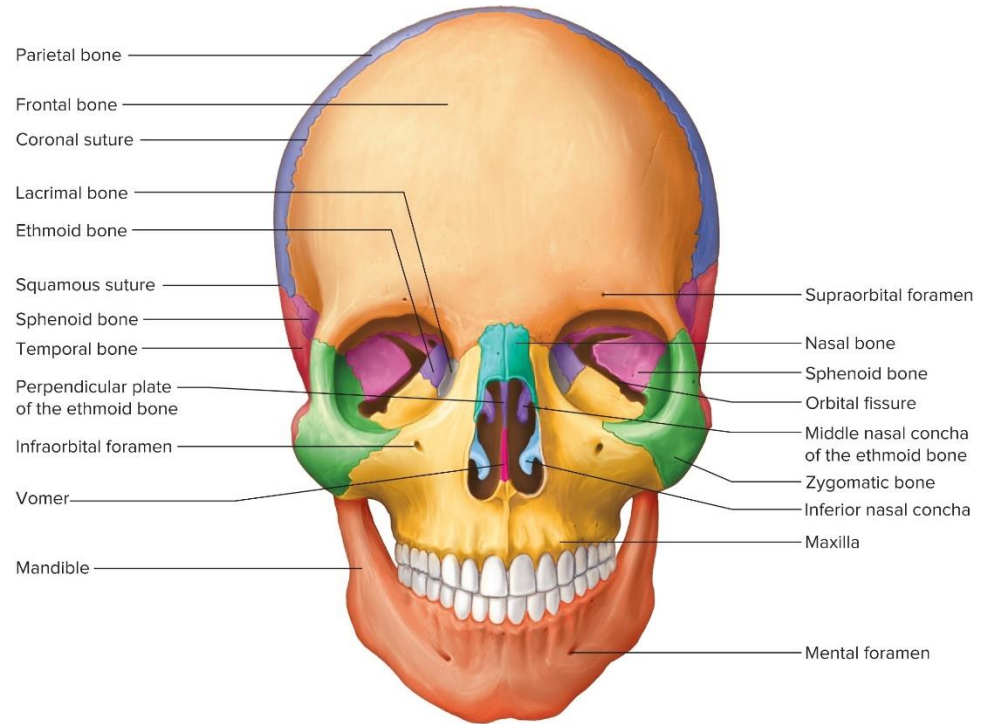




# Figure 7.18 Facial Skeleton

## Maxillae (Maxillary Bones, 2):

- Upper jaw
- Anterior roof of mouth (hard palate)
- Floors of orbits
- Sides & floors of nasal cavity
- Alveolar processes
- Maxillary sinuses
- Palatine processes

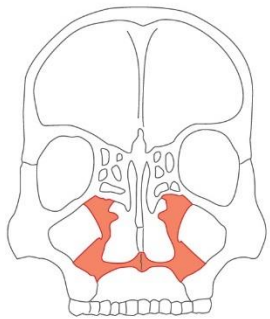
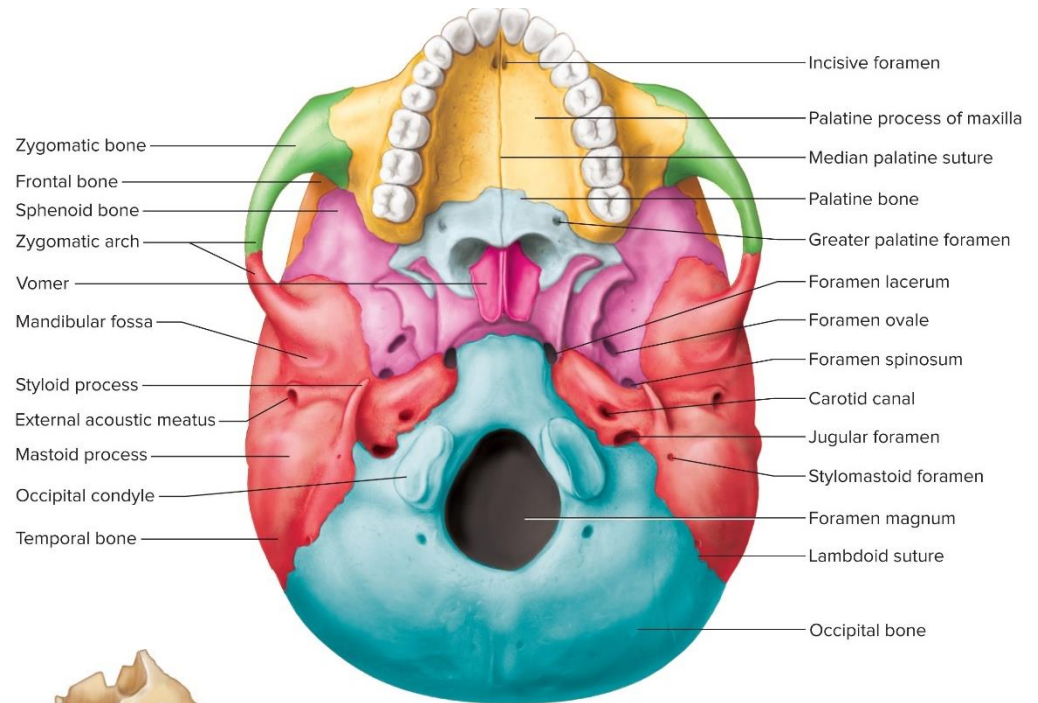




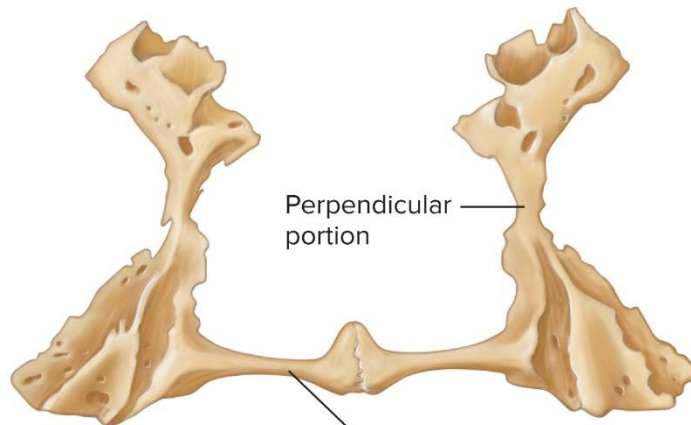
# Figure 7.22 and Figure 7.27 Facial Skeleton

## Palatine Bones (2):

- L-shaped bones located behind the maxillae
- Posterior section of hard palate
- Floor & lateral walls of nasal cavity



Frontal section



Perpendicular portion

Horizontal portion

# Figure 7.19 Facial Skeleton

## Zygomatic Bones (2):

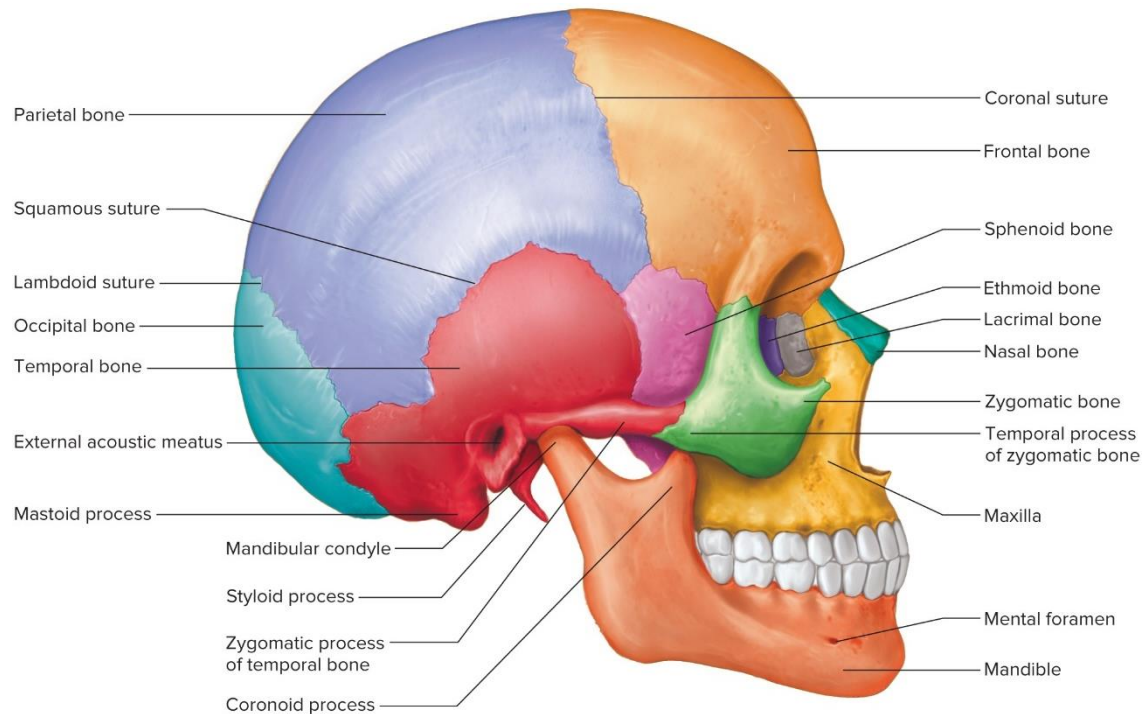
- Prominences of cheeks
- Lateral walls & floors of orbits
- Temporal process
- Zygomatic arch

