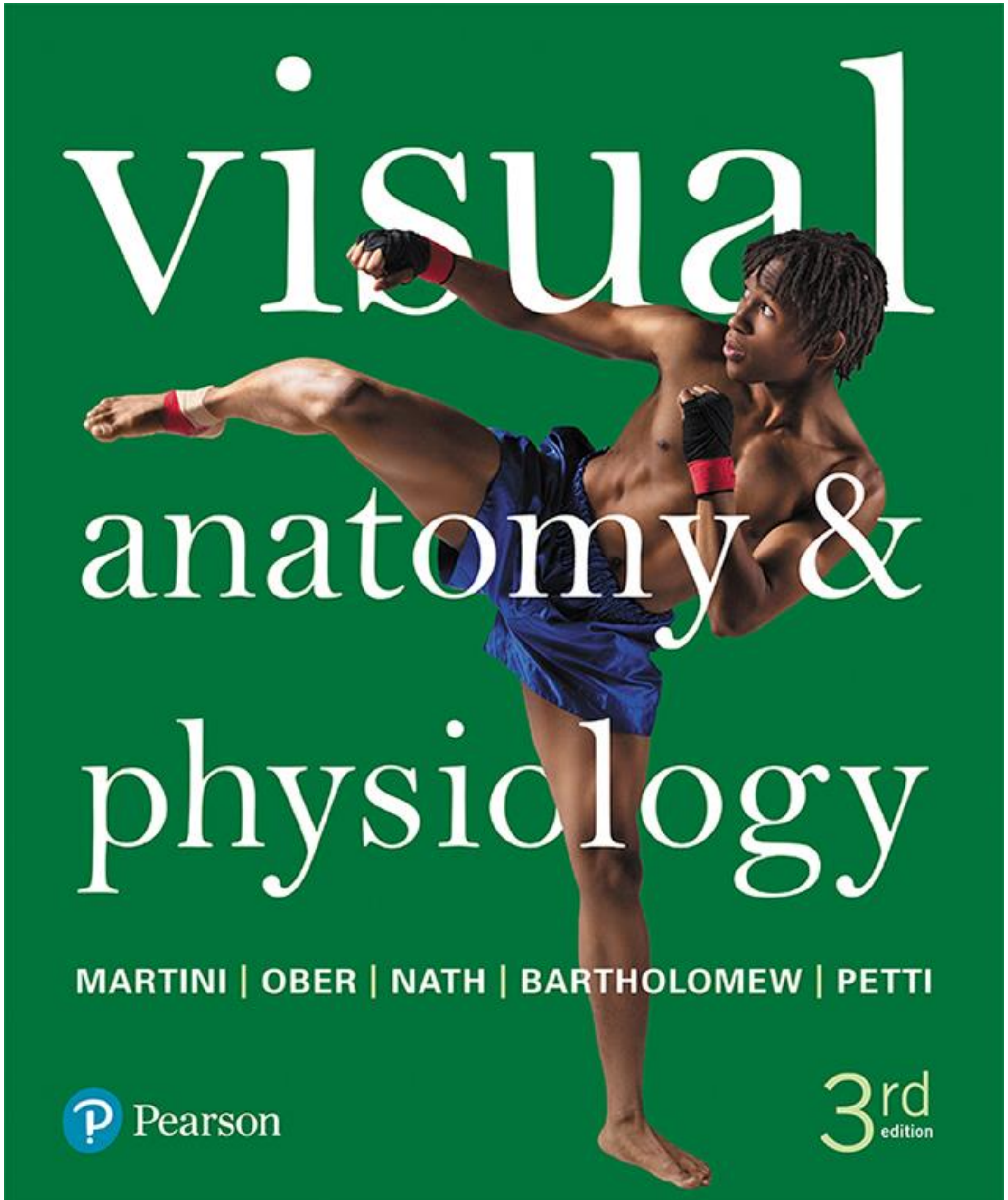



# 6

## *Bones and Bone Structure*

Lecture Presentation by
Lori Garrett

## Section 1: Introduction to the Structure and Growth of Bones

### Learning Outcomes

6.1 Describe the two main divisions of the skeleton, and list the major functions of the skeletal system.

6.2 Classify bones according to their shapes, identify the major types of bone markings, and explain the functional significance of bone markings

6.3 Identify the parts of a typical long bone, and describe its internal structures.

6.4 Identify the types of cells in bone, and list their major functions.

## Section 1: Introduction to the Structure and Growth of Bones

**Learning Outcomes** (continued)

6.5 Compare the structures and functions of compact bone and spongy bone.

6.6 Describe the process of appositional bone growth.

6.7 Describe the process of endochondral ossification.

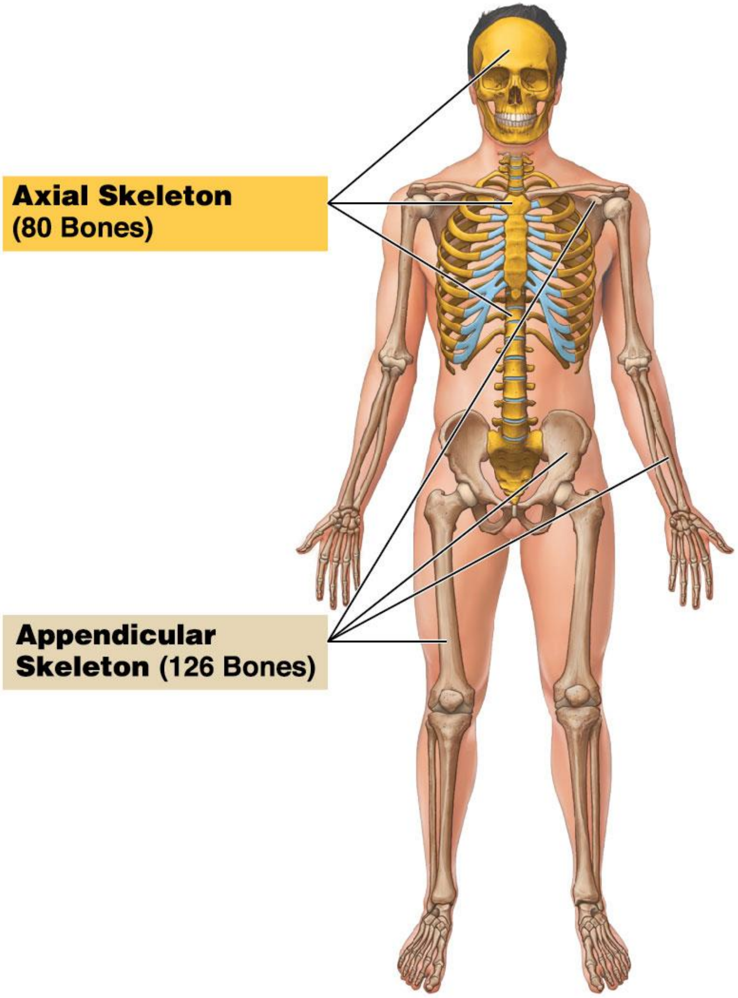
6.8 Describe the process of intramembranous ossification.

6.9 **Clinical Module:** Discuss various abnormalities of bone formation and growth.

# Module 6.1: The skeletal system is made up of the axial and appendicular divisions

## Bones (~206 total)

1. **Axial skeleton (80 bones)**
   - Bones of skull, thorax, and vertebral column
   - Form longitudinal axis of body
2. **Appendicular skeleton (126 bones)**
   - Bones of the limbs and girdles that attach them to the axial skeleton




- Associated cartilages
- Ligaments and other connective tissues

# Functions of the skeletal system

## Functions of the Skeletal System

- Support
- Store minerals and lipids
- Produce blood cells
- Protection
- Leverage

## Module 6.1: Review

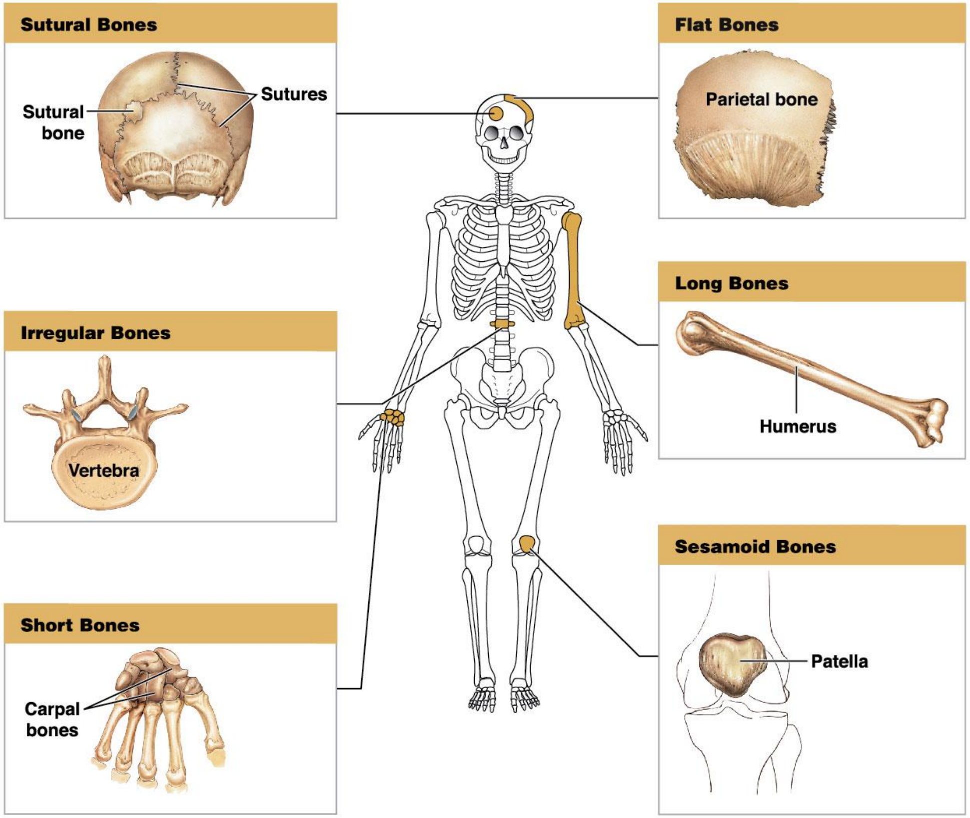
A. Describe the axial and appendicular divisions of the skeleton.
B. Identify the functions of the skeletal system.

*Learning Outcome:* Describe the two main divisions of the skeleton, and list the major functions of the skeletal system.

# Module 6.2: Bones are classified according to shape and structure and have varied bone markings

## Six categories of bone based on shape

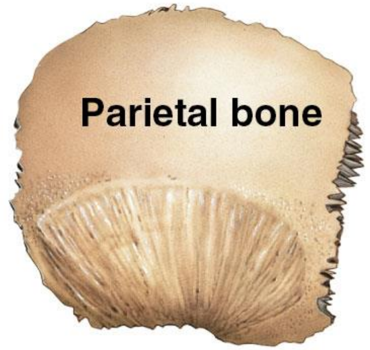
1. Flat bones
2. Sutural bones
3. Long bones
4. Irregular bones
5. Sesamoid bones
6. Short bones



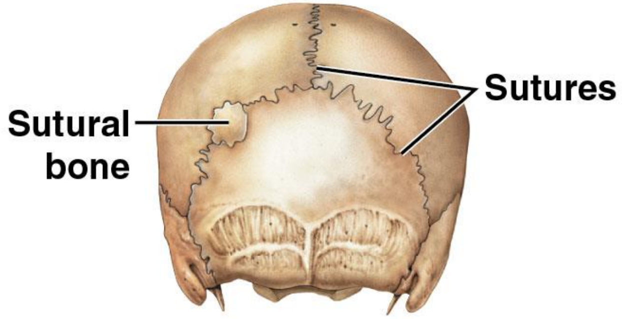
# Module 6.2: Bone classification and surface markings

1. **Flat bones**
   - Thin, roughly parallel surfaces
   - *Examples:* cranial bones, sternum, ribs, scapulae
   - Protect underlying soft tissues
   - Provide surface area for skeletal muscle attachment
2. **Sutural bones (Wormian bones)**
   - Irregular bones formed between cranial bones
   - Number, size, and shape vary

**Flat Bones**

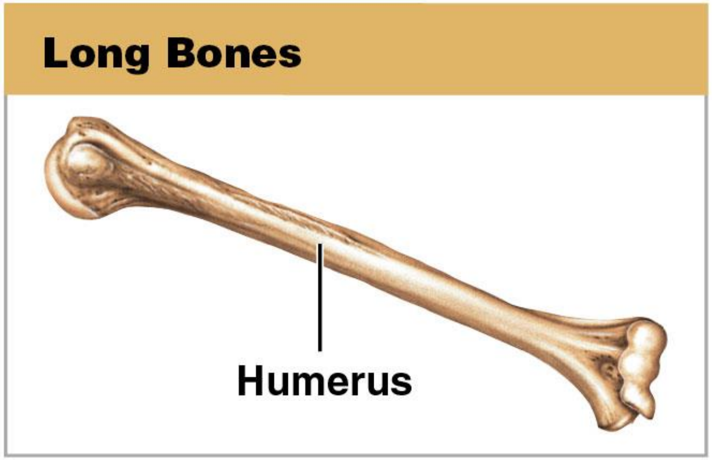



**Sutural Bones**

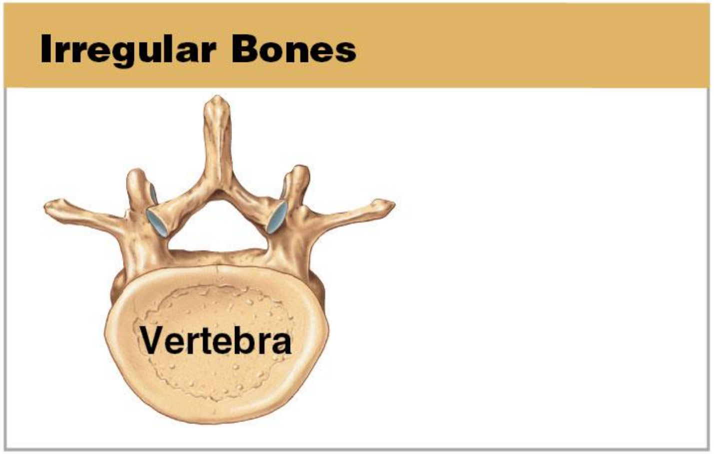


# Module 6.2: Bone classification and surface markings

3. **Long bones**
   - Relatively long and slender
   - *Examples:* various bones of the limbs



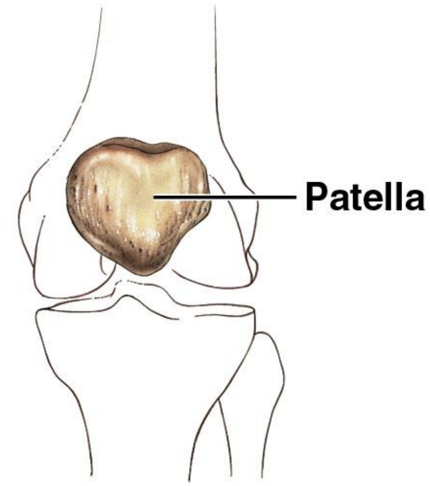

4. **Irregular bones**
   - Complex shapes with short, flat, notched, or ridged surfaces
   - *Examples:* vertebrae, bones of pelvis, facial bones



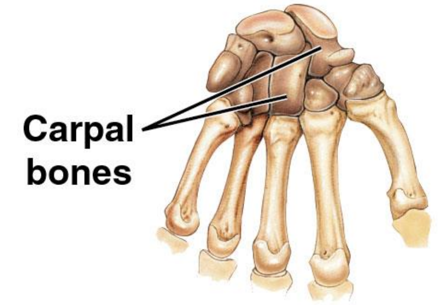
# Module 6.2: Bone classification and surface markings

5. **Sesamoid bones**
   - Small, flat, and somewhat shaped like sesame seed
   - Develop inside tendons of knee, hands, and feet
   - Individual variation in location and number
6. **Short bones**
   - Small and boxy
   - *Examples:* bones of the wrist (carpals) and ankles (tarsals)

