Chapter 6

The Skeletal System: Bone Tissue

Functions of the Skeletal System

- **Support –** supports soft tissues and provides an attachment point for tendons
- **Protection –** examples?
- **Movement –** how does this work?
- **Storage -** Ca and P are stored and released as needed to maintain homeostasis
- **Blood cell production –** red bone marrow gives rise to red blood cells, white blood cells, and platelets
- **Triglyceride storage –** in adipose cells of yellow bone marrow

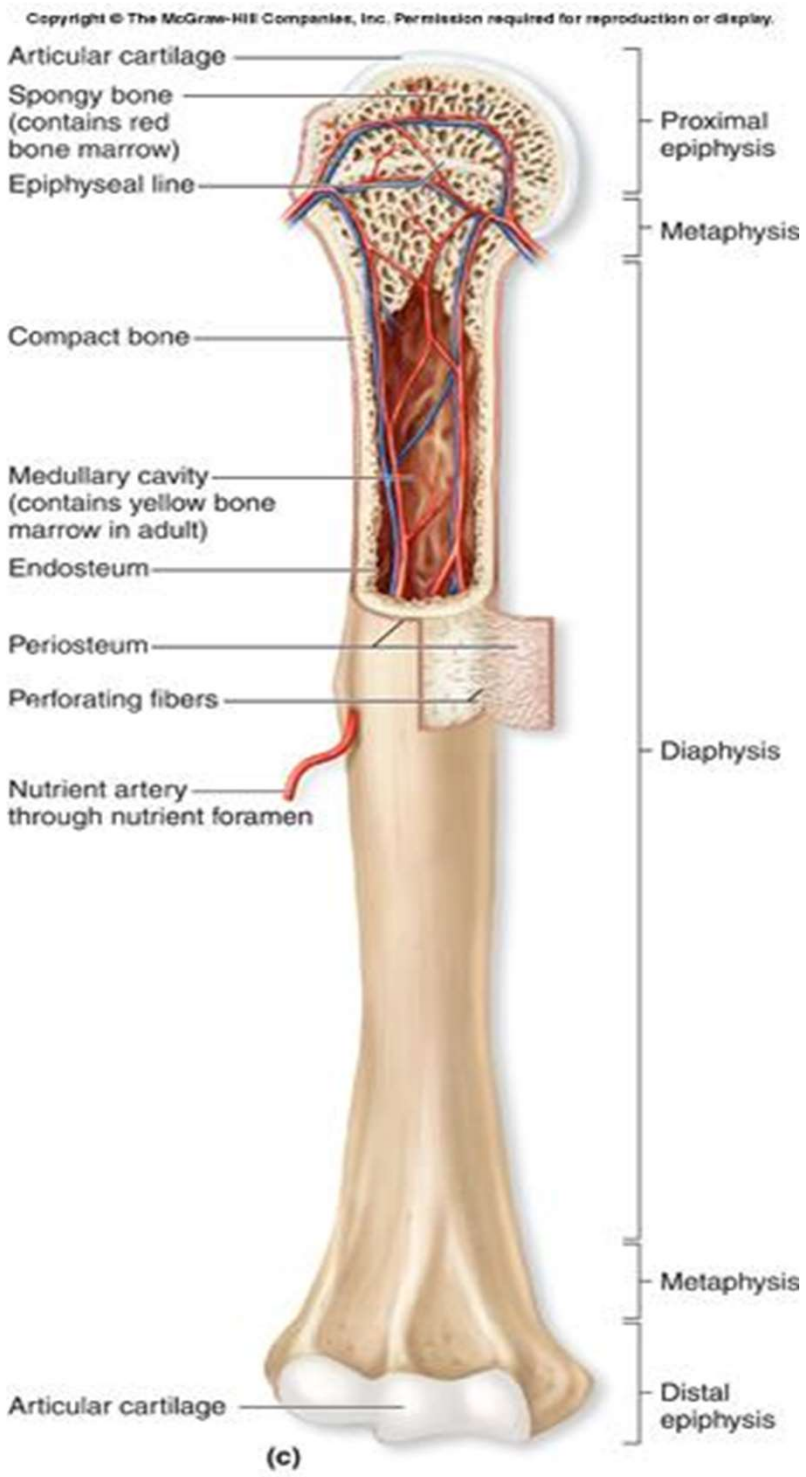
Components of Skeletal System

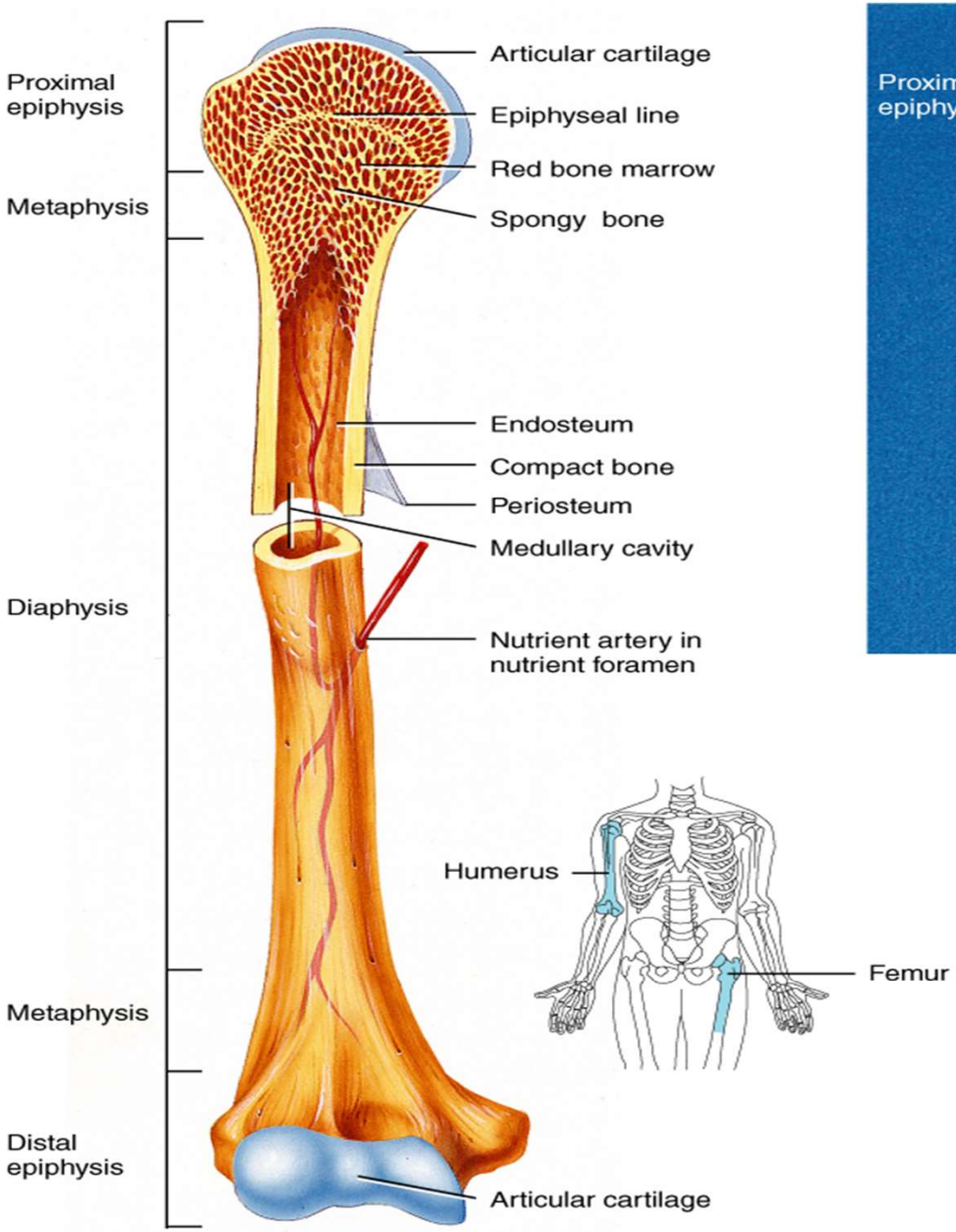
- Bone Tissue
- Cartilage
  - **Hyaline**
  - **Fibrocartilage**
  - **Elastic**
- Dense Connective Tissue
- Epithelium
- Adipose Tissue
- Nervous Tissue

- Each bone is a(n) _____.

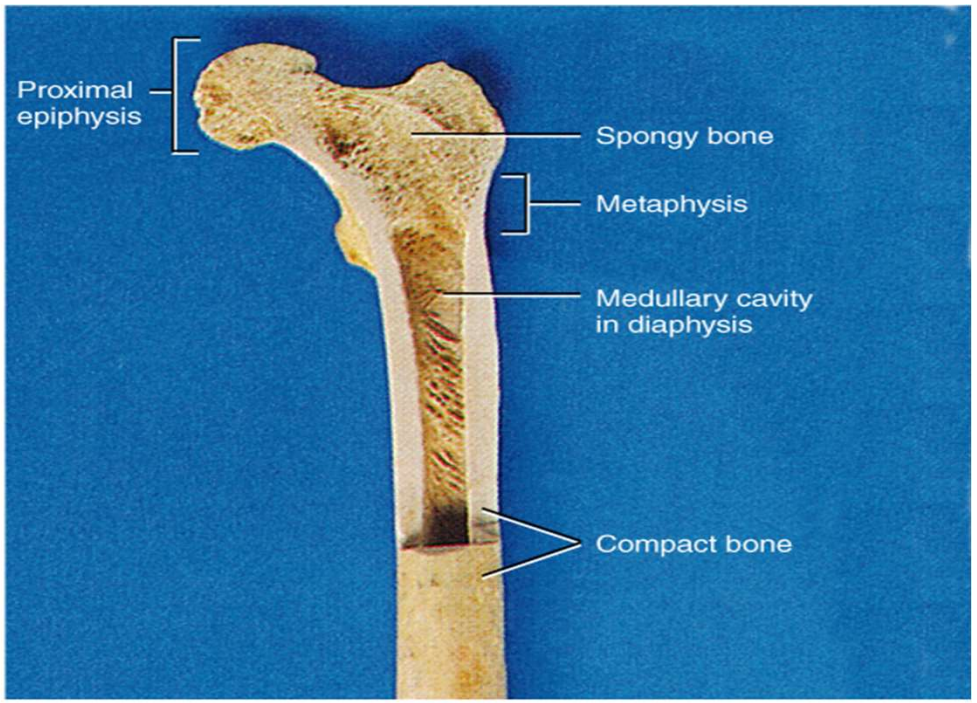
Structure of a Long Bone

- **Diaphysis -** Shaft
- **Epiphysis -** Distal and proximal ends of the bone
- **Metaphysis –** region in mature bone where the diaphysis meets the epiphysis
  - **Epiphyseal plate (growth plate) -** layer of hyaline cartilage in growing bones that allows the diaphysis to grow in length
- **Articular Cartilage –** layer of hyaline cartilage that covers the epiphysis
- **Periosteum –** tough covering (like a coat) made of dense irregular connective tissue that surrounds the bone where there is no articular cartilage
- **Endosteum –** thin membrane that lines the medullary cavity
- **Medullary cavity -** space (cavity) within the diaphysis that contains fatty yellow bone marrow





(a) Partially sectioned humerus (arm bone)