## Lacrimal Bones (2):

- Medial walls of orbits
- Groove from orbit to nasal cavity for tears

## Nasal Bones (2):

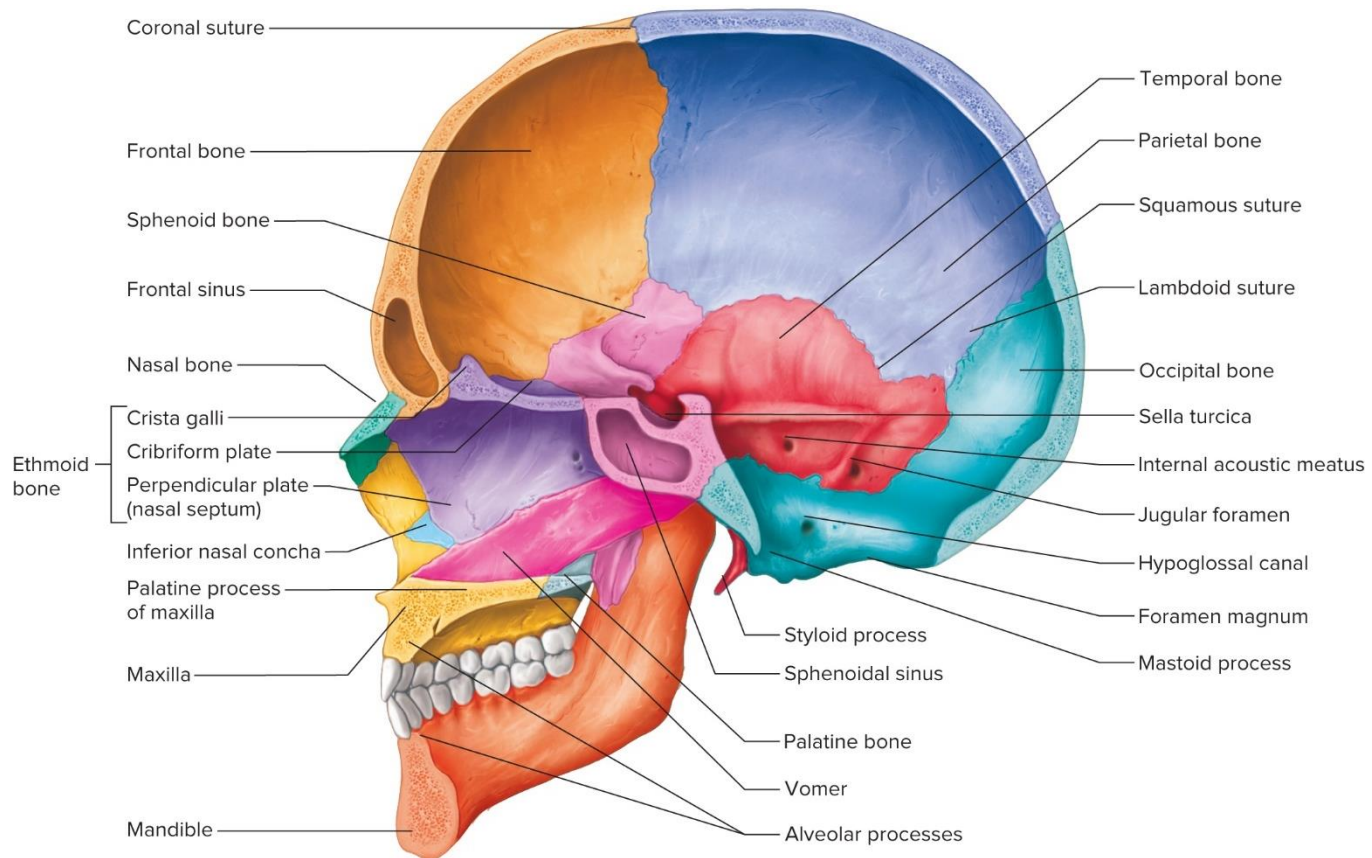
- Bridge of nose



# Figure 7.28 Facial Skeleton

## Vomer Bone (1):

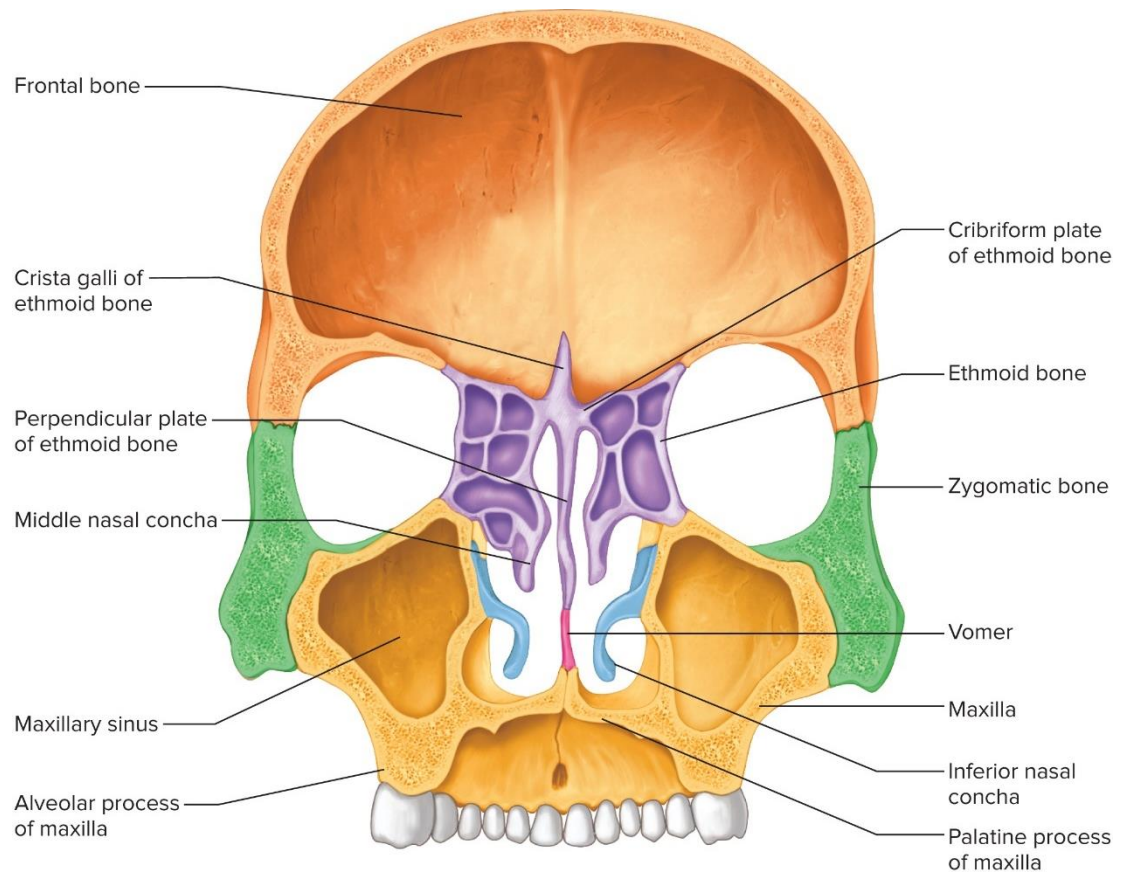
- Along midline of nasal cavity
- Inferior portion of nasal septum



# Figure 7.29 Facial Skeleton

## Inferior Nasal Conchae (2):

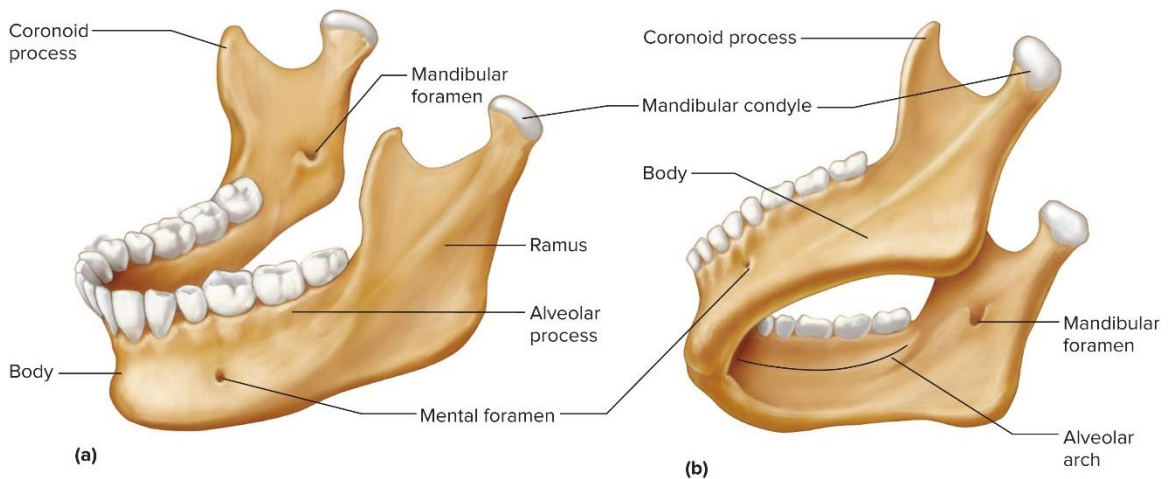
- Scroll-shaped bones
- Extend from lateral walls of nasal cavity
- Largest of the conchae



# Figure 7.30 Facial Skeleton

## Mandible (1):

- Lower jawbone
- Horseshoe-shaped body
- Ramus
- Mandibular condyle
- Coronoid process
- Alveolar process
- Mandibular foramen
- Mental foramen

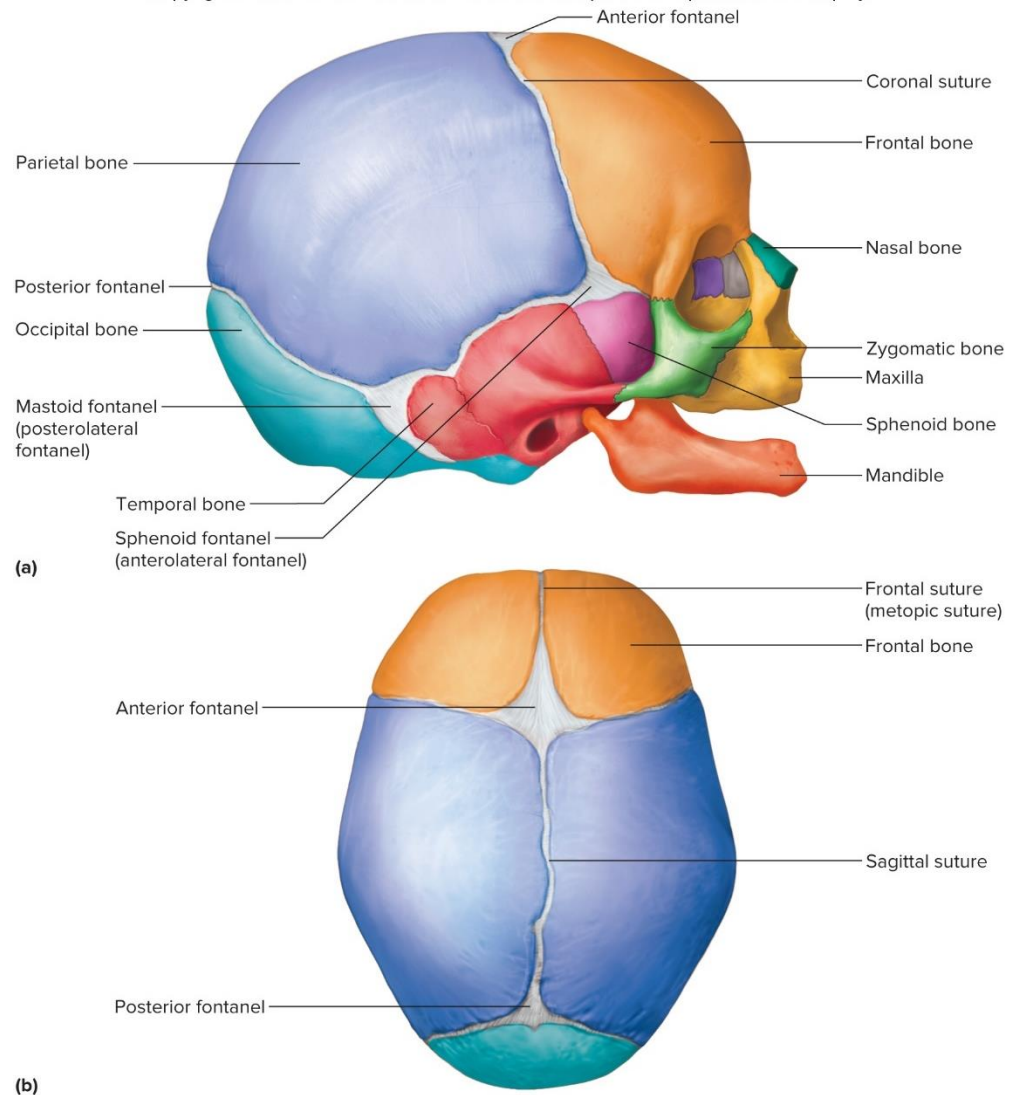




# Figure 7.32 Infantile Skull

## Fontanelles (soft spots):

Fibrous membranes connect cranial bones, where intramembranous ossification is incomplete



# Vertebral Column

## Vertebral Column:

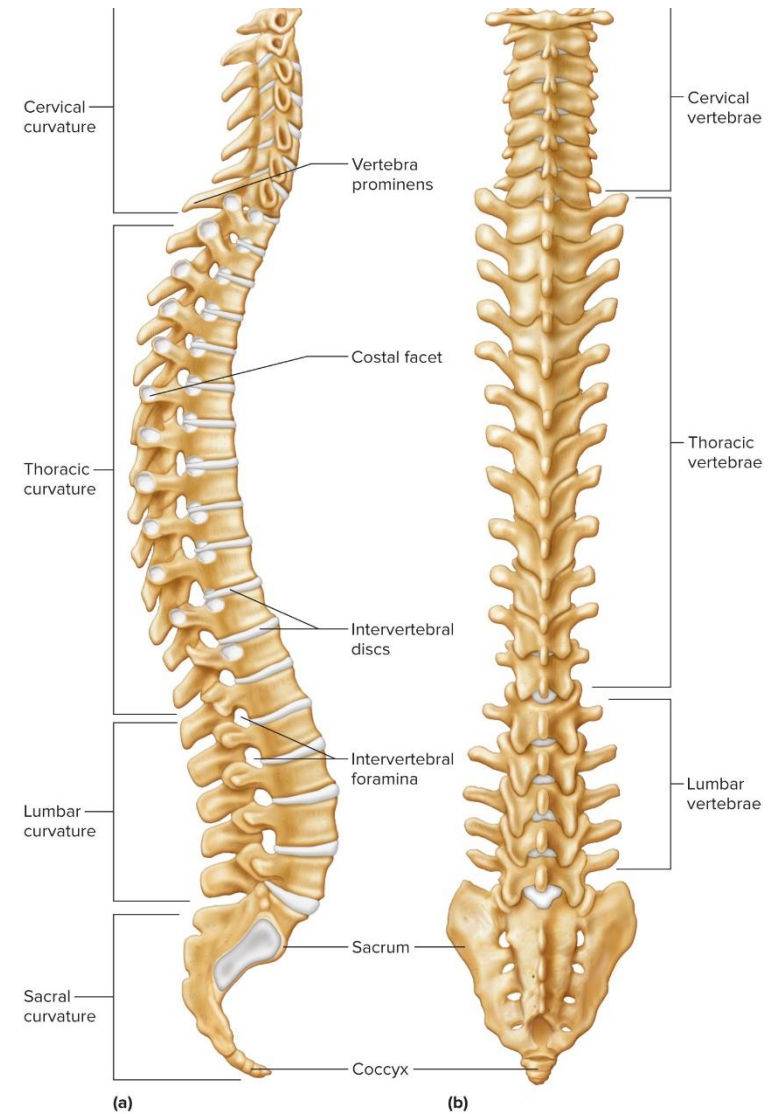
- Forms vertical axis of skeleton
- Consists of many vertebrae separated by cartilaginous intervertebral discs, and connected by ligaments
- Supports head and trunk, permits several types of movements
- Protects spinal cord in vertebral canal
- 33 separate bones in infant, 26 in adult