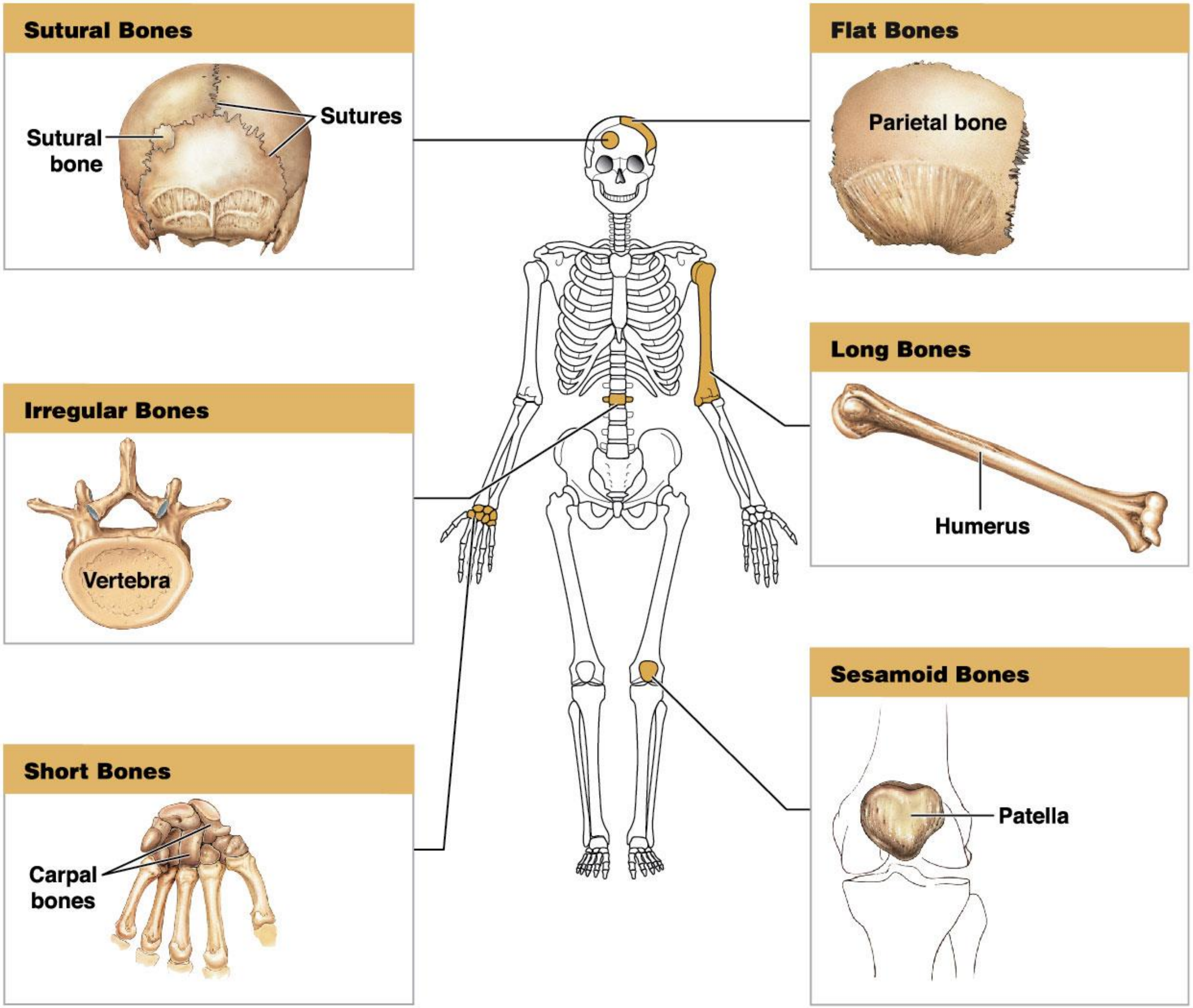
**Sesamoid Bones**




**Short Bones**



# Bone classifications



# Module 6.2: Bone classification and markings

## Bone markings

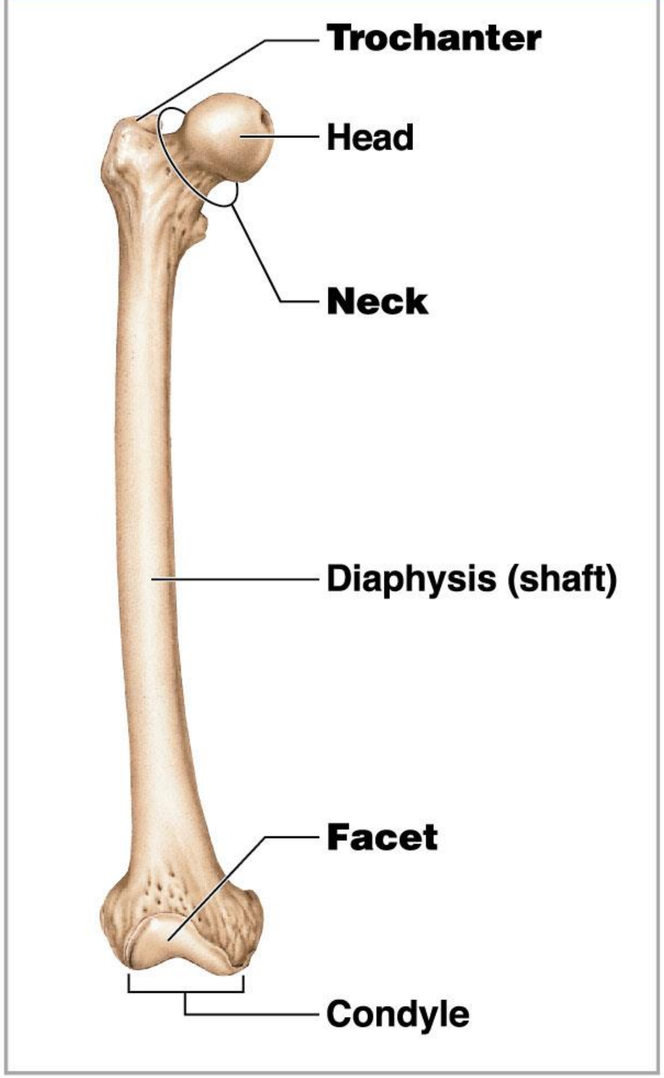
- Also known as surface features
- Related to particular functions
  - Elevations/projections
    - Muscle, tendon, and ligament attachment
    - At joints where adjacent bones articulate
  - Depressions/grooves/tunnels
    - Sites for blood vessels or nerves to lie alongside or penetrate bone

# Module 6.2: Bone classification and markings

**Bone markings**—general

- **Head**
  - Expanded proximal end of a bone that forms part of a joint
- **Diaphysis** (shaft)
  - Elongated body of a long bone
- **Neck**
  - Narrow connection between the head and diaphysis of a bone

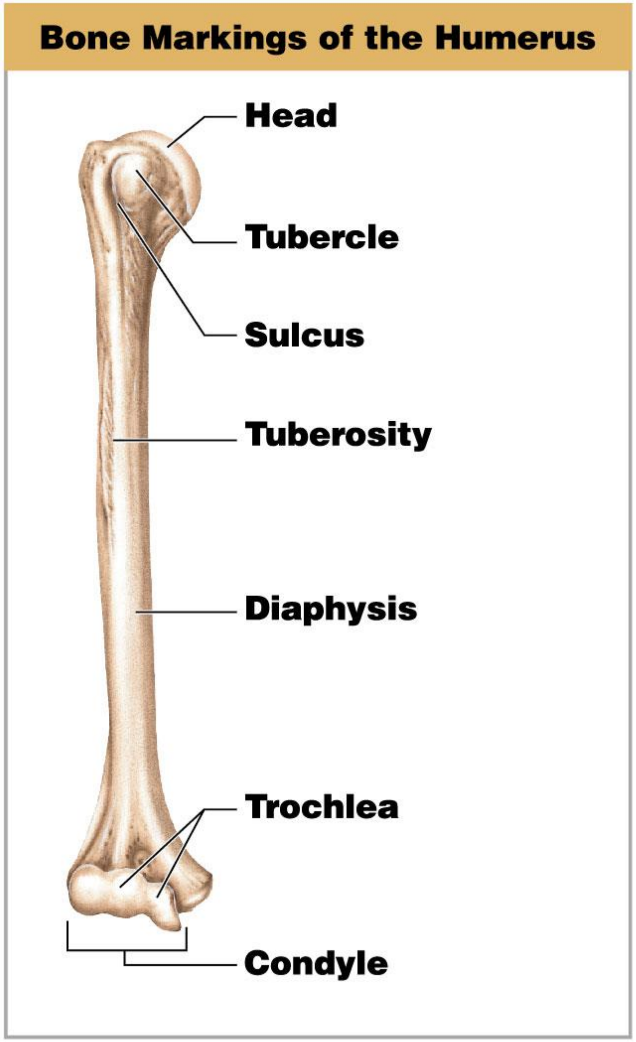
**Bone Markings of the Femur**



# Module 6.2: Bone classification and markings

**Bone markings**—elevations or projections

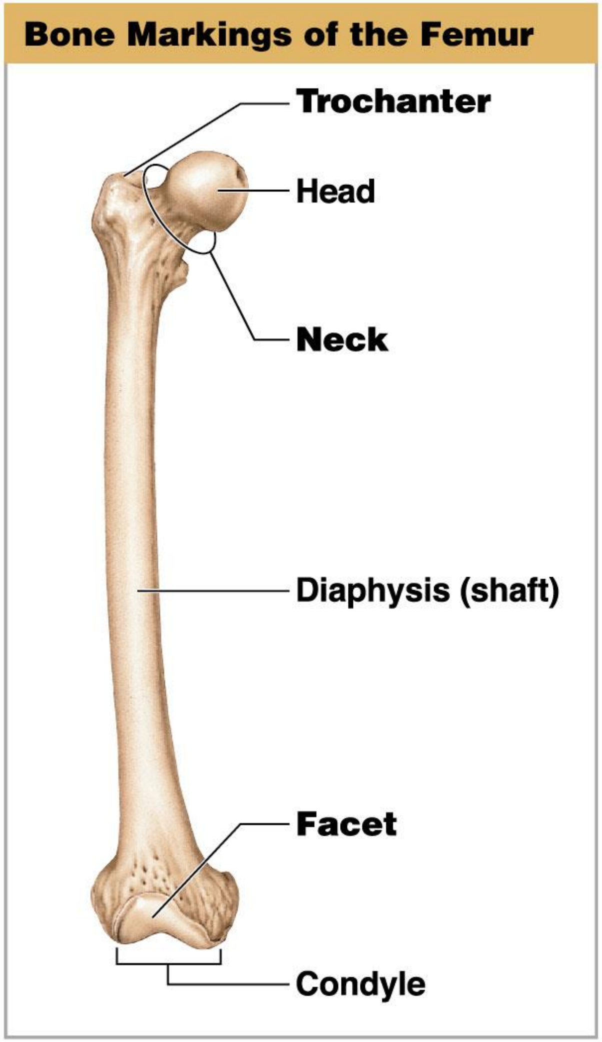
- **Process**—any projection or bump
- **Tubercle**—small, rounded projection
- **Tuberosity**—small, rough projection that takes up a broad area
- **Trochlea**—smooth, grooved articular process shaped like a pulley
- **Condyle**—smooth, rounded articular process



# Module 6.2: Bone classification and markings

**Bone markings**—elevations or projections (continued)

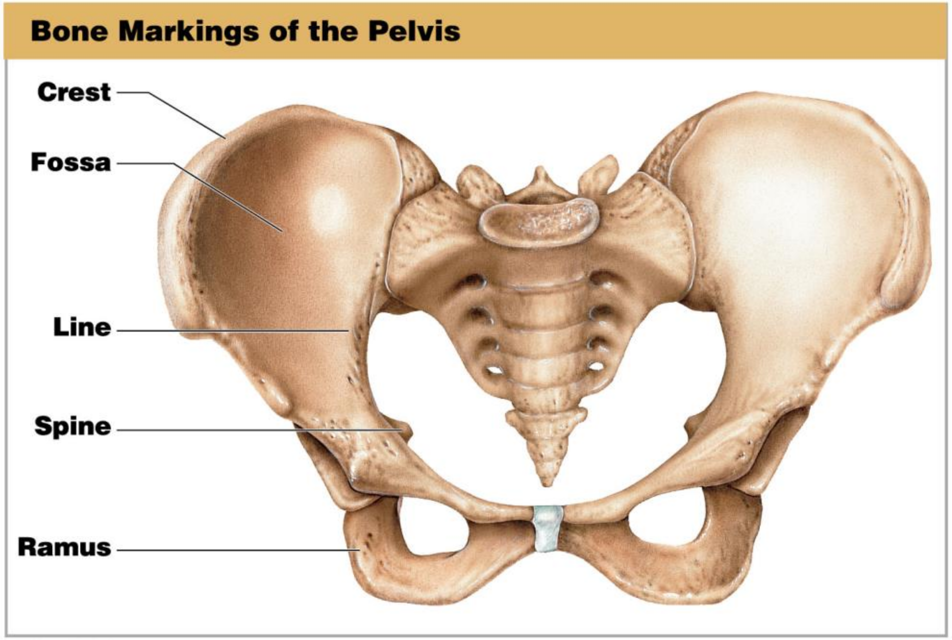
- **Trochanter**—large, rough projection
- **Facet**—small, flat articular surface



# Module 6.2: Bone classification and markings

**Bone markings**—elevations or projections (continued)

- **Crest**—prominent ridge
- **Line**—low ridge, more delicate than a crest
- **Spine**—pointed or  narrow process
- **Ramus**—extension of a bone that makes an angle with the rest of a structure

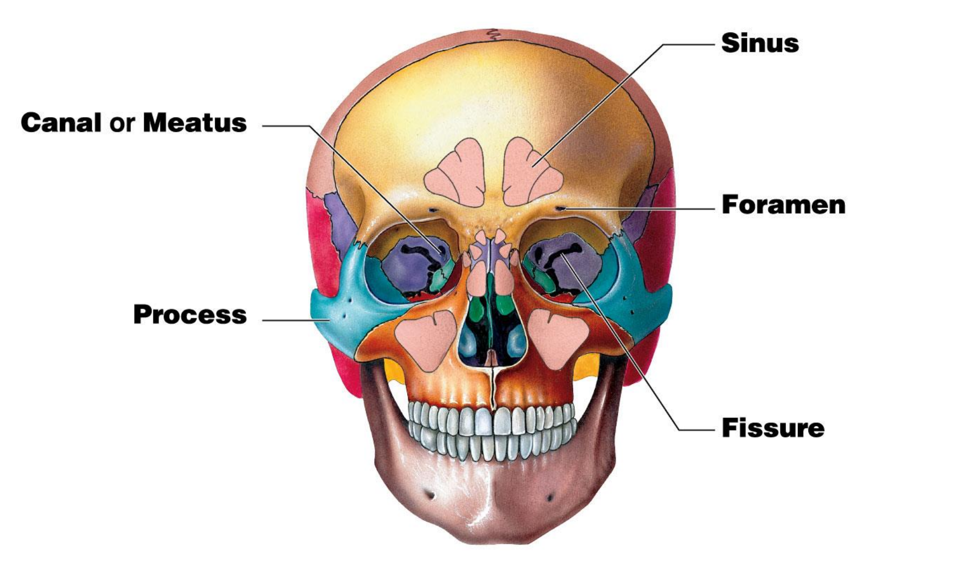


# Module 6.2: Bone classification and markings

**Bone markings**—depressions, grooves, and tunnels

- **Canal** or **meatus**—large passageway through a bone
- **Sinus**—chamber within a bone, normally filled with air
- **Foramen**—small, rounded passageway for blood vessels or nerves to pass through bone

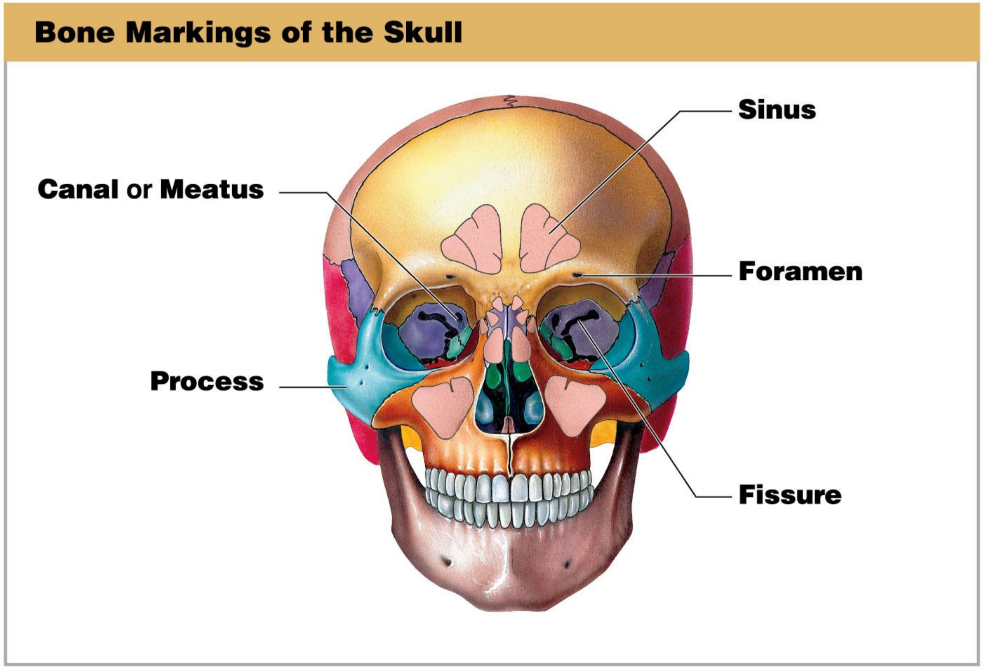
**Bone Markings of the Skull**



# Module 6.2: Bone classification and markings

**Bone markings**—depressions, grooves, and tunnels (continued)

- **Fissure**—elongated cleft or gap
- **Sulcus**—deep, narrow groove
- **Fossa**—shallow depression or recess in bone surface



# Module 6.2: Review

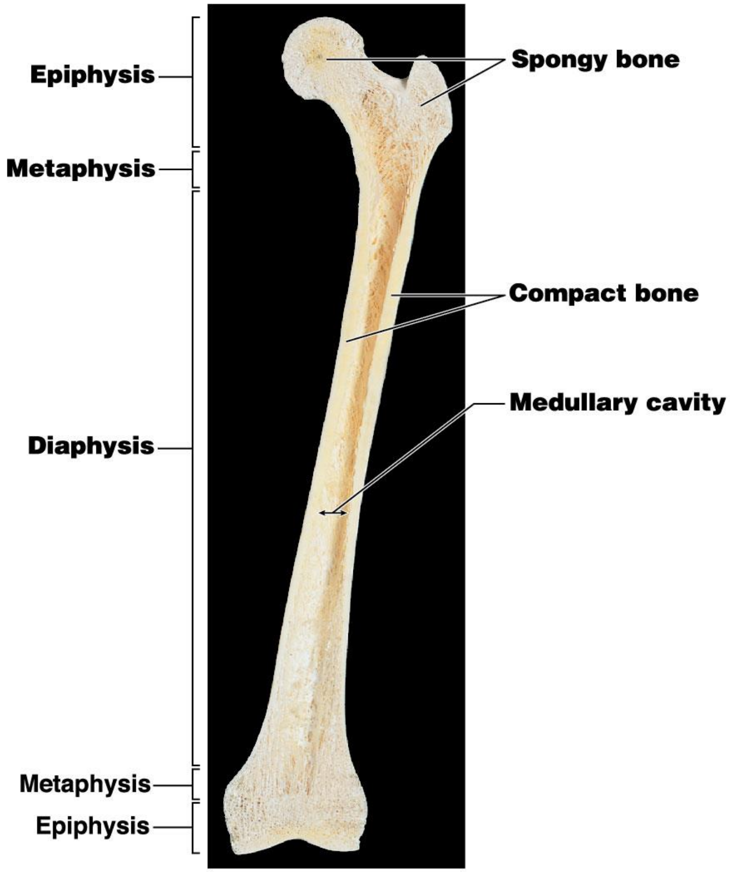
A. Identify the six broad categories for classifying a bone according to shape.
B. Define *bone markings*.
C. List the different terms used to describe projections.

*Learning Outcome:* Classify bones according to their shapes, identify the major types of bone markings, and explain the functional significance of bone markings.