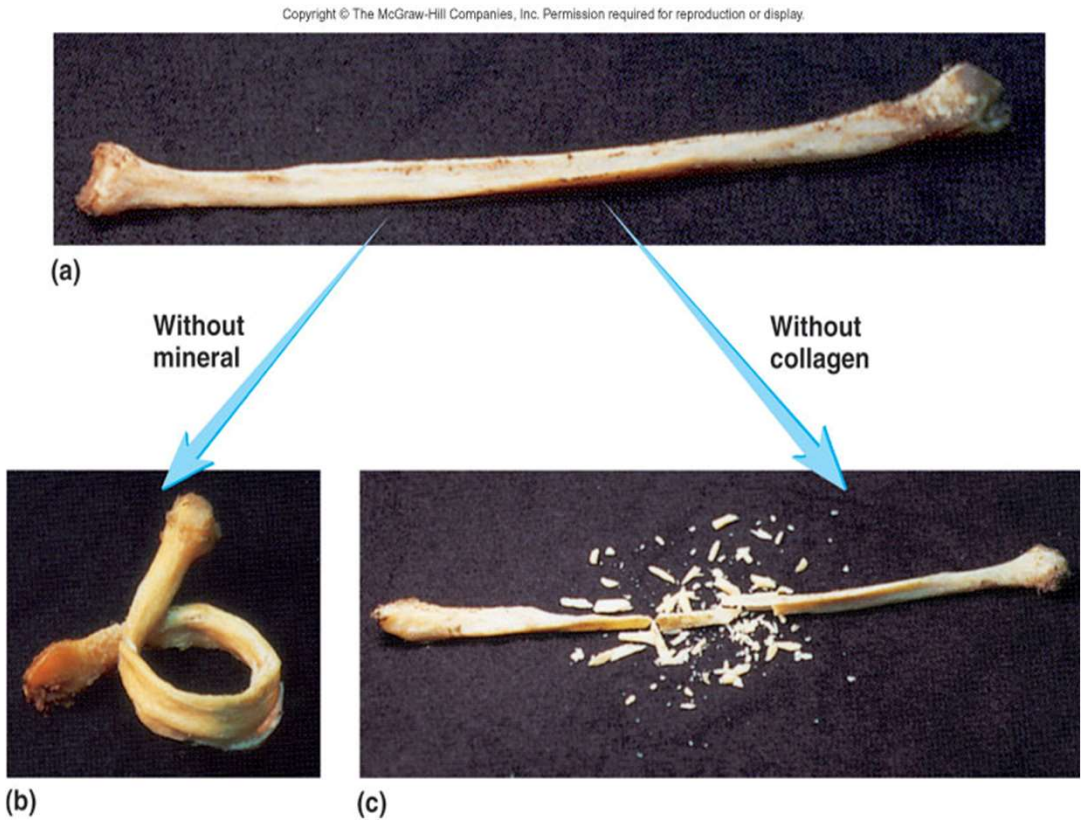


(b) Partially sectioned femur (thigh bone)

06.01

Bone Histology

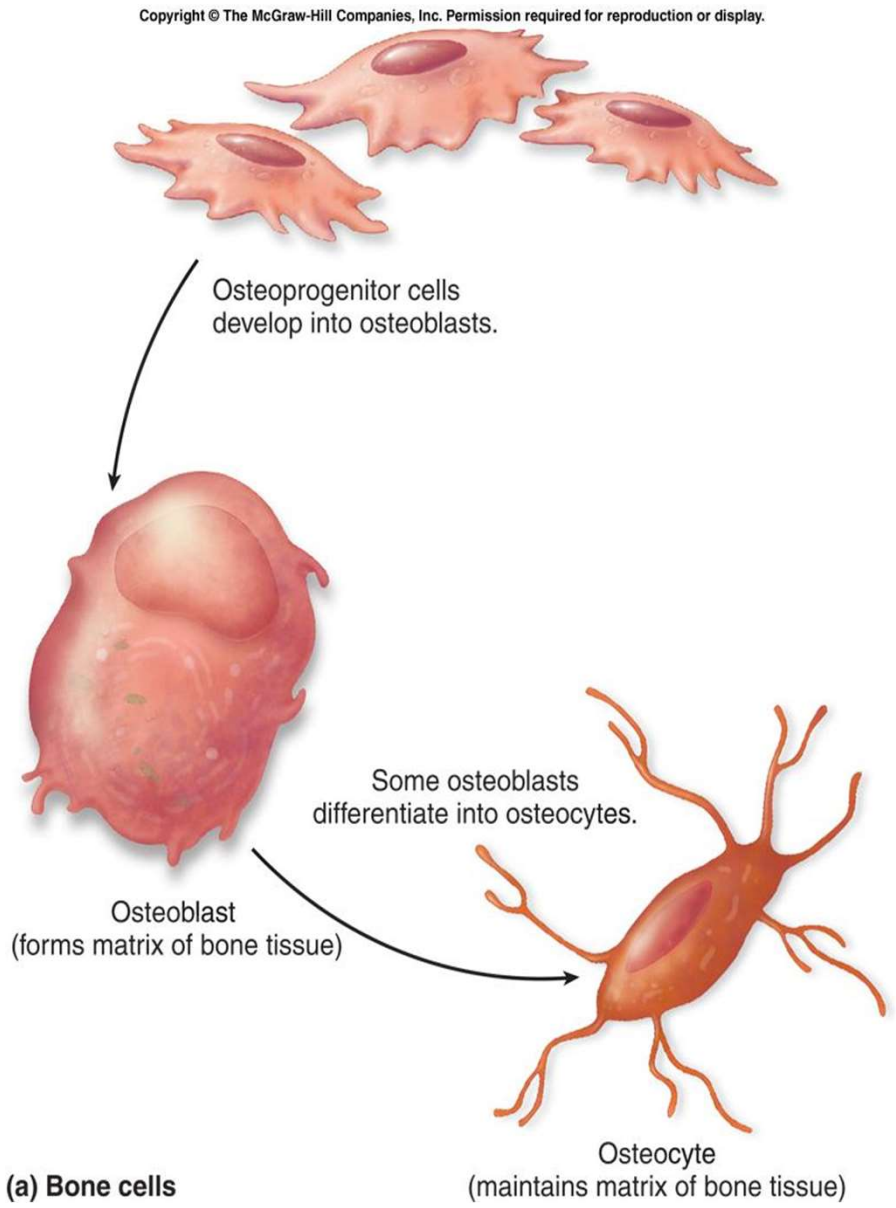
- Osseous tissue contains abundant matrix with widely separated cells.
  - **Matrix is 25% water, 25% collagen fibers, and 50% crystallized mineral salts**
  - **The crystallized salts and collagen fibers give bone its characteristic hardness.**
    - Collagen fibers also give bone resistance to being stretched or torn apart (flexibility)



•If mineral is removed, bone is too bendable
•If collagen is removed, bone is too brittle

Four Types of Bone Cells

- **Osteogenic cells**
  - Unspecialized stem cells that divide and develop into osteoblasts
- **Osteoblasts**
  - Bone-building cells; secrete the matrix, become trapped in it, and become osteocytes
- **Osteocytes**
  - Mature bone cells; maintain daily metabolism; cannot divide
- **Osteoclasts**
  - Huge cells that break down bone matrix in a process called resorption
    - This is part of our normal development, growth, maintenance, and repair



Four Types of Bone Cells

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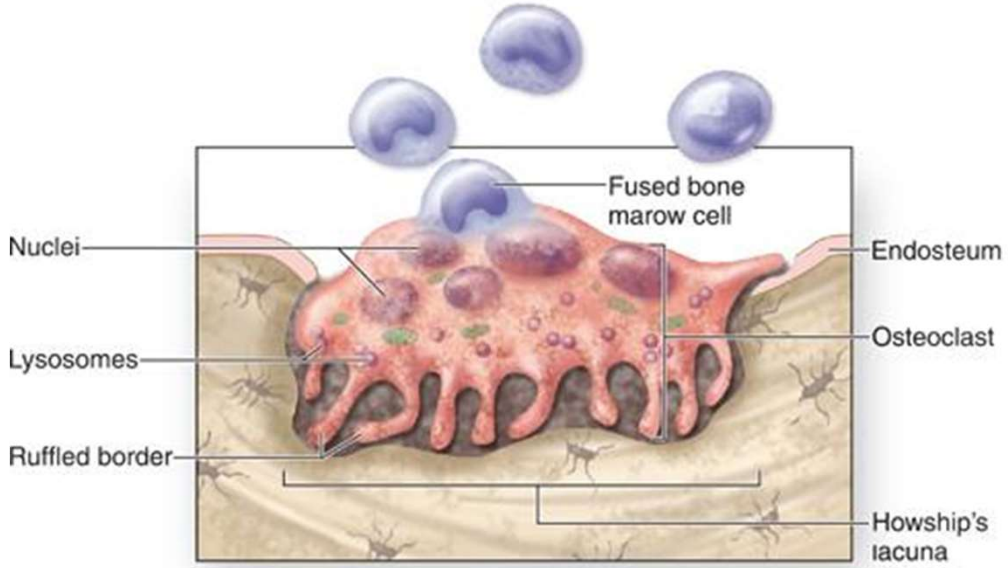
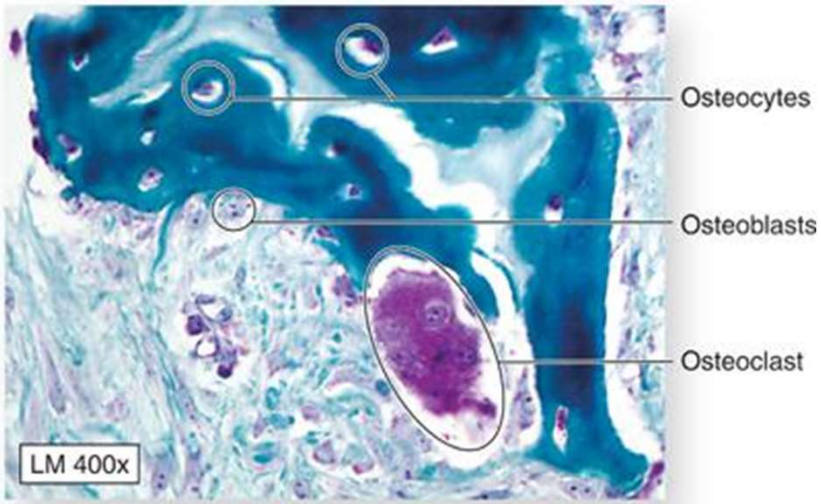


(b) Osteoclast



(c) Bone tissue

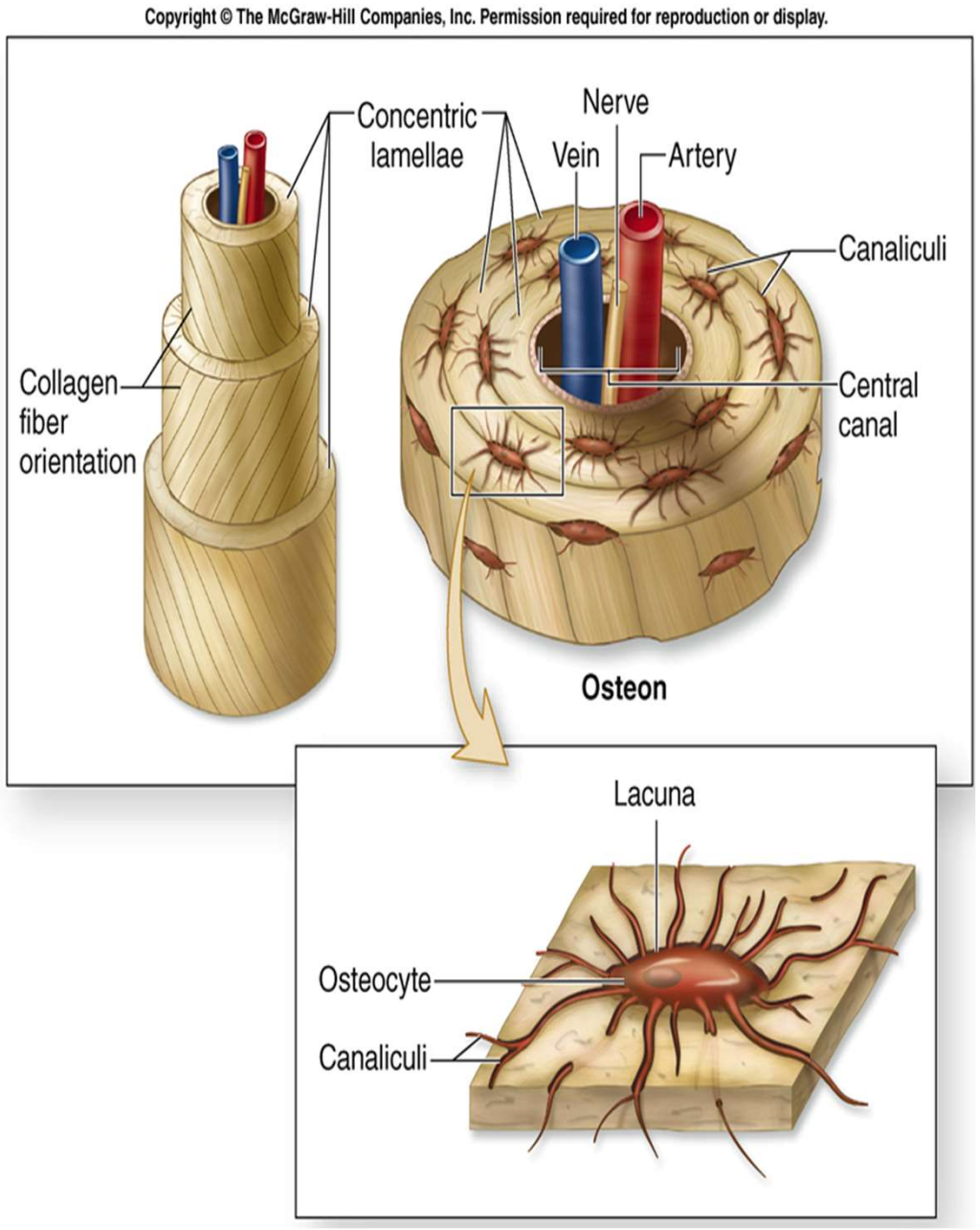
Compact Bone

- 80% of the skeleton
- Characteristics
  - External layer of all bones and makes up most of the diaphyses of long bones
  - Provides protection and support
  - Resists stresses of weight and movement
  - Contains few spaces