# Figure 7.33 Vertebral Column

## 4 Curvatures of Vertebral Column:

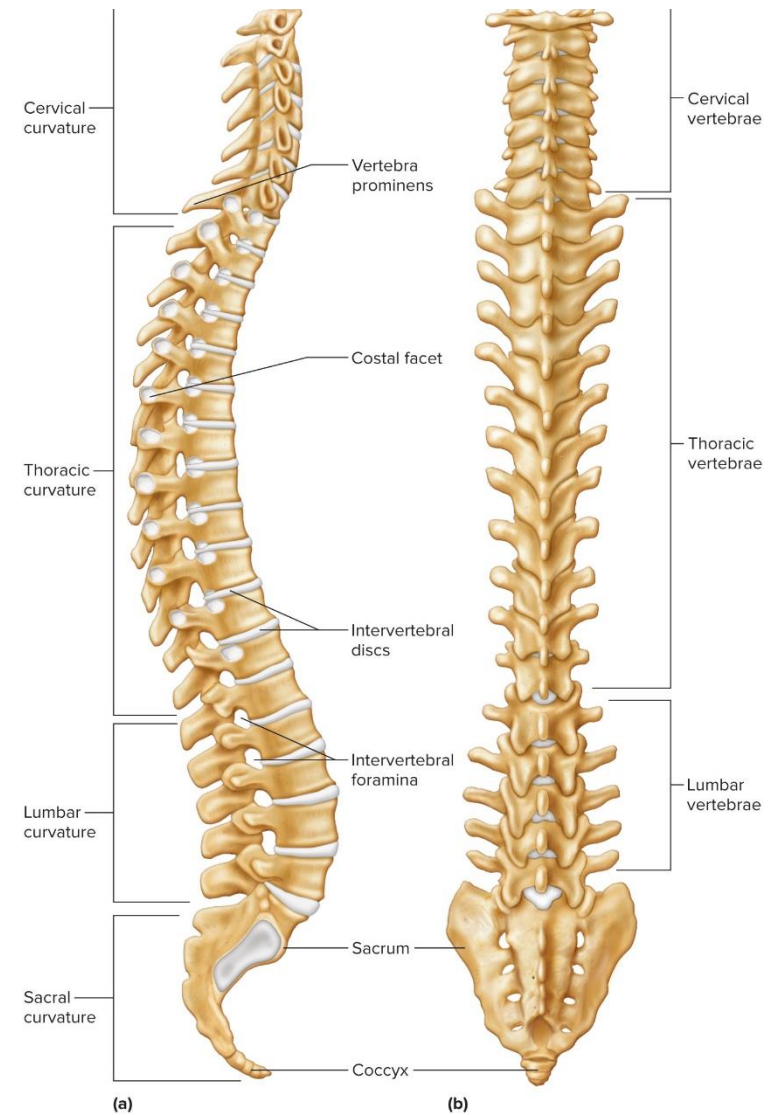
- Cervical curvature (secondary)
- Thoracic curvature (primary)
- Lumbar curvature (secondary)
- Sacral curvature (primary)



# Figure 7.33 Vertebral Column

## Vertebral Column consists of:

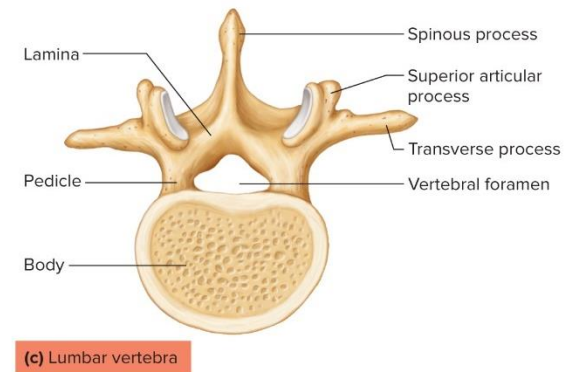
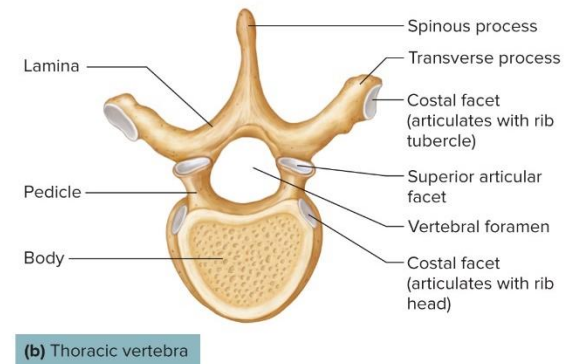
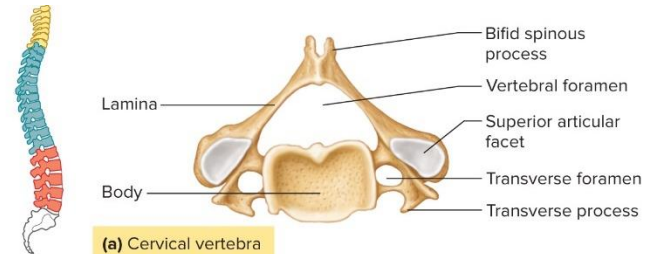
- 7 cervical vertebrae
- 12 thoracic vertebrae
- 5 lumbar vertebrae
- 5 fused sacral vertebrae form sacrum
- 4 fused coccygeal vertebrae form coccyx



# Figure 7.37 A Typical Vertebra

A typical vertebra contains the following parts:

- Body
- Pedicles
- Laminae
- Spinous process
- Transverse processes
- Vertebral foramen
- Facets
- Superior and inferior articular processes



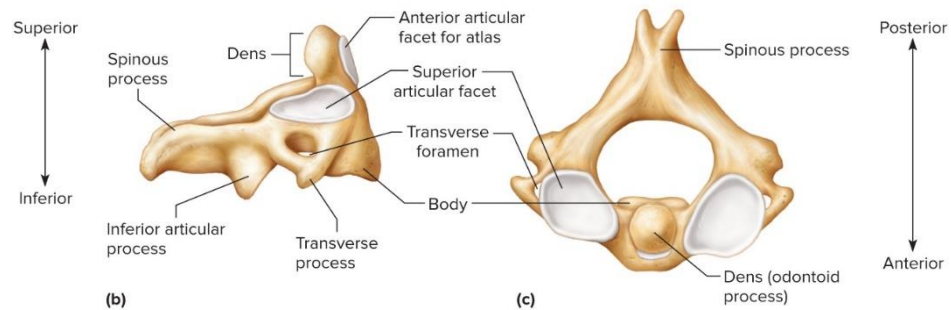
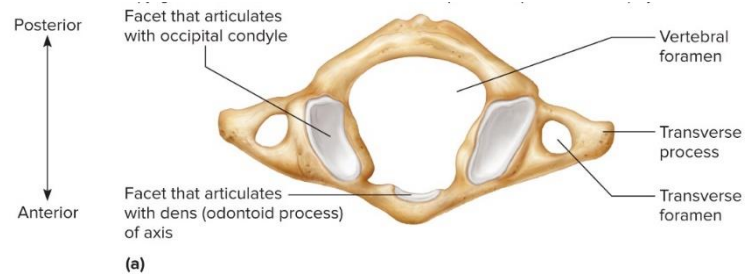
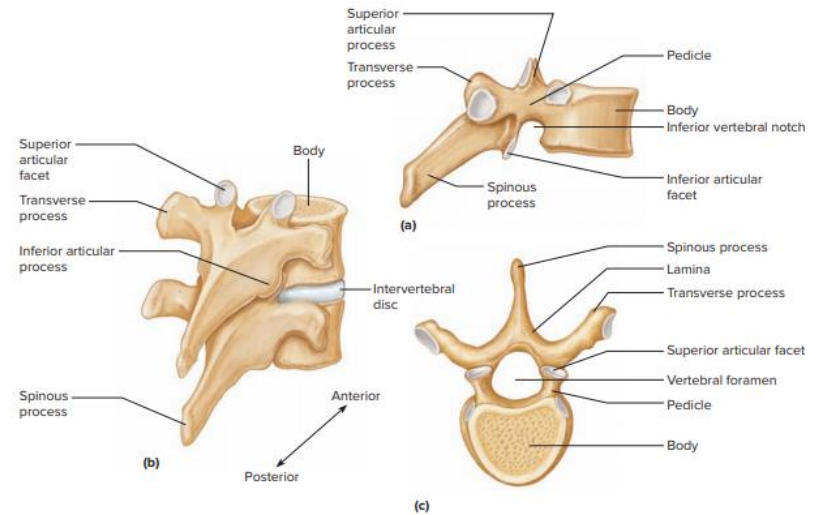
# Figure 7.34 and Figure 7.35 Cervical Vertebrae

## 7 cervical vertebrae in neck region:

- Smallest vertebrae
- Transverse foramina
- Bifid spinous processes (on C2-C6)
- Vertebral prominens (on C7)

**Atlas:** C1,  
supports head

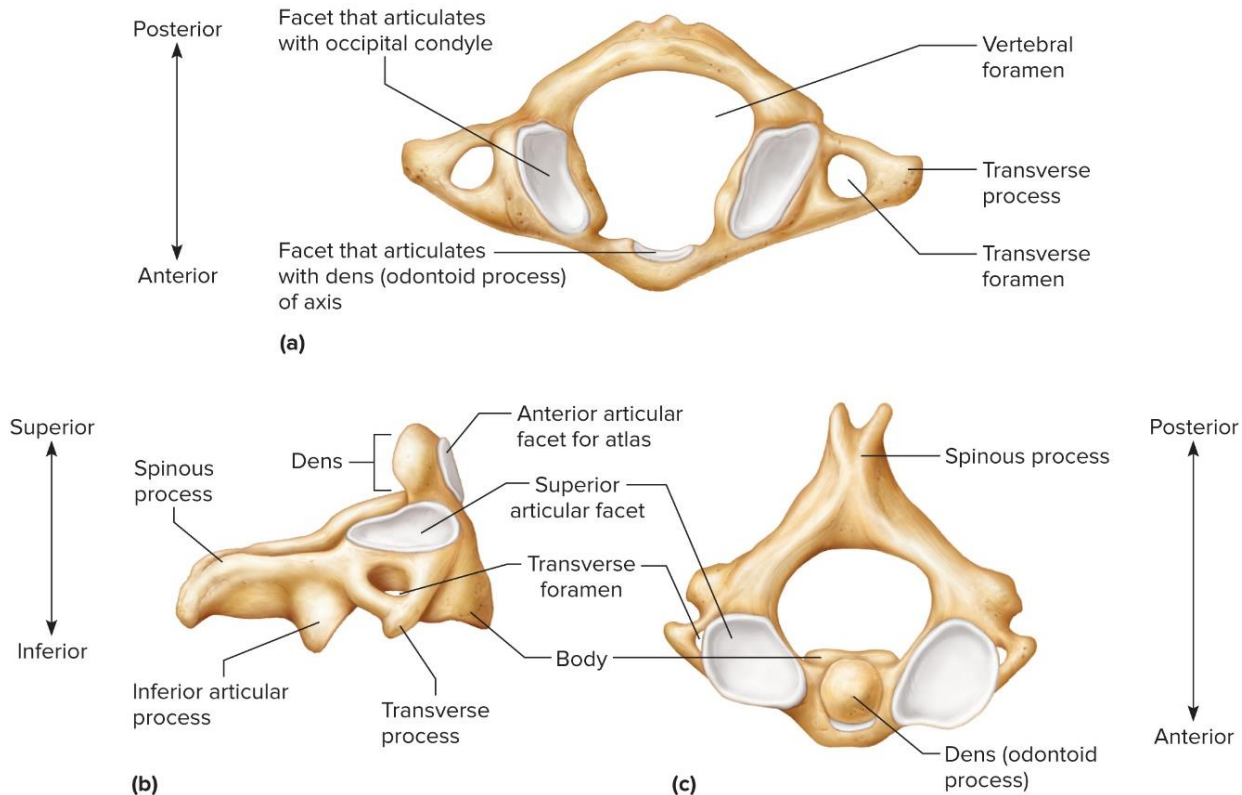
**Axis:** C2; Atlas  
pivots around the *dens*



# Figure 7.35 Thoracic Vertebrae

## 12 thoracic vertebrae in chest region:

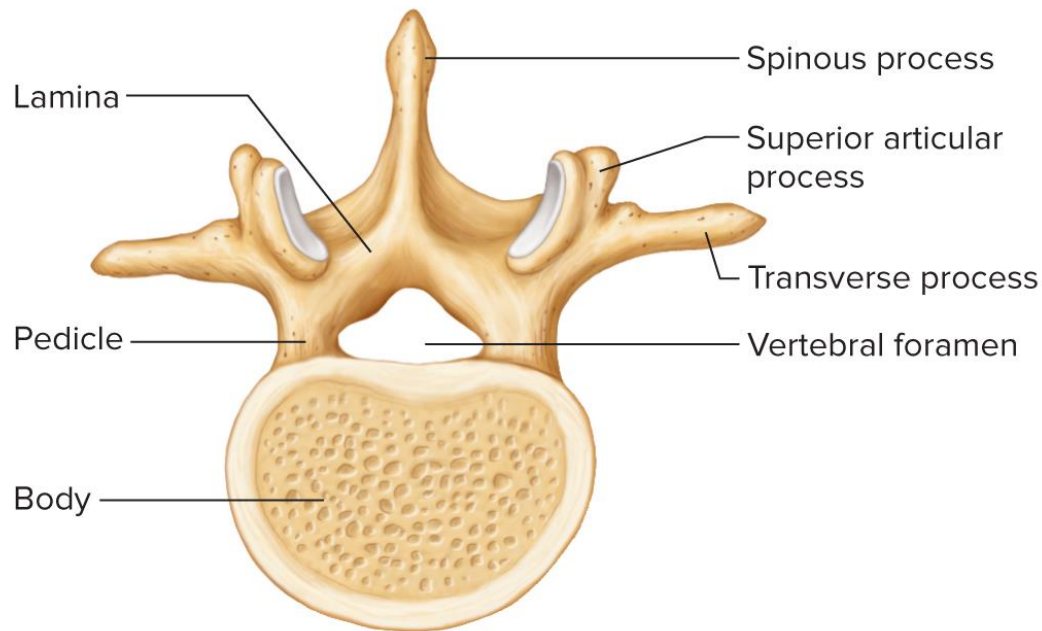
- Larger than cervical vertebrae
- Articulate with ribs
- Long, pointed spinous process



# Figure 7.37c Lumbar Vertebrae

## 5 lumbar vertebrae in small of back:

- Large bodies
- Thick, short spinous processes
- Weight-bearing
- Spinous processes are thick, almost horizontal