# Module 6.3: Long bones transmit forces along the shaft and have a rich blood supply

## Long bone features

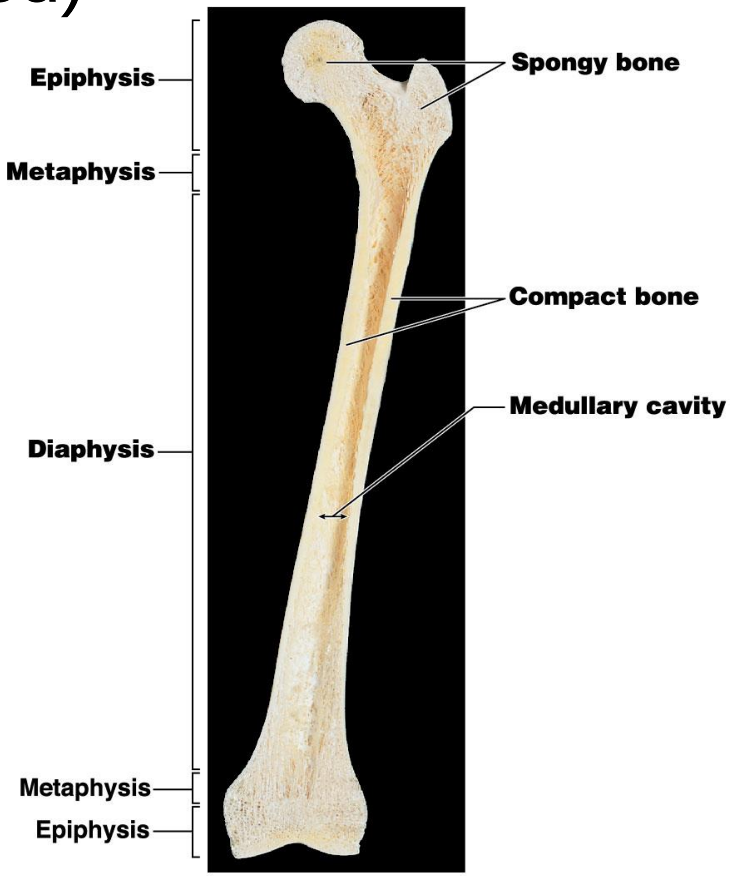
- **Epiphysis** (expanded area at each end of the bone)
  - Consists largely of **spongy bone** (**trabecular bone**)
  - Outer covering of **compact bone** (cortical bone)
    - Strong, organized bone
  - **Articular cartilage**
    - Covers portions of epiphysis that form articulations



# Module 6.3: Functional anatomy of a long bone

## **Long bone features** (continued)

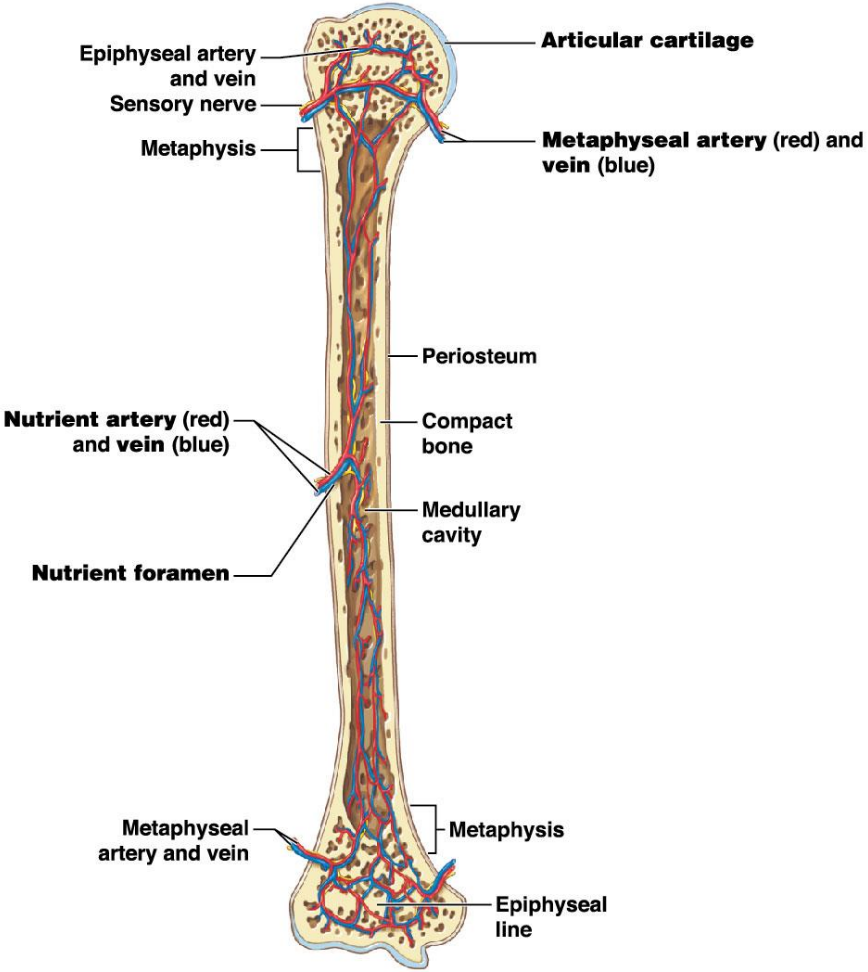
- **Metaphysis** (connects epiphysis to shaft)
- **Diaphysis** (shaft)
  - Contains **medullary cavity** (marrow cavity)
    - Filled with two types of marrow
      - **Red bone marrow** (involved in red blood cell production)
      - **Yellow bone marrow** (adipose tissue; important as energy reserve)



# Module 6.3: Functional anatomy of a long bone

## Growth and maintenance require extensive blood supply

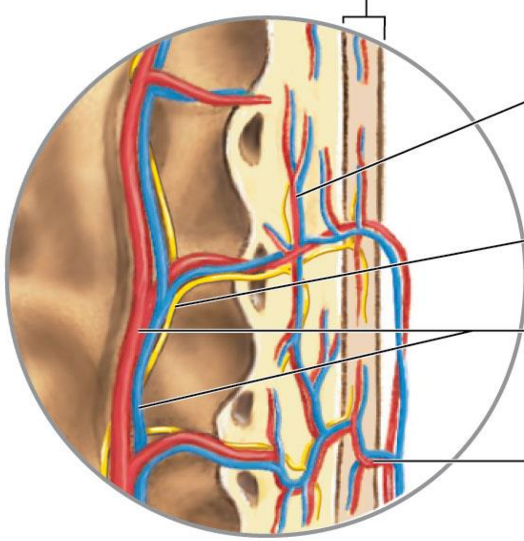
- Vascular features
  - **Nutrient artery** and **nutrient vein** (commonly one of each per bone)
    - **Nutrient foramen** (tunnel providing access to marrow cavity)
  - **Metaphyseal artery** and **metaphyseal vein**
    - Carry blood to/from metaphysis
    - Connect to epiphyseal arteries/veins



# Module 6.3: Functional anatomy of a long bone

## Blood supply and innervation of the periosteum

- Smaller blood vessels supply superficial osteons
- Lymphatic vessels collect lymph from bone and osteons
- Sensory nerves innervate diaphysis, medullary cavity, and epiphyses



# Module 6.3: Review

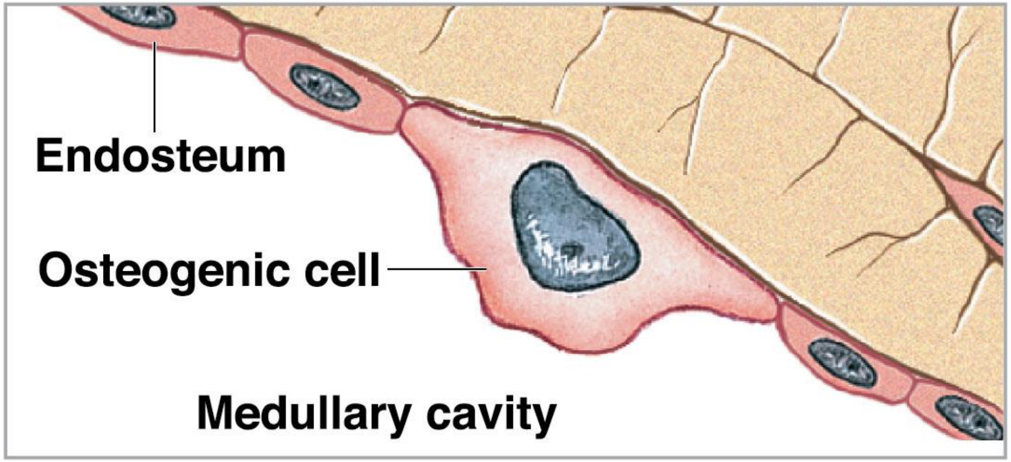
A. List the major parts of a long bone.
B. Describe the function of the medullary cavity.
C. Where is articular cartilage found, and how is it nourished?
D. Why are bone injuries usually painful?

*Learning Outcome:* Identify the parts of a typical long bone, and describe its internal structures.

# Module 6.4: Bone has a calcified matrix maintained and altered by osteogenic cells, osteoblasts, osteocytes, and osteoclasts

**Osteogenic cells** (osteoprogenitor cells)

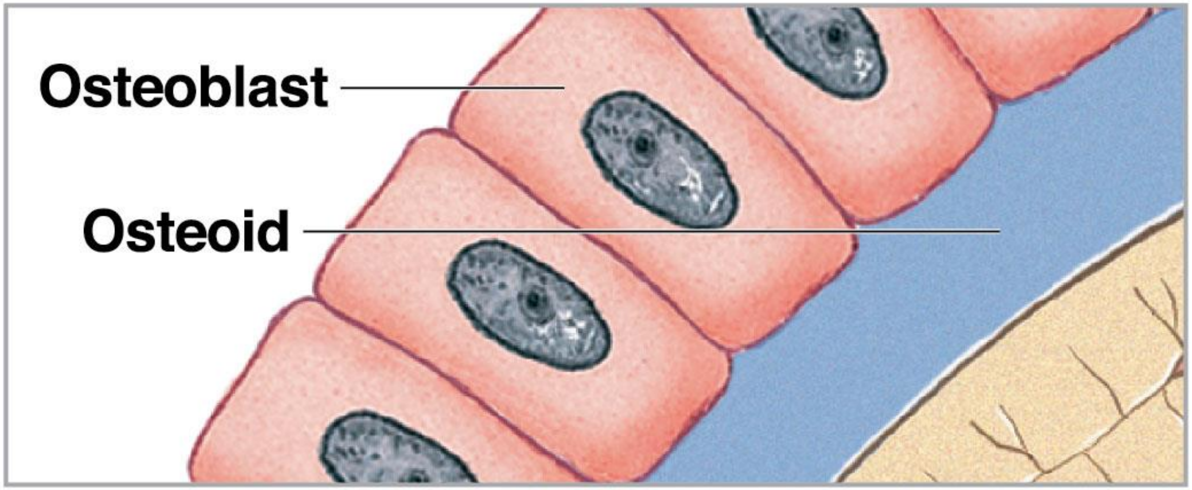
- Mesenchymal (stem) cells that produce cells that differentiate into osteoblasts
  - Important in fracture repair
  - Locations
    - Inner lining of periosteum
    - Lining endosteum in medullary cavity
    - Lining passageways containing blood vessels



# Module 6.4: Bone tissue

**Osteoblasts** (*blast*, precursor)

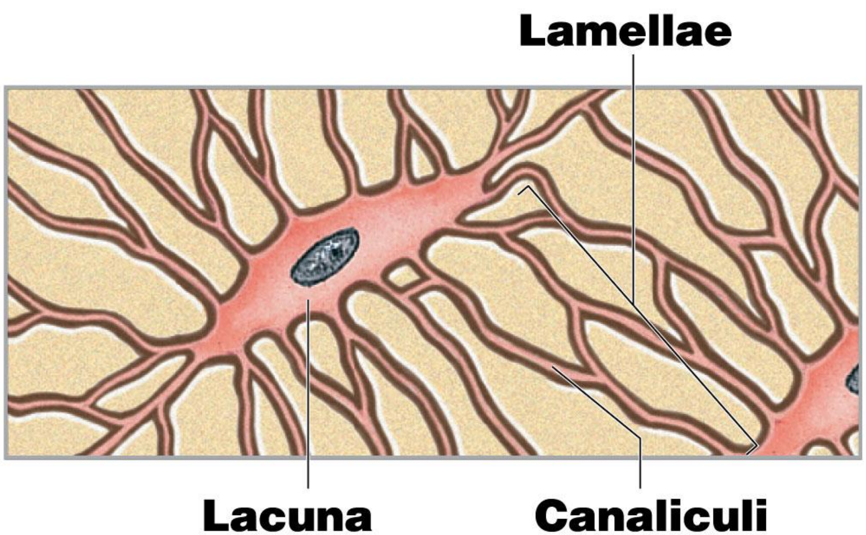
- Produce new bony matrix (**osteogenesis** or **ossification**)
  - Produces unmineralized matrix (**osteoid**)
  - Then assists in depositing calcium salts to convert osteoid to bone
- Become **osteocytes** once surrounded by bony matrix



# Module 6.4: Bone tissue

**Osteocytes** (*osteo-*, bone + *cyte*, cell)

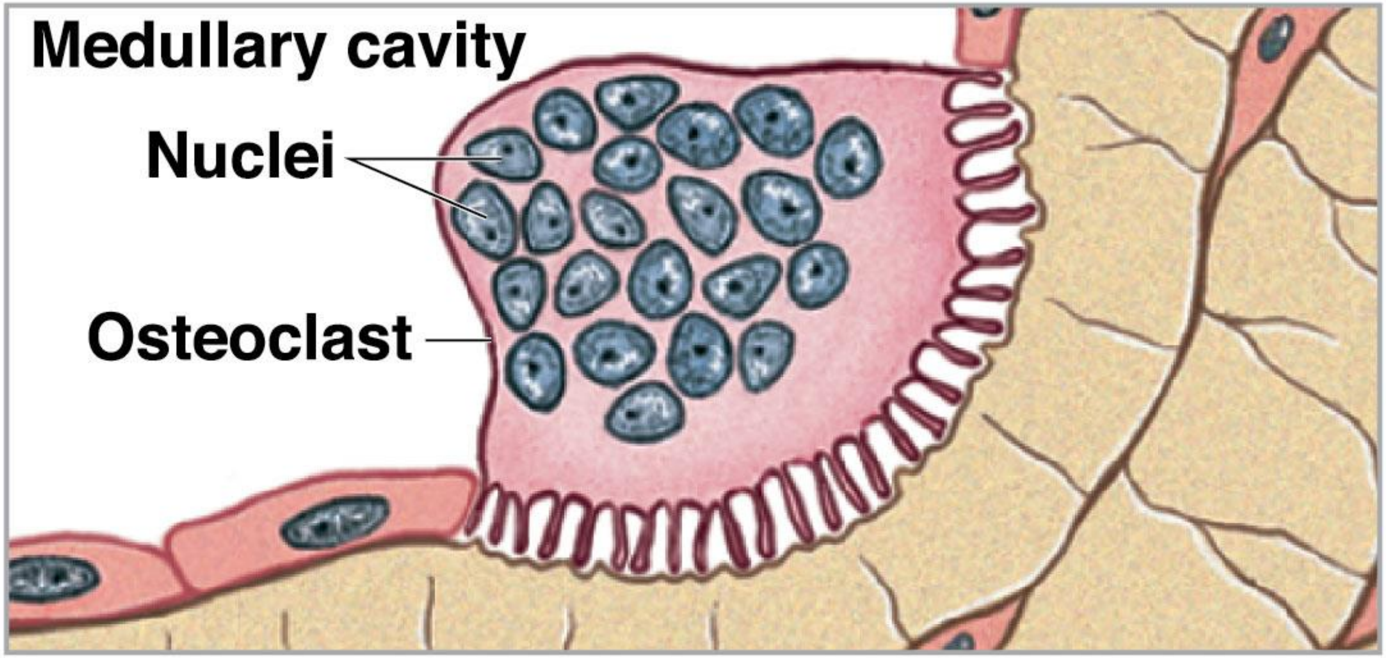
- Mature bone cells that cannot divide
- Maintain protein and mineral content of surrounding matrix
- Occupy **lacunae** (pockets)
  - Separated by layers of matrix (**lamellae**)
  - Interconnected by **canaliculi**



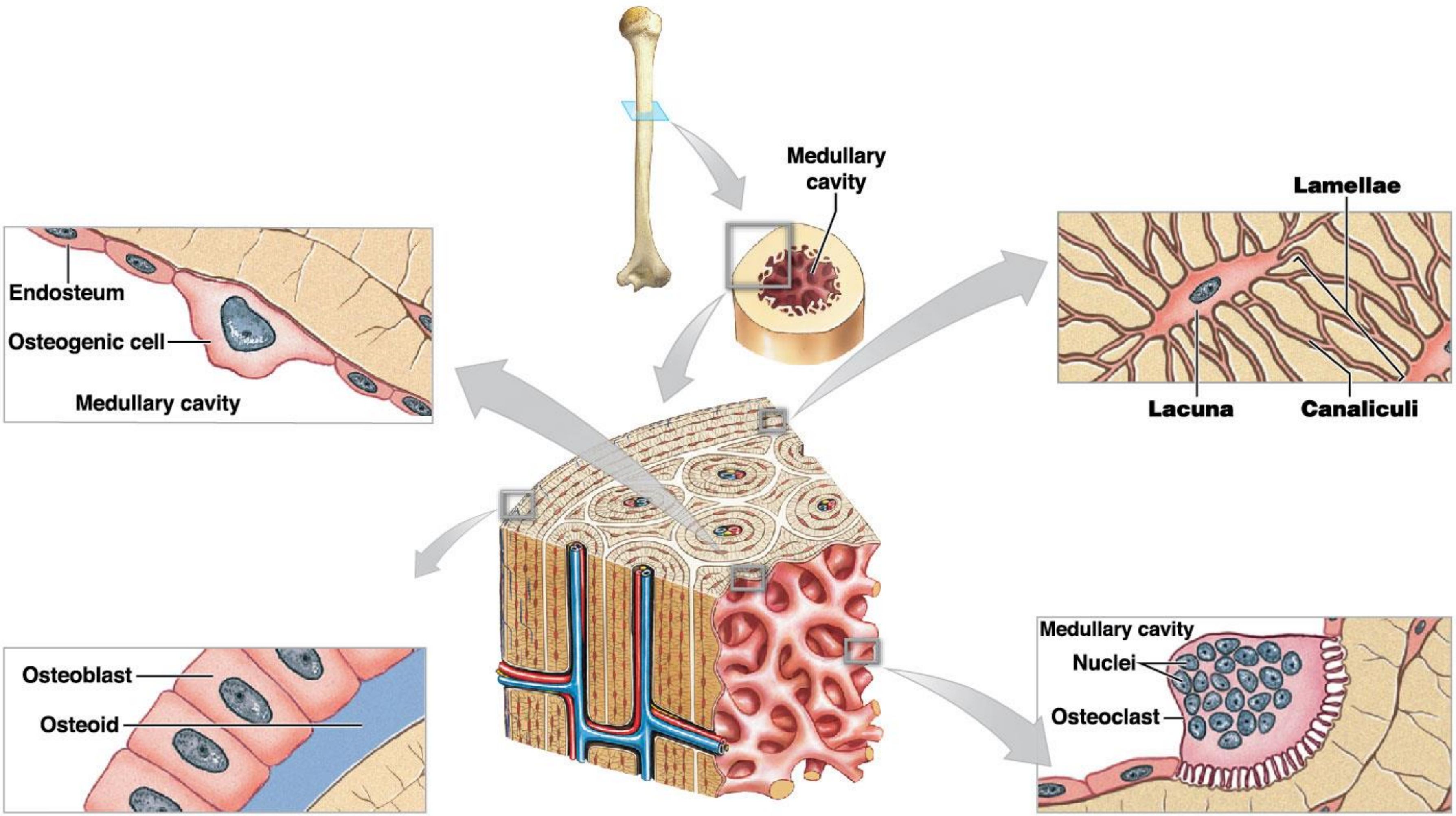
# Module 6.4: Bone tissue

**Osteoclasts** (*klastos*, broken)

- Remove and remodel bone matrix
- Release acids and proteolytic enzymes to dissolve matrix and release stored minerals
  - Process called **osteolysis** (*lysis,* loosening)



# Bone tissue


Medullary
cavity
Endosteum
Osteogenic cell
Medullary cavity
Lamellae
Lacuna
Canaliculi
Osteoblast
Osteoid
Medullary cavity
Nuclei
Osteoclast

# Module 6.4: Bone tissue

## Bone matrix

- Collagen fibers account for ~1/3 bone weight
  - Provide flexibility
- Calcium phosphate ($Ca_3(PO_4)_2$) accounts for ~2/3 bone weight
  - Interacts with calcium hydroxide ($Ca(OH)_2$) to form crystals of **hydroxyapatite** ($Ca_{10}(PO_4)_6(OH)_2$) salts
    - Incorporates other salts (calcium carbonate, $CaCO_3$) and ions ($Na^+$, $Mg^{2+}$, $F^-$)
    - Provides strength

# Module 6.4: Review

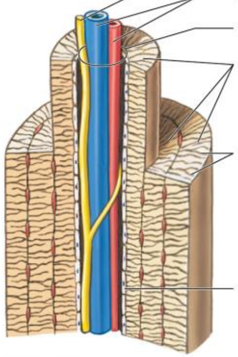
A. Describe the functions of osteogenic cells and osteoblasts.
B. Describe the functions of osteocytes.
C. How would the compressive strength of a bone be affected if the ratio of collagen to hydroxyapatite increased?
D. If osteoclast activity exceeds osteoblast activity in a bone, how will the bone mass be affected?