Compact Bone

- Arranged into osteons
  - Blood vessel-filled central canal (Haversian canal)
  - Concentric lamellae of bone surround central canal
  - Lacunae (spaces) – contain osteocytes
  - Canaliculi (channels) – filled with extracellular fluid and fingerlike processes of osteocytes

****Read first column on p. 166****



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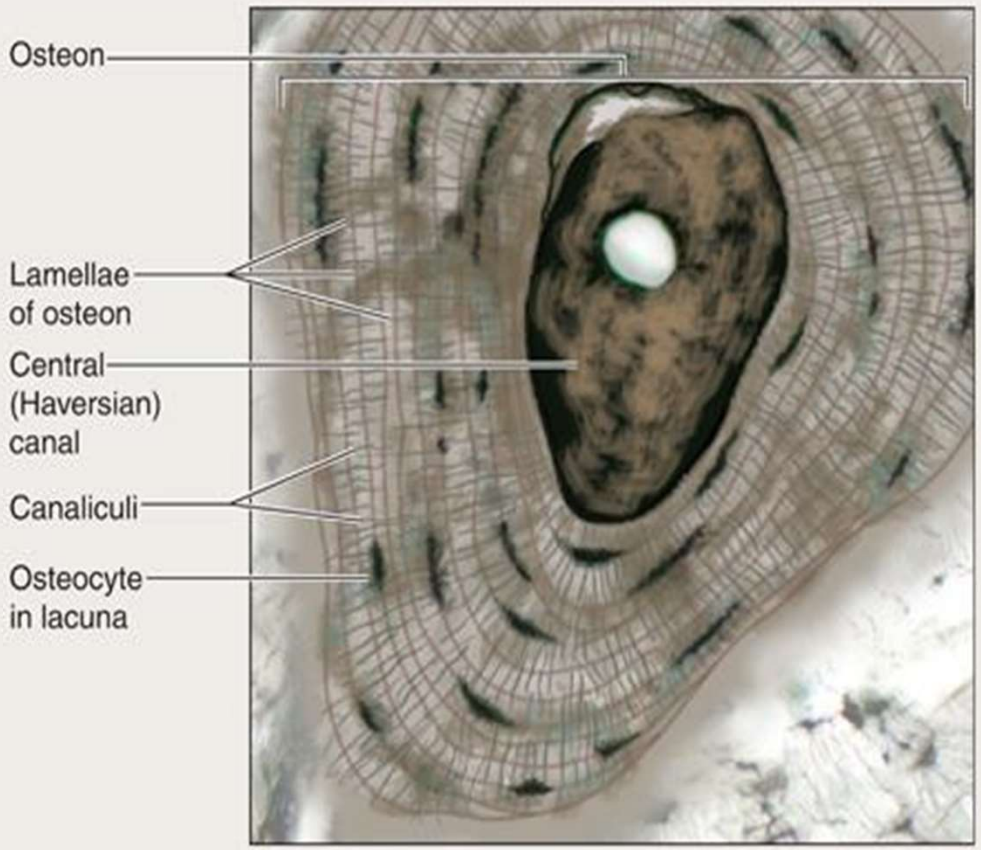

Bone	
Structure	Compact bone: calcified matrix arranged in osteons (concentric lamellae arranged around a central canal containing blood vessels). Spongy bone: lacks the organization of compact bone; contains macroscopic spaces; bone arranged in a meshwork pattern.
Function	Supports soft structures; protects vital organs; provides levers for movement; stores calcium and phosphorus. Spongy bone is the site of hemopoiesis.
Location	Bones of the body

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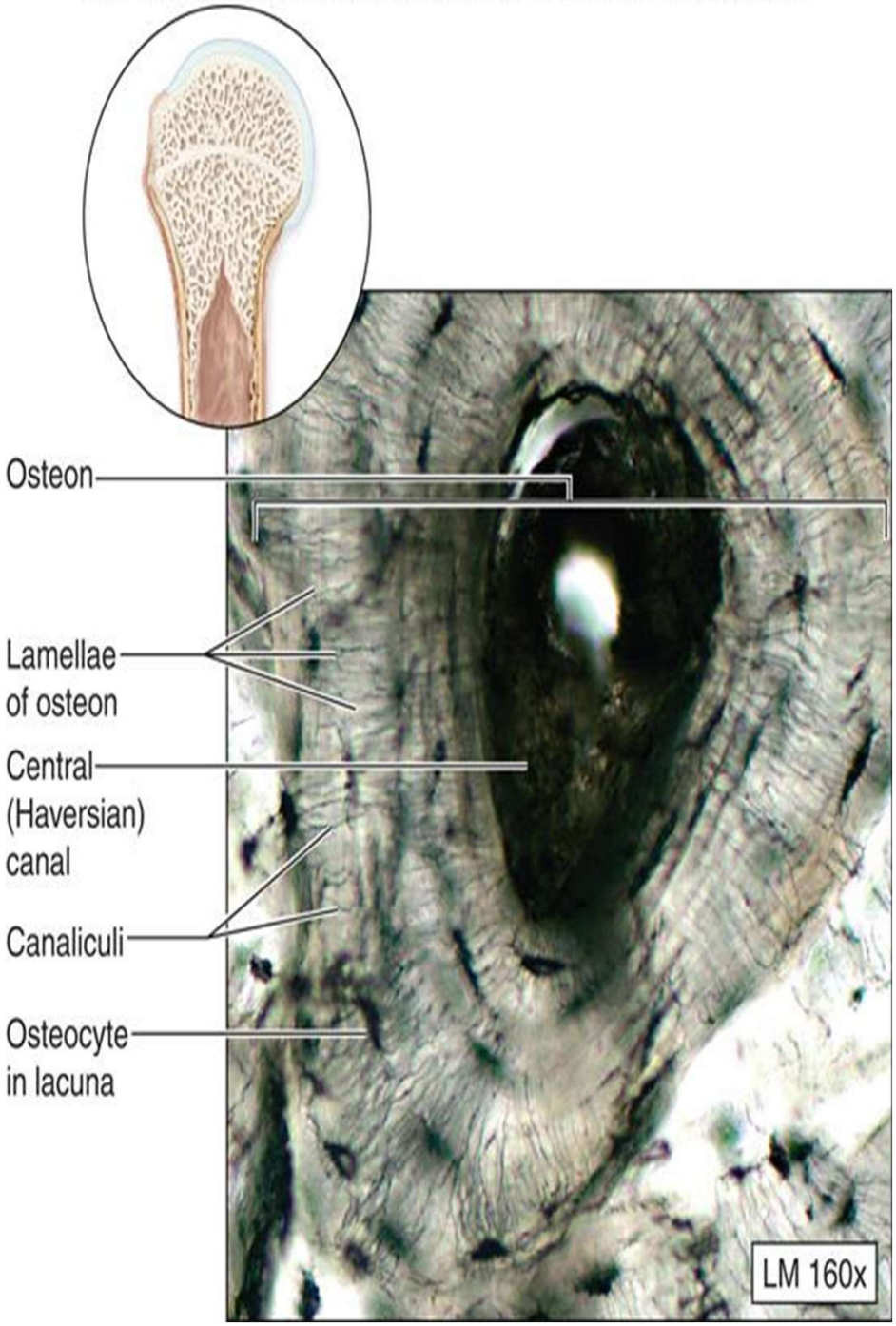

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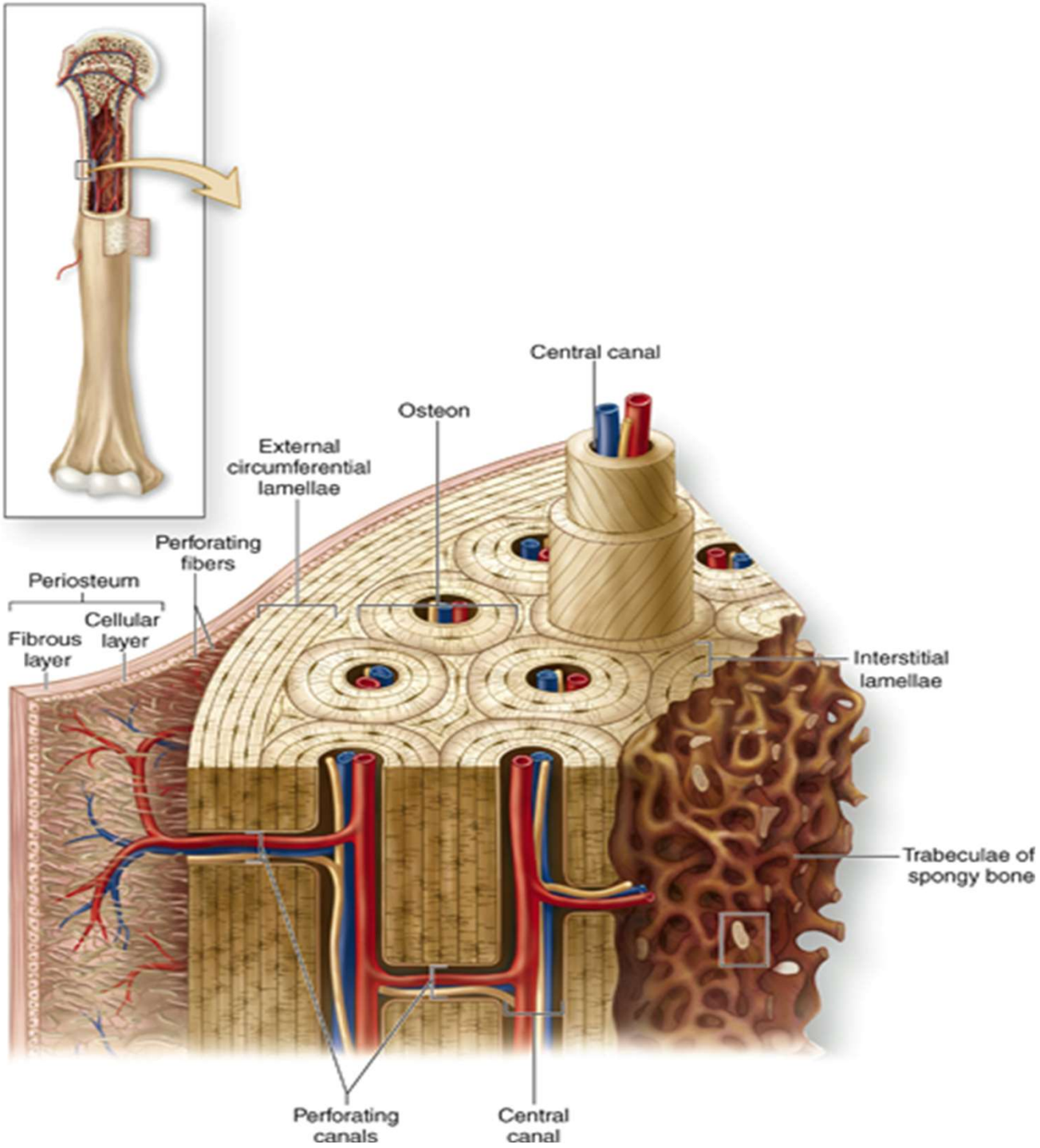