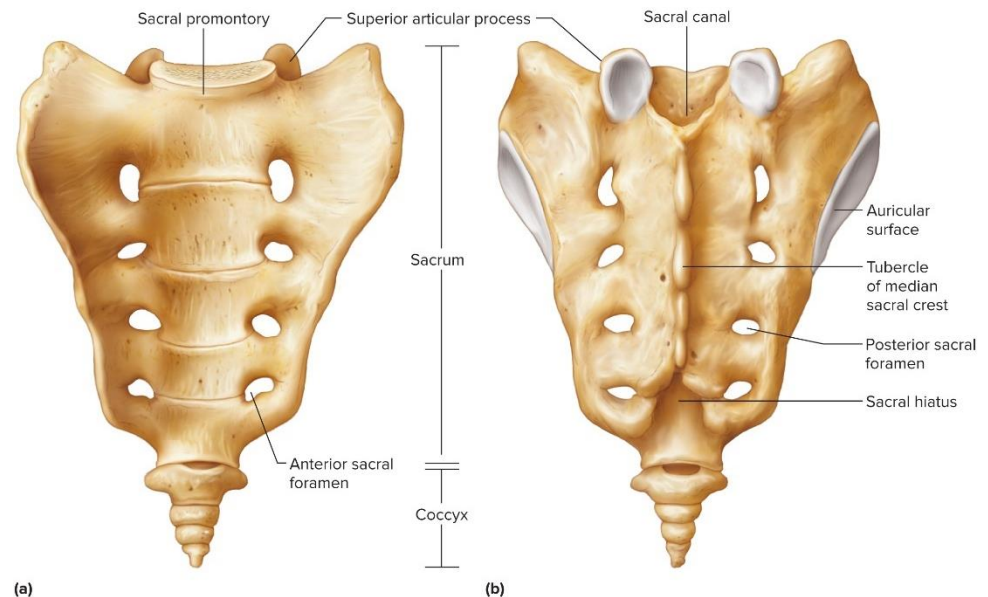
**(c)** Lumbar vertebra



# Figure 7.38 Sacrum

**Sacrum:** triangular structure, at base of vertebral column

- Typically 5 fused vertebrae
- Median sacral crest
- Posterior sacral foramina
- Forms sacroiliac joints
- Forms posterior wall of pelvic cavity
- Sacral promontory: upper margin
- Sacral canal
- Sacral hiatus

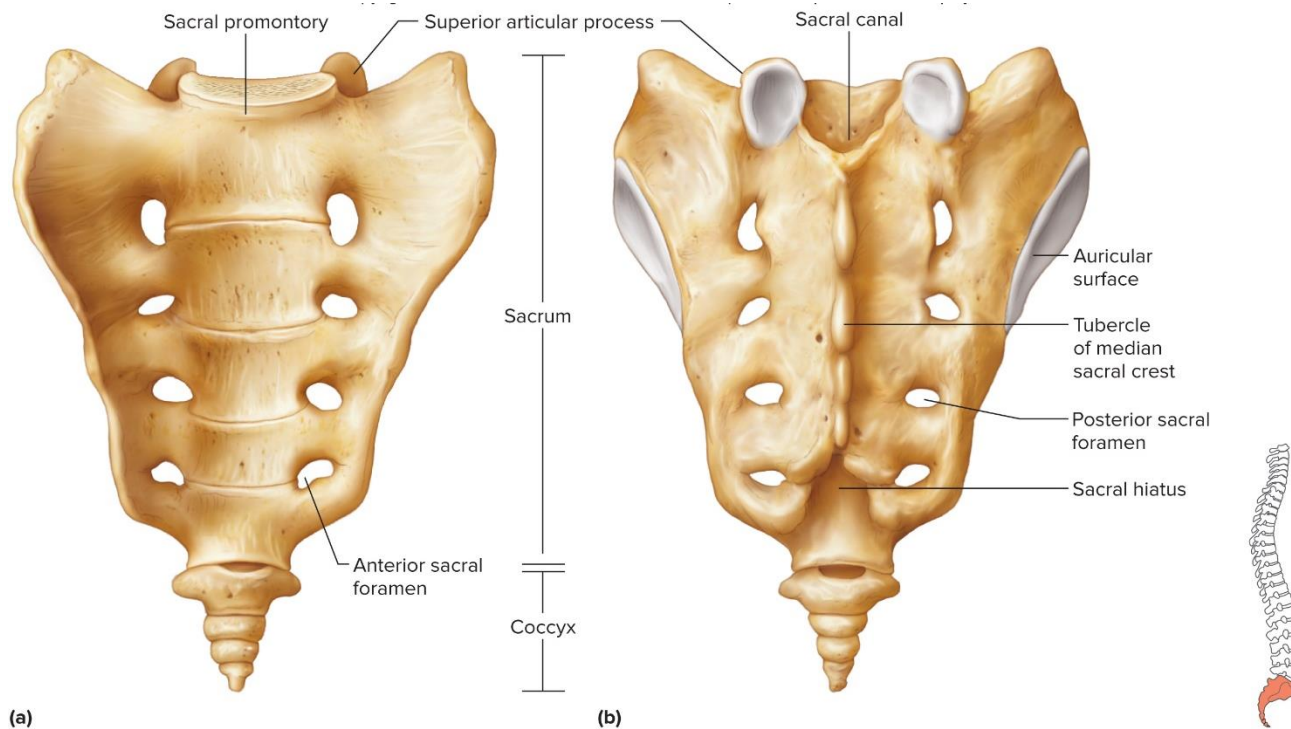




# Figure 7.38 Coccyx

## Coccyx:

- Tailbone
- Usually 4 fused vertebrae
- Fuse between ages of 25 and 30



# Table 7.8 Bones of the Vertebral Column

Bones	Number	Special Features	Bones	Number	Special Features
Cervical vertebra	7	Transverse foramina; facets of atlas that articulate with occipital condyles of skull; dens of axis that articulates with atlas; spinous processes of second through sixth vertebrae are bifid	Lumbar vertebra	5	Large bodies; thinner transverse processes that project laterally; short, thick spinous processes that project posteriorly nearly horizontal
Thoracic vertebra	12	Transverse processes that project posteriorly at sharp angles; pointed spinous processes that slope downward; facets that articulate with ribs	Sacrum	5 vertebrae fused	Posterior sacral foramina, auricular surfaces, sacral promontory, sacral canal, sacral hiatus, anterior sacral foramina
			Coccyx	4 vertebrae fused	Attached by ligaments to the margins of the sacral hiatus

# Clinical Application 7.3

## Disorders of the Vertebral Column

**Herniated or Ruptured (protruding) disc:** break in the outer portion of an intervertebral disc; compresses spinal nerves, causing numbness, pain, loss of muscle function

**Kyphosis:** exaggerated thoracic curvature of the spine; rounded shoulders and hunchback; caused by poor posture, injury, disease

**Scoliosis:** abnormal lateral curvature of the spine; one shoulder or hip may be lower than the other, leading to compression of visceral organs

**Lordosis:** exaggerated lumbar curvature of the spine; swayback

**Compression fractures:** fractures of vertebral bodies become more common with age, as intervertebral discs become rigid and shrink; back may bow due to accentuated curvature

# Thoracic Cage

- The thoracic cage includes the ribs, the thoracic vertebrae, the sternum, and the costal cartilages that attach the ribs to the sternum.
- Supports pectoral girdle and upper limbs
- Protects thoracic and upper abdominal viscera
- Role in breathing

# Figure 7.39 Ribs

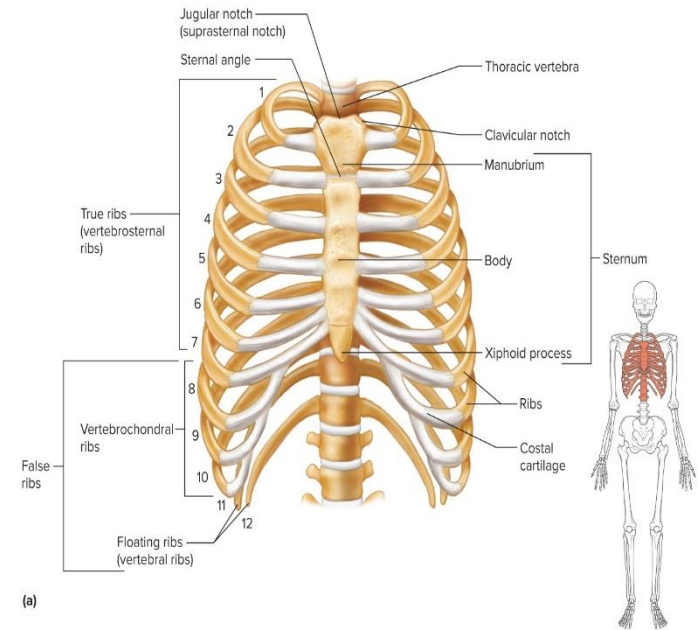
Humans have 12 pairs of ribs:

True ribs (vertebrosternal, 7 pairs)

False ribs (5 pairs):

- Vertebrochondral ribs (upper 3 pairs of false ribs)
- Floating ribs (vertebral, lower 2 pairs of false ribs)

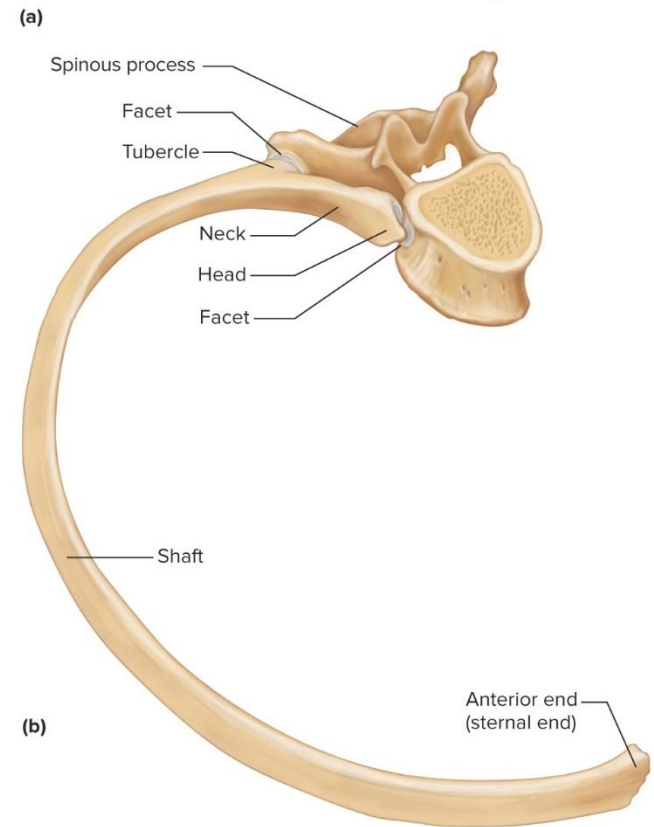
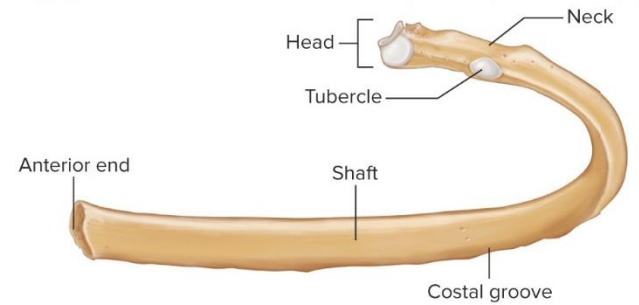
There is some individual variation, in that occasionally a person has an extra rib



# Figure 7.40 Rib Structure

## Structure of a rib:

- Shaft: main portion; long and slender
- Head: posterior end; articulates with vertebrae
- Tubercle: articulates with vertebra
- Costal cartilage: hyaline cartilage; connects rib to sternum

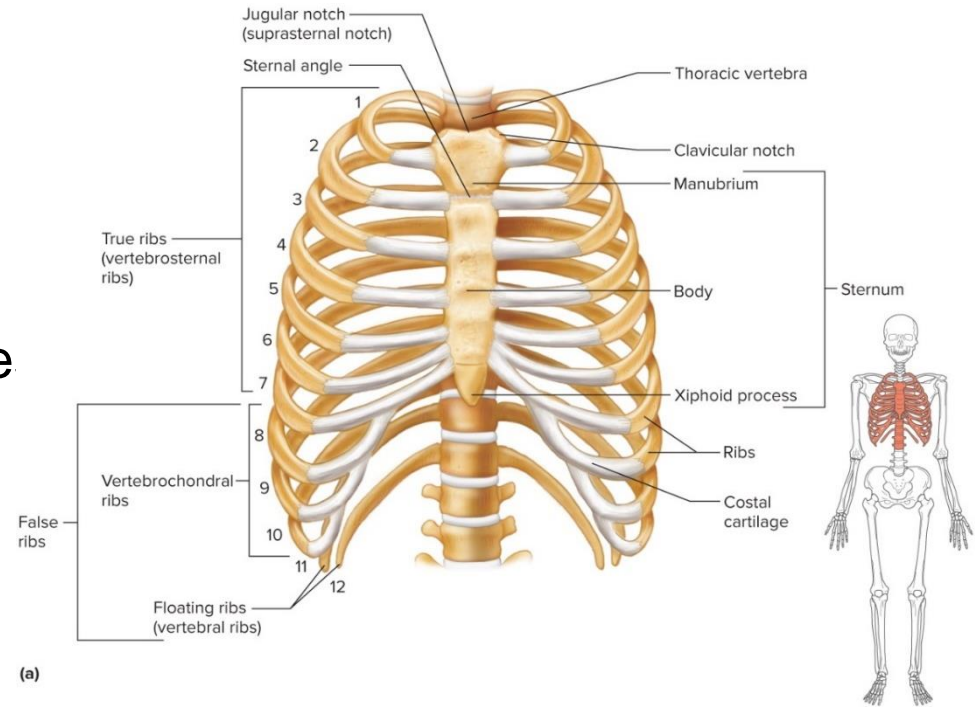


# Figure 7.39a Sternum

## Sternum (breastbone):

3 parts:

- Manubrium
- Body
- Xiphoid process
- Articulates with costal cartilage and clavicles



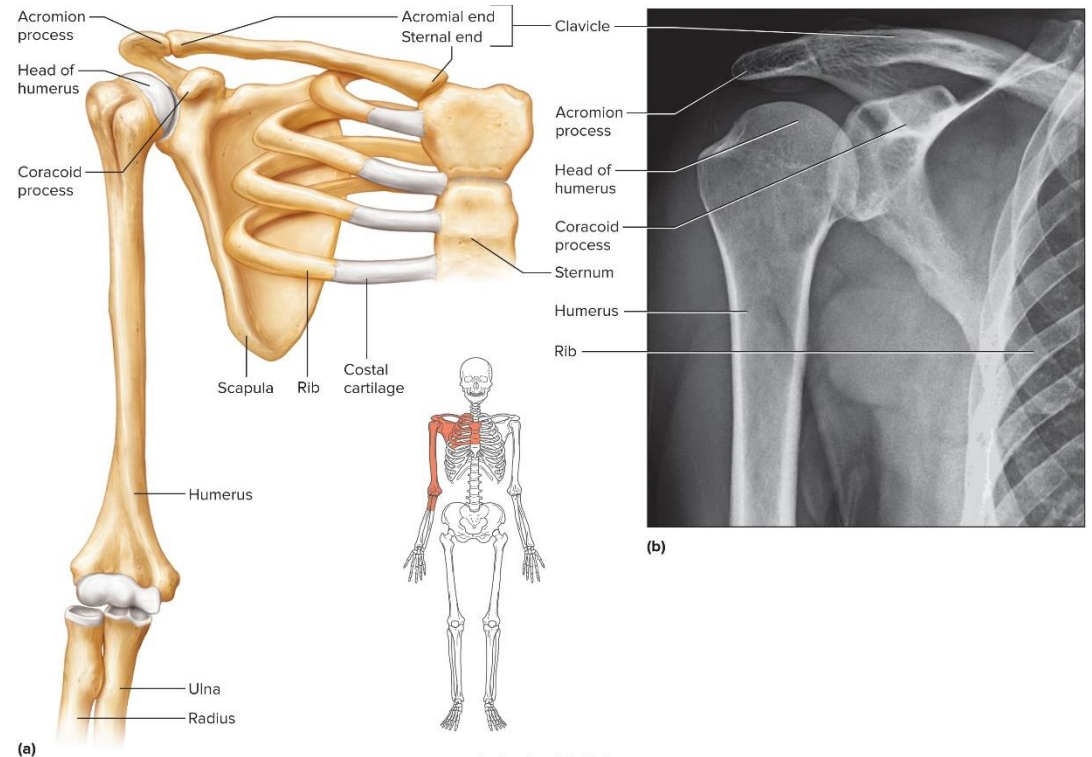


# Figure 7.41 Pectoral Girdle

## Pectoral (shoulder) girdle:

Consists of 2 clavicles and 2 scapulae

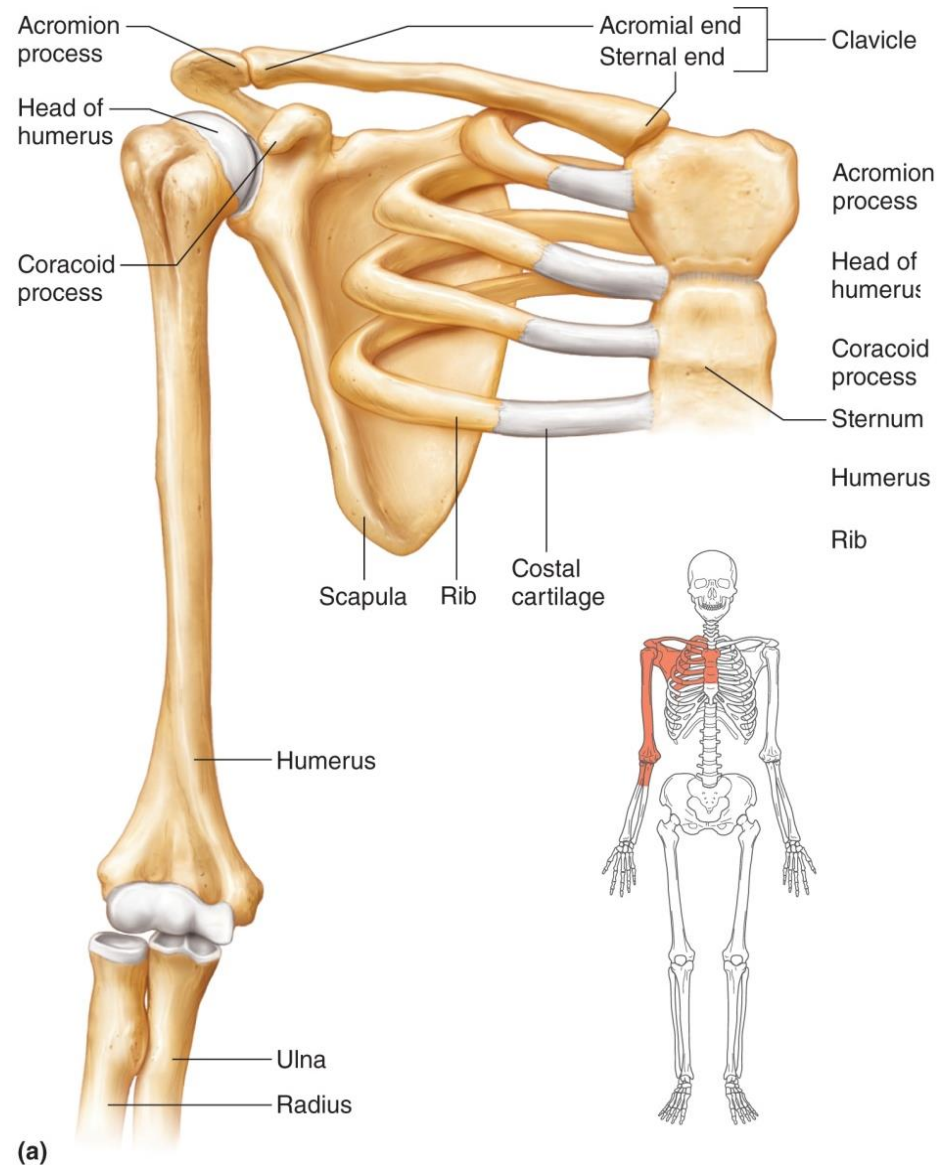
- Clavicles = collarbones
- Scapulae = shoulder blades
- Supports upper limbs



# Figure 7.41a Clavicles

## Clavicles:

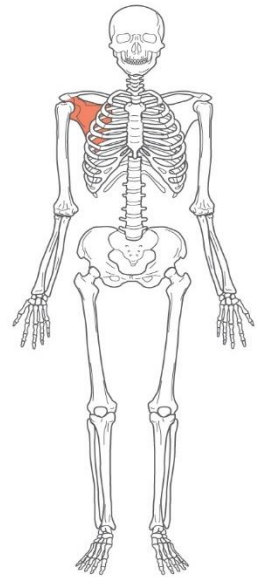
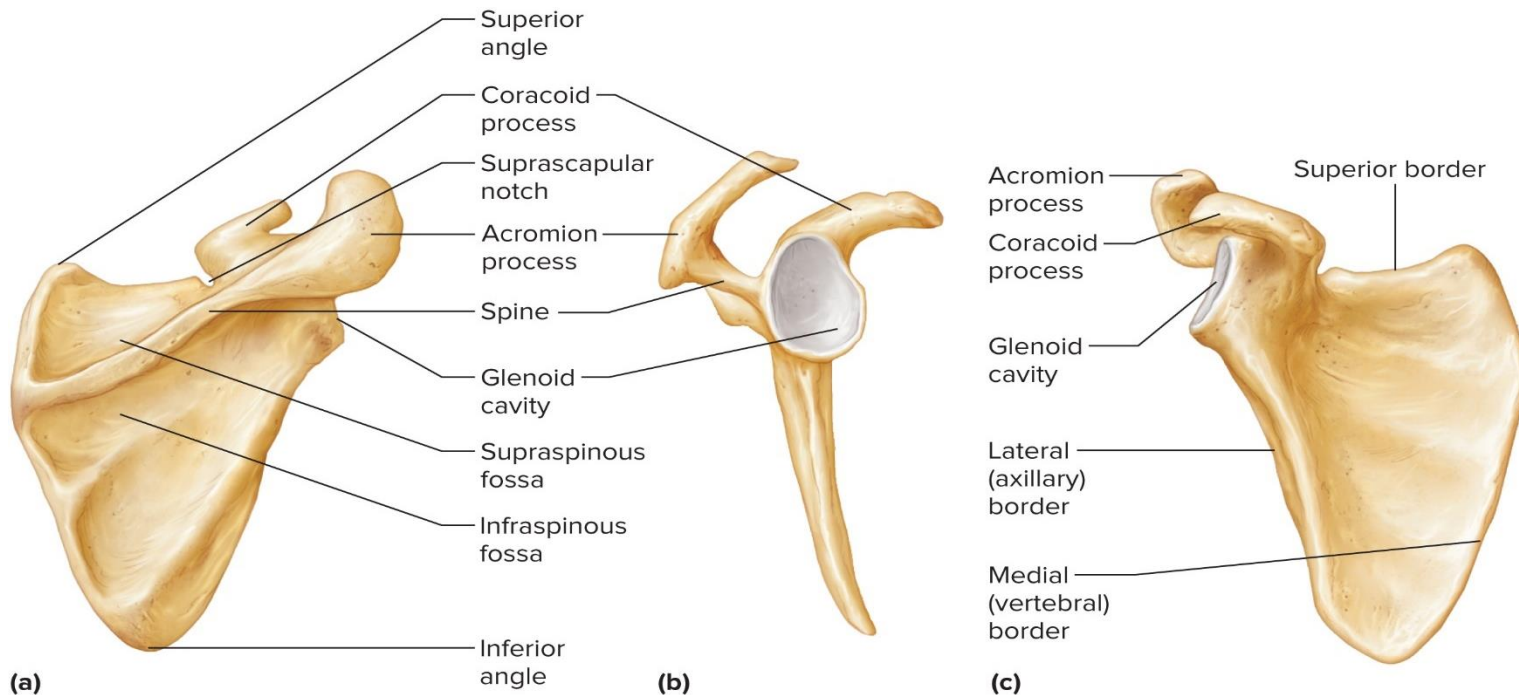
- S-shaped
- Articulate with manubrium and scapulae
- Brace the scapulae, which are freely movable



# Figure 7.42 Scapulae

## Scapulae:

- Spine
- Suprascapular fossa
- Infraspinous fossa
- Acromion process
- Coracoid process
- Glenoid fossa or cavity

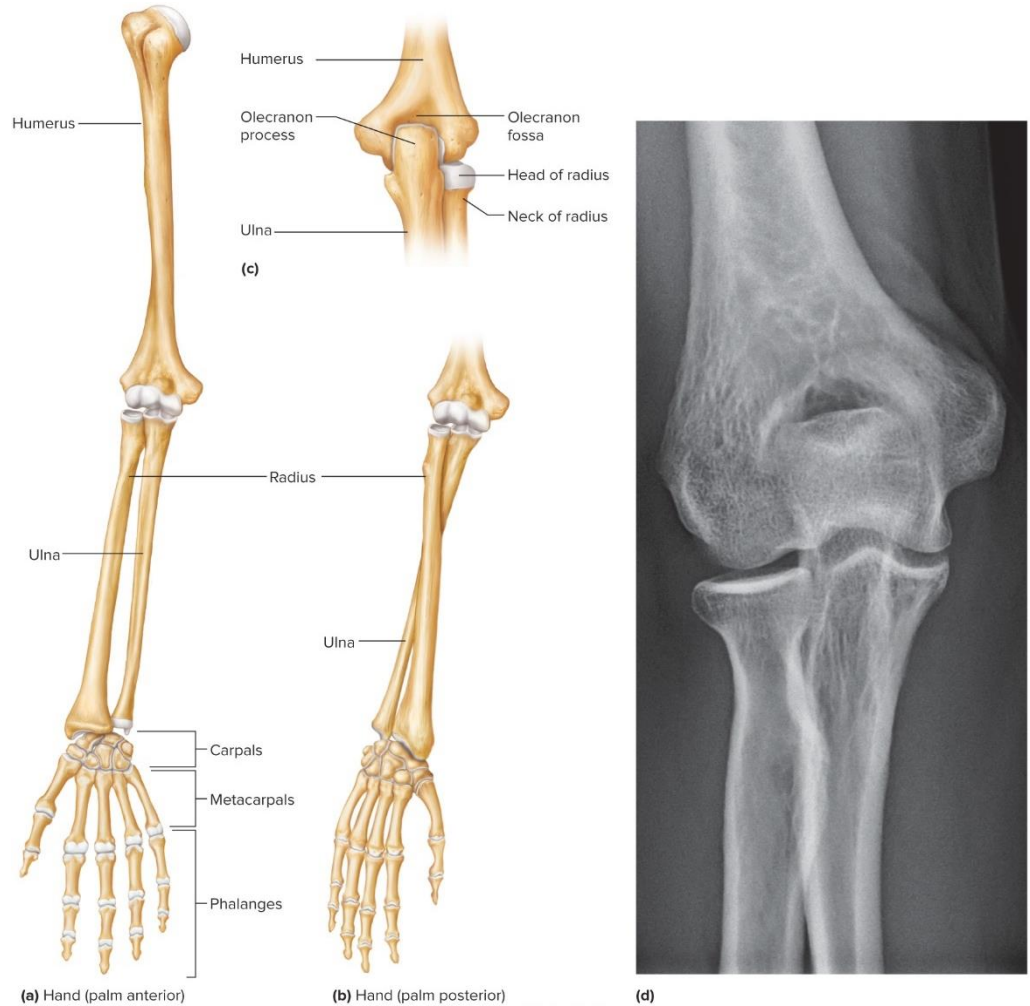


# Figure 7.43 Upper Limb

## Upper Limb Bones:

Framework of upper arm, forearm, hand

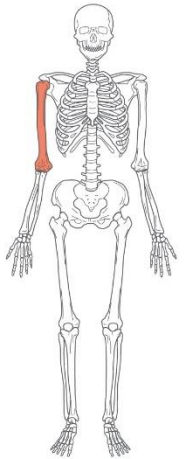
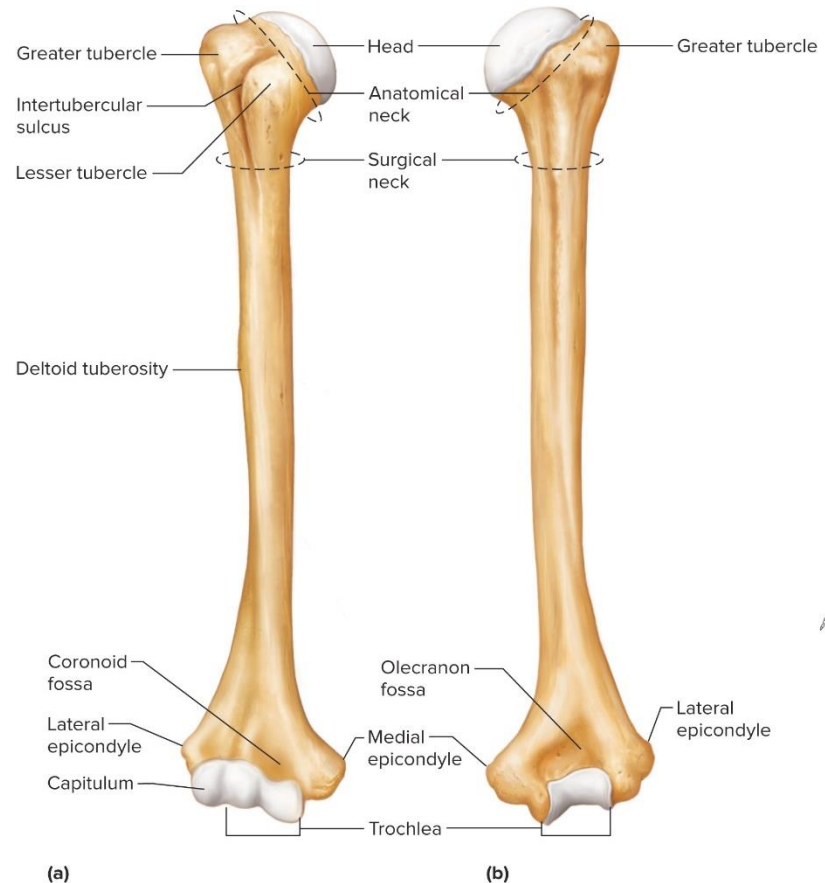
- Humerus
- Radius
- Ulna
- Carpals
- Metacarpals
- Phalanges



# Figure 7.44 Humerus

## Humerus:

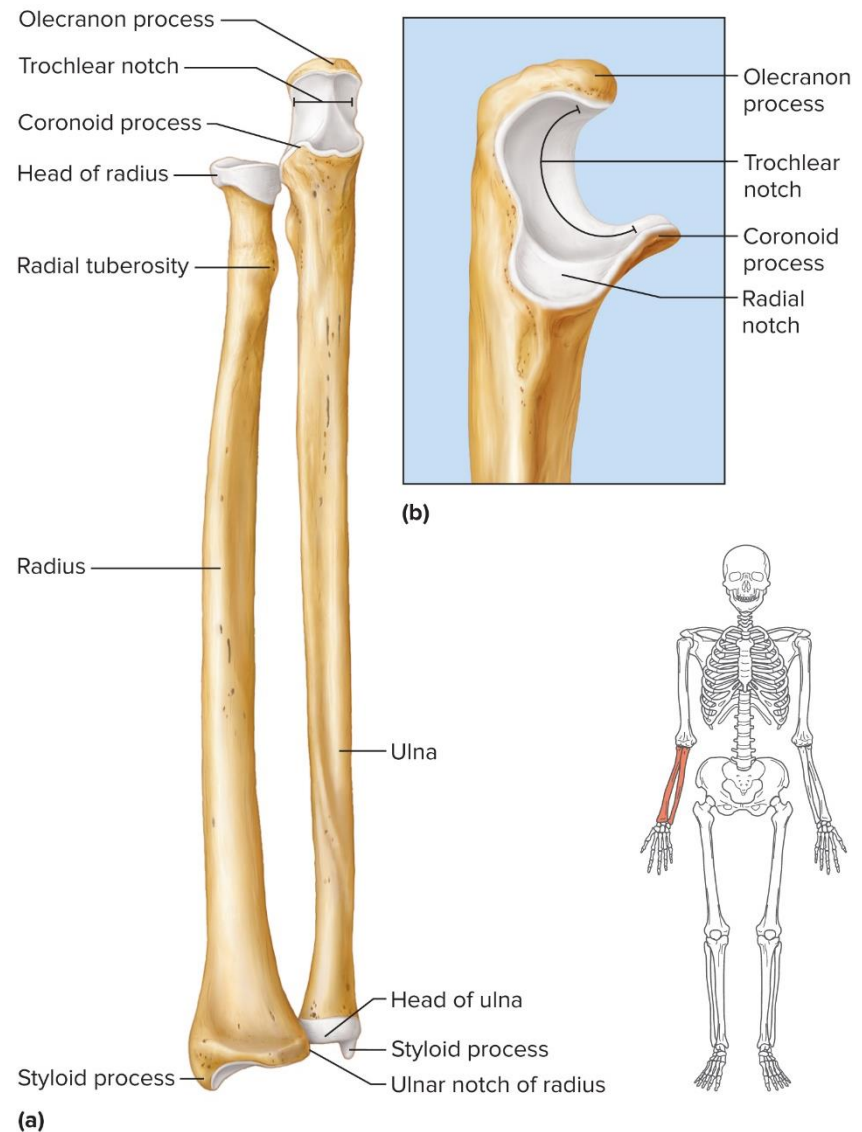
- Only bone of upper arm
- Head
- Greater tubercle
- Lesser tubercle
- Anatomical neck
- Surgical neck
- Deltoid tuberosity
- Capitulum (lateral condyle)
- Trochlea (medial condyle)
- Lateral epicondyle
- Medial epicondyle
- Coronoid fossa
- Olecranon fossa



# Figure 7.45 Radius

## Radius:

- Lateral forearm bone
- Shorter than ulna
- Head
- Radial tuberosity
- Styloid process
- Ulnar notch

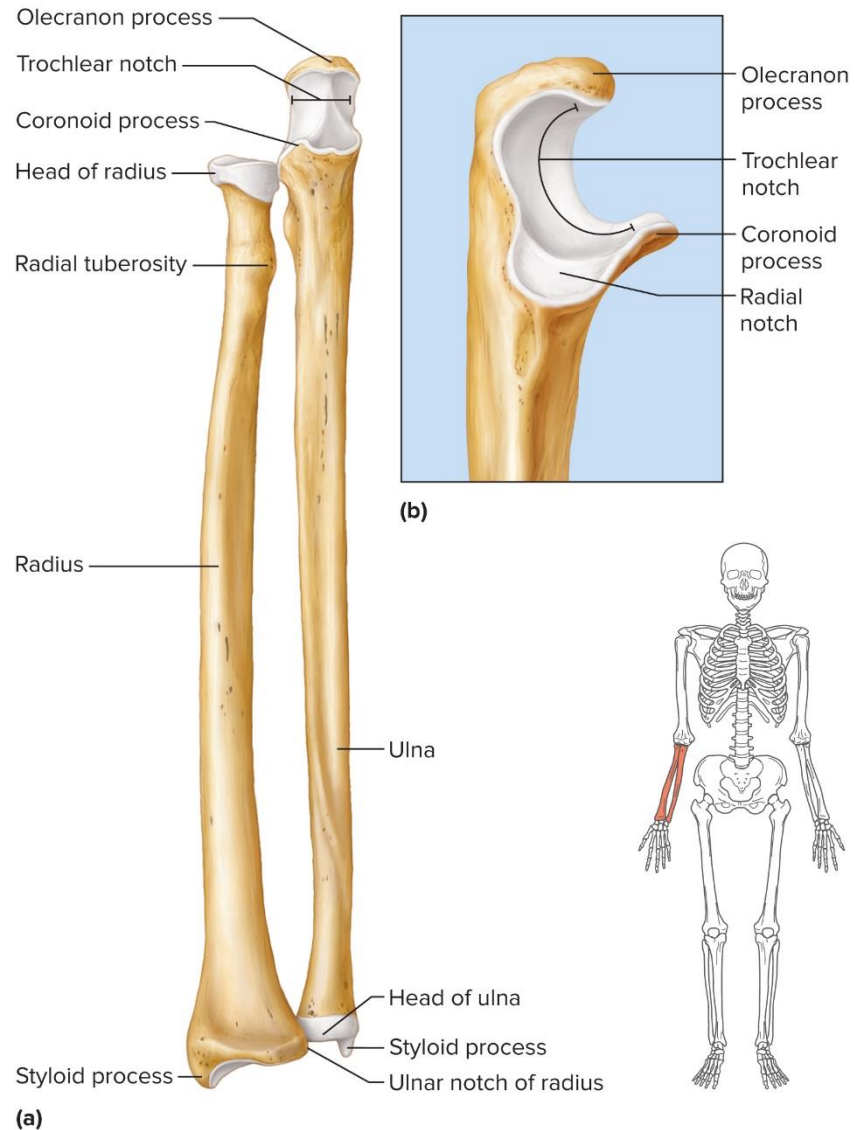




# Figure 7.45 Ulna

## Ulna:

- Medial forearm bone
- Trochlear notch (U-shaped)
- Olecranon process
- Coronoid process
- Radial notch
- Head (at distal end)
- Styloid process





# Figure 7.46 Hand

Each hand consists of the wrist, palm, and fingers (digits):

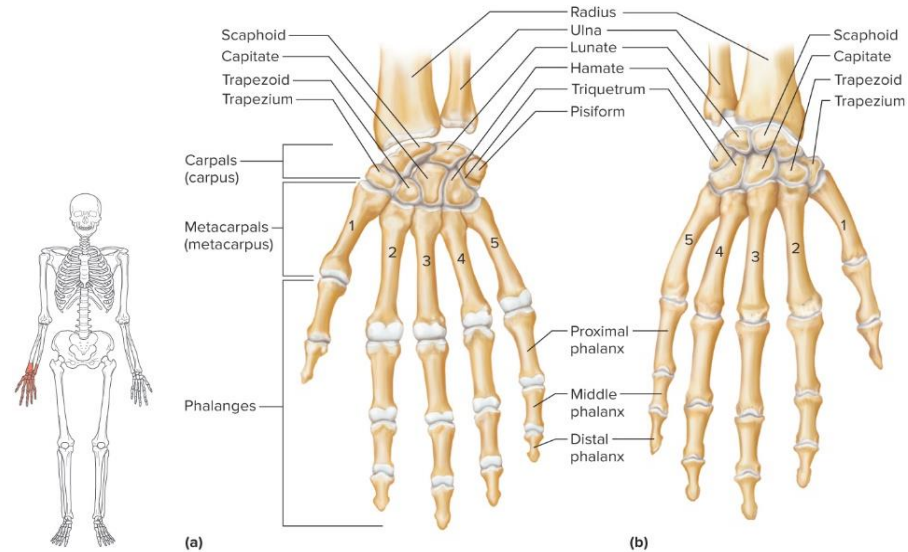
## Carpal (wrist) bones (8 ):

- Scaphoid
- Lunate
- Triquetrum
- Pisiform
- Hamate
- Capitate
- Trapezoid
- Trapezium

## Metacarpal (hand) bones (5)

## Phalanges (finger bones, 14):

- Proximal phalanx
- Middle phalanx
- Distal phalanx



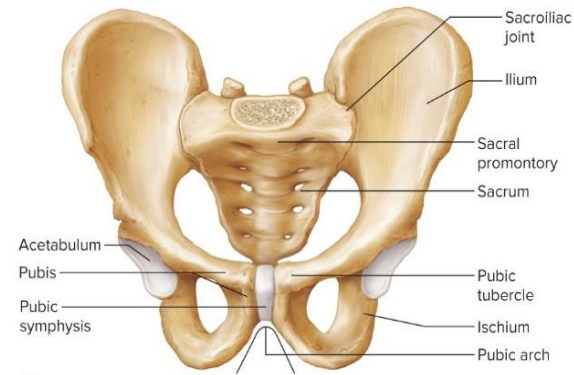
(c)

# Figure 7.48 Pelvic Girdle

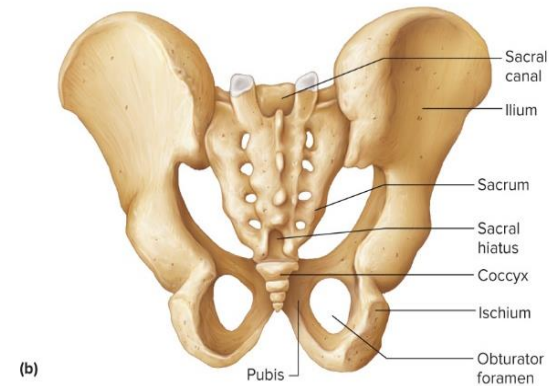
**Pelvic Girdle** consists of 2 coxal bones (hip or pelvic bones)

**Pelvis** = pelvic girdle + sacrum + coccyx

- Supports trunk of body
- Protects viscera
- Transmits weight to lower limbs
- Provides attachment for lower limbs



(a)



(b)



(c)

# Figure 7.49 Hip Bones

**Hip bones** are also called **coxal bones**. Each hip bone consists of 3 fused bones:

1. Ilium (largest, most superior part):

- Iliac crest
- Iliac spines
- Greater sciatic notch

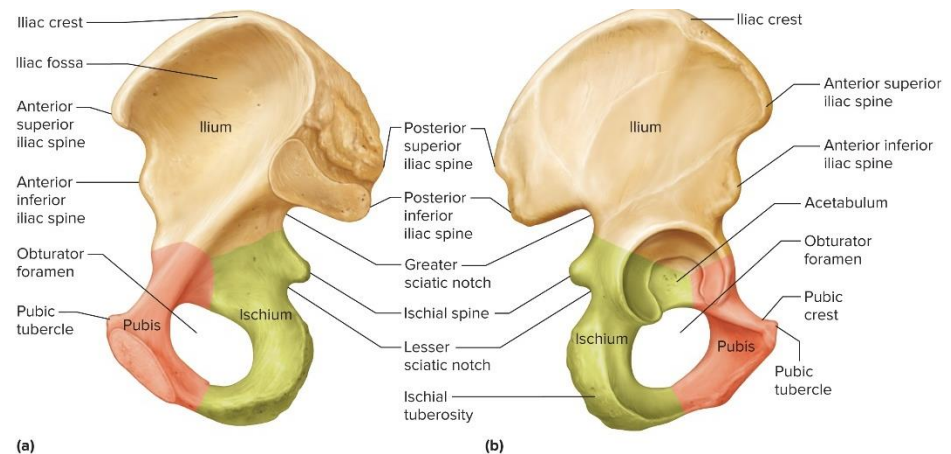
2. Ischium (L-shaped, lowest part):

- Supports weight while sitting
- Ischial spines
- Ischial tuberosity

3. Pubis (anterior portion):

- Pubic symphysis
- Pubic arch

Acetabulum: depression for head of femur  
Obturator foramen

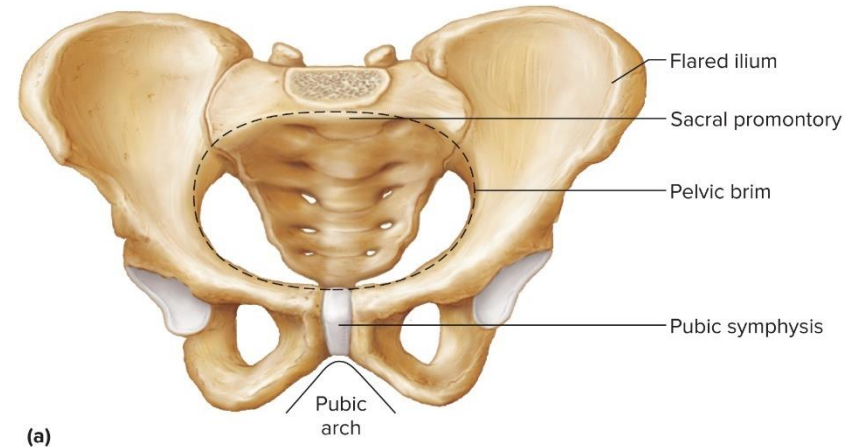


# Figure 7.50 True Pelvis and False Pelvis

## False (Upper, Greater) Pelvis:

Superior to pelvic brim

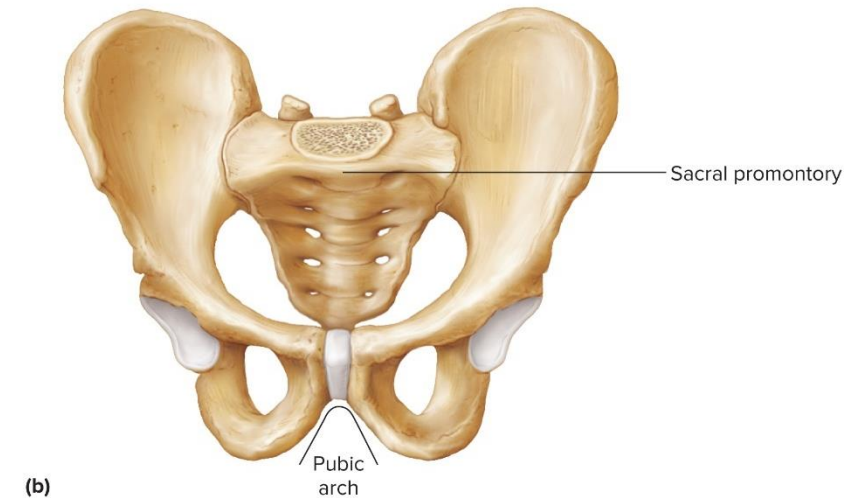
- Lumbar vertebrae posteriorly
- Iliac bones laterally
- Abdominal wall anteriorly
- Helps support abdominal organs



## True (Lower, Lesser) Pelvis:

Inferior to pelvic brim

- Sacrum and coccyx posteriorly
- Lower ilium, ischium, and pubic bones laterally and anteriorly



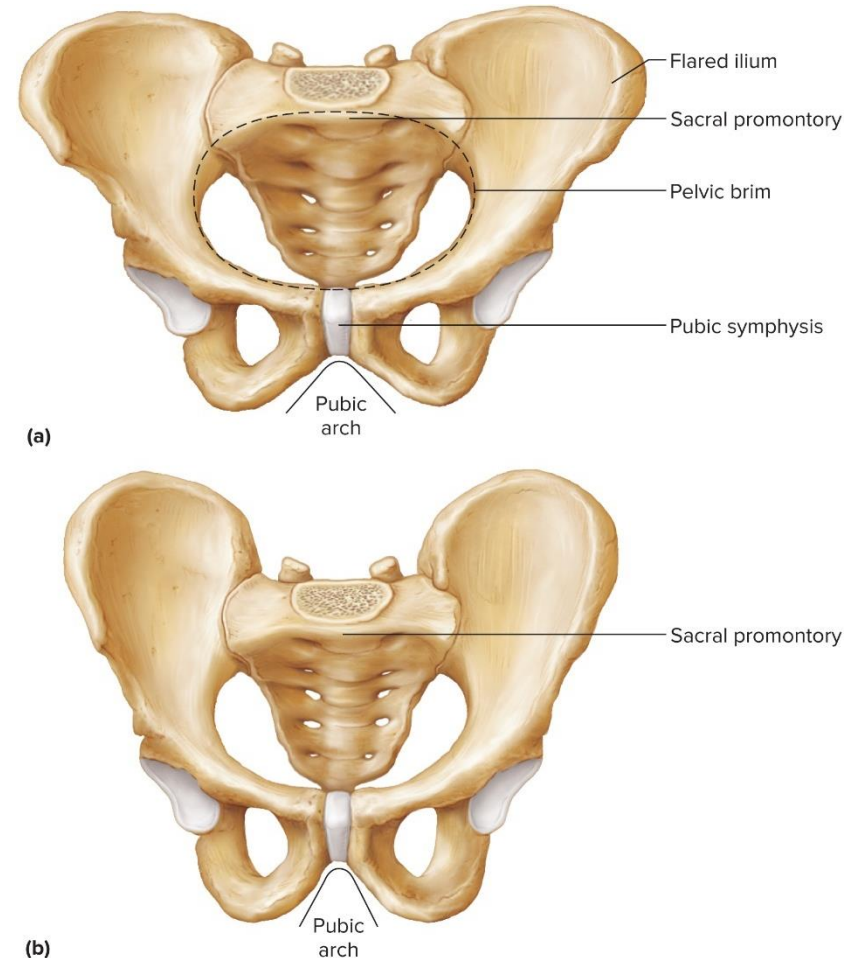
# Figure 7.50 Differences Between Male Pelvis and Female Pelvis

## Female pelvis:

- Functions as birth canal
- Iliac bones more flared
- Broader hips than male
- Pelvic cavity wider than male
- Pubic arch angle greater
- More distance between ischial spines and ischial tuberosities
- Sacral curvature shorter and flatter
- Lighter in weight

## Male pelvis:

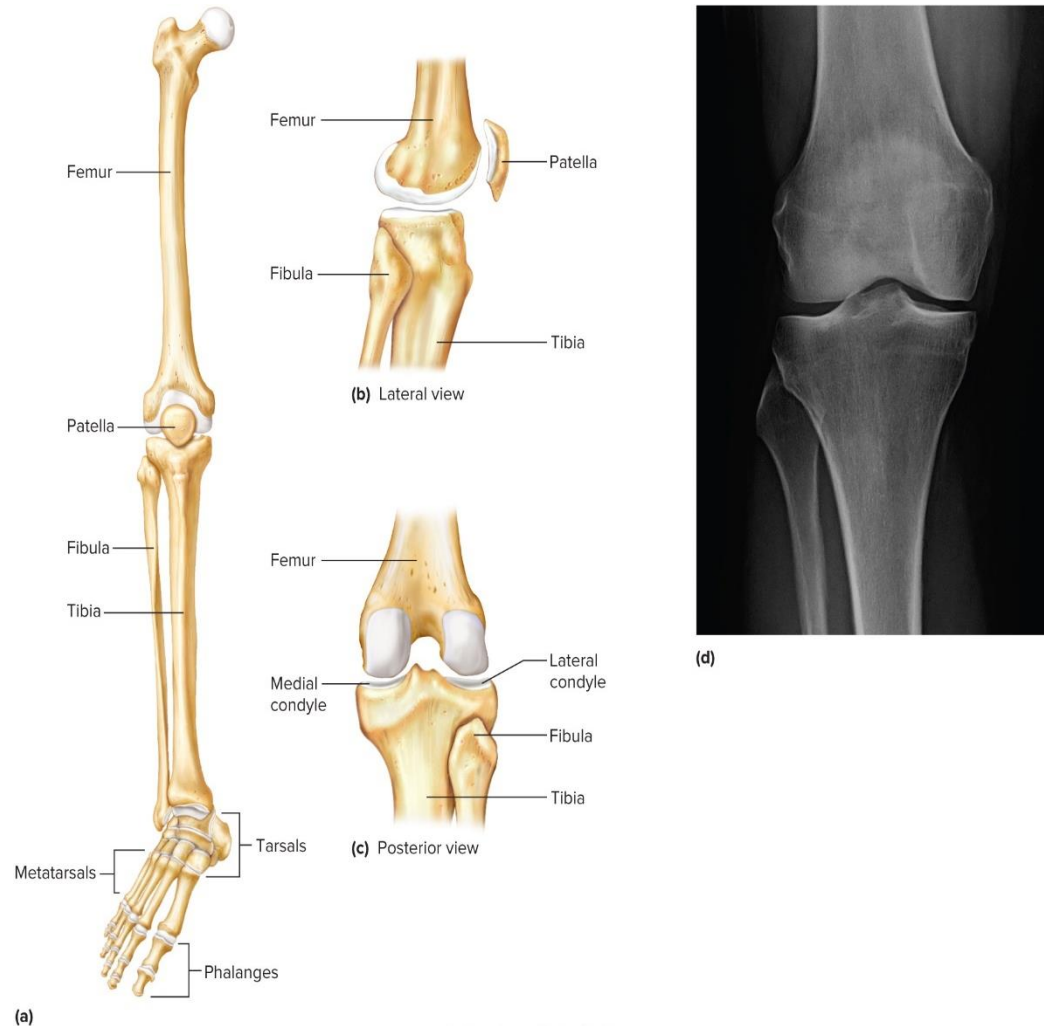
- Less flared
- Heavier in weight



# Figure 7.51 Lower Limb

Lower limb bones form framework of each thigh, leg and foot:

- Femur
- Patella
- Tibia
- Fibula
- Tarsals
- Metatarsals
- Phalanges

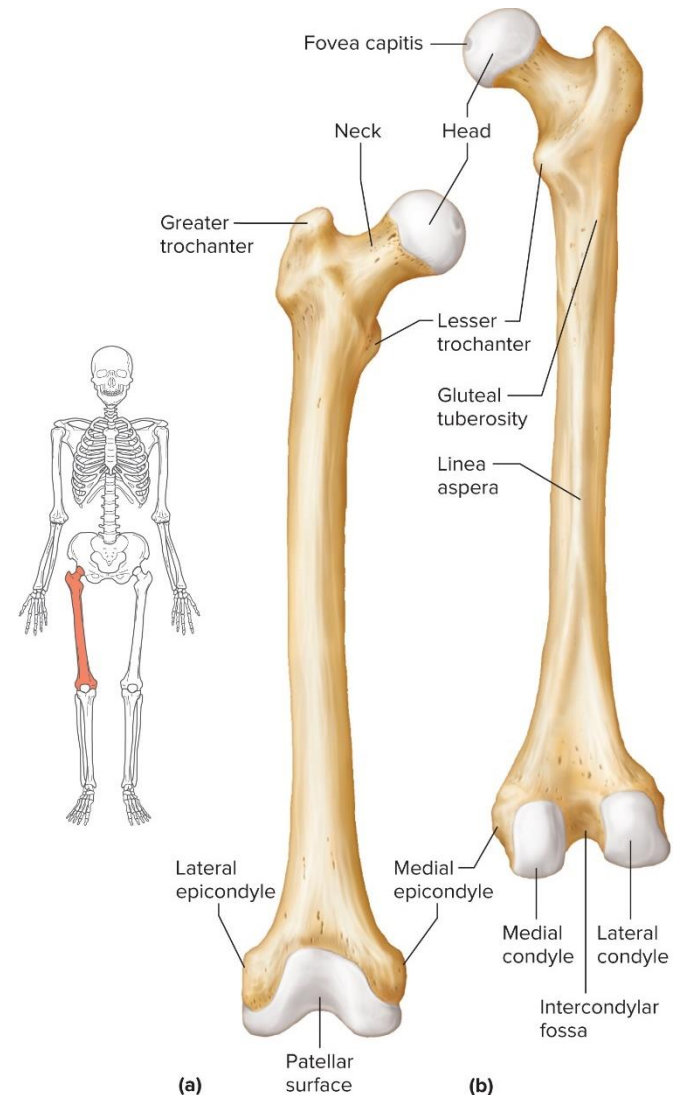




# Figure 7.52 Femur

## Femur (thigh bone):

- Longest bone of body
- Head
- Fovea capitis
- Neck
- Greater trochanter
- Lesser trochanter
- Linea aspera
- Medial & lateral condyles
- Medial & lateral epicondyles

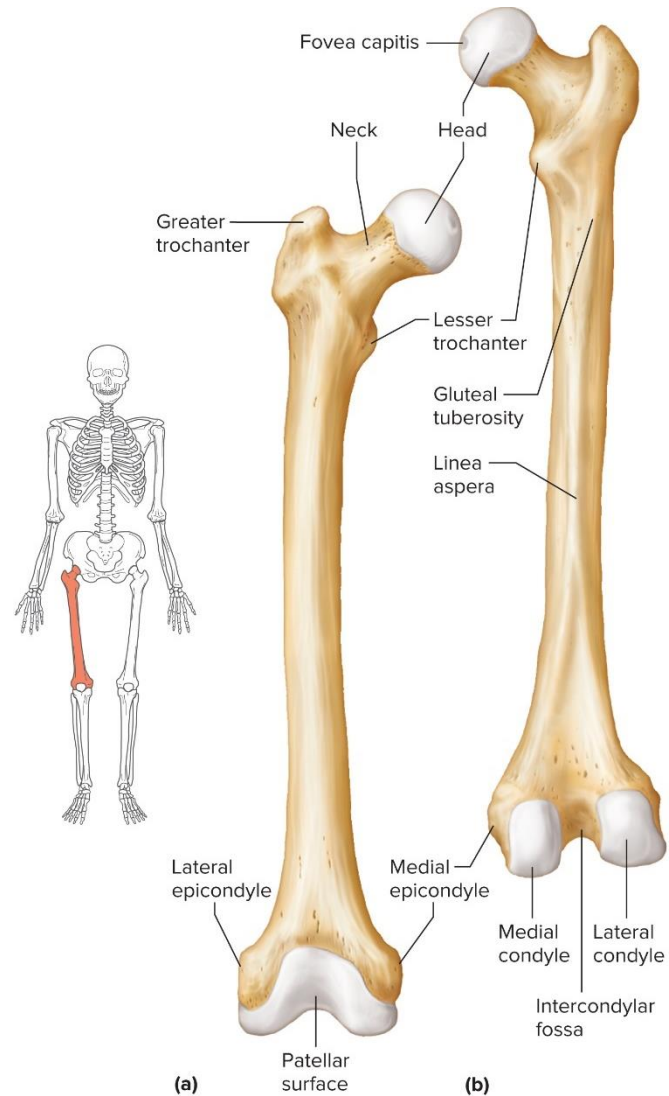




# Figure 7.52 Patella

## Patella (Kneecap):

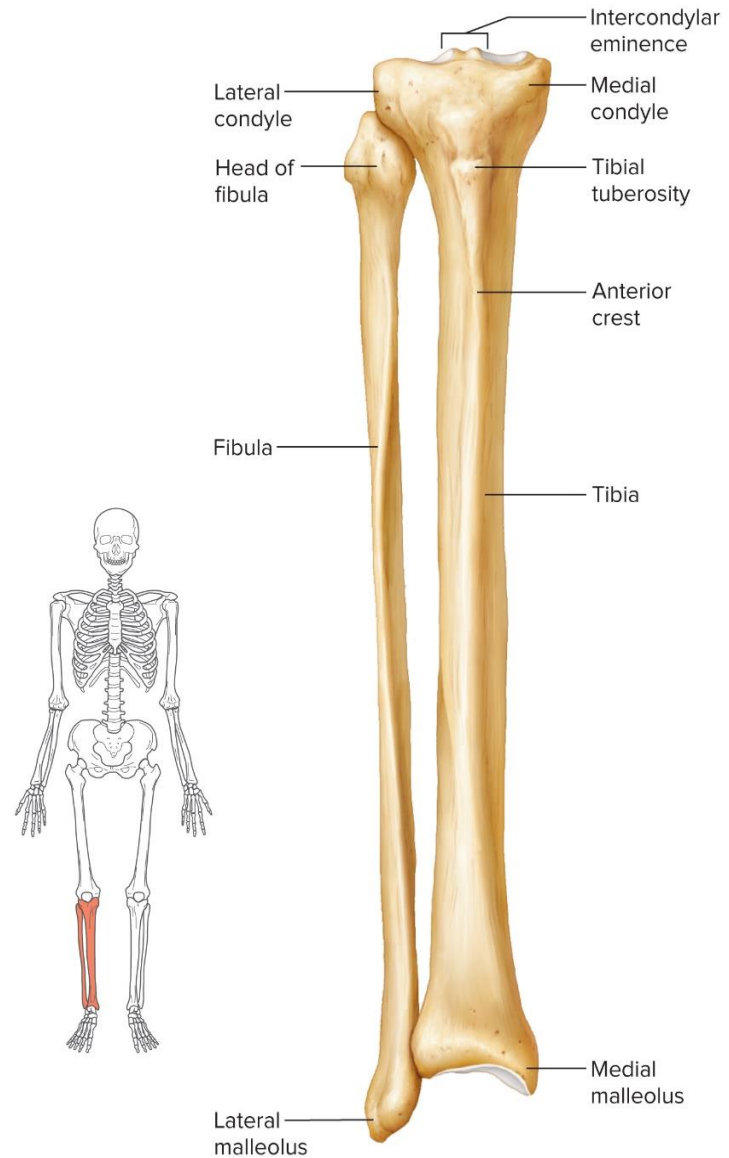
- Flat sesamoid bone located in the quadriceps tendon
- Anterior surface of knee joint
- Helps with lever actions with movement of lower limbs



# Figure 7.53 Tibia

## Tibia (shin bone):

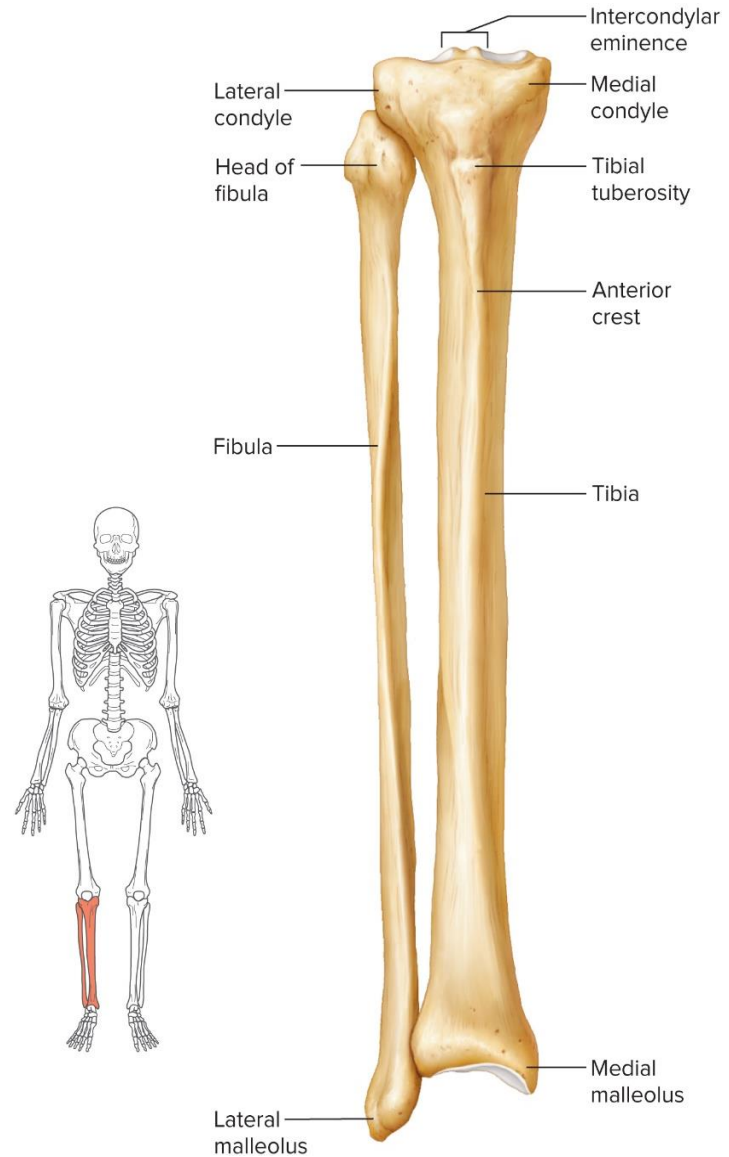
- Larger of 2 leg bones
- Lies medial to fibula
- Condyles at proximal end
- Tibial tuberosity is attachment site for patellar ligament
- Anterior crest
- Medial malleolus



# Figure 7.53 Fibula

## Fibula:

- Lateral side of tibia
- Long, slender bone
- Head
- Lateral malleolus
- Non-weight bearing



# Figure 7.54 Foot

## Tarsal (Ankle) Bones (7 ):

- Calcaneus
- Talus
- Navicular
- Cuboid
- Lateral cuneiform
- Intermediate cuneiform
- Medial cuneiform

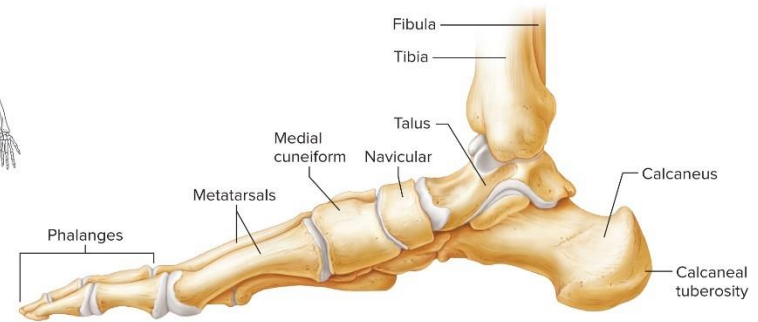
## Metatarsal (Foot) Bones (5)

## Phalanges (Toe Bones, 14 ):

- Proximal
- Middle
- Distal



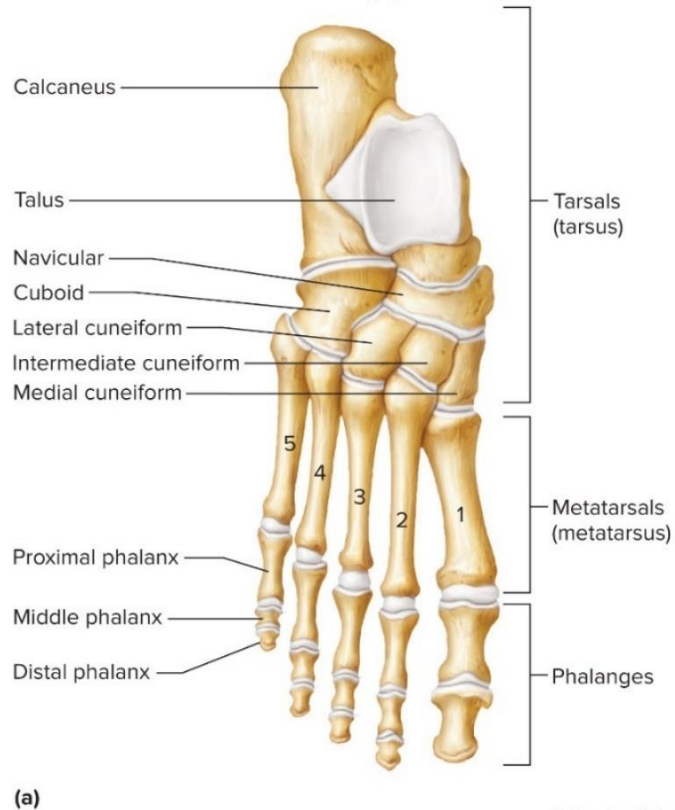
(a)



(b)

# Figure 7.55 Foot

- The calcaneus is the large heel bone.
- The talus lies just inferior to the tibia, and allows the foot to pivot up and down.



# Life-Span Changes

- Decrease in height begins at about age 30
- Calcium levels fall
- Bones become brittle & more prone to fracture
- Osteoclasts outnumber osteoblasts
- Spongy bone weakens before compact bone
- Bone loss rapid in menopausal women
- Hip fractures common
- Vertebral compression fractures common