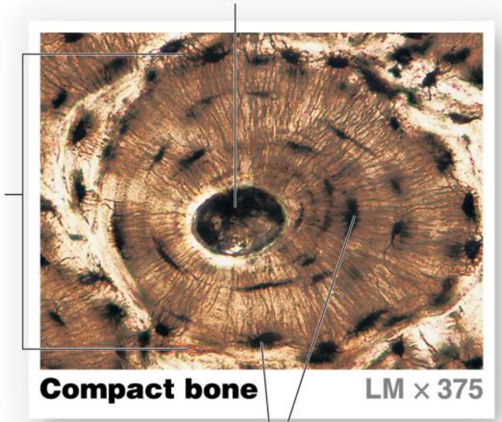
*Learning Outcome:* Identify the types of cells in bone, and list their major functions.

# Module 6.5: Compact bone consists of parallel osteons, and spongy bone consists of a network of trabeculae

## Compact bone

- Functional unit is **osteon** (Haversian system)
  - Organized **concentric lamellae** around a **central canal**
    - Osteocytes (in lacunae) lie between lamellae
    - Central canal contains small blood vessels

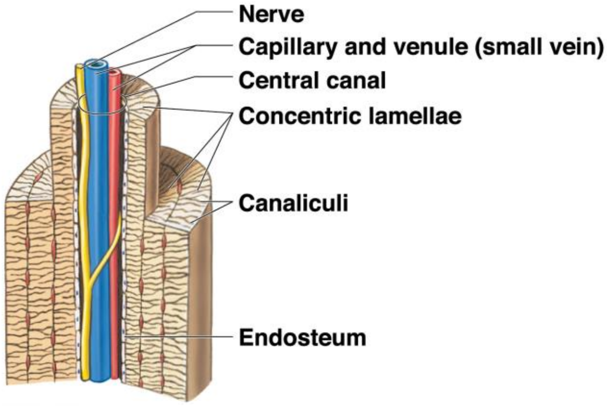


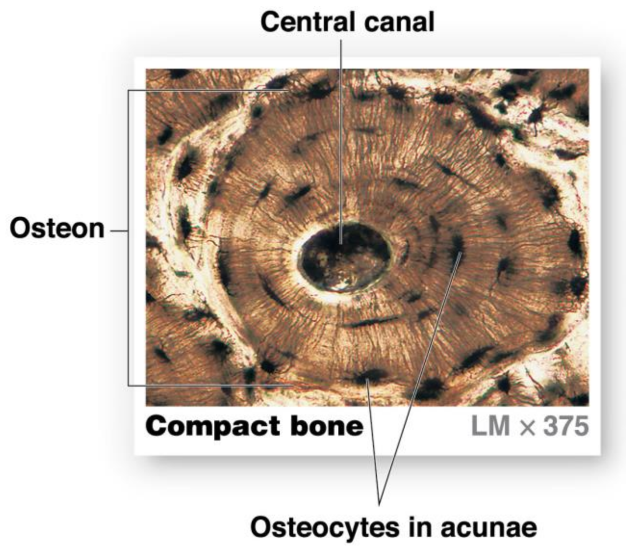



# Module 6.5: Compact and spongy bone structure

**Compact bone** (continued)

- Functional unit is **osteon** (Haversian system) (continued)
  - Canaliculi connect lacunae with each other and central canal
  - Strong along its length



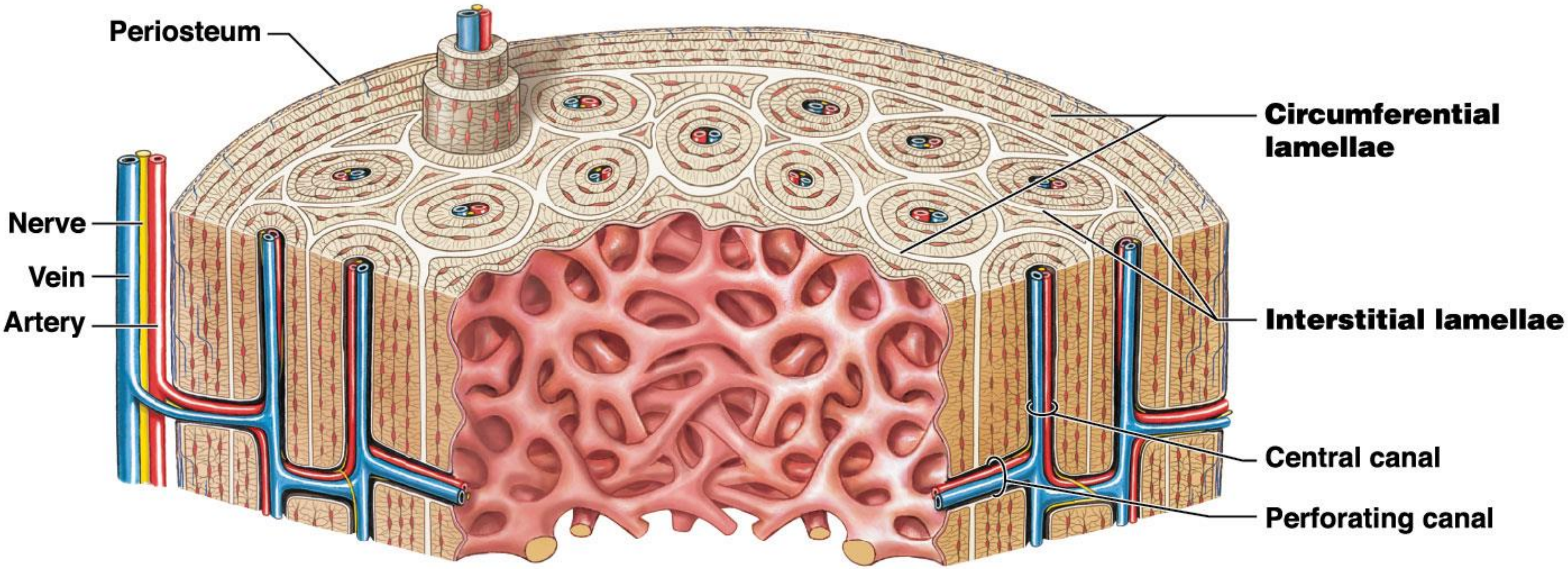



# Module 6.5: Compact and spongy bone structure

## Long bone organization

- Periosteum—outermost layer
- Compact bone—outer bone tissue layer
  - **Circumferential lamellae** (*circum-*, around + *ferre,* to bear) at outer and inner surfaces
  - **Interstitial lamellae** fill spaces between osteons
  - Osteons
    - Connected by **perforating canals** (perpendicular to surface)
- Spongy bone—innermost layer

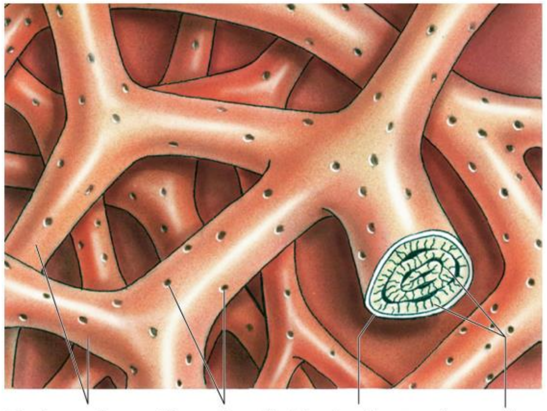
# Long bone organization



# Module 6.5: Compact and spongy bone structure

## Spongy bone

- Lamellae form struts and plates (**trabeculae**) creating an open network
  - No blood vessels in matrix
    - Nutrients reach osteons through canaliculi open to trabeculae surfaces
  - Red bone marrow is found between trabeculae



# Module 6.5: Review

A. Define *osteon*.

B. Compare compact bone and spongy bone.

C. A sample of bone has lamellae that are not arranged in osteons. Is the sample more likely from the epiphysis or from the diaphysis?

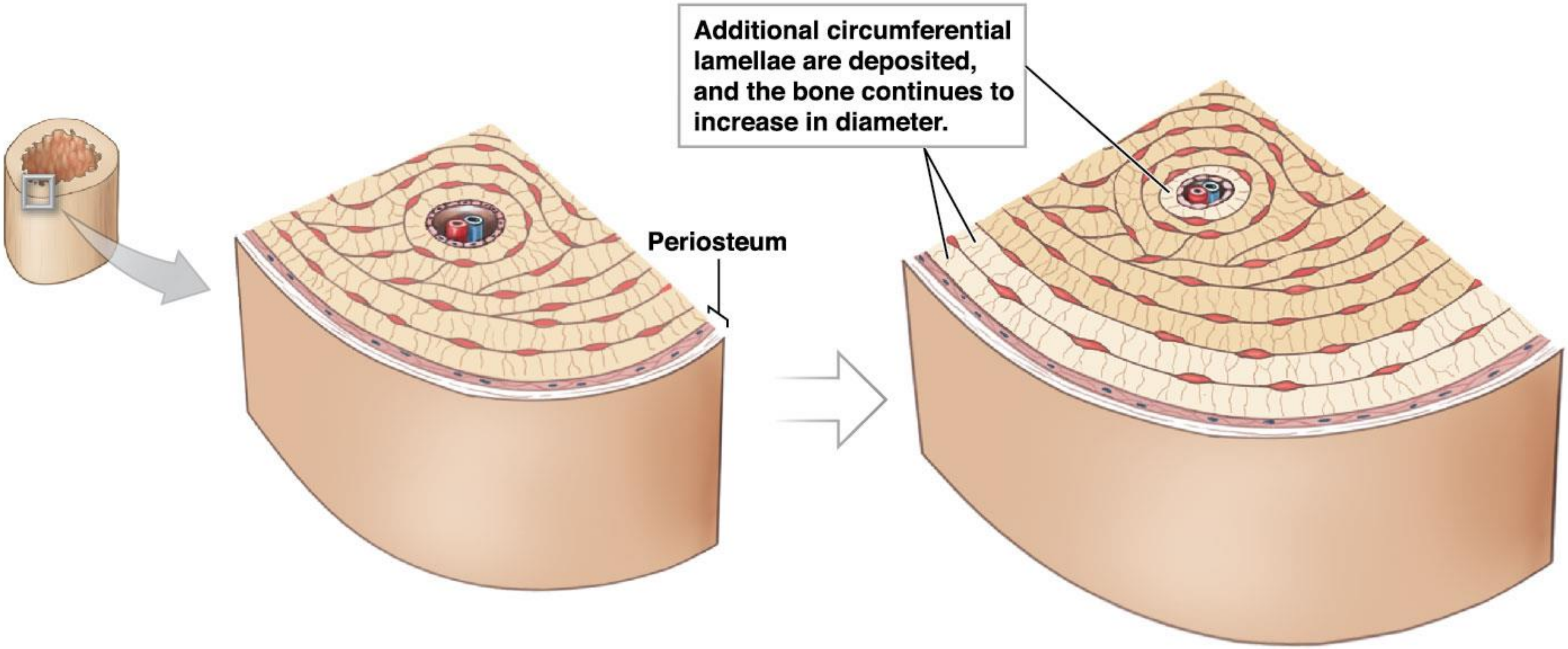
*Learning Outcome*: Compare the structures and functions of compact bone and spongy bone.

# Module 6.6: Appositional bone growth involves the periosteum and the endosteum

## Appositional growth in bones

- Increases bone diameter of existing bones
- Osteogenic cells differentiate into osteoblasts that add bone matrix under periosteum
  - Adds successive layers of circumferential lamellae
  - Trapped osteoblasts become osteocytes

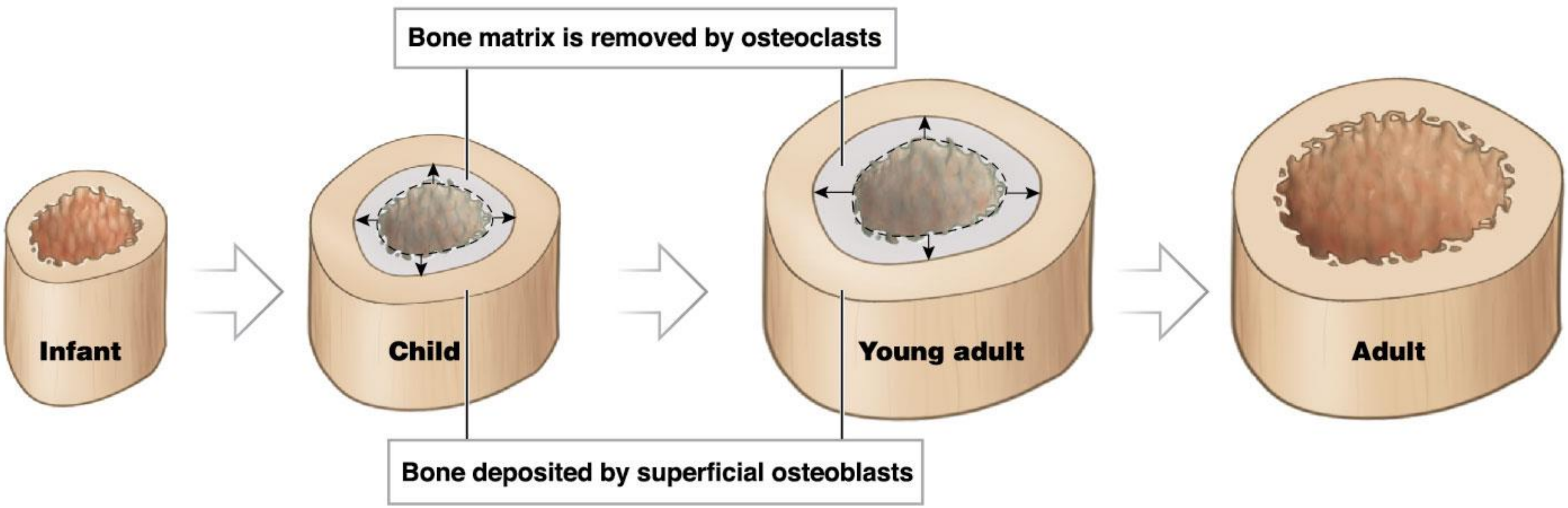
# Appositional growth



# Module 6.6: Appositional bone growth

**Appositional growth in bones** (continued)

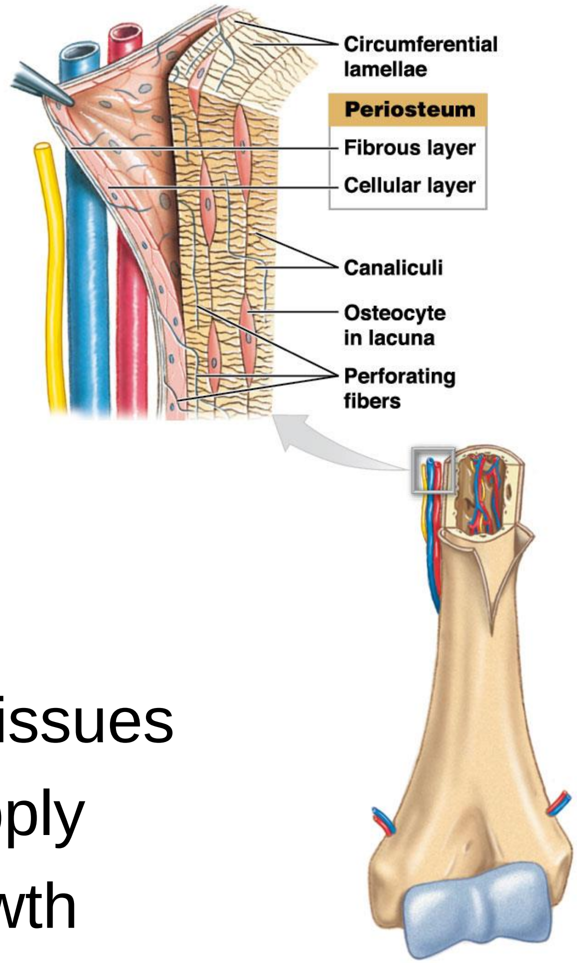
- Deeper lamellae recycled and replaced by osteons
- Osteoclasts remove matrix at inner surface to enlarge medullary cavity



# Module 6.6: Appositional bone growth

## The periosteum

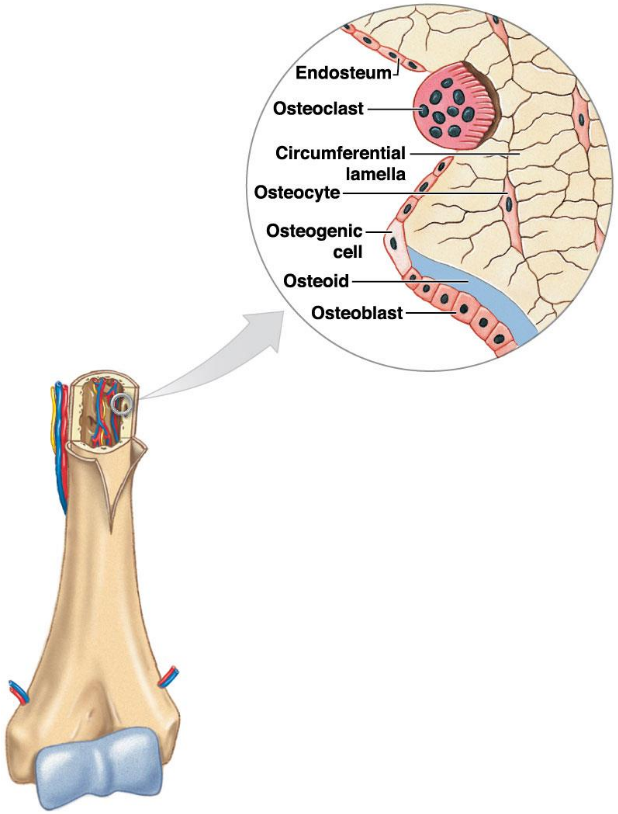
- Wraps the superficial layer of compact bone
- Two layers
  1. Fibrous outer layer
  2. Cellular inner layer
- Functions
  1. Isolates bone from surrounding tissues
  2. Route for blood and nervous supply
  3. Actively participates in bone growth and repair
- **Perforating fibers** allow for strong attachment



# Module 6.6: Appositional bone growth

## Endosteum

- Incomplete cellular layer lining medullary cavity
- Active during bone growth, repair, remodeling
- Covers spongy bone and lines central canals
- Where layer is incomplete, exposed matrix is remodeled by osteoclasts and osteoblasts
  - Osteoclasts in shallow depressions called **osteoclastic crypts** (Howship's lacunae)



# Module 6.6: Review

A. Define *appositional growth.*
B. As a bone increases in diameter, what happens to the medullary cavity?
C. Distinguish between the periosteum and the endosteum.

*Learning Outcome:* Describe the process of appositional bone growth.