Compact Bone

Spongy Bone

- 20% of the skeleton
- Lighter than compact bone (reduces weight for easier movement)
- Characteristics
  - Forms ends of long bones, narrow rim around medullary cavity of long bones, and most of the tissue of short, flat, and irregularly shaped bones
  - Site of red bone marrow
    - Found in ends of long bones, hip bones, ribs, sternum, and backbones
  - Consists of trabeculae – an irregular latticework of thin columns of bone
    - Trabeculae are intricately designed and oriented along lines of stress, which helps resist stress and transfer of force

Spongy Bone

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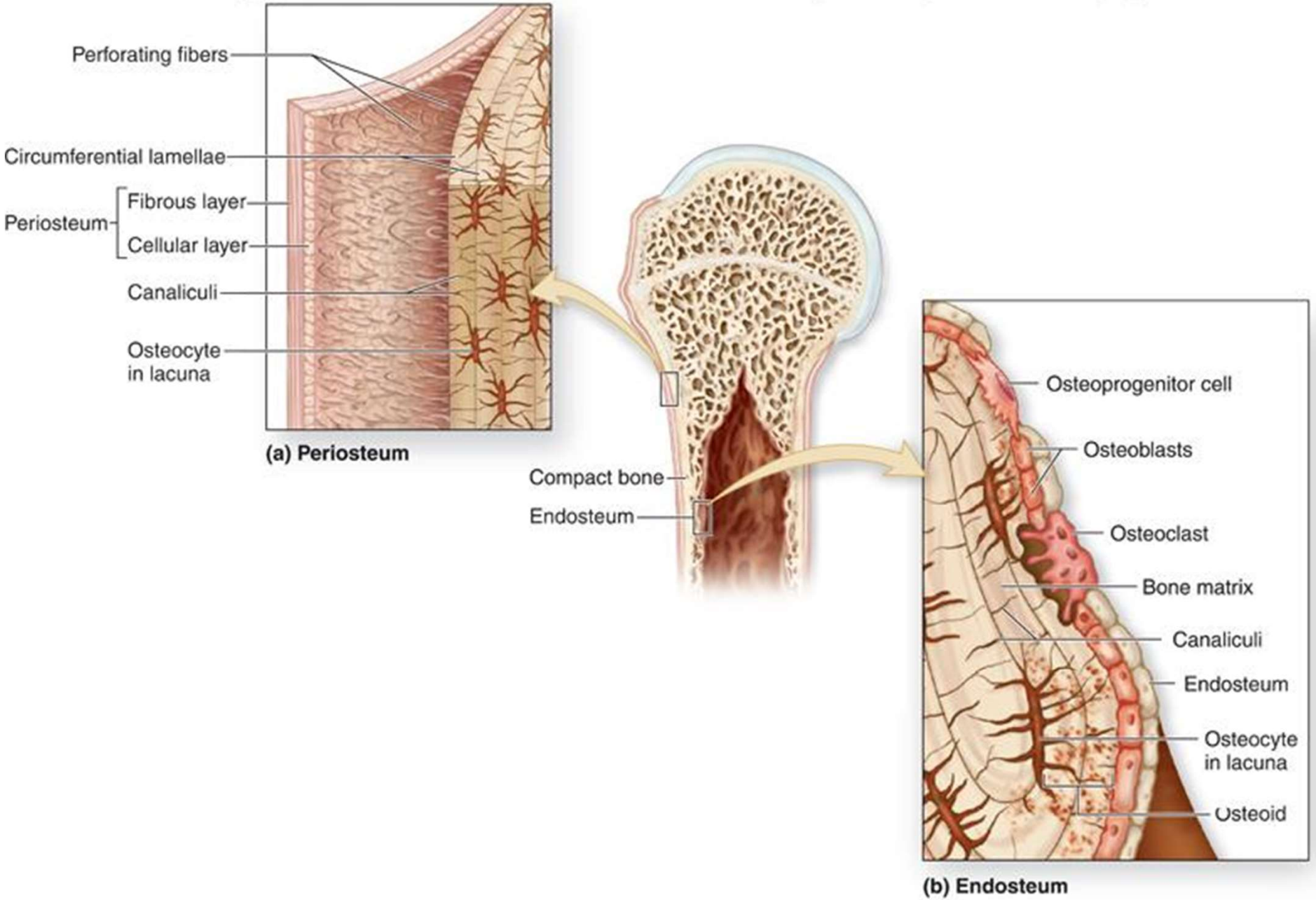

Spongy Bone

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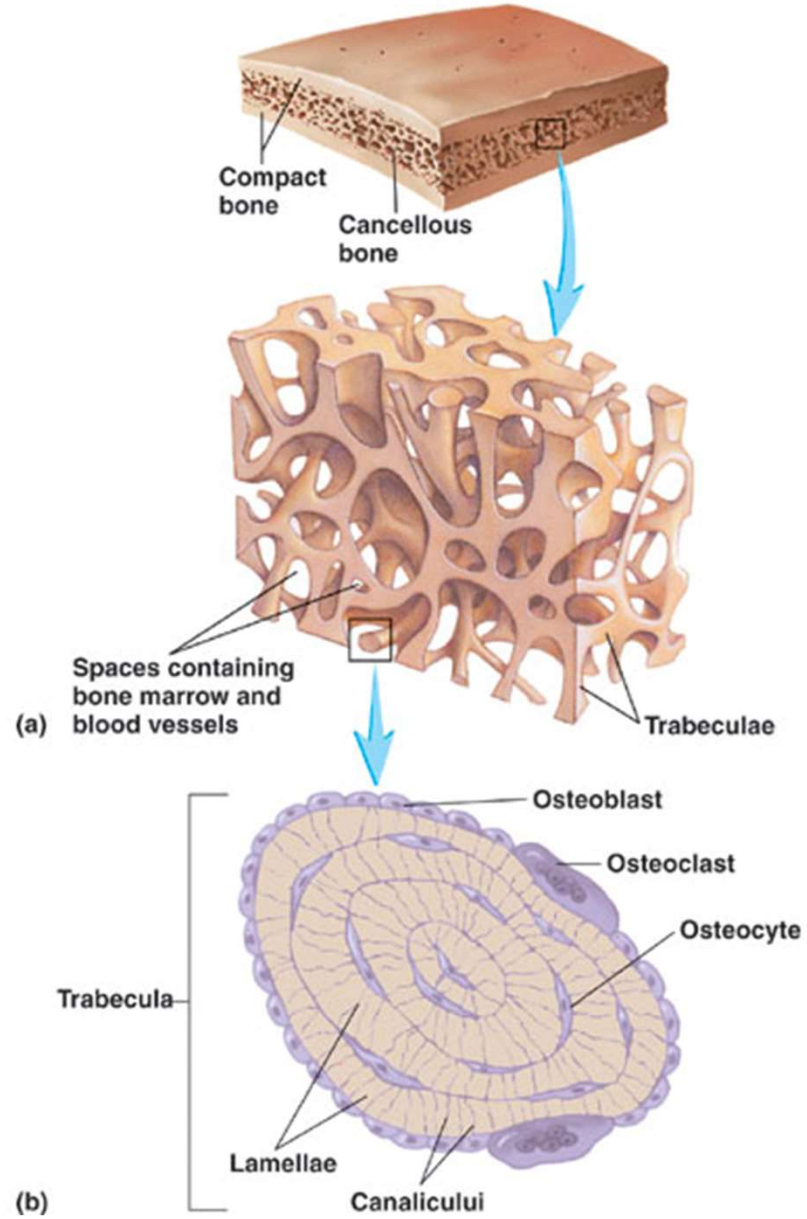

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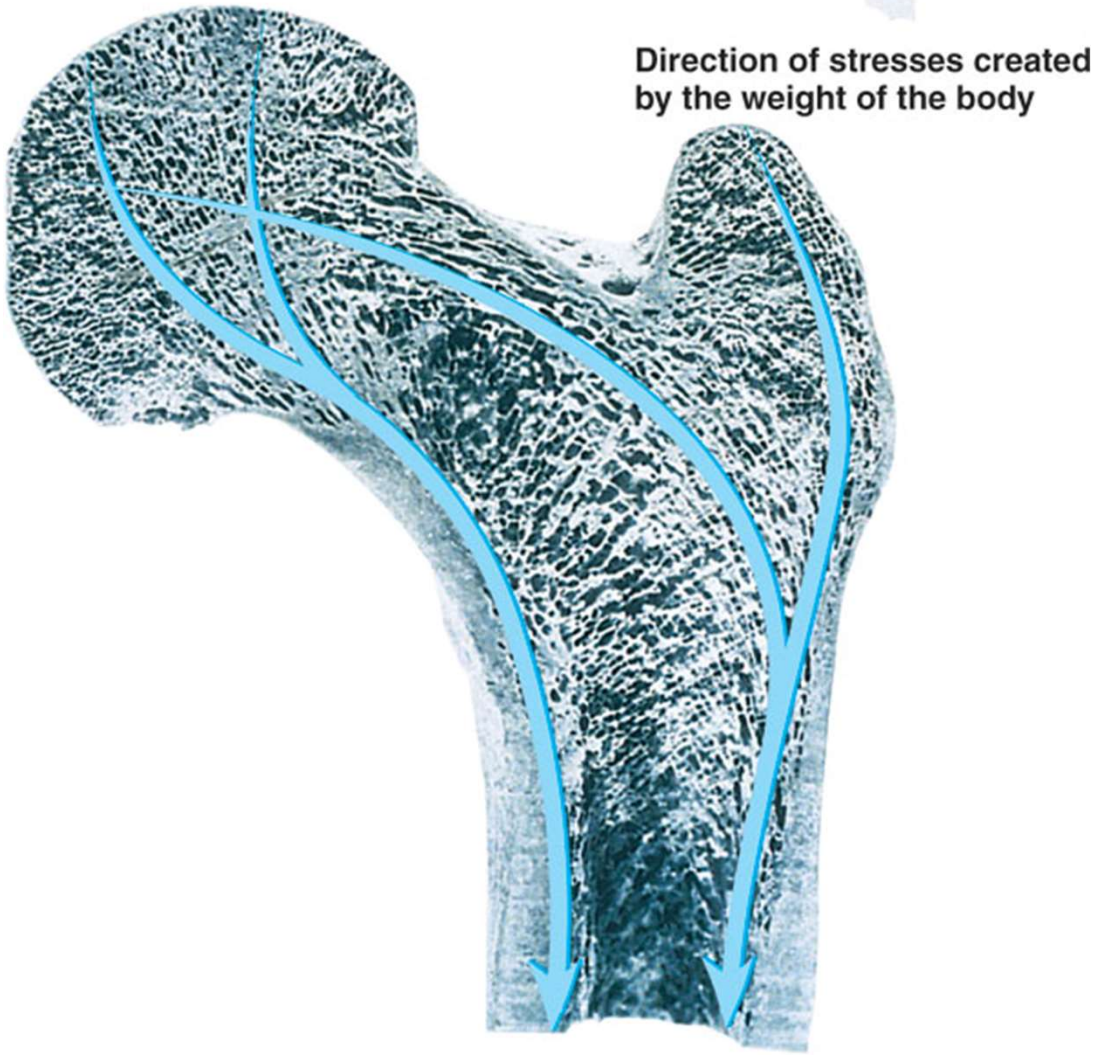

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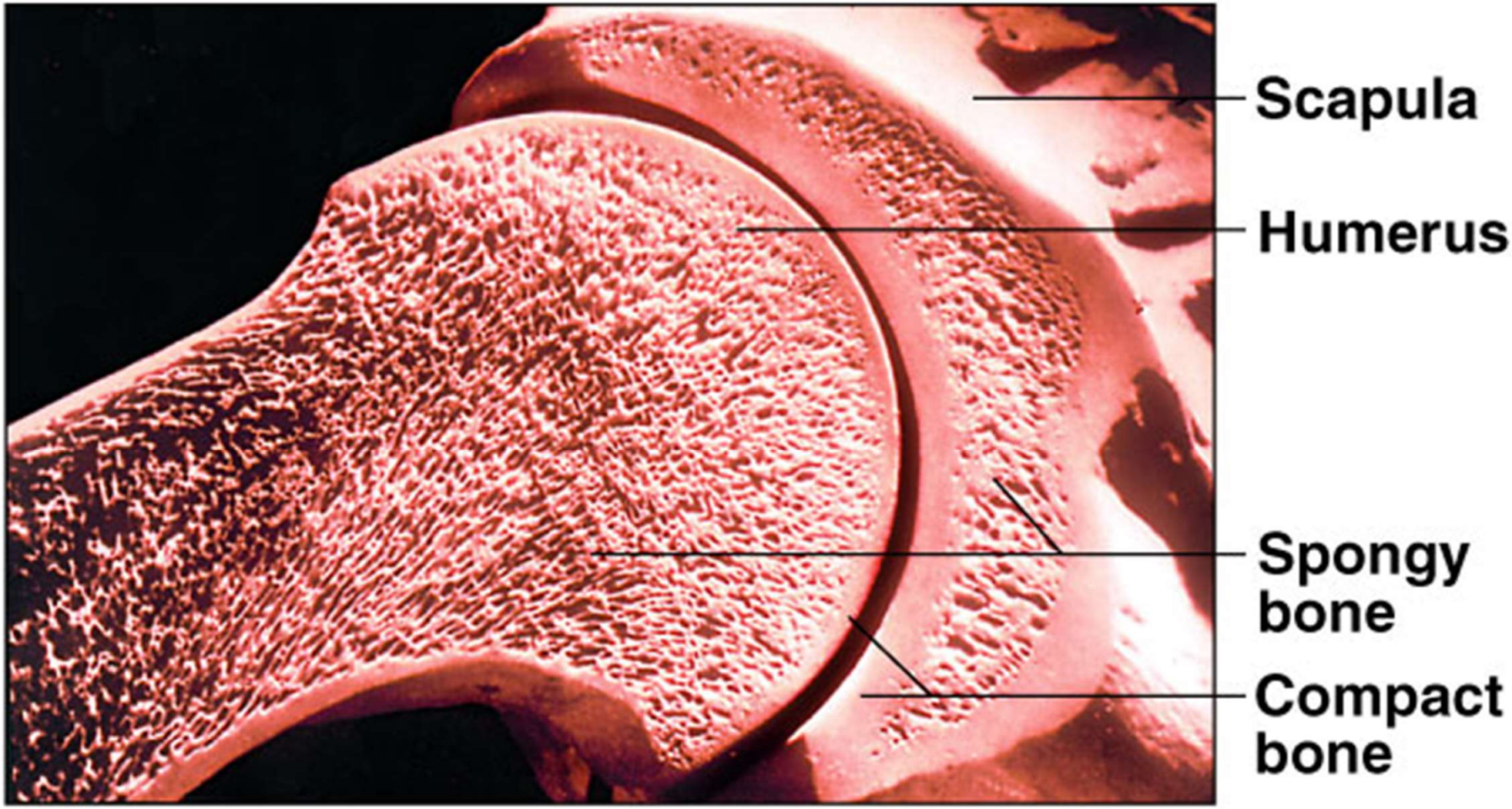


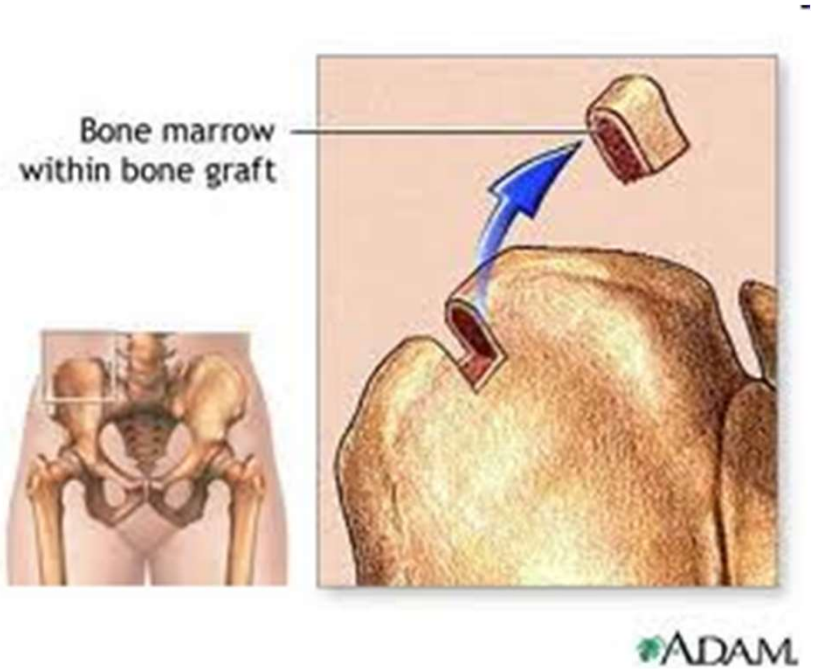
(a)

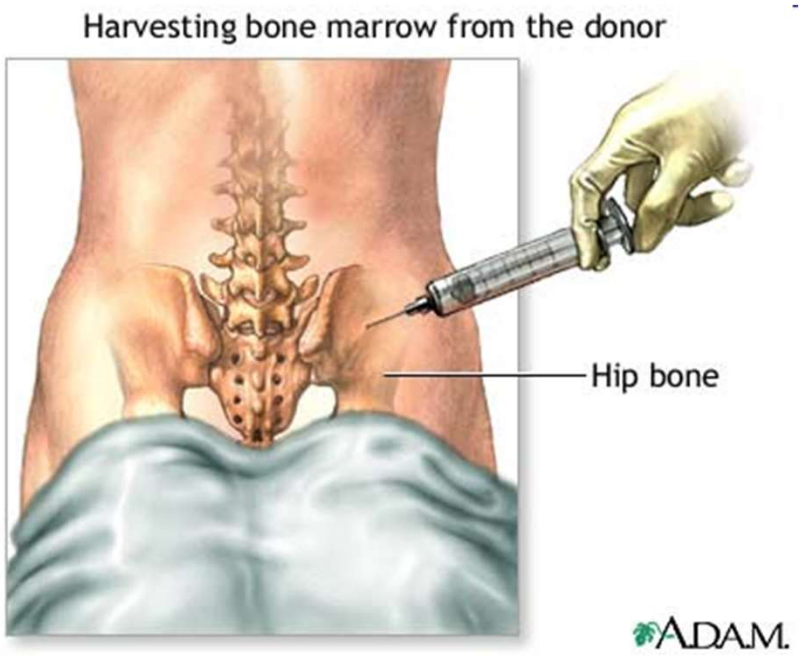
Bone marrow

- Yellow marrow is found in medullary cavity of long bones and is not hematopoietic in adults. Yellow marrow replaces red marrow as we mature and is made up mainly of fat.

Bone Marrow

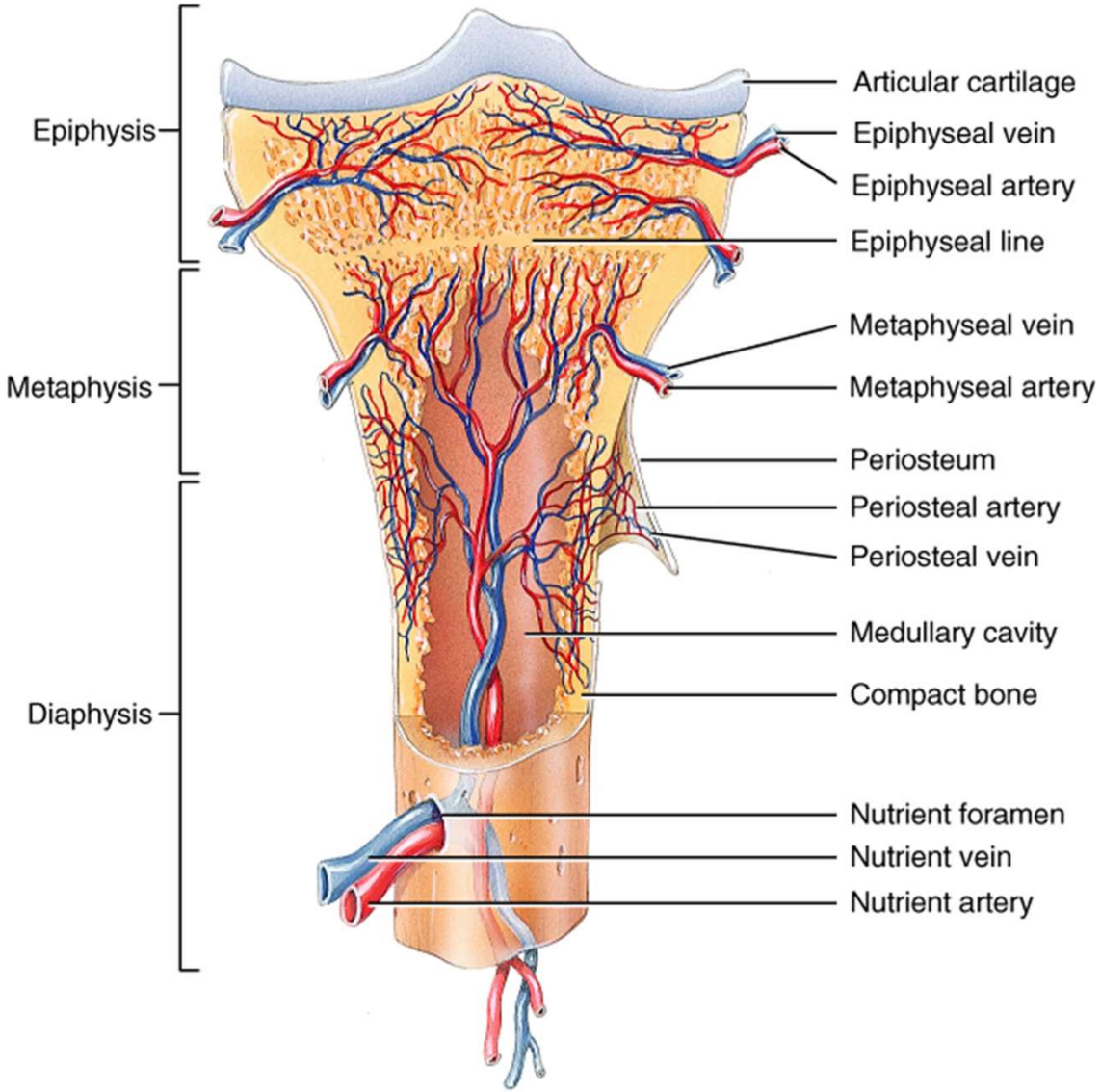
- Red marrow is very hematopoietically active.
  - Hemopoiesis – blood cell production





•Bone Marrow Transplant

Blood Supply of a Mature Long Bone



06.05

Bone Formation (p. 168-170)

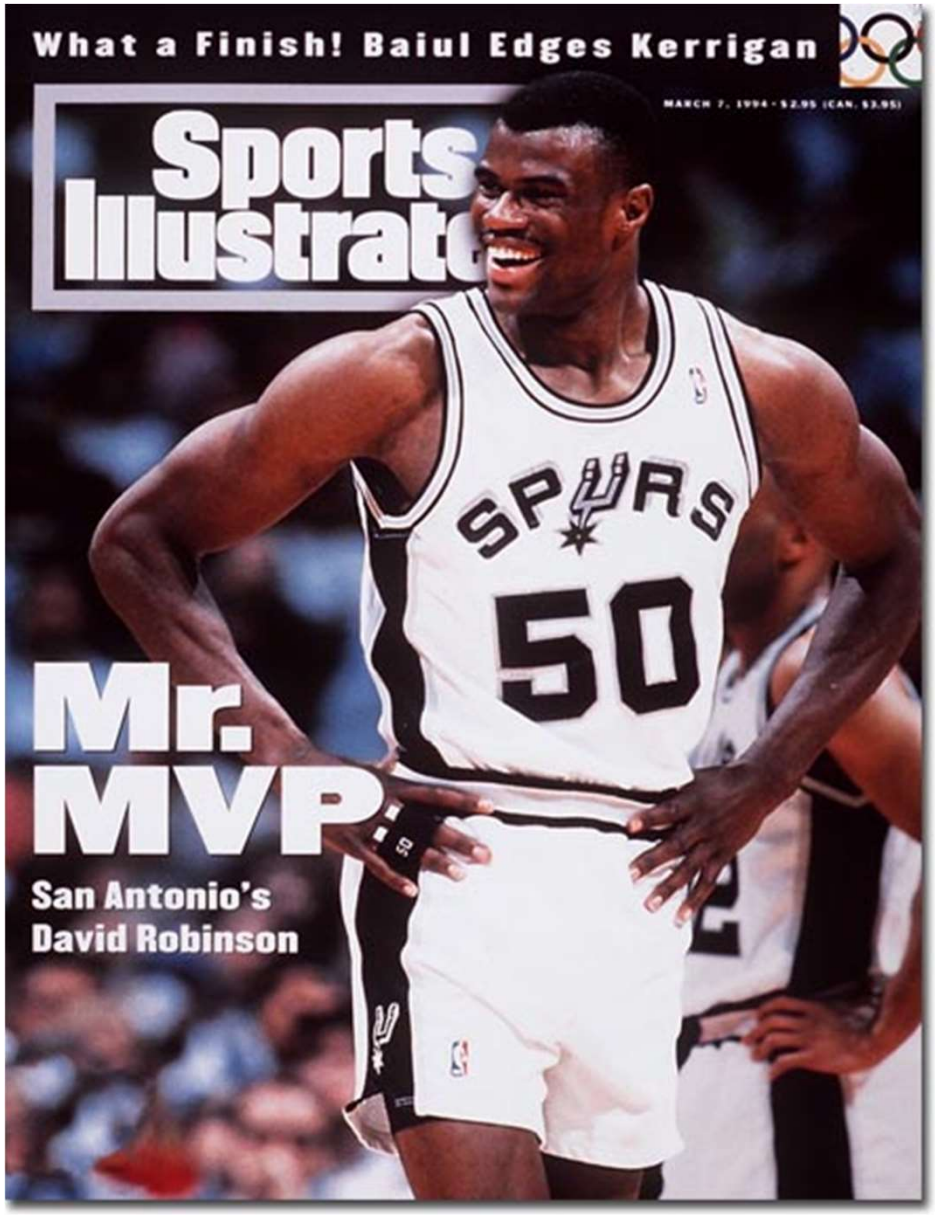
- Ossification – the process by which bone forms
  - Also known as osteogenesis

****This is all you need to know from this section****

Bone Growth (p. 170)

- During childhood bones grow in two ways
  - In thickness by appositional growth
  - In length at the epiphyseal plate

- Bones stop growing in length between the ages of 12 and 25 but may continue to thicken



Growth in Length

- The epiphyseal plate is a layer of hyaline cartilage in the metaphysis
- In a growing bone, it consists of 4 zones
  - Zone of resting cartilage - anchor
  - Zone of proliferating cartilage – cell division
  - Zone of hypertrophic cartilage – maturation of cells
  - Zone of calcified cartilage – calcified cartilage is replaced by bone

Zones of the Epiphyseal Plate

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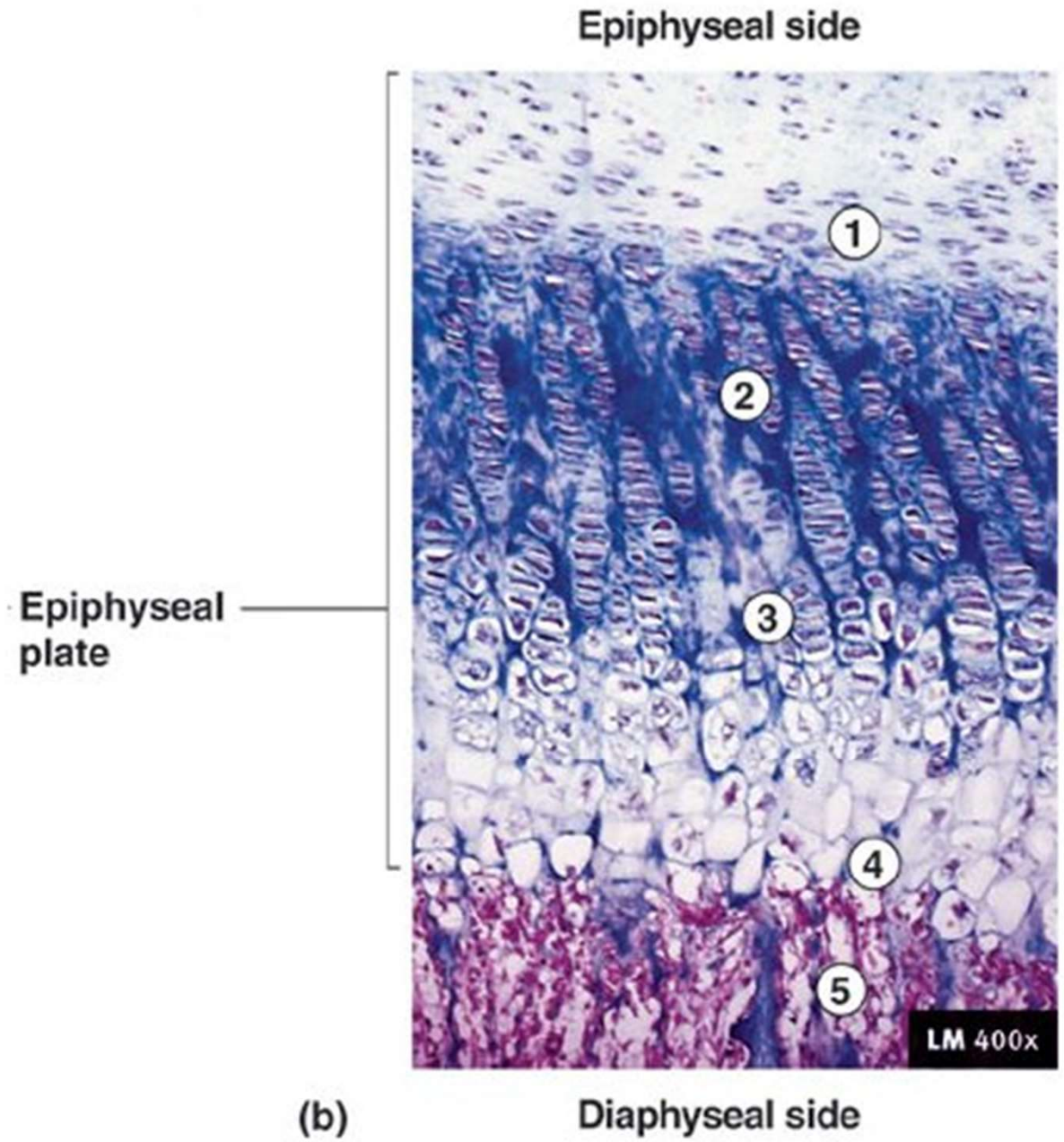

- Zone of resting cartilage
- Zone of proliferating cartilage
- Zone of hypertrophic cartilage
- Zone of calcified cartilage

Growth in Length

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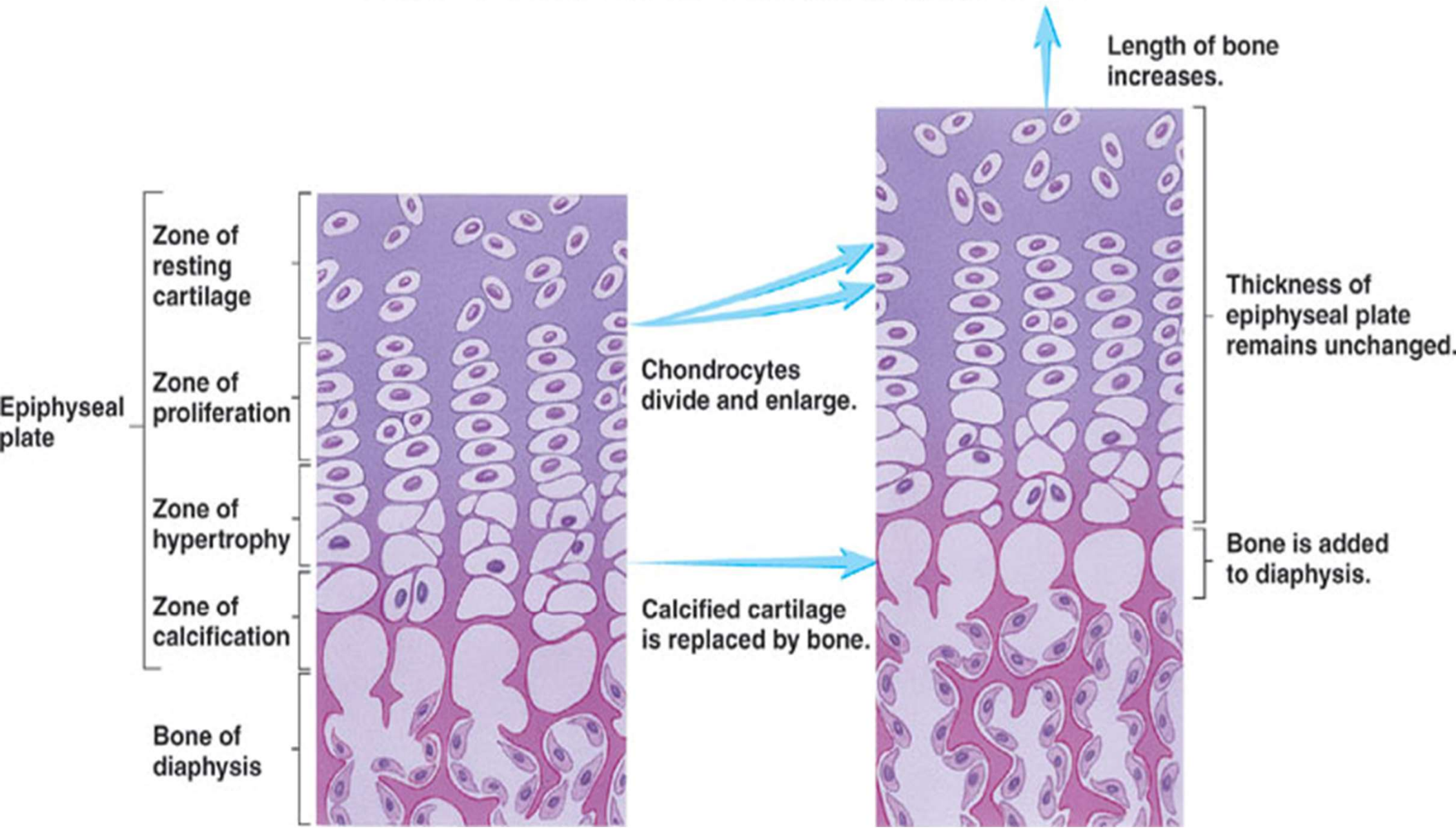

End of Bone Growth in Length

- Epiphyseal plates “close”
  - Epiphyseal cartilage cells stop dividing and bone replaces all of the cartilage
  - The epiphyseal plate is replaced by a bony epiphyseal line
    - The appearance of this line means the bone has stopped growing in length

Fracture of the Epiphyseal Plate

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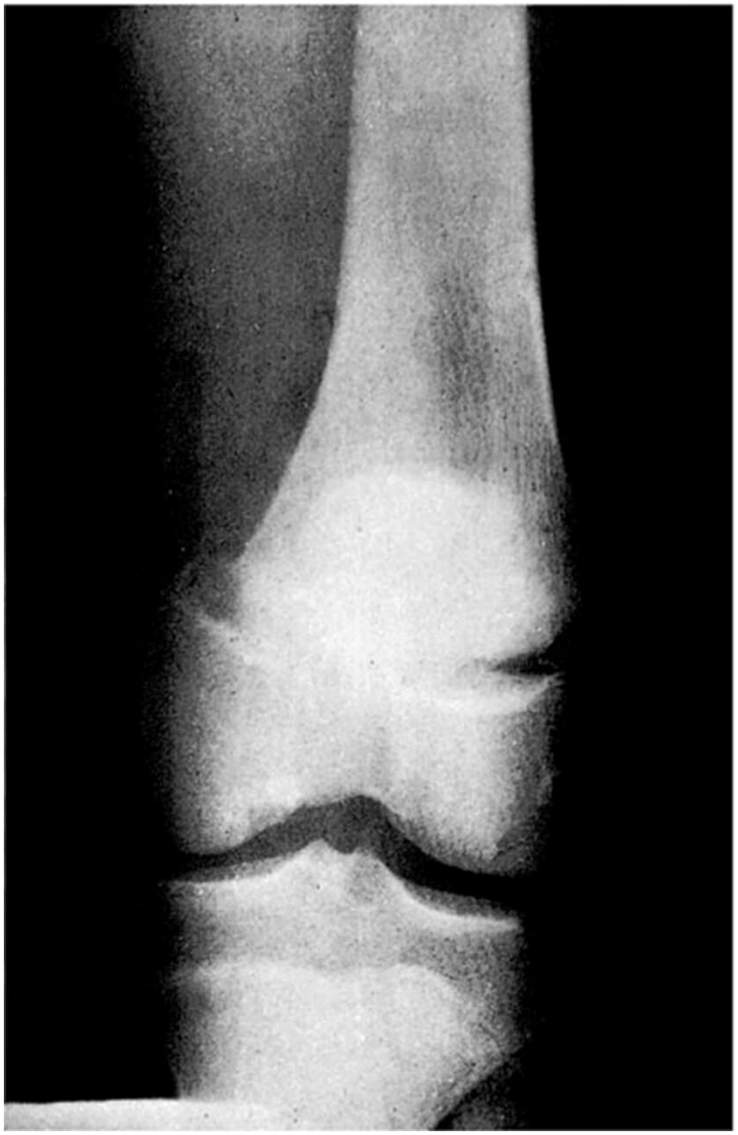
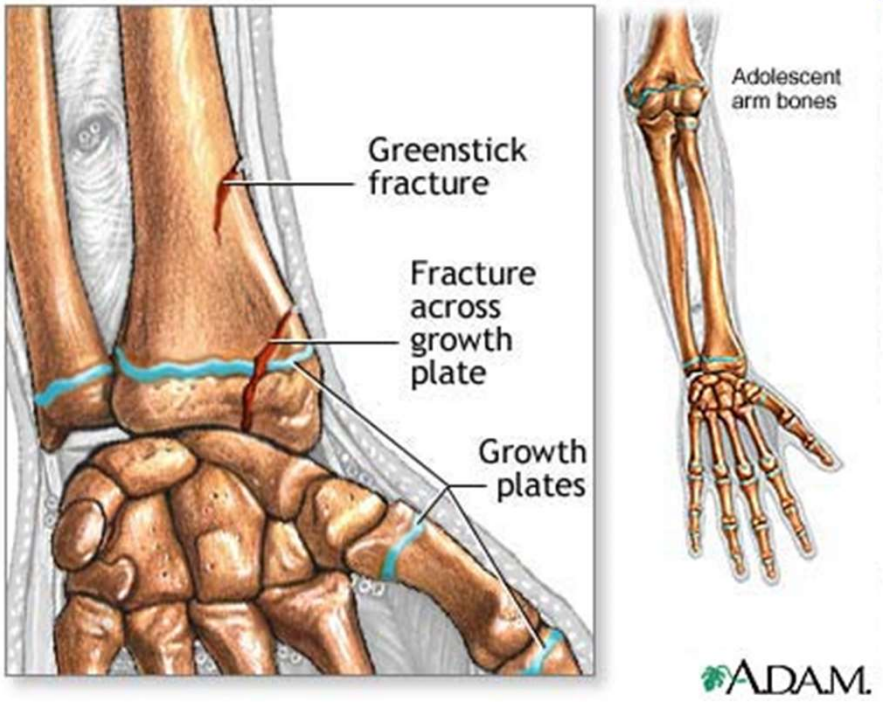


- A fracture that damages the plate may cause the bone to be shorter
  - Damage to the cartilage accelearates the closing of the plate



Growth in Bone Width (p. 173)

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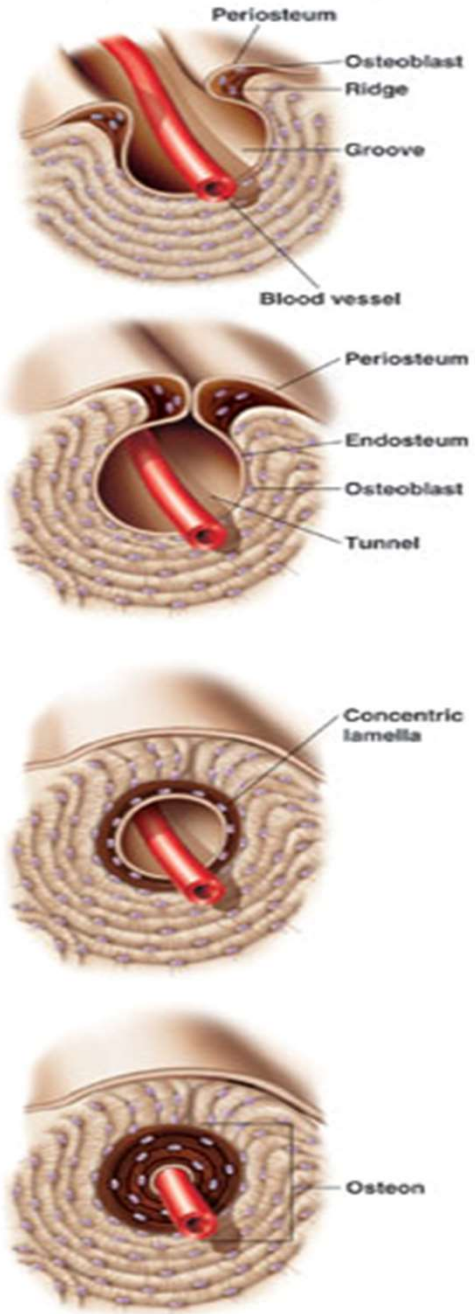

- Appositional Growth – growth due to surface deposition of material

Factors Affecting Bone Growth

- Size and shape of a bone determined genetically but can be modified and influenced by nutrition and hormones
- Nutrition
  - Lack of calcium, protein and other nutrients during growth and development can cause bones to be small
  - Vitamin A
    - Stimulate osteoblast activity
  - Vitamins B12 and K
    - Needed for protein synthesis
  - Vitamin D
    - Necessary for absorption of calcium from intestines
  - Vitamin C
    - Necessary for collagen synthesis by osteoblasts

Factors Affecting Bone Growth (2)

- Hormones
  - Growth hormone from anterior pituitary
  - Thyroid hormone required for growth of all tissues
  - Sex hormones such as estrogen and testosterone
    - Cause growth at puberty but also cause closure of the epiphyseal plates and the cessation of growth
    - Read 3rd paragraph down on page 174

Bone Remodeling

- Bone remodeling is an ongoing process in which osteoclasts carve tunnels in old bone tissue and osteoblasts build new tissue
  - This must be balanced in order to maintain homeostasis
  - Purposes
    - Renews bone tissue before it deteriorates
    - Redistrubutes bone matrix along lines of stress
    - Heals injured bones

Bone Fractures

- Fracture – a break in a bone; named according to severity, shape or position of fracture line, or the physician who first described them
- Common Fractures
  - Open (compound)- bone break with open wound. Bone may be sticking out of wound.
  - Closed (simple)- does not break skin.
  - Greenstick: incomplete fracture in which one side of the bone is broken and the other side bends (occurs in children whose bones are not fully ossified)
  - Comminuted fractures: complete with break into more than two pieces
  - Impacted – one end of the bone is driven into the interior of the other end
  - Stress fractures – microscopic fissures in bone formed due to repeated stress

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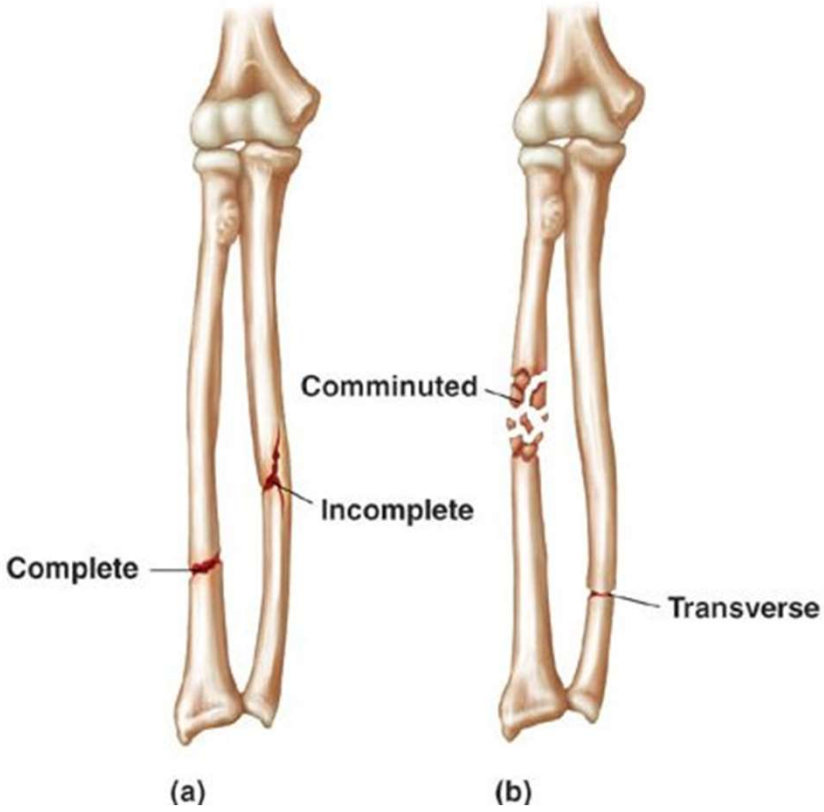
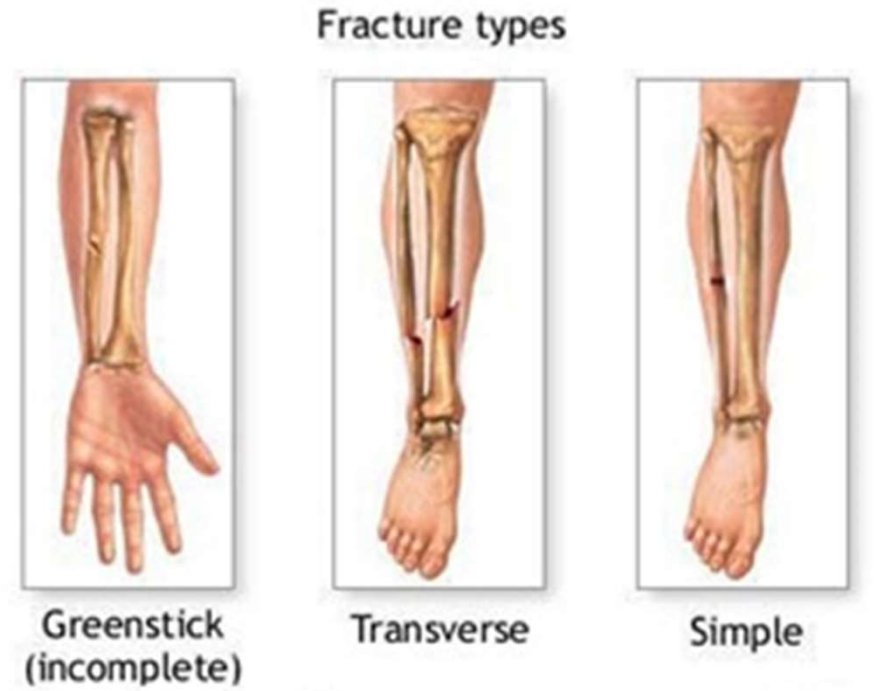
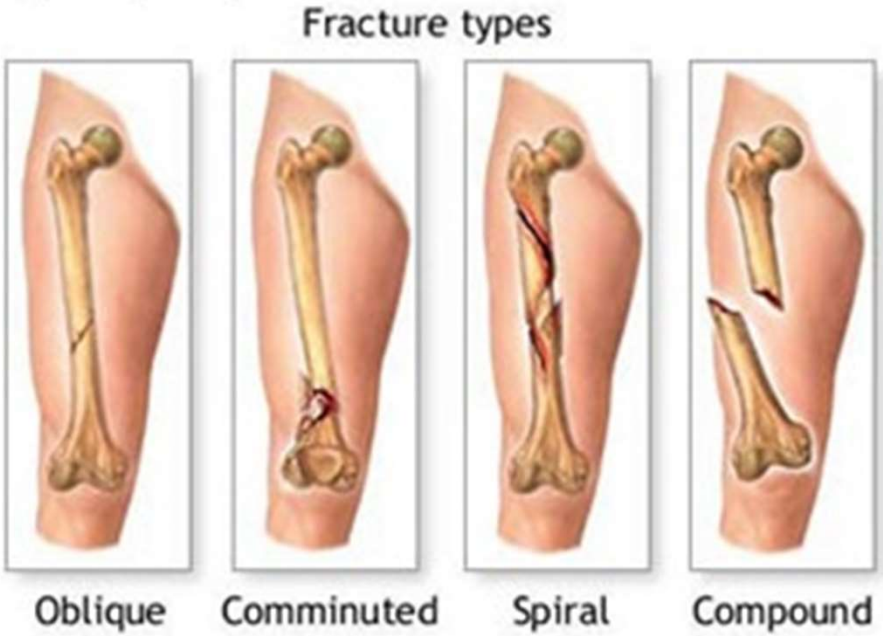






Types of Fractures

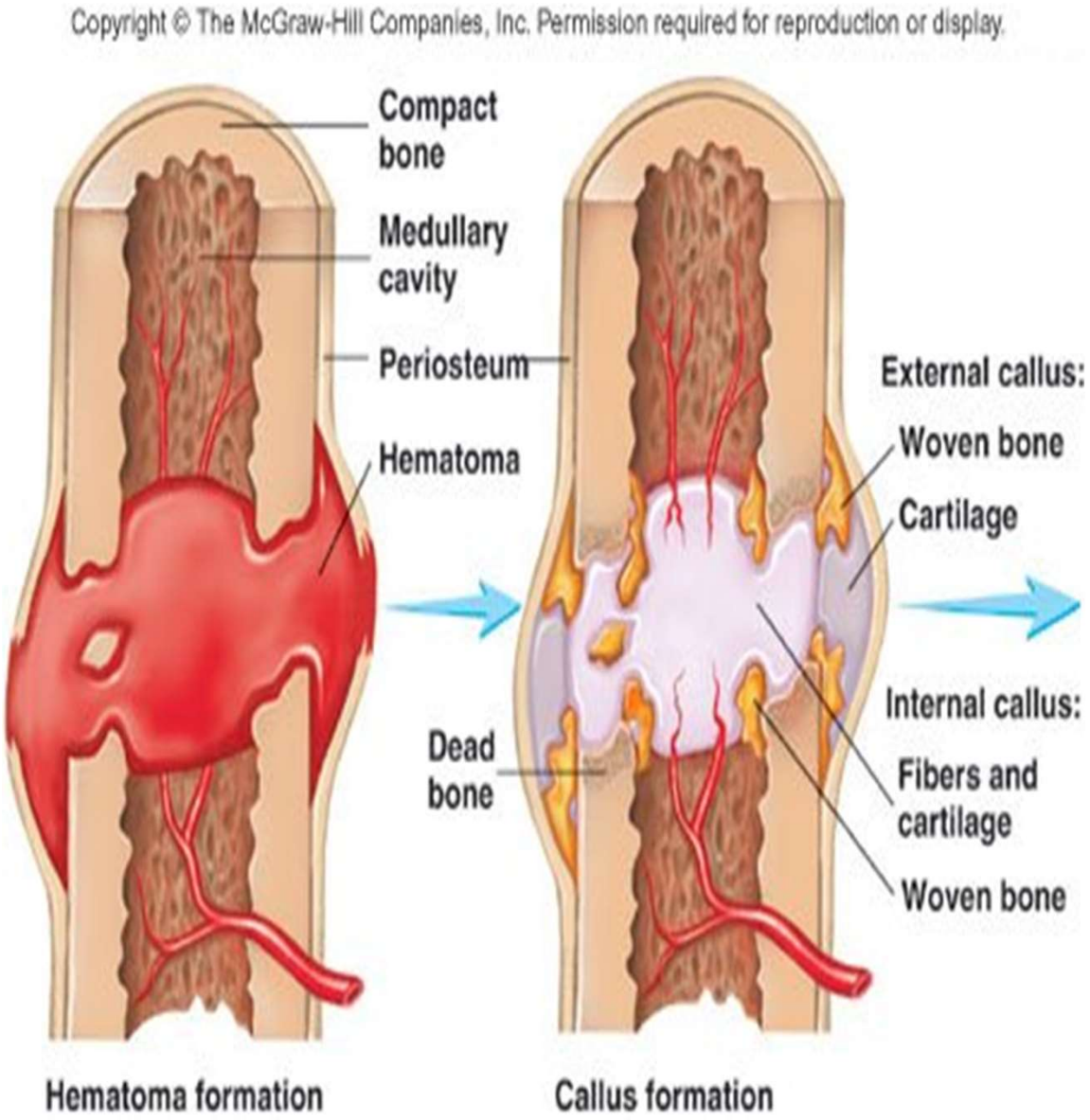
A.D.A.M.

Treatment of Fractures

- Varies according to age, type of fracture and the bone involved
- Goals are immobilization, realignment, and restoration of function
- Closed Reduction – manual manipulation is used to align bones
- Open Reduction – surgery is required; may use screws, plates, pins, rods, or wires

Bone Repair

1. **Hematoma formation** – Blood escapes from ruptured blood vessels forms a clot between the broken bones; area is inflamed and swollen
2. **Fibrocartilage callus formation**. **Callus**: mass of tissue that forms at a fracture site and connects the broken ends of the bone. Collagen fibers tie bones together.



Bone Repair (2)

3. **Bony callus formation**. Osteoblasts help convert the fibrocartilage into spongy bone.
4. **Bone remodeling**. Replacement of spongy bone and damaged material by compact bone. Sculpting of site by osteoclasts.

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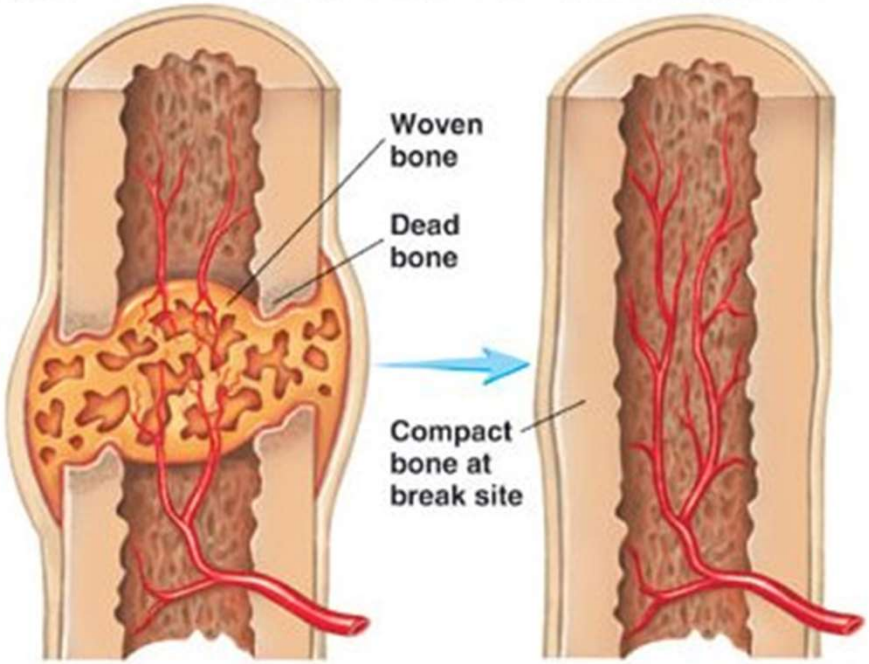
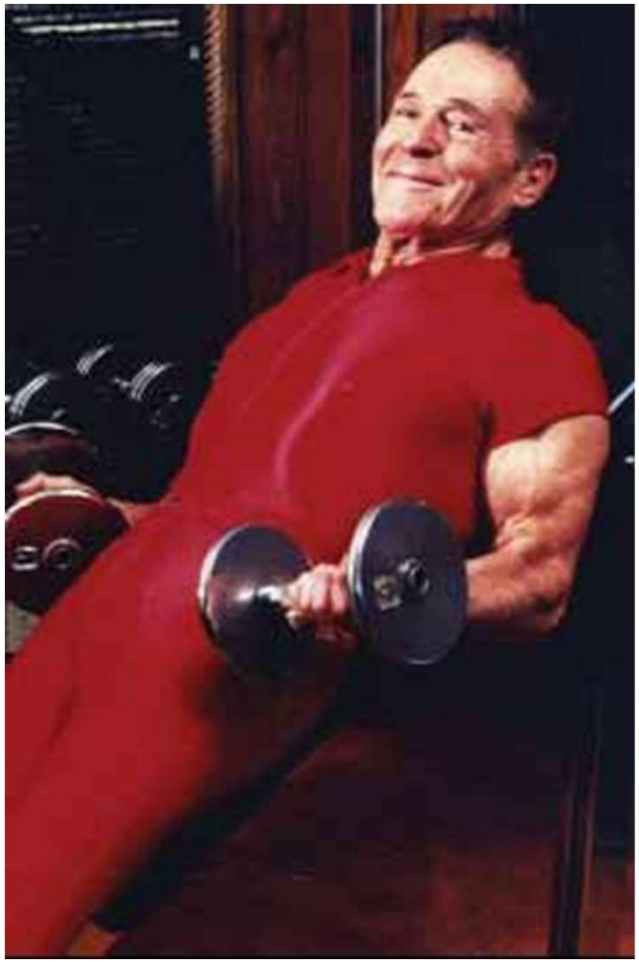


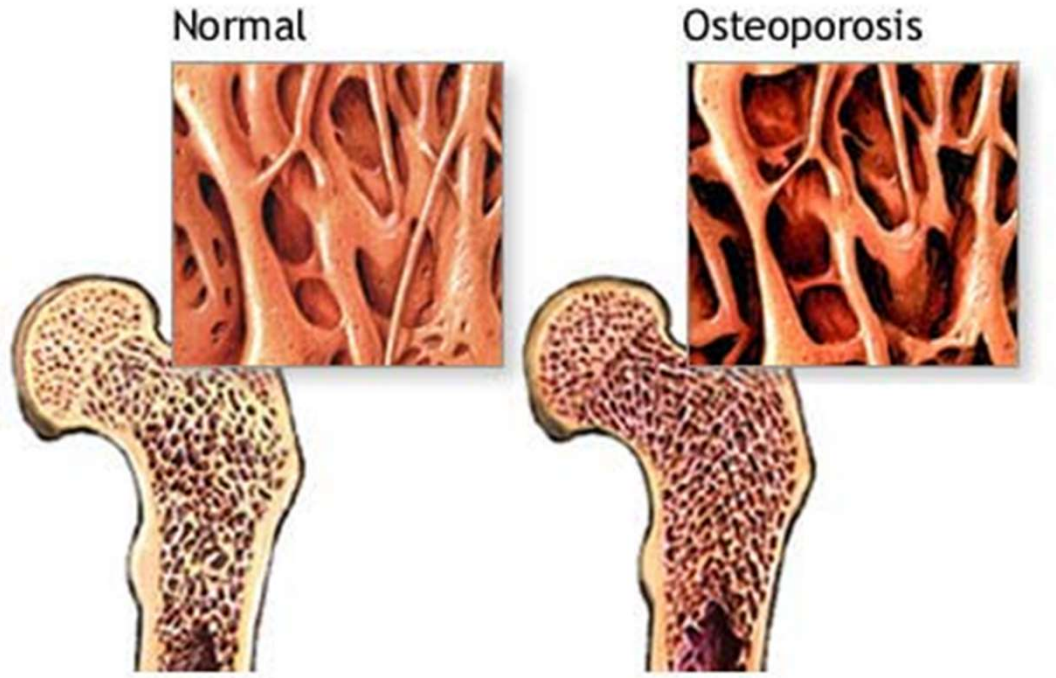
Exercise and Bone Tissue
Aging and Bone Tissue

- Read these sections on p. 178 and p. 180.



Bone Disorders

- Osteoarthritis – degeneration of articular cartilage
- Osteomyelitis – infection of bone, typically caused by *Staph* bacteria
- Osteogenic sarcoma – bone cancer often affecting osteoblasts
  - Most often occurs in teenagers during growth spurt
- Osteoporosis – condition of porous bones
  - Bone resorption outpaces deposition



Good Review Sources

- AMGEN Bone Biology videos on YouTube