Bone tissue

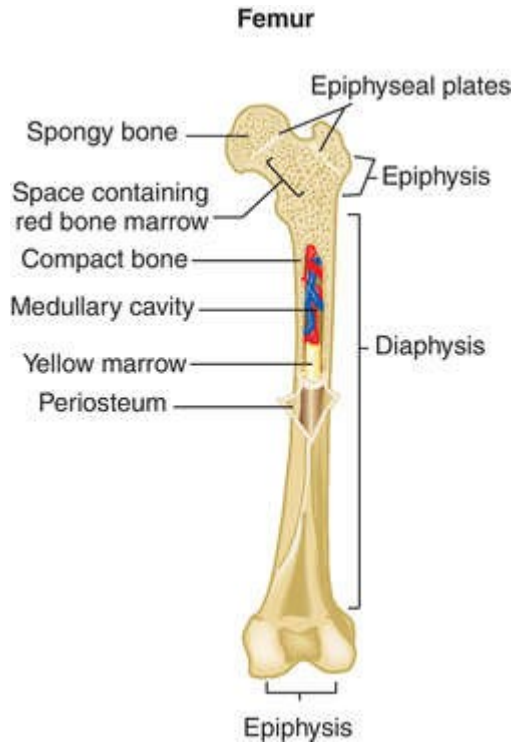
Bone is a connective tissue that is characterized by a mineralized extracellular matrix. The matrix is secreted by cells called osteocytes.

Bone tissue

- UNIQUE QUALITIES OF BONE
  - HYDROXYAPATITE: Calcium Phosphate crystals.
    - It prevents diffusion of metabolites.
    - It prevents interstitial growth -- all bone growth occurs from the periosteum.
  - A CANALICULAR SYSTEM: Tiny canals connect one haversian system to the other.
  - VASCULARITY: All bone cells are in close proximity to vessels!
  - APPOSITIONAL GROWTH: All growth occurs by appositional growth.
  - BONE RECONSTRUCTION: Bone is dynamic tissue, constantly changing shape.

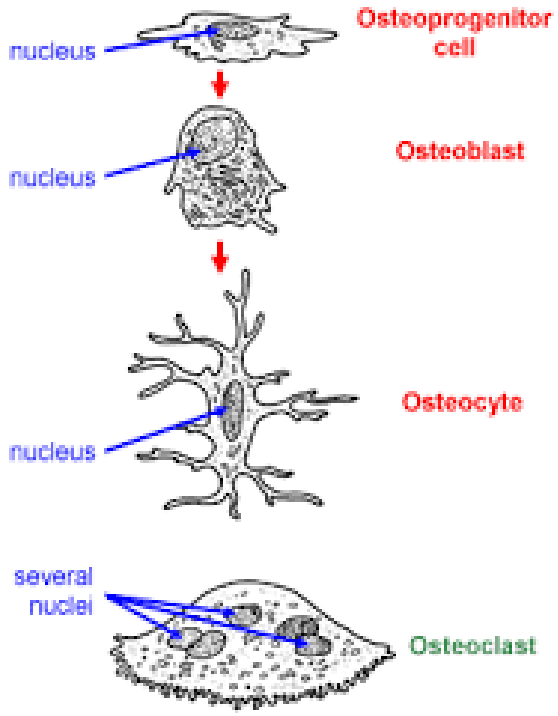
Bone tissue

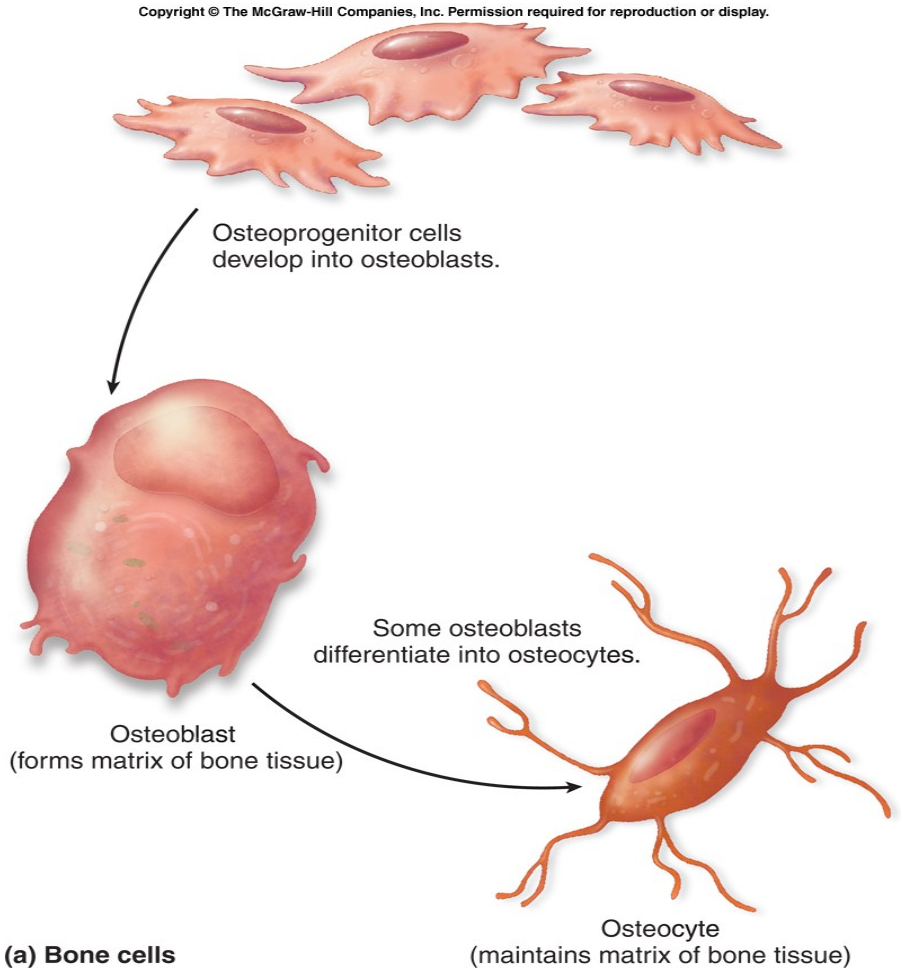
- **<u>LONG-BONE GROSS STRUCTURE</u>**:
  - **DIAPHYSIS:** the shaft with a medullary cavity on inside.
  - **EPIPHYSIS:** the ends.
  - **METAPHYSIS:** the site of ossification, between the diaphysis and epiphysis.
  - **ARTICULAR CARTILAGE:** hyaline cartilage covering compact bone at the ends of long bones. It lacks perichondrium.
  - **PERIOSTEUM:** osteogenic potential around the outside.
  - **ENDOSTEUM:** lines the marrow cavity and also has osteogenic potential.



Bone tissue

- Consists of **cells** in lacunae, in an extracellular matrix





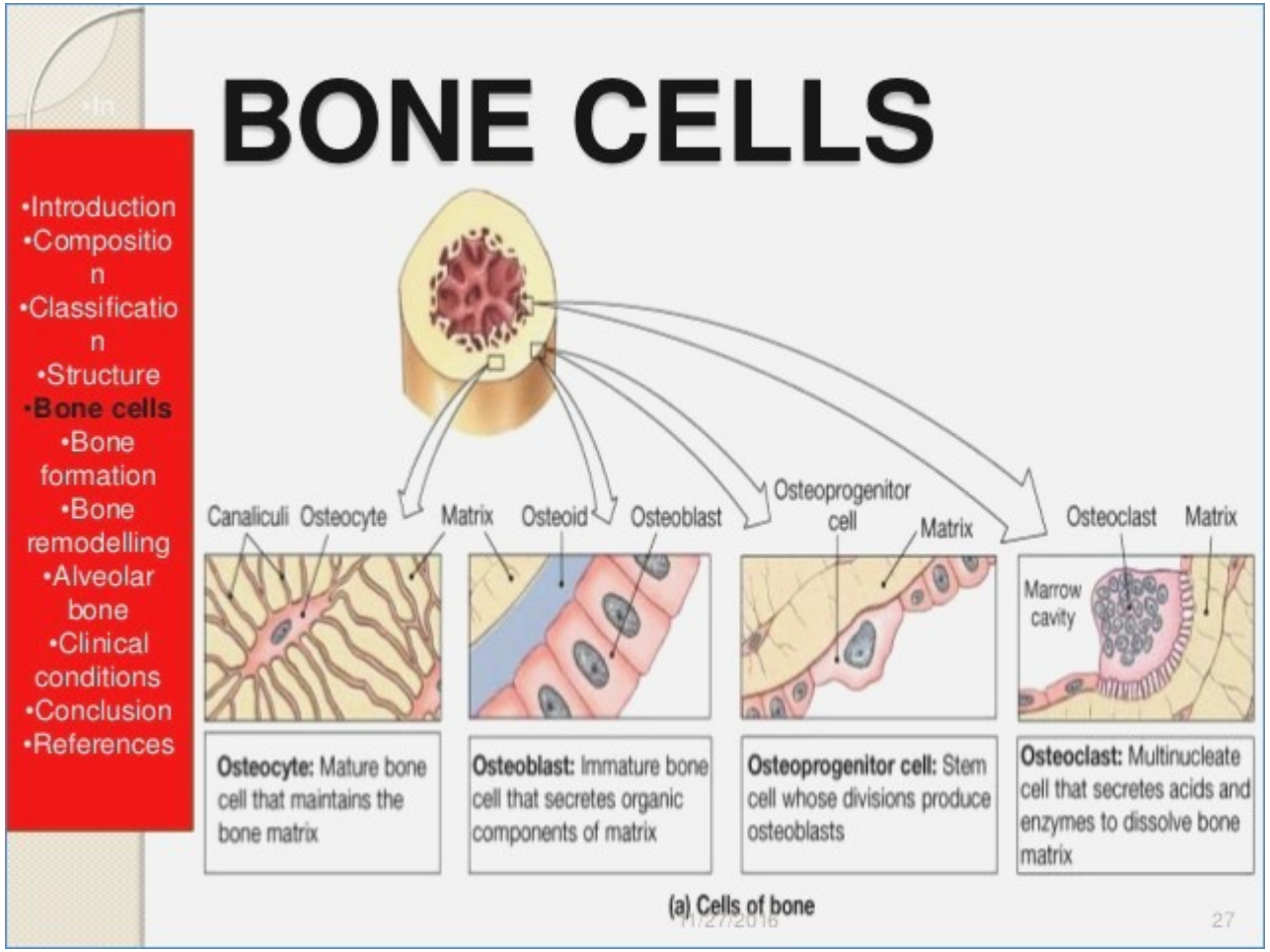
Bone tissue

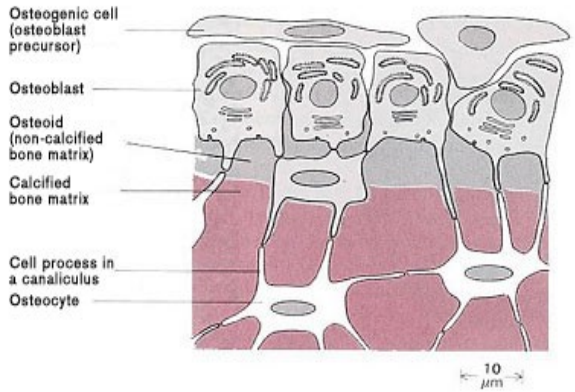
- **BONE CELL TYPES**
  - **A) OSTEOPROGENITOR CELLS:**
    the stem-Cells of bone, on the inner lining of the periosteum and endosteum
  - **B) OSTEOBLASTS:**
    secretory cells, secrete the bone matrix
    - **ALKALINE PHOSPHATASE** which calcifies the matrix.

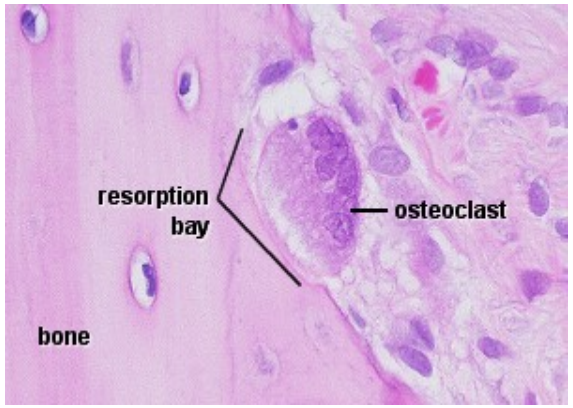
    have polarity and resemble other secretory cells
  - **C) OSTEOCYTES:**
    they are osteoblasts that have become trapped in their own matrix, found in lacunae, between layers of **lamellae**, in the matrix of cortical bone
    CANALICULI: fine cytoplasmic extensions of the osteocytes running perpendicular to the haversian canals
  - **D) OSTEOCLASTS:** large, multinucleate cells derived from monocytes, have **acid hydrolases**, many lysosomes and are eosinophilic
    - **HOWSHIP'S LACUNAE:** the spaces for bone resorption, between the osteoclast and the bone resorption surface

- **BONE-MATRIX**
  - **COLLAGEN:** Type I Collagen = 85% - 90% of total bone protein
  - **HYDROXYAPATITE:** Bone salts (Calcium Phosphate) composes the non-protein inorganic part.

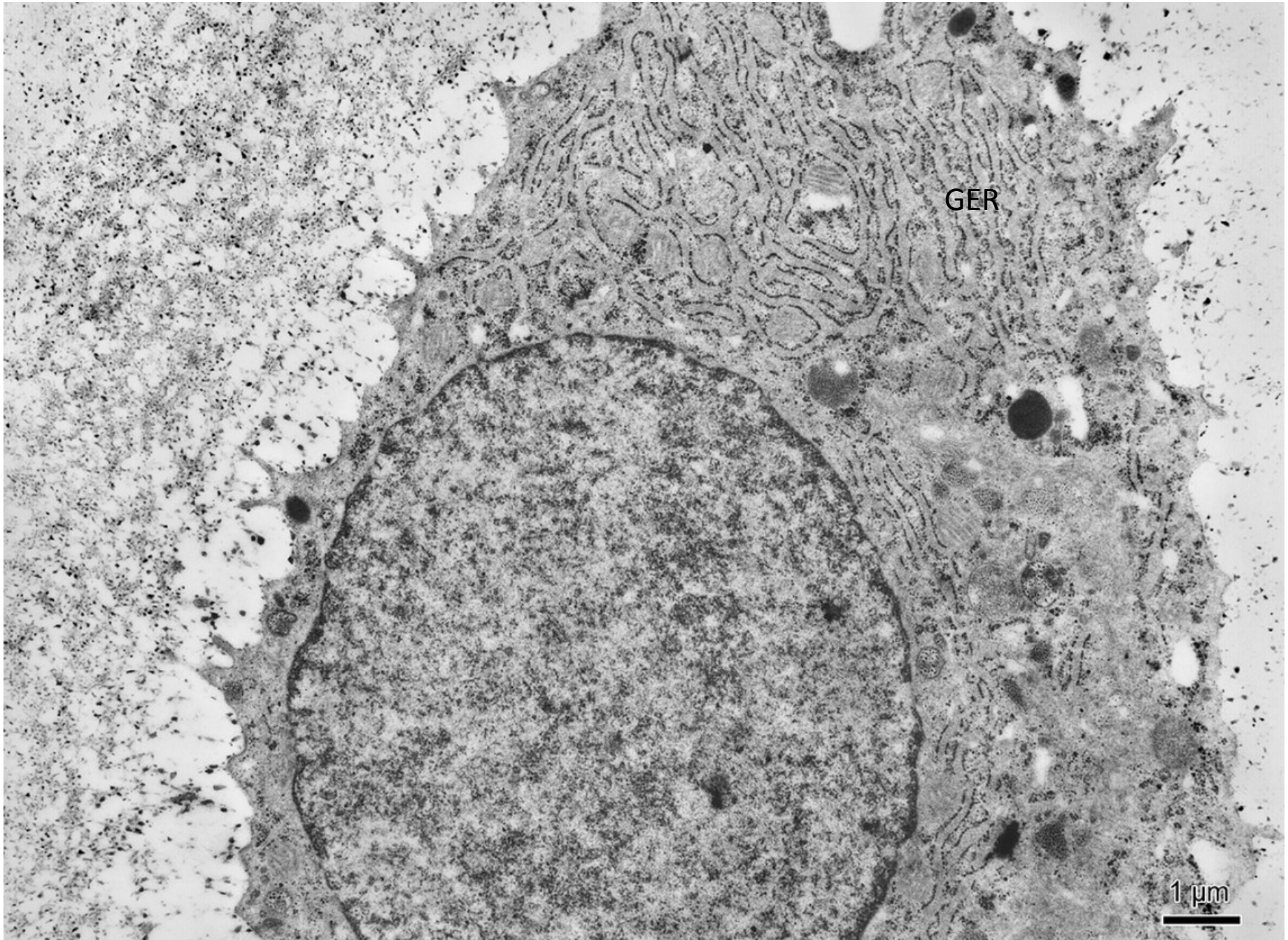
Bone tissue


BONE CELLS
•Introduction
•Compositio n
•Classificatio n
•Structure
•Bone cells
•Bone formation
•Bone remodelling
•Alveolar bone
•Clinical conditions
•Conclusion
•References
Canaliculi
Osteocyte
Matrix
Osteoid
Osteoblast
Osteoprogenitor cell
Matrix
Osteoclast
Matrix
Marrow cavity
Osteocyte: Mature bone cell that maintains the bone matrix
Osteoblast: Immature bone cell that secretes organic components of matrix
Osteoprogenitor cell: Stem cell whose divisions produce osteoblasts
Osteoclast: Multinucleate cell that secretes acids and enzymes to dissolve bone matrix
(a) Cells of bone
11/27/2016
27

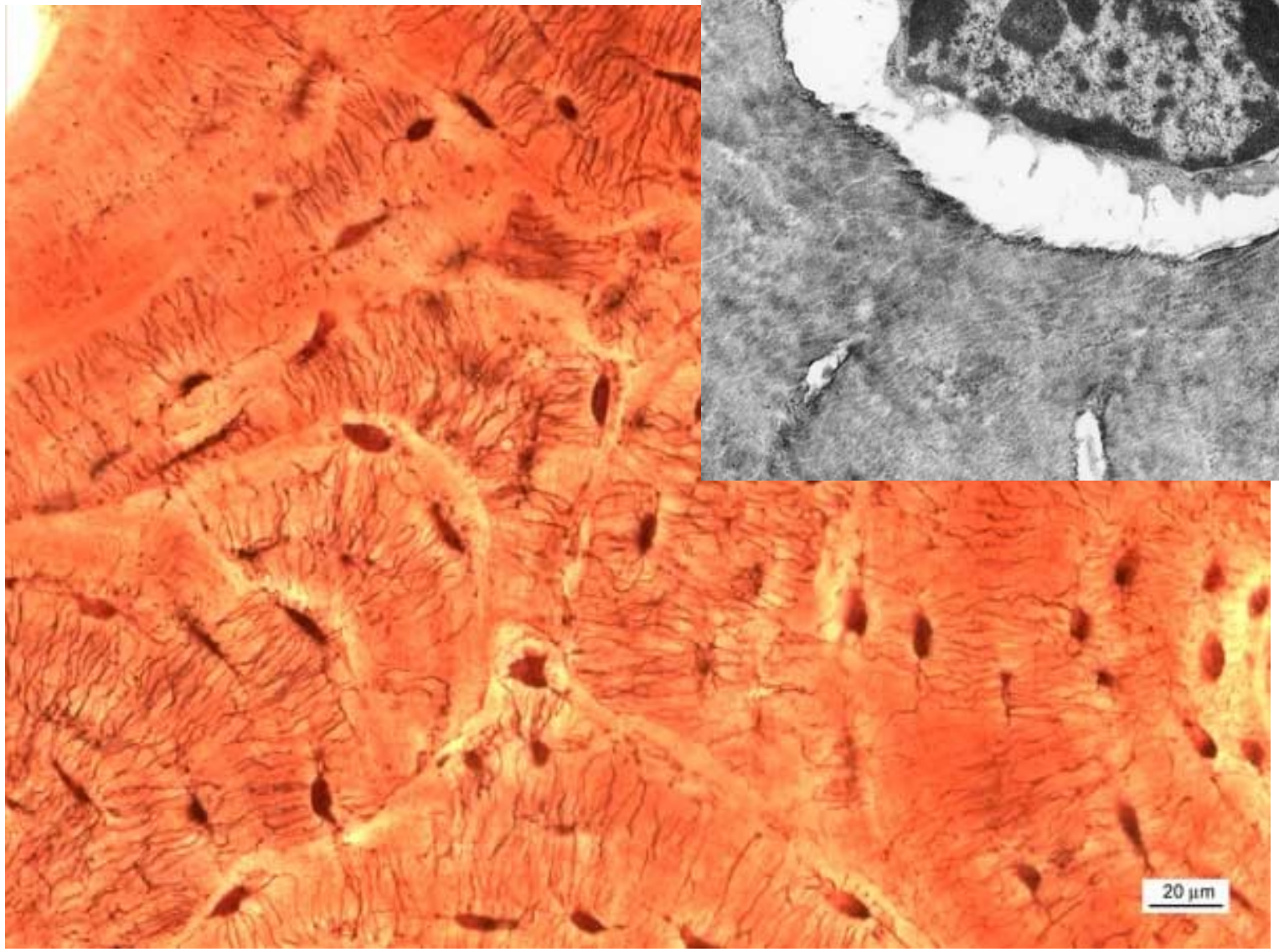

Osteogenic cell (osteoblast precursor)
Osteoblast
Osteoid (non-calcified bone matrix)
Calcified bone matrix
Cell process in a canaliculus
Osteocyte
10 μm


resorption bay
osteoclast
bone

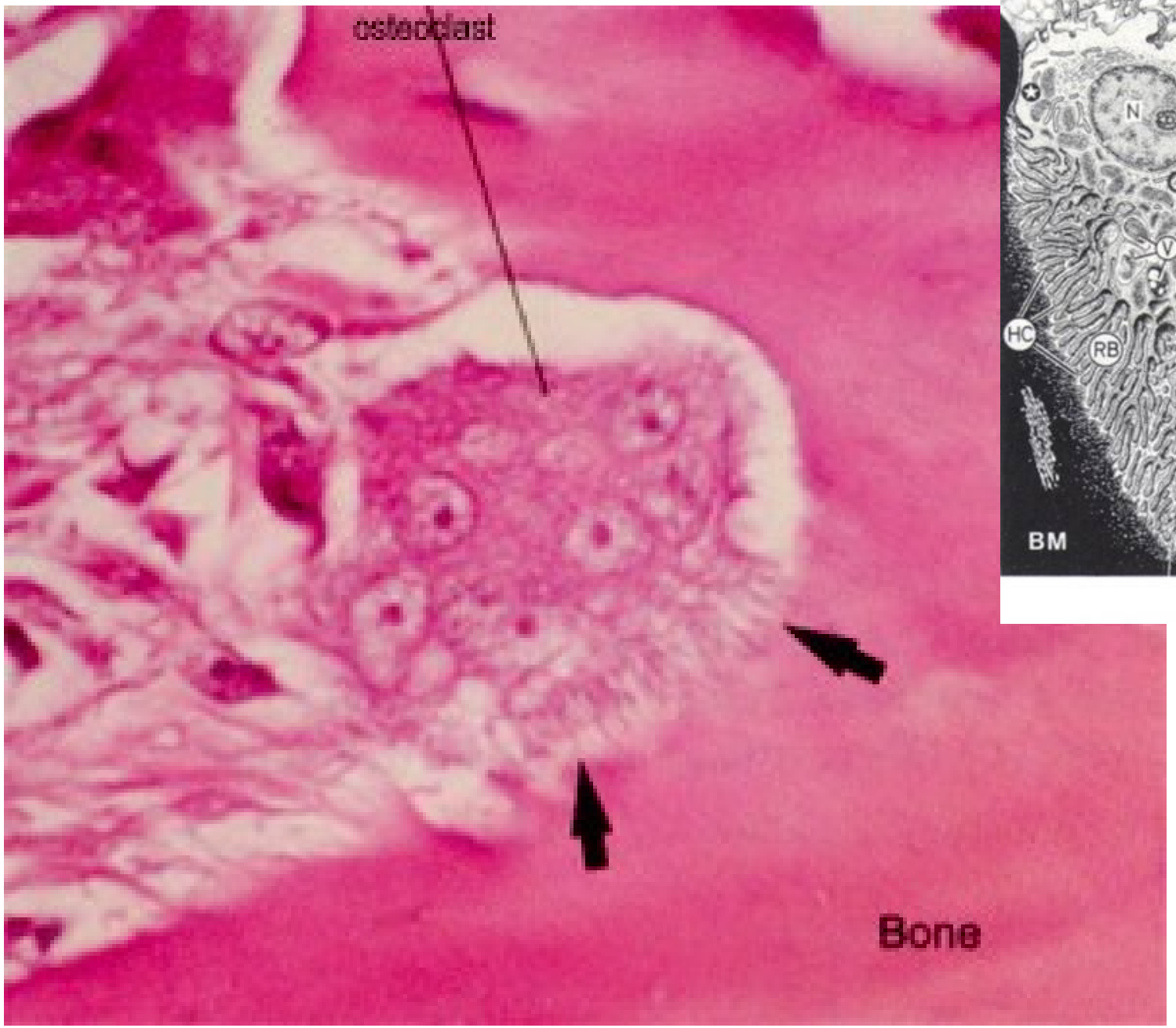
Osteoblast



Osteocyte



Osteoclast



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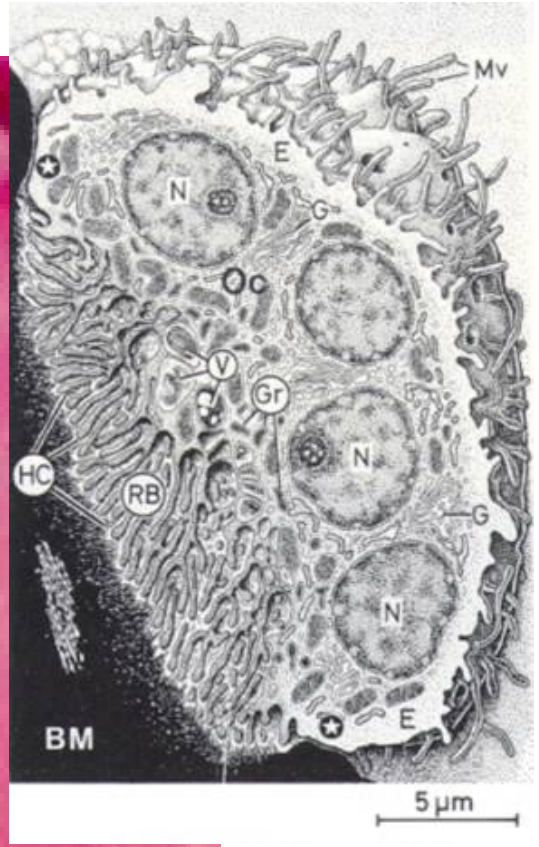
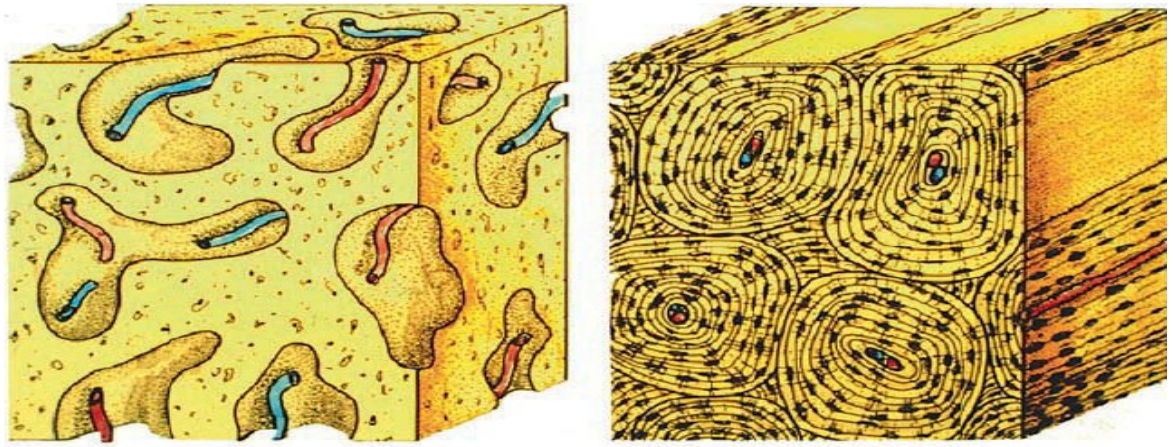


www.studyblue.com


osteoblasts
tchealth.com
osteoclasts
osteocytes

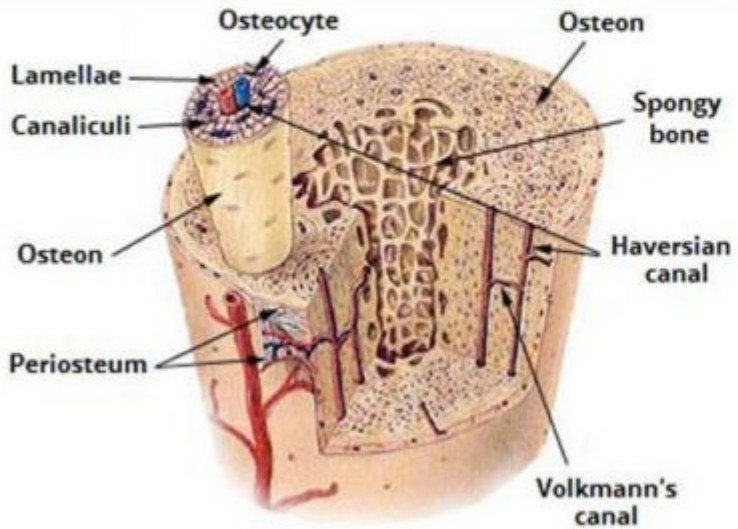
Bone tissue – types

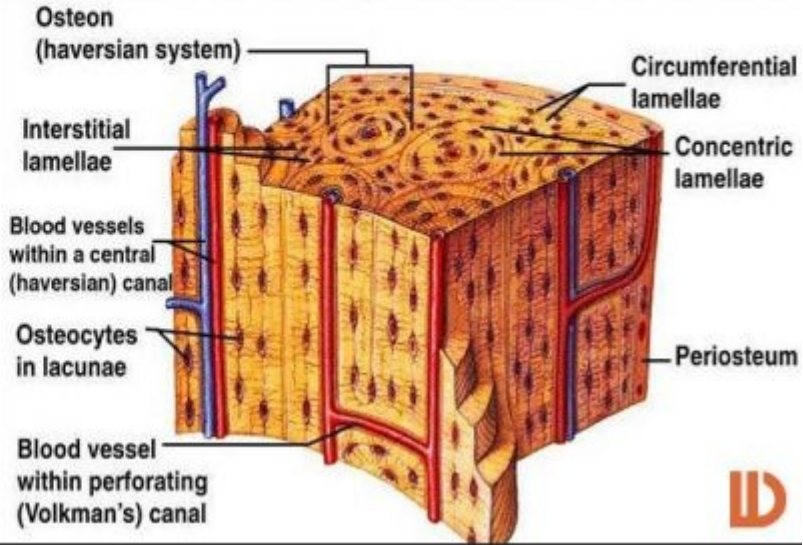
- **WOVEN BONE -** collagen fibers are not arrenged into lamellae and running in different directions, they form a network in gound substance, osteocytes in lacunae are situated in this network
- **COMPACT BONE -** is recognized as:
  - **Lamellar bone**: arranged in concentric layers called **lamellae**, with **Haversian Canals** containing blood vessels in the center, often found around the outside of large bones
  - **Spongy bone**: forms **trabeculae** inside of bone cavity with the bone-marrow, lamellae are organized in parallel way to their surface



Woven Lamellar

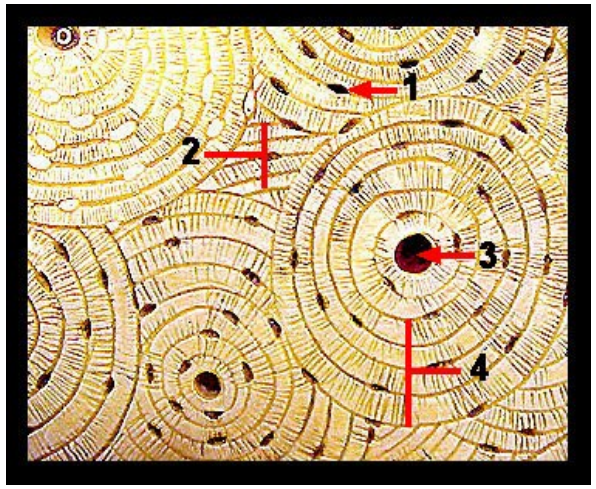
SPONGY BONE VS COMPACT BONE





Compact lamellar bone

- **Haversian Lamellae:** lamellae around central **Haversian Canals**
- contain blood vessels and nerves
- **Osteocytes** are within the lamellae, with **canaliculi** radiating toward the central haversian canal
- **Volkmann's Canals:** run perpendicular (transverse) to the Haversian Canals, they connect the haversian canals to each other, or to the marrow cavity



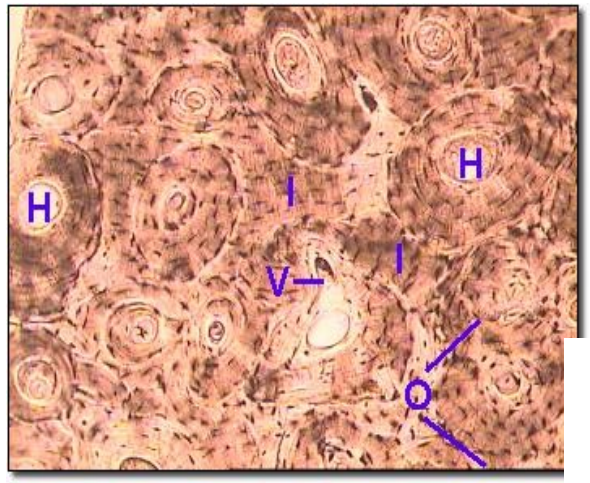
1 – osteocyte, 2 – interstitial lamellae, 3 – haversian canal, 4 - lamellae

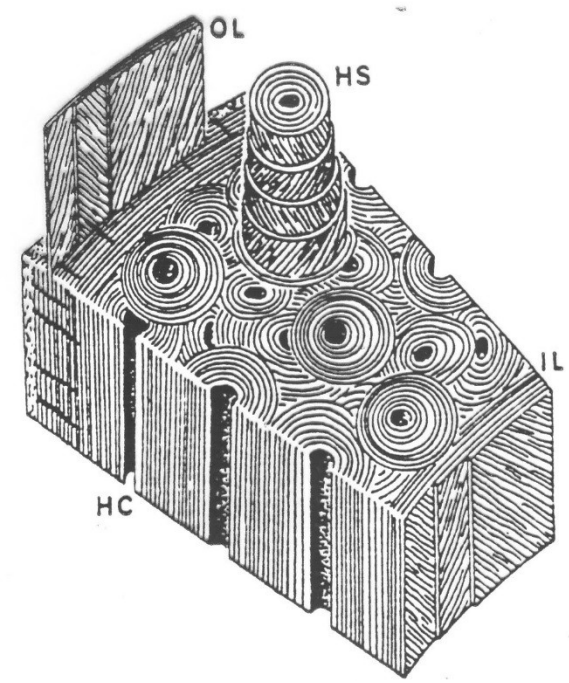
Compact lamellar bone

- **Interstitial Lamellae:** remnants of older haversian lamellae, they are not concentrically arranged, but lie in between the haversian systems
- **Circumferential Lamellae:** the external and internal borders of cortical bone.

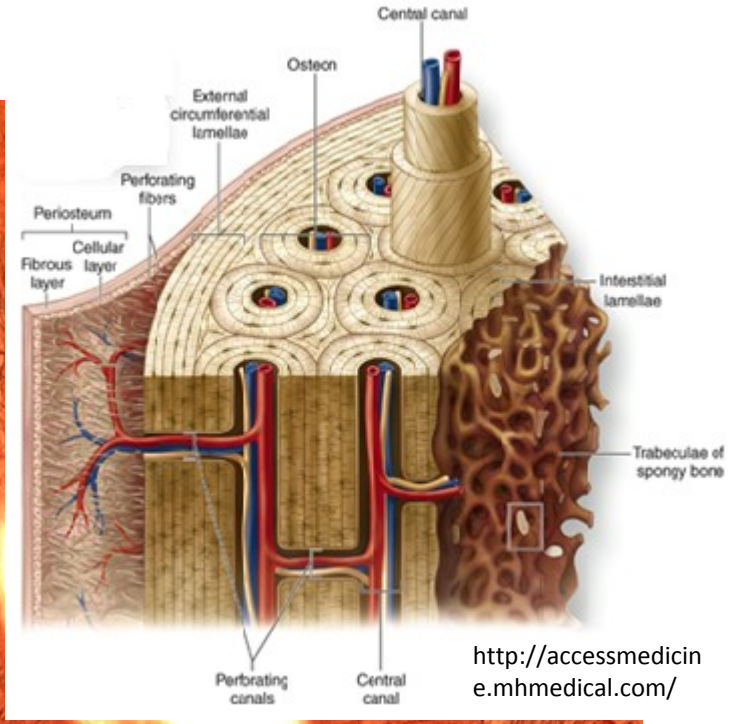
Outer Circumferential Lamellae: adjacent to the periosteum

Inner Circumferential Lamellae: adjacent to the endosteum





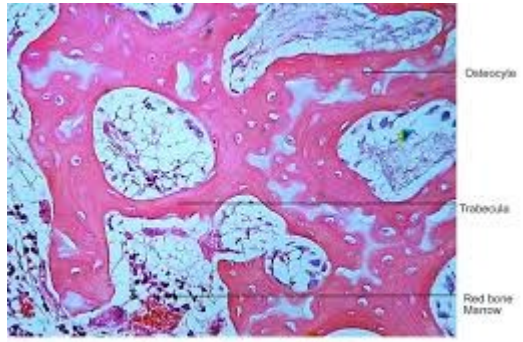
Lamellar compact bone (Schmorl)



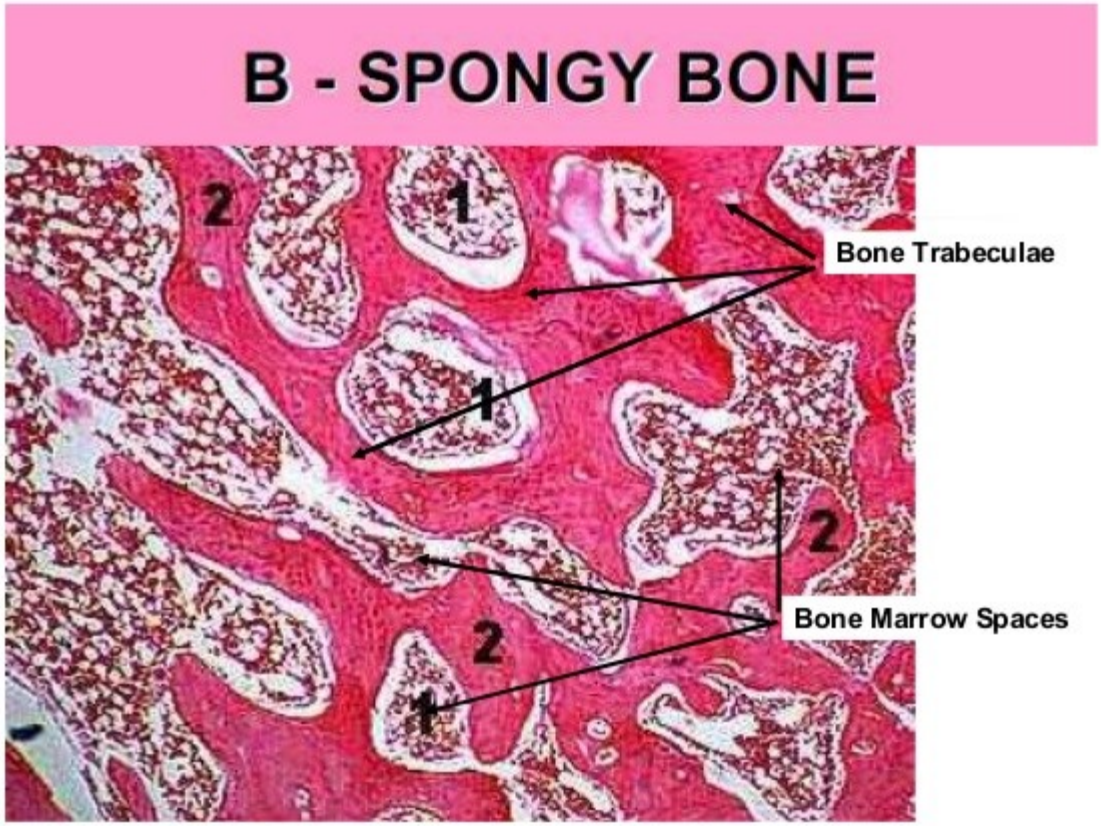
http://accessmedicine.mhmedical.com/

Spongy bone

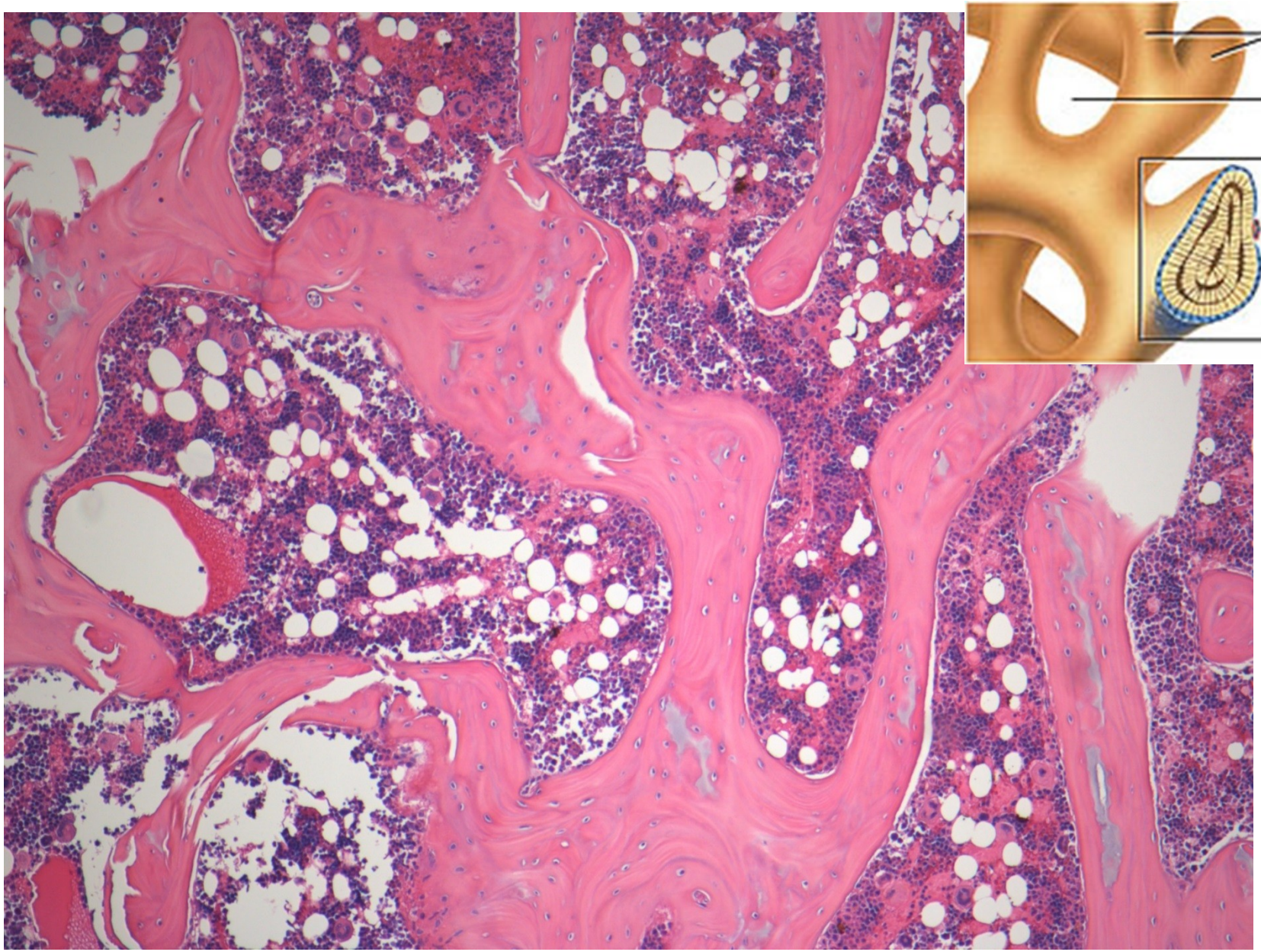
- forms **trabeculae** inside of bone cavity with the bone-marrow. Lamellae are organized in parallel way to their surface



Cancellous (Spongy) Bone (400x)



Lamellar spongy bone (HE)



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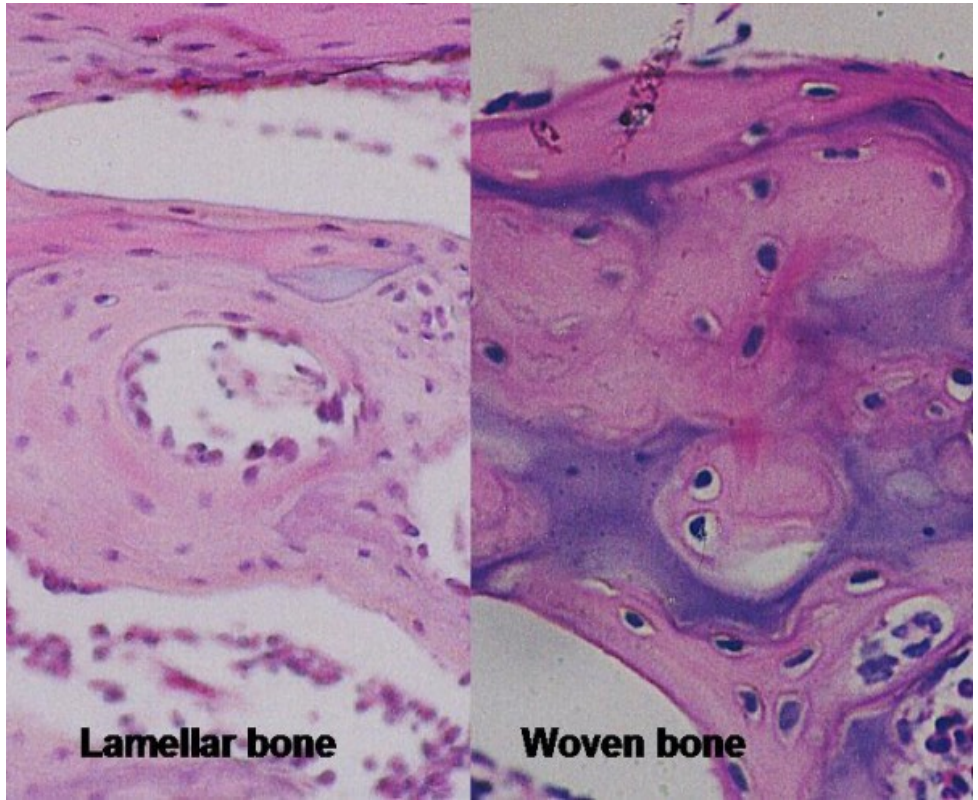
Woven bone

- **WOVEN BONE:** Osteocytes are uniformly distributed and randomly oriented throughout the bone !all bone starts as woven bone!
- Bone first appears as little spikes called **spicules**, which then form **trabeculae**
- The woven bone is reformed to make either cortical bone or spongy bone.



Intramembranous ossification

- Formation of bone directly from osteoblasts, **with no cartilage intermediate.**
  - Mesenchymal cells --> osteoblasts
  - **Osteoblasts** secrete the osteoid matrix
  - Osteoblasts then secrete alkaline phosphatase to calcify the matrix, trapping themselves in it forming **Osteocytes**
  - Some flat bones are formed by intramembranous ossification (bones of the skull, jaws, clavicula)

Enchondral ossification

- Long bones are formed on a cartilage model.
- **GENERAL PROCESS**:
    - Cartilage matrix is laid down
    - **Perichondrium** then becomes **periosteum**, when a **vascular bud** invades the perichondrial space, the vascular bud contains blood cells, bone marrow cells, macrophages, endothelial cells
    - GROWTH IN LENGTH: Occurs by proliferation of chondrocytes at the epiphyseal plates and at the primary ossification front.
    - GROWTH IN DIAMETER: Occurs by deposition of new bone under the **periosteal collar** along with simultaneous osteoclastic resorption, in order to maintain bone shape. The osteoclastic resorption is necessary to enlarge the medullary cavity.

Enchondral ossification

- **PRIMARY OSSIFICATION CENTER:** Occurs in the center of the diaphysis, and extends toward both epiphyses.
  - Thus there are two fronts of primary ossification.
  - Primary ossification centers close around the time of birth. Thereafter, long-bone growth occurs from the secondary ossification centers.
- **SECONDARY OSSIFICATION CENTER:** Forms at the **epiphyseal plate**.
  - The orderly columns of chondrocytes are not seen here.
  - Growth occurs from the epiphysis downward, toward the epiphyseal plate.
- **EPIPHYSEAL CLOSURE:** The end of longitudinal growth in long bone, when the primary ossification center overtakes (i.e. calcifies) the secondary ossification center, and hence long-bone growth ceases.

Enchondral ossification

OSSIFICATION ZONES

RESERVE ZONE: This is the zone of normal hyaline cartilage. Little cellular activity or cell division is occurring.

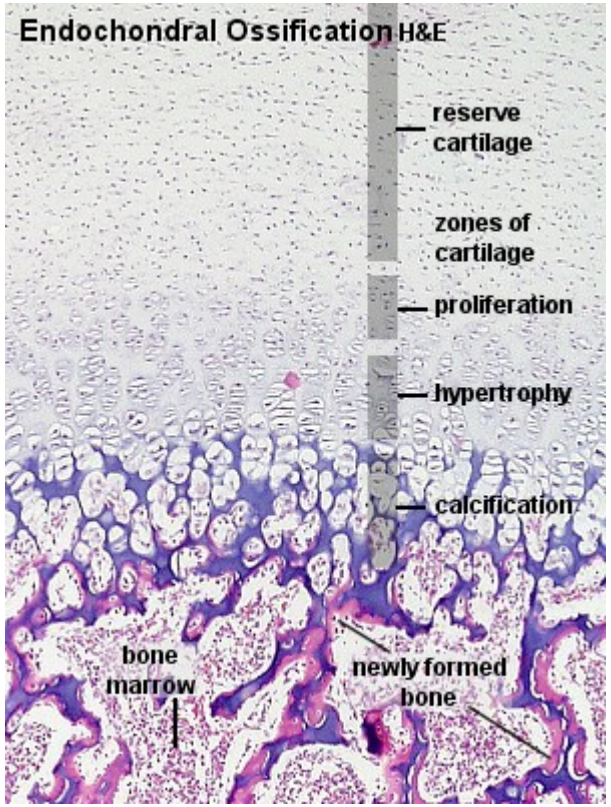
PROLIFERATIVE ZONE: Chondrocytes are multiplying and arrange themselves in long parallel isogenous columns: This is the main zone responsible for growth of the long axis of the bone.