# Module 6.7: Endochondral ossification replaces a cartilage model with bone

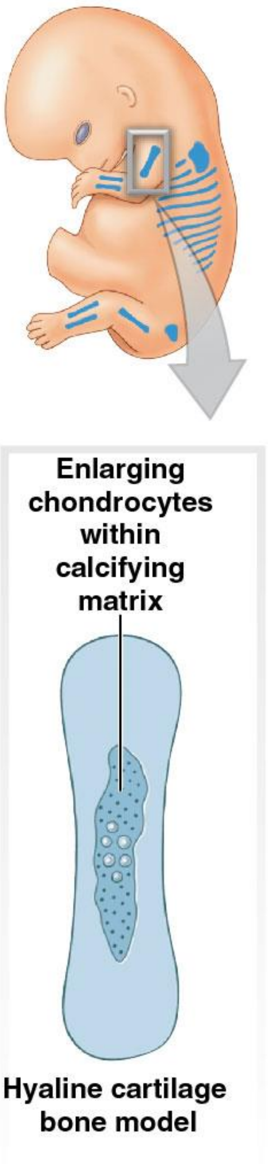
## Endochondral ossification

- Initial skeleton of embryo formed of hyaline cartilage
- Cartilage gradually replaced by bone through **endochondral** (*endo-*, inside + *chondros*, cartilage) **ossification**
  - Uses cartilage as small model
  - Bone grows in diameter and length
    - Diameter growth involves appositional bone deposition

# Module 6.7: Endochondral ossification

## Steps in endochondral ossification

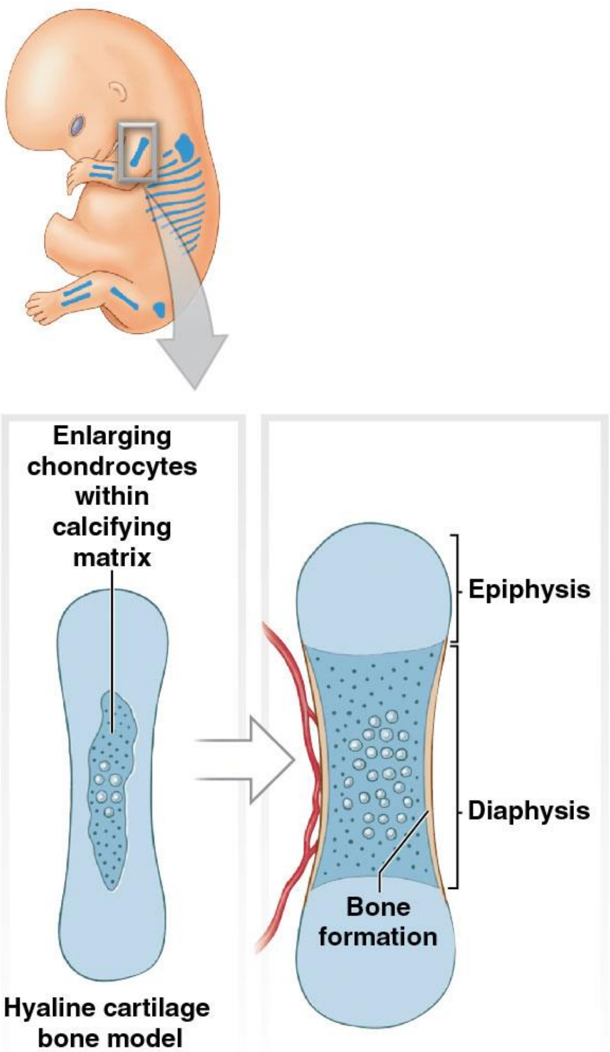
1. Cartilage model enlarges
   - Chondrocytes near center of shaft enlarge
   - Enlarged chondrocytes die and disintegrate
   - Disintegration leaves cavities within cartilage



# Module 6.7: Endochondral ossification

## Steps in endochondral ossification (continued)

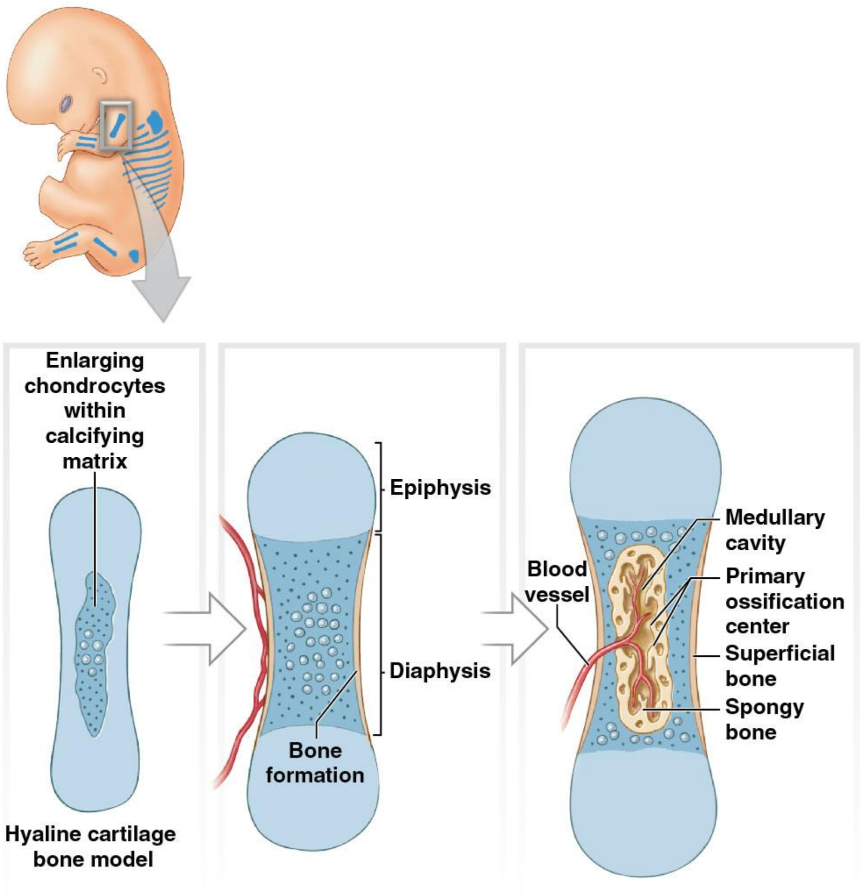
2. Blood vessels grow around the edge of the cartilage model
   - Cells of perichondrium convert to osteoblasts
   - Osteoblasts form superficial layer of bone along the shaft



# Module 6.7: Endochondral ossification

## **Steps in endochondral ossification** (continued)

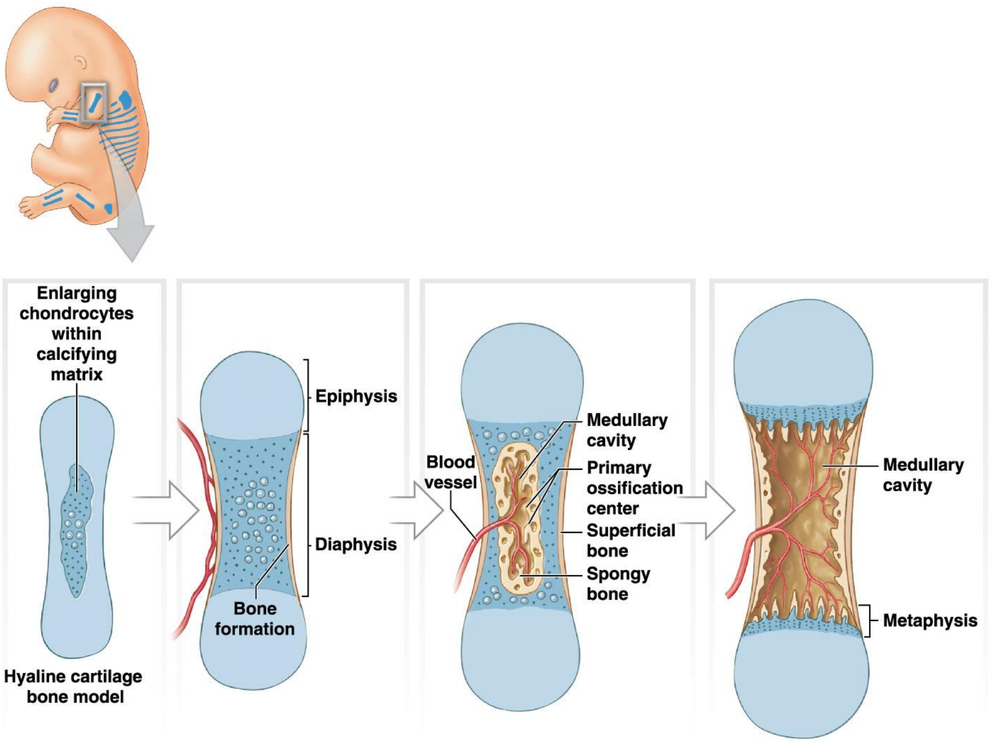
3. Blood vessels penetrate cartilage and enter central region
   - Entering fibroblasts differentiate into osteoblasts
   - Begin spongy bone production at **primary ossification center**
   - Bone formation spreads along the shaft toward both ends



# Module 6.7: Endochondral ossification

## **Steps in endochondral ossification** (continued)

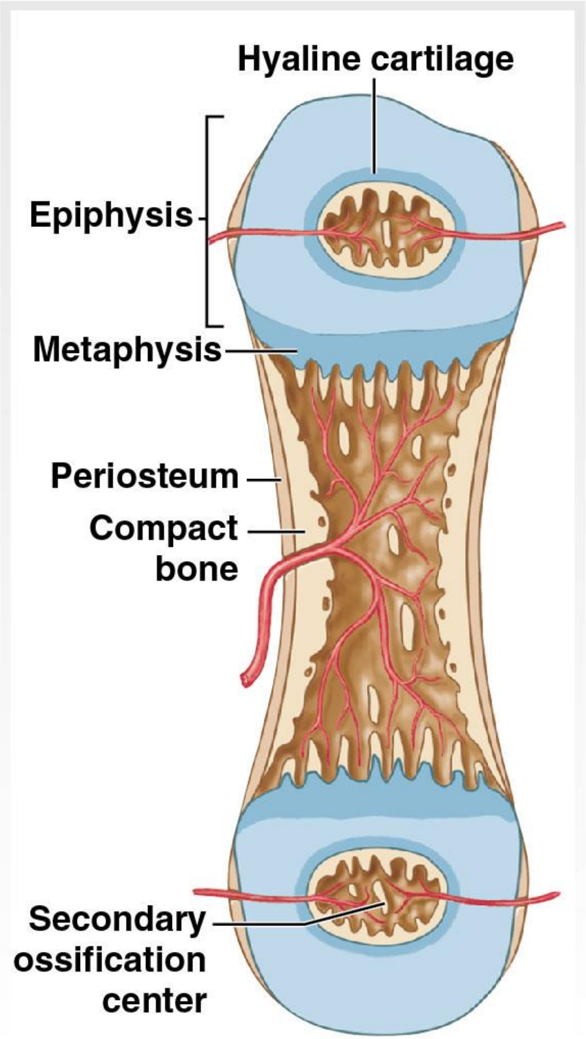
4. Growth continues along with remodeling
   - Medullary cavity created
   - Osseous tissue of the shaft thickens
   - Cartilage near the epiphyses is replaced by shafts of bone
   - Bone grows in length and diameter



# Module 6.7: Endochondral ossification

## **Steps in endochondral ossification** (continued)

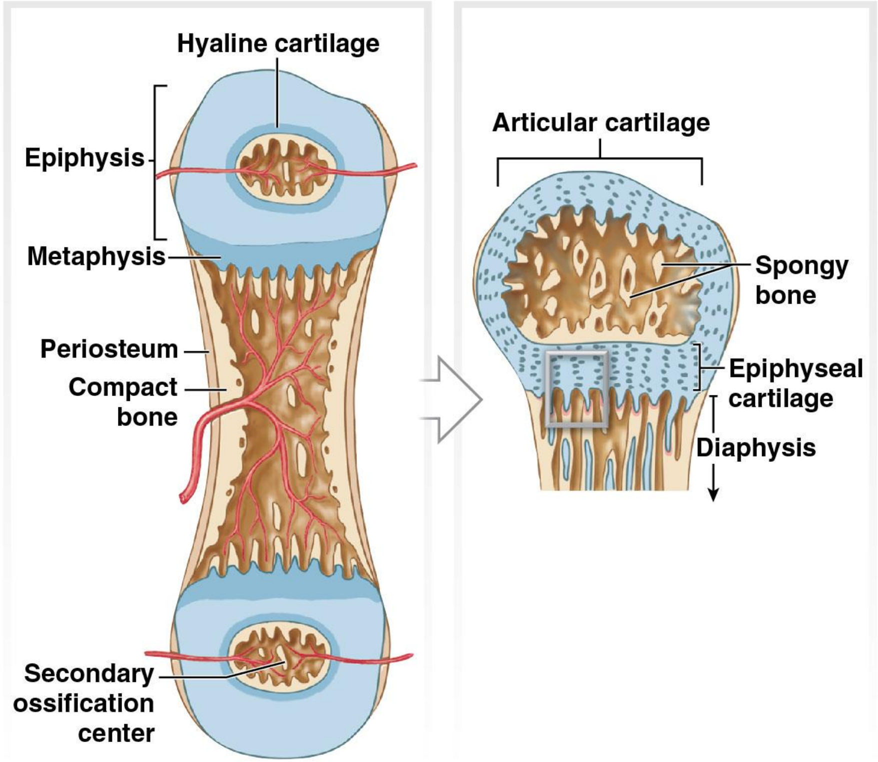
5. Capillaries and osteoblasts migrate into the epiphyses
   - Create **secondary ossification centers**



# Module 6.7: Endochondral ossification

## **Steps in endochondral ossification** (continued)

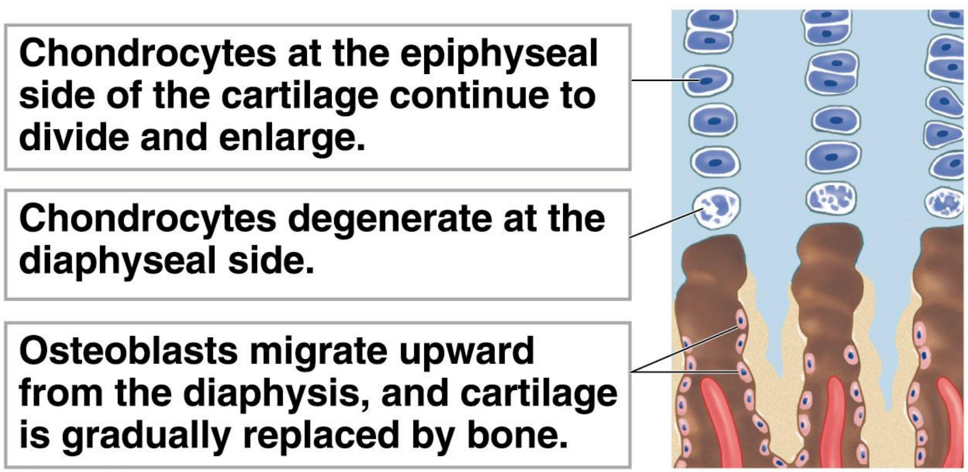
6. Epiphyses fill with spongy bone
   - Articular cartilage remains exposed to joint cavity
   - **Epiphyseal cartilage (epiphyseal plate)** separates epiphysis from diaphysis



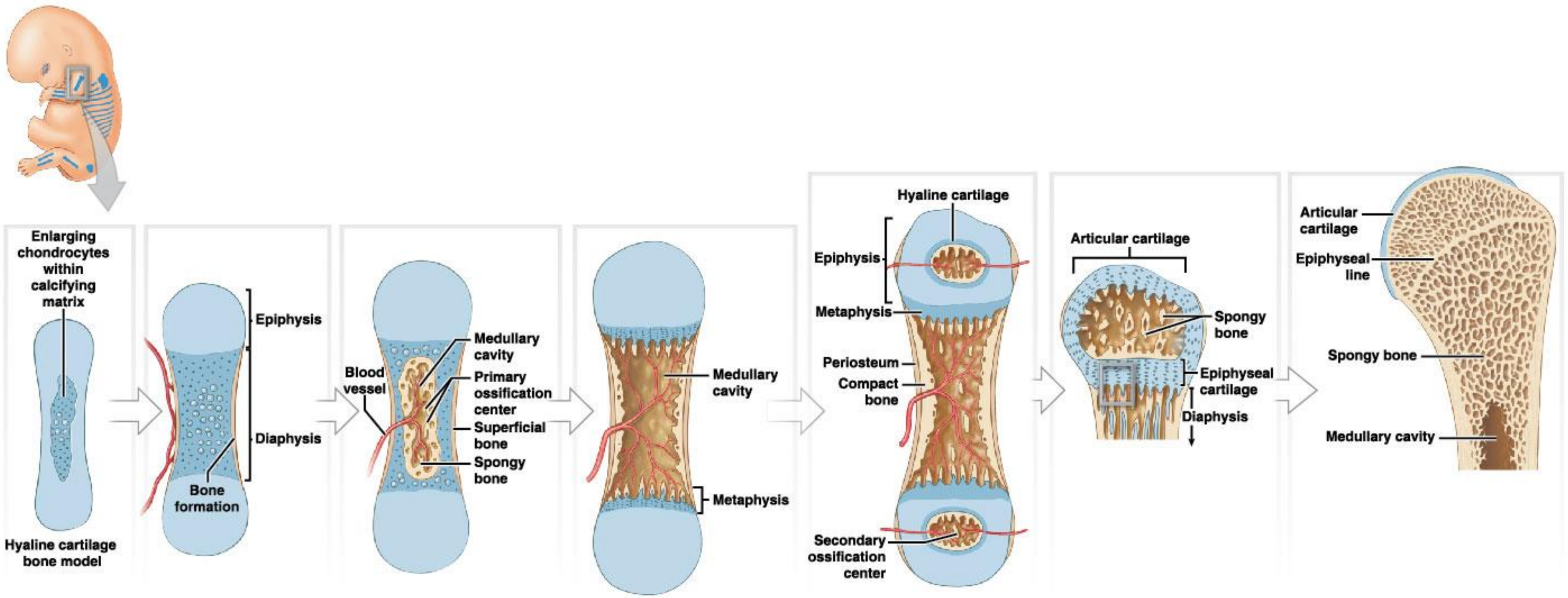
# Module 6.7: Endochondral ossification

**Steps in endochondral ossification** (continued)

7. Bone grows in length at the epiphyseal cartilage
   - Chondrocytes actively produce more cartilage on epiphyseal side
   - Osteoblasts actively replace cartilage with bone on diaphyseal side
   - Epiphyses are pushed away by continued production of new cartilage



# Endochondral ossification



# Module 6.7: Endochondral ossification

## Bone growth


- At puberty, hormones stimulate increased bone growth, and epiphyseal cartilage is replaced
  - Osteoblasts produce bone faster than chondrocytes produce cartilage
  - Epiphyseal cartilage narrows until it disappears
    - Process called **epiphyseal closure**
    - Leaves **epiphyseal line** in adults

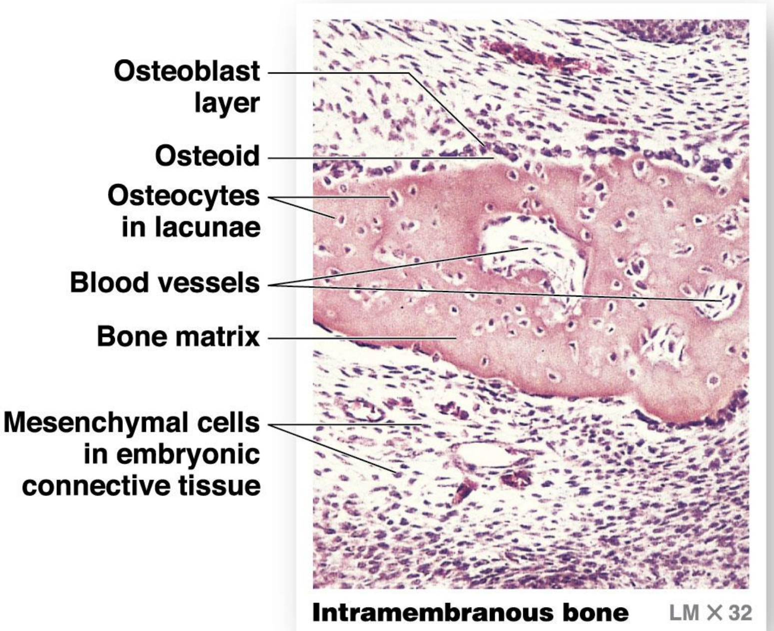
# Module 6.7: Review

A. Define *endochondral ossification*.
B. In endochondral ossification, what is the original source of osteoblasts?
C. How could x-rays of the femur be used to determine whether a person has reached full height?

*Learning Outcome:* Describe the process of endochondral ossification.

# Module 6.8: Intramembranous ossification forms bone without a prior cartilage model

- Begins when mesenchymal (stem) cells differentiate into osteoblasts within embryonic or fibrous connective tissue
- Normally occurs in deeper layers of dermis
- Bones called **dermal bones** or membrane bones
- *Examples:* roofing bones of skull, lower jaw, collarbone, sesamoid bones (patella)



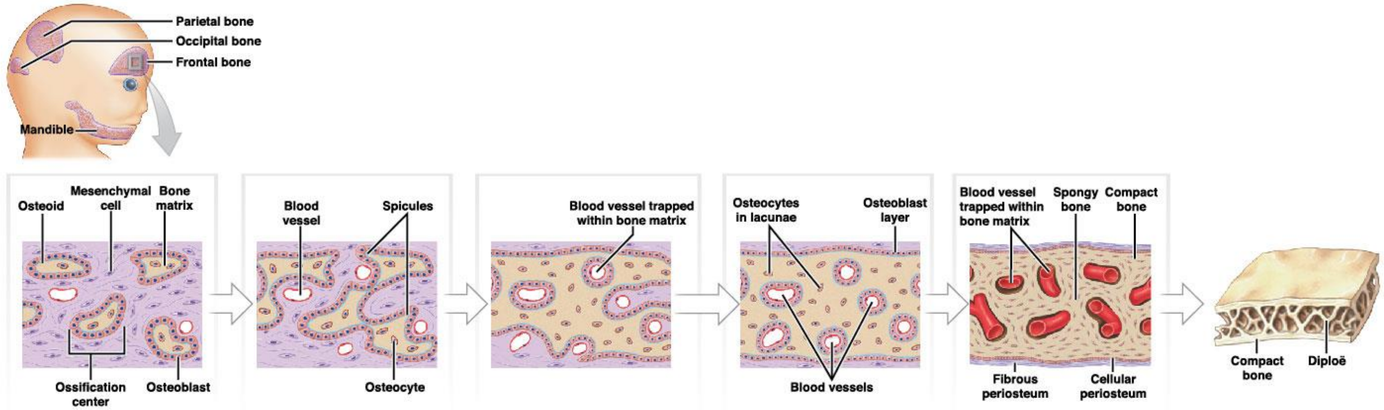

Intramembranous bone

# Module 6.8: Intramembranous ossification

## Steps of intramembranous ossification

1. Mesenchymal cells cluster
   - Differentiate into osteoblasts
     – Secrete osteoid matrix
   - Osteoid matrix becomes mineralized
     – Forms bone matrix

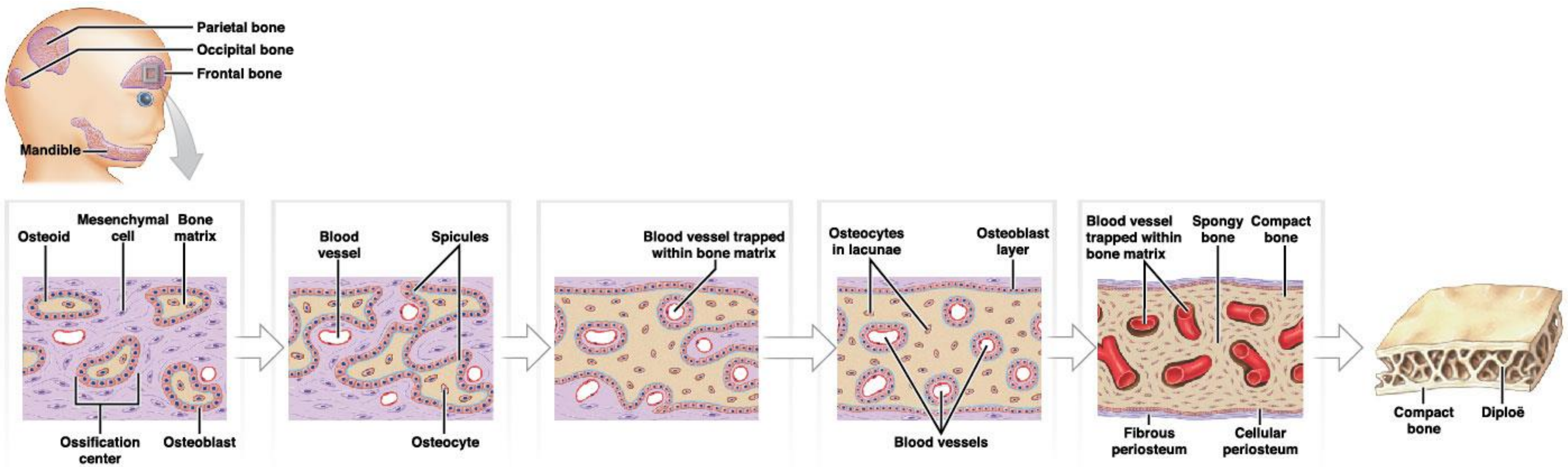
- Location in tissue where ossification begins is **ossification center**



# Module 6.8: Intramembranous ossification

## Steps of intramembranous ossification (continued)

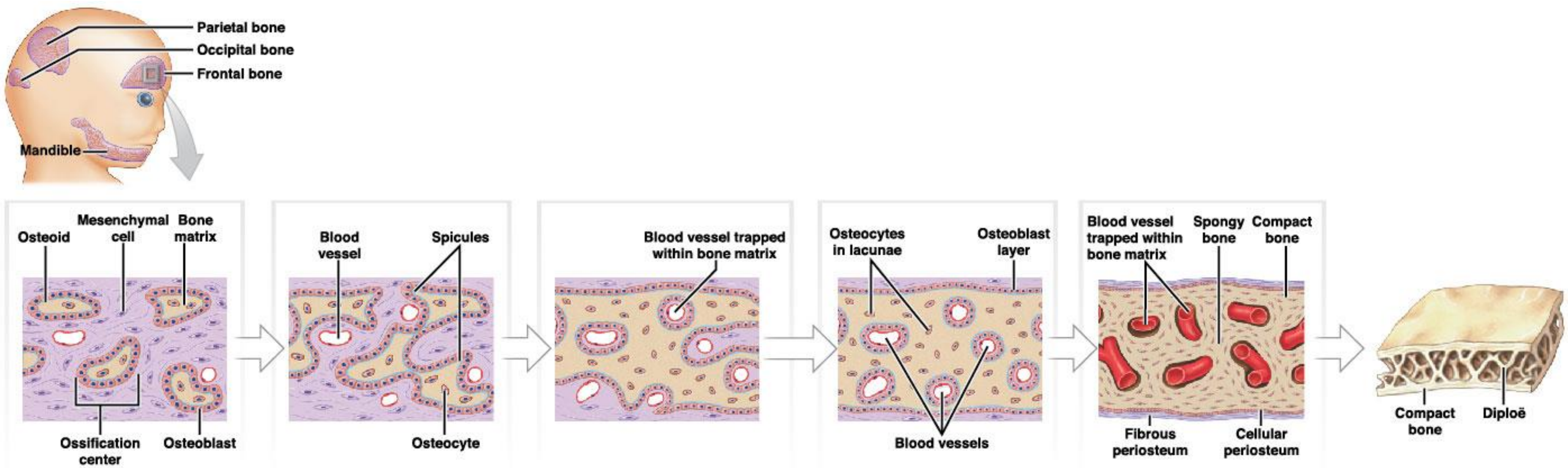
2. Bone grows out in small struts (**spicules**)
   - Osteoblasts become trapped in pockets and mature into osteocytes
   - Mesenchymal cells produce more osteoblasts



# Module 6.8: Intramembranous ossification

## Steps of intramembranous ossification (continued)

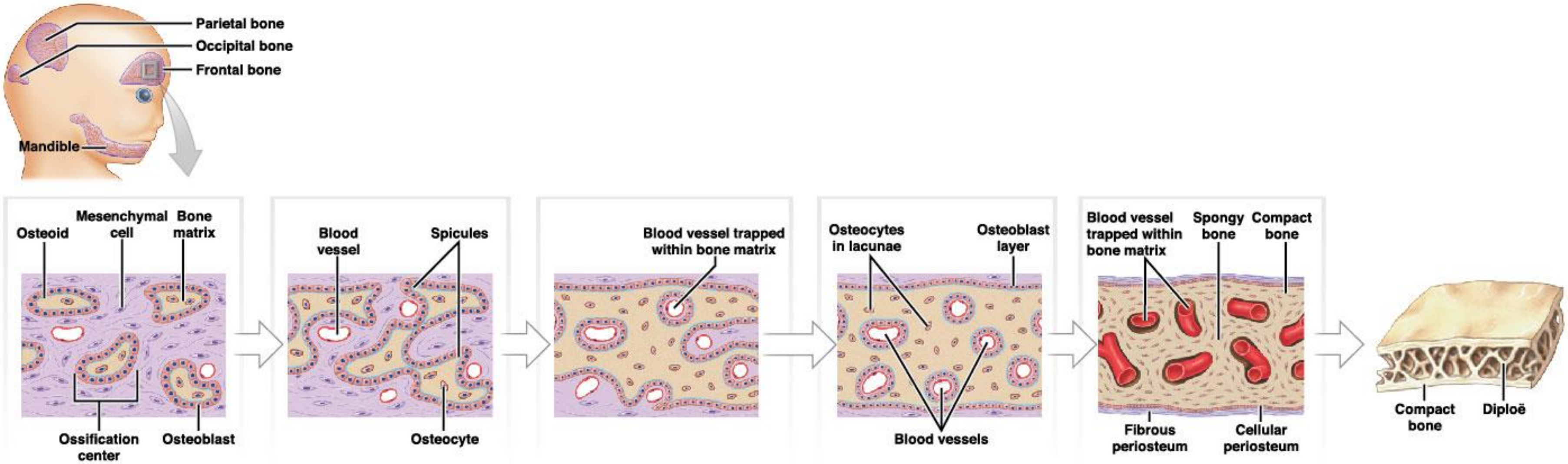
3. Blood vessels enter area
   - Bone spicules meet and fuse
   - Blood vessels trapped in developing bone



# Module 6.8: Intramembranous ossification

## Steps of intramembranous ossification (continued)

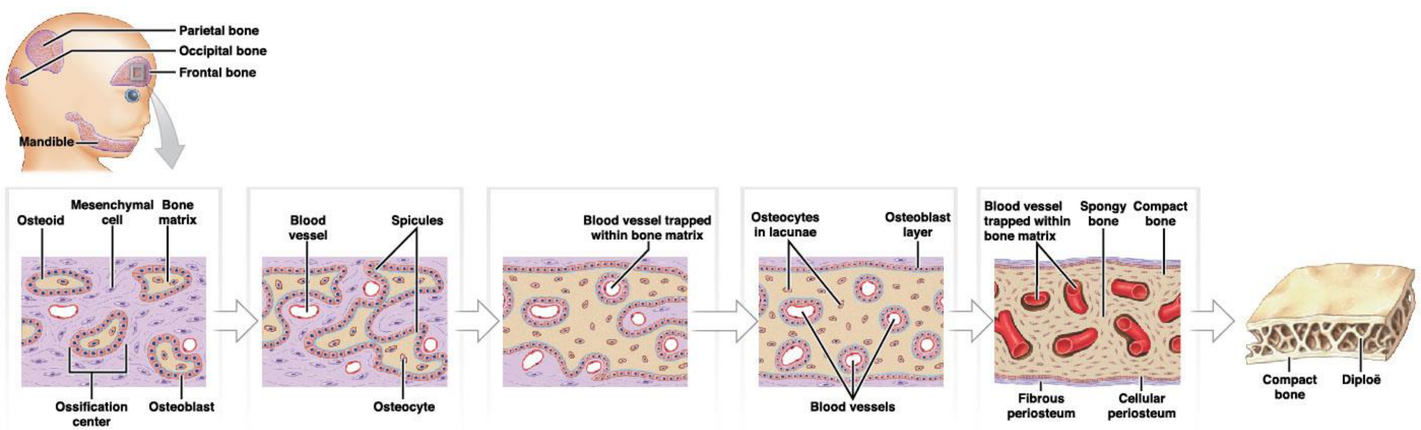
4. Continued deposition of bone by osteoblasts close to blood vessel
   - Results in spongy bone with interwoven blood vessels



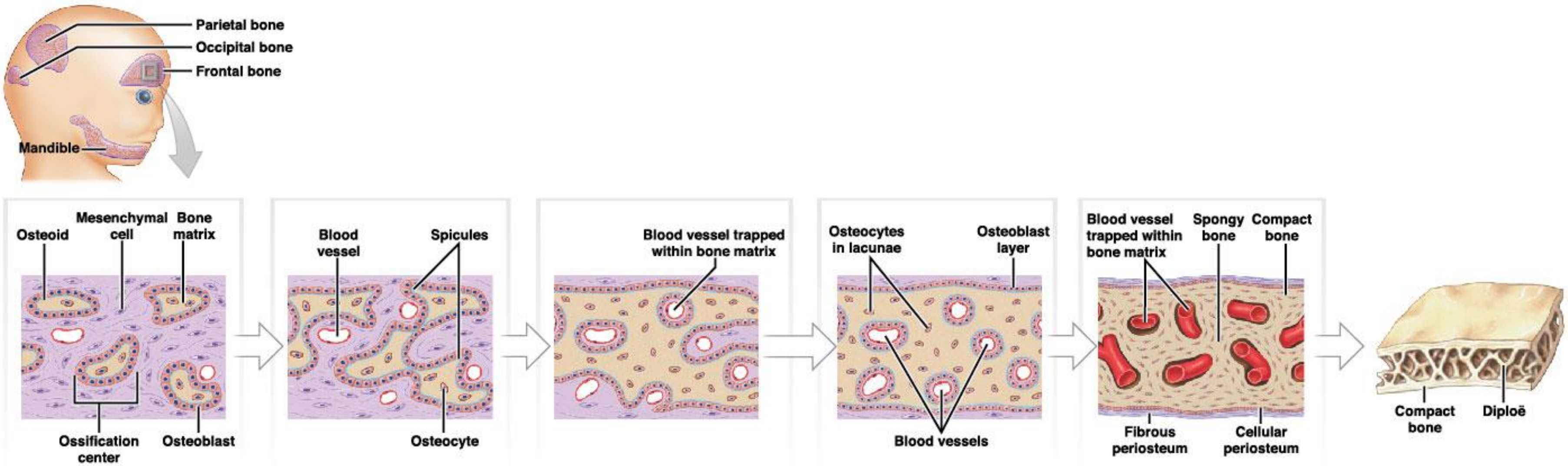
# Module 6.8: Intramembranous ossification

## **Steps of intramembranous ossification** (continued)

5. Remodeling around blood vessels produces osteons of compact bone
   - Connective tissue around bone organizes into fibrous layer of the periosteum
   - Osteoblasts near bone surface remain as cellular layer of periosteum



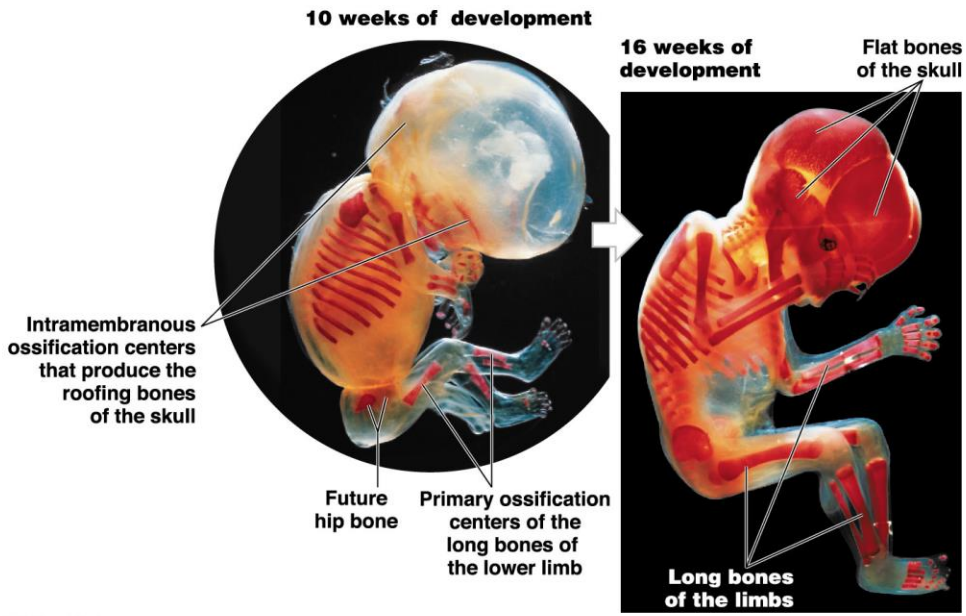
# Intramembranous ossification



# Module 6.8: Intramembranous ossification

## Intramembranous ossification in development

- Begins during the eighth week of embryonic development
- Can see ossification centers and progressing bone formation at 10 weeks
- At 16 weeks, most of the bones of the adult skeleton can be identified



## Module 6.8: Review

A. Define *intramembranous ossification.*
B. During intramembranous ossification, bone replaces which type of tissue?
C. Explain the primary difference between endochondral ossification and intramembranous ossification.

*Learning Outcome:* Describe the process of intramembranous ossification.

# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth and development produce recognizable physical signs

## Disorders causing shortened bones

- **Pituitary growth failure**
  - Inadequate growth hormone production
  - Reduced epiphyseal cartilage activity; abnormally short bones
  - Rare in United States due to treatment with synthetic growth hormone

# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth

**Disorders causing shortened bones** (continued)

- **Achondroplasia**
  - Epiphyseal cartilage of long bones grows slowly
    - Replaced by bone early in life
  - Short, stocky limbs result
  - Trunk is normal size
  - No effects on sexual or mental development

# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth

## Disorders causing lengthened bones

- **Marfan syndrome**
  - Inherited metabolic condition
  - Excessive cartilage formation at epiphyseal cartilages
  - Results in very tall person with long, slender limbs
  - Affects other connective tissues throughout the body
    - Commonly causes cardiovascular problems

# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth

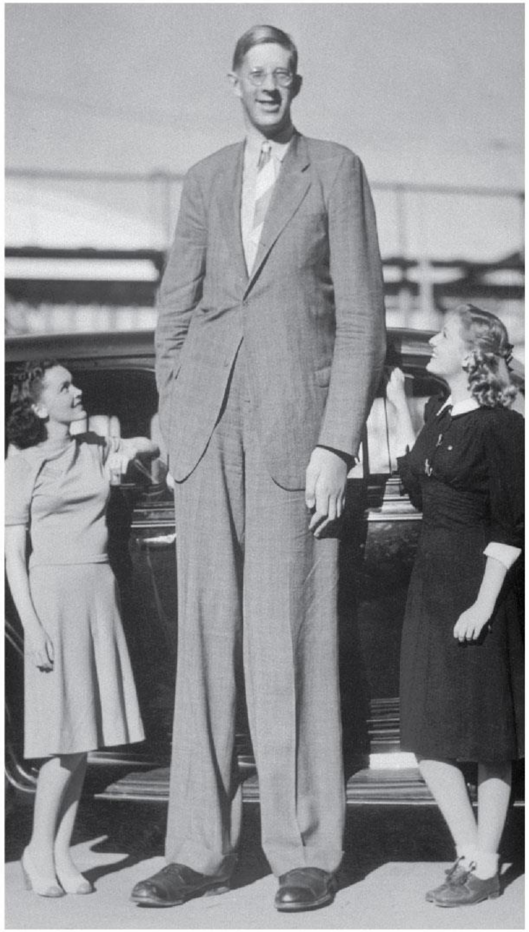
## Other skeletal growth abnormalities

- **Congenital talipes equinovarus (clubfoot)**
  - Inherited developmental abnormality
    - Affects 2 in 1000 births
    - Boys roughly twice as often as girls
  - May affect one or both feet
  - Abnormal muscle development distorts growing bones
    - Feet turn medially and are inverted
  - Treated with casts or supports

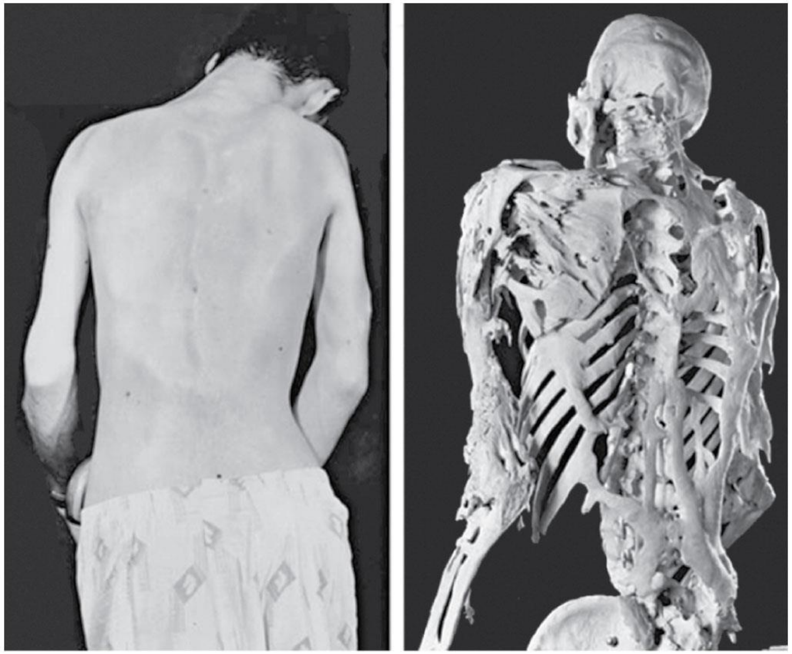
# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth

## Gigantism

- Disorder causing lengthened bones
- Overproduction of growth hormone before puberty
- Can reach heights of over 2.7 m (8 ft. 11 in.)
- Puberty often delayed
- Most common cause is a pituitary tumor
- Treated by surgery, radiation, or medications suppressing growth hormone release



# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth



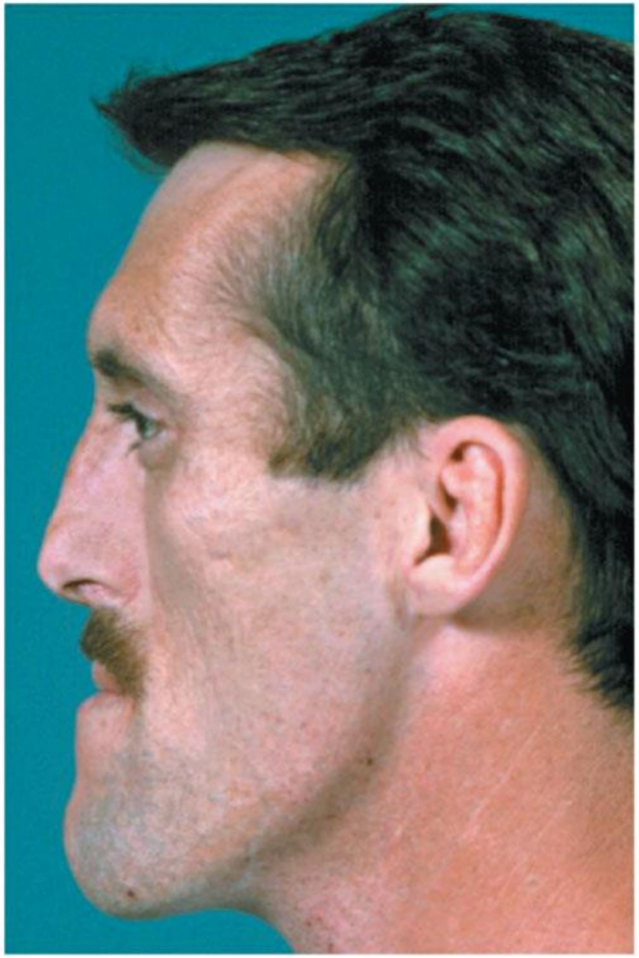
## Other skeletal growth abnormalities

- **Fibrodysplasia ossificans progressiva (FOP)**
  - Gene mutation that causes bone deposition around skeletal muscles
  - Bones develop in unusual places
    - Called **heterotopic** (*hetero*, place) or **ectopic** (*ektos*, outside) **bones**
  - No effective treatment

# Module 6.9: CLINICAL MODULE: Abnormalities of bone growth

**Other skeletal growth abnormalities** (continued)

- **Acromegaly**
  - Overproduction of growth hormone after epiphyseal plates close
  - Bones get thicker, not longer
    - Especially those in face, jaw, and hands
  - Alterations in soft-tissue structure changes physical features



# Module 6.9: Review

A. Why is pituitary growth failure less common today in the United States?
B. Describe Marfan syndrome.
C. Compare gigantism with acromegaly.

*Learning Outcome:* Discuss various abnormalities of bone formation and growth.

# Section 2: Physiology of Bones

## Learning Outcomes

6.10 List the minerals stored in the bones, and identify the organs involved in calcium homeostasis.

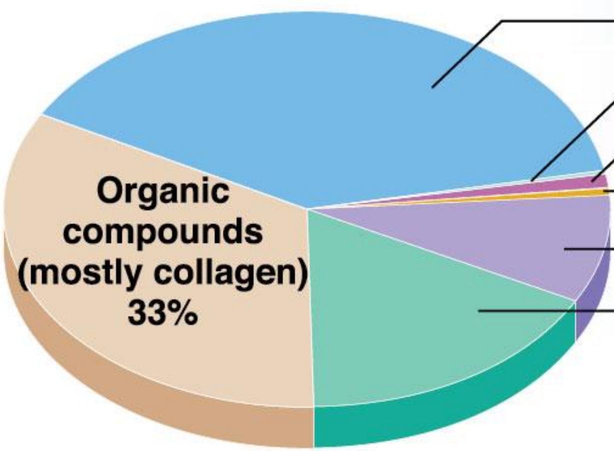
6.11 Discuss the effects of hormones on bone development, and explain the homeostatic mechanisms involved.

6.12 **Clinical Module:** Describe the types of fractures, and explain how fractures heal.

# Module 6.10: Bones play an important role as mineral reservoirs

Minerals

- Inorganic ions contributing to the osmotic balance of body fluids
- Vital in many physiological processes




| Bone Composition | Bone Contains |
|---|---|
| Calcium 39% | 99% of the body's calcium |
| Potassium 0.2% | 4% of the body's potassium |
| Sodium 0.7% | 35% of the body's sodium |
| Magnesium 0.4% | 50% of the body's magnesium |
| Carbonate 9.7% | 80% of the body's carbonate |
| Phosphate 17% | 99% of the body's phosphate |
| Total inorganic components 67% | |

# Module 6.10: Bones as mineral reservoirs

## The importance of calcium

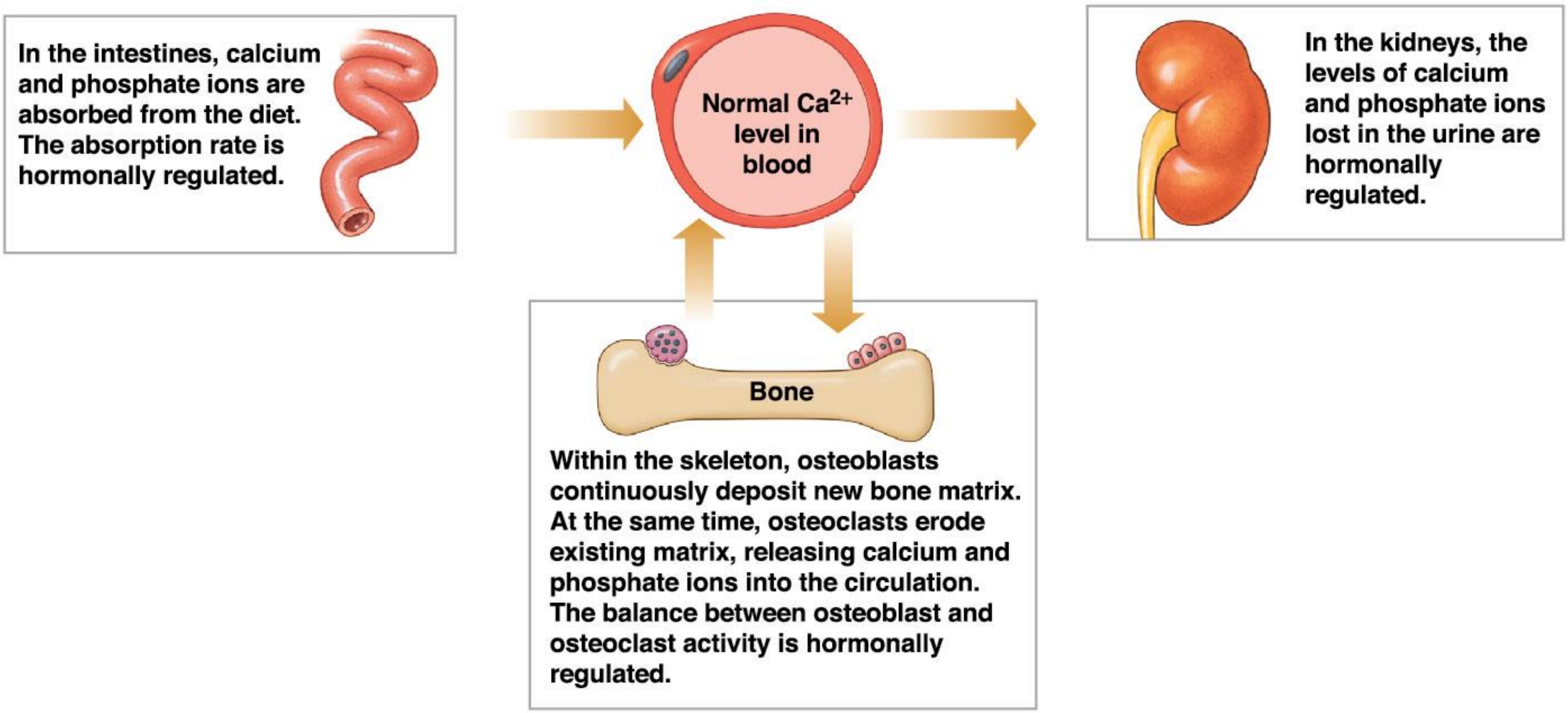
- Most abundant mineral in body
- 1–2 kg (2.2–4.4 lb)
- ~99 percent deposited in skeleton
- Variety of physiological functions (muscle contraction, blood coagulation, nerve impulse generation)
  - Concentration variation greater than 30–35 percent affects neuron and muscle function
  - Normal daily fluctuations are <10 percent

# Module 6.10: Bones as mineral reservoirs

## Maintaining calcium levels

- Controlled by activities of:
  - Intestines
    - Absorb calcium and phosphate under hormonal control
  - Bones
    - Osteoclasts erode matrix and release calcium
    - Osteoblasts use calcium to deposit new matrix
  - Kidneys
    - Varying levels of calcium and phosphate loss in urine under hormonal control

# Calcium level maintenance



# Module 6.10: Review

A. What is the ratio of organic compounds to inorganic components in the composition of bone?

B. Which three organ systems coordinate to maintain normal blood calcium levels?

C. What physical signs would be expected in a person whose blood calcium was abnormally low?

*Learning Outcome:* List the minerals stored in the bones, and identify the organs involved in calcium homeostasis.

# Module 6.11: The primary hormones regulating calcium ion metabolism are parathyroid hormone, calcitriol, and calcitonin

## Factors that increase blood calcium levels

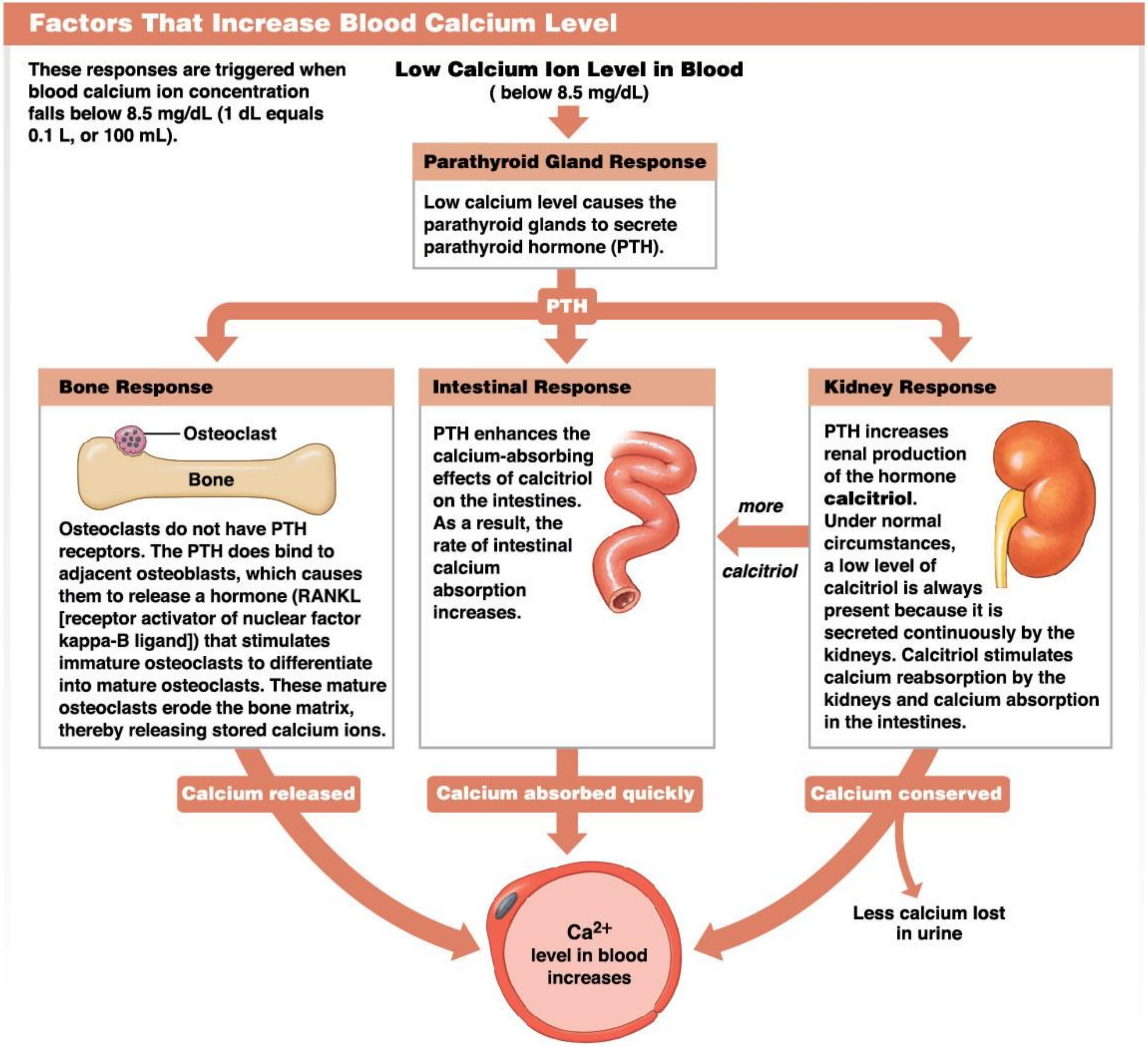
- **Parathyroid hormone (PTH)**
  - Secreted from **parathyroid glands**
  - Responses
    - In bones:
      - Osteoclasts stimulated to erode matrix, releasing stored calcium

# Module 6.11: Hormones regulating calcium ion metabolism

**Factors that increase blood calcium levels** (continued)

- **Parathyroid hormone (PTH)** (continued)
  - Responses (continued)
    - In intestines:
      - Calcitriol effects enhanced and calcium absorption increased
    - In kidneys:
      - Increased release of hormone **calcitriol**, stimulating calcium reabsorption in kidneys

# Parathyroid hormone and calcium

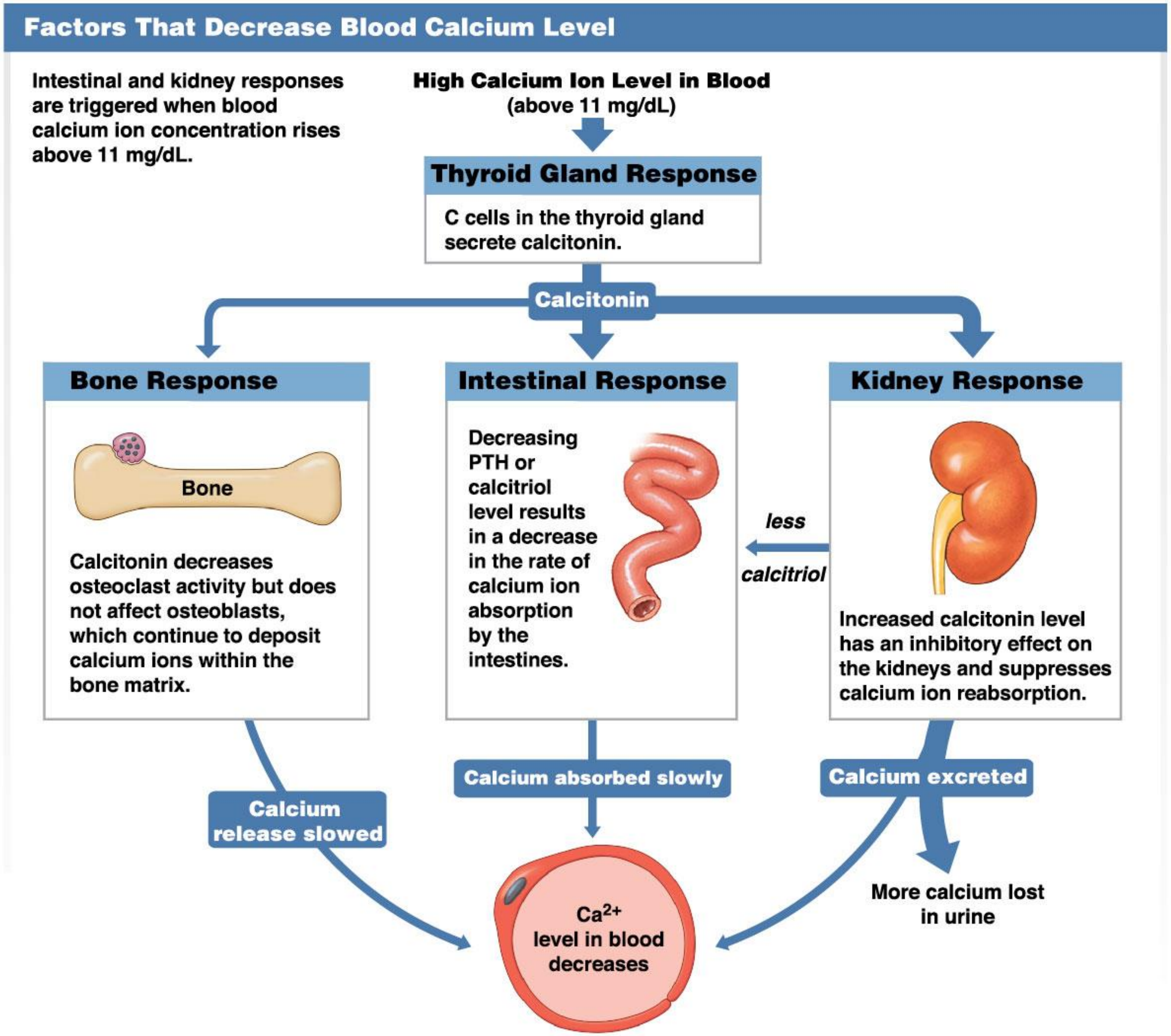


# Module 6.11: Hormones regulating calcium ion metabolism

## Factors that decrease blood calcium levels

- **Calcitonin**
- Secreted from **C cells** in the **thyroid gland**
- Responses
  - In bones:
    - Osteoclast activity inhibited; calcium deposited in bone matrix
  - In intestines:
    - Calcium absorption decreased with decreasing PTH and calcitriol
  - In kidneys:
    - Inhibits calcitriol release and calcium reabsorption

# Thyroid regulation of calcium



# Module 6.11: Hormones regulating calcium ion metabolism

## Calcium and the skeleton

- As a calcium reserve, skeleton has primary role in calcium homeostasis
- Has direct effect on shape and strength of bones
  - Release of calcium into blood weakens bones
  - Deposition of calcium salts strengthens bones

# Module 6.11: Review

A. Identify the hormone that stimulates the release of calcium ions from bone matrix. Explain its mechanism of action.

B. Describe the kidney and intestinal responses to PTH.

C. How does calcitonin act to lower blood calcium?

*Learning Outcome:* Discuss the effects of hormones on bone development, and explain the homeostatic mechanisms involved.

# Module 6.12: CLINICAL MODULE: A fracture is a crack or a break in a bone

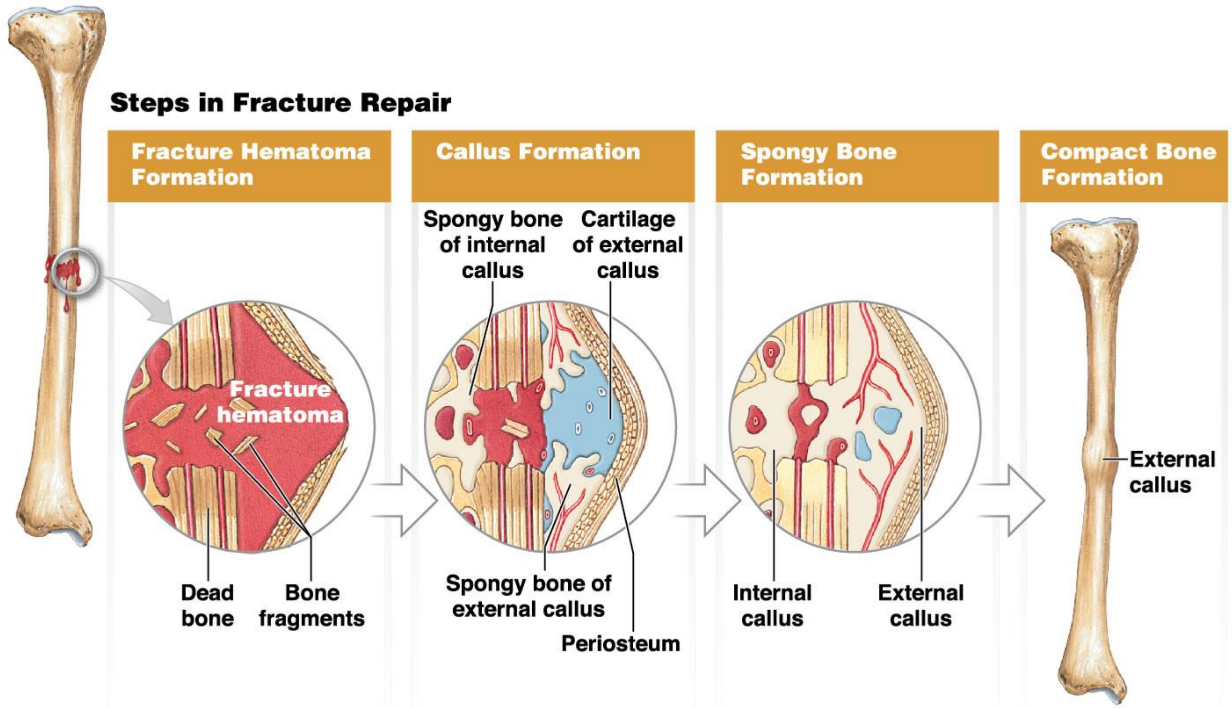
## Fracture

- Crack or break due to extreme mechanical stress
- Most heal as long as blood supply and cellular parts of periosteum and endosteum survive
- Repair involves four steps

# Module 6.12: CLINICAL MODULE: Bone fractures

## Steps in fracture repair

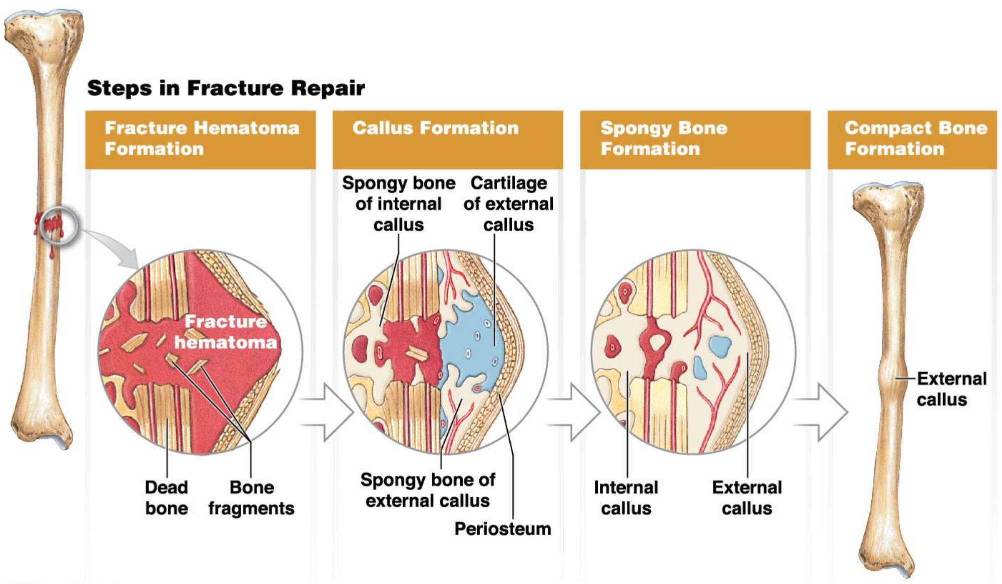
1. **Fracture hematoma** formation
   - Large clot closes injured vessels
   - Develops within several hours



# Module 6.12: CLINICAL MODULE: Bone fractures

**Steps in fracture repair** (continued)

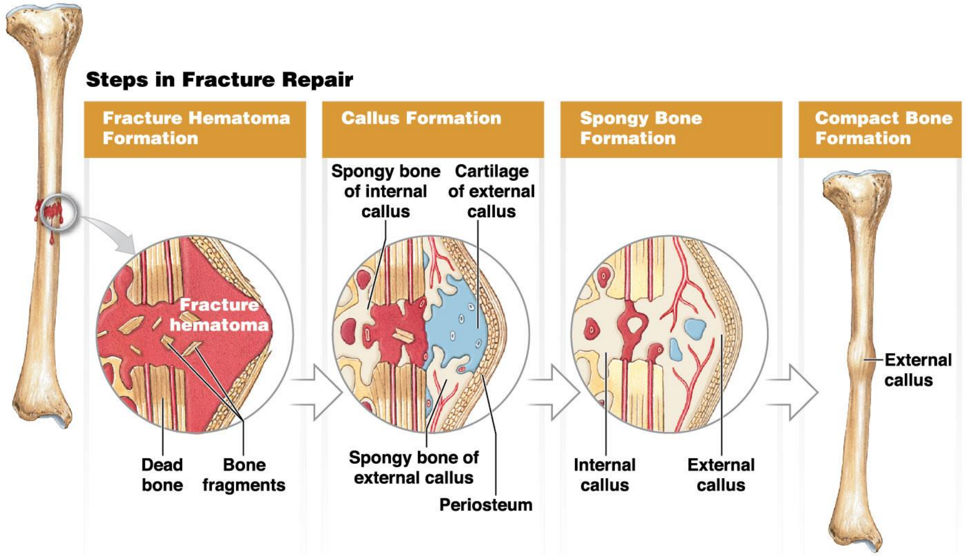
2. Callus formation
   - **Internal callus**
     - Network of spongy bone
     - Unites inner edges of fracture
   - **External callus**
     - Composed of cartilage and bone
     - Stabilizes outer edges of fracture



# Module 6.12: CLINICAL MODULE: Bone fractures

**Steps in fracture repair** (continued)

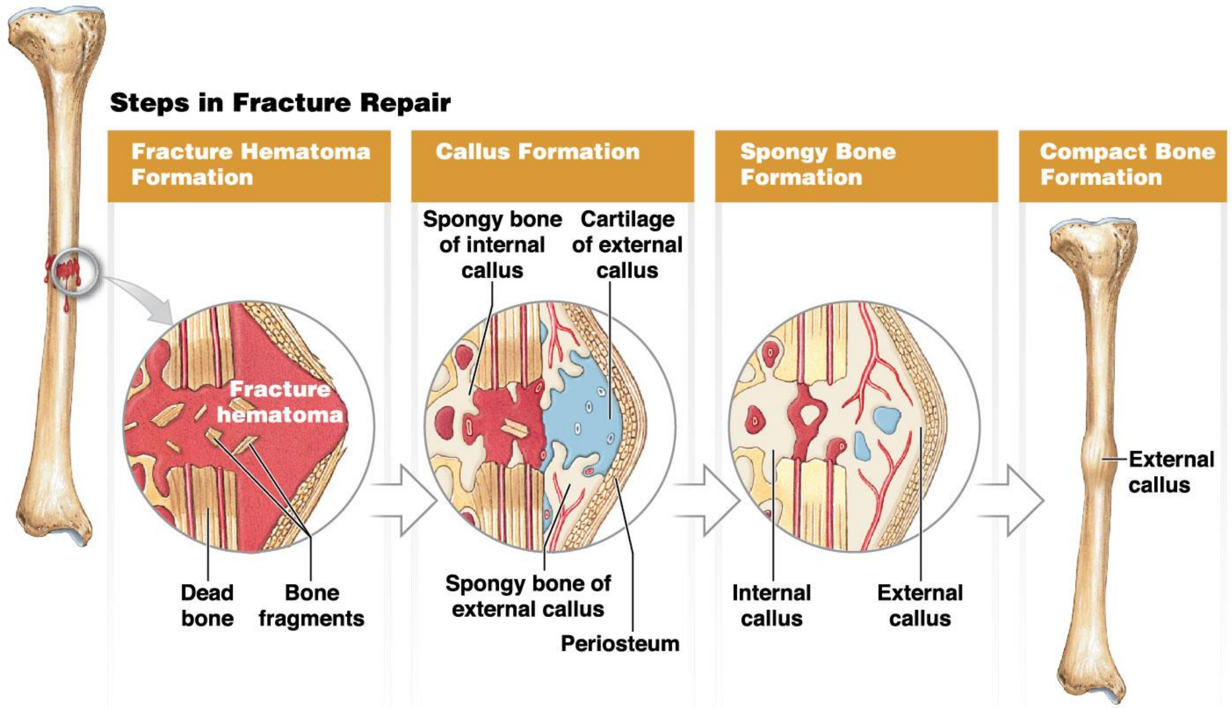
3. Spongy bone formation
   - Cartilage of external callus replaced by spongy bone
   - Bone fragments and dead bone are removed and replaced
   - Ends of fracture held firmly in place



# Module 6.12: CLINICAL MODULE: Bone fractures

**Steps in fracture repair** (continued)

4. Compact bone formation
   - Spongy bone replaced by compact bone
   - Remodeling over time eliminates evidence of fracture



# Module 6.12: CLINICAL MODULE: Bone fractures

## General categories of fractures

- **Closed** or **simple**
  - Completely internal (no break in skin)
  - Only seen on x-rays
- **Open** or **compound**
  - Project through the skin
  - More dangerous due to:
    - Infection
    - Uncontrolled bleeding

# Module 6.12: CLINICAL MODULE: Bone fractures

## Specific types of fractures

- **Transverse fractures**
  - Break shaft across long axis
- **Spiral fractures**
  - Produced by twisting stresses
  - Spread along length of bone

**Transverse fractures**

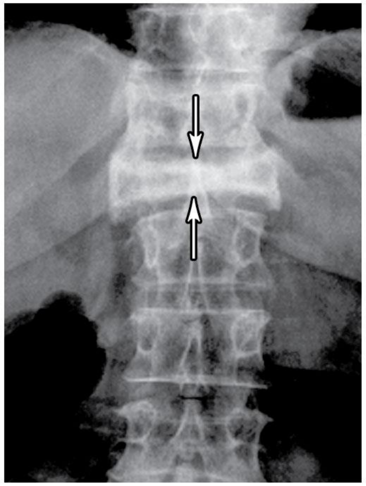
**Spiral fractures**

# Module 6.12: CLINICAL MODULE: Bone fractures

**Specific types of fractures** (continued)

- **Displaced fractures**
  - Produce new and abnormal bone arrangements
  - **Nondisplaced fractures** retain normal alignment
- **Compression fractures**
  - Occur in vertebrae subjected to extreme stresses
  - Often associated with osteoporosis

**Displaced fractures**



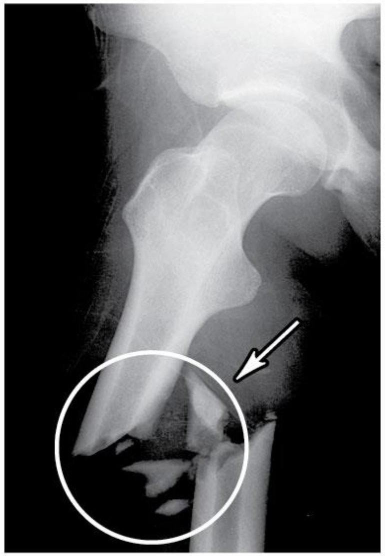
**Compression fractures**

# Module 6.12: CLINICAL MODULE: Bone fractures

**Specific types of fractures** (continued)

- **Greenstick fractures**
  - One side of shaft broken, one side bent
  - Generally occurs in children
    - Long bones have yet to fully ossify
- **Comminuted fractures**
  - Shatter affected area producing fragments

**Greenstick fracture**

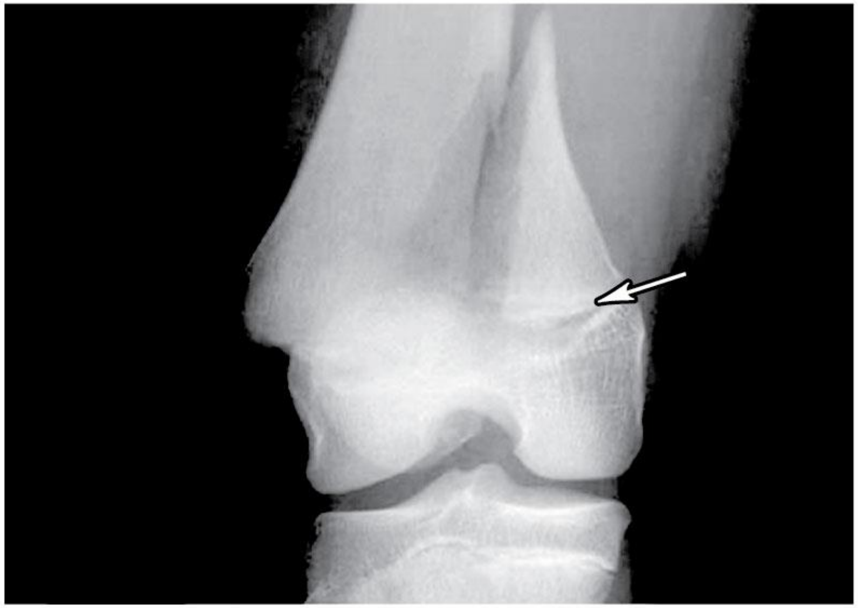


**Comminuted fractures**

# Module 6.12: CLINICAL MODULE: Bone fractures

## **Specific types of fractures** (continued)

- **Epiphyseal fractures**
  - Occur where bone matrix is calcifying
  - A clean transverse fracture of this type heals well
  - If not monitored, breaks between epiphyseal plate and cartilage can stop growth at site



**Epiphyseal fracture**

# Module 6.12: CLINICAL MODULE: Bone fractures

## **Specific types of fractures** (continued)

- **Pott's** (bimalleolar) **fracture**
  - Occurs at ankle and affects both medial malleolus and lateral malleolus
- **Colles fracture**
  - Break in distal radius

**Pott's fracture**

**Colles fracture**

# Module 6.12: Review

A. List the steps involved in fracture repair, beginning just after the fracture occurs.
B. Define *open fracture* and *closed fracture*.

*Learning Outcome:* Describe the types of fractures, and explain how fractures heal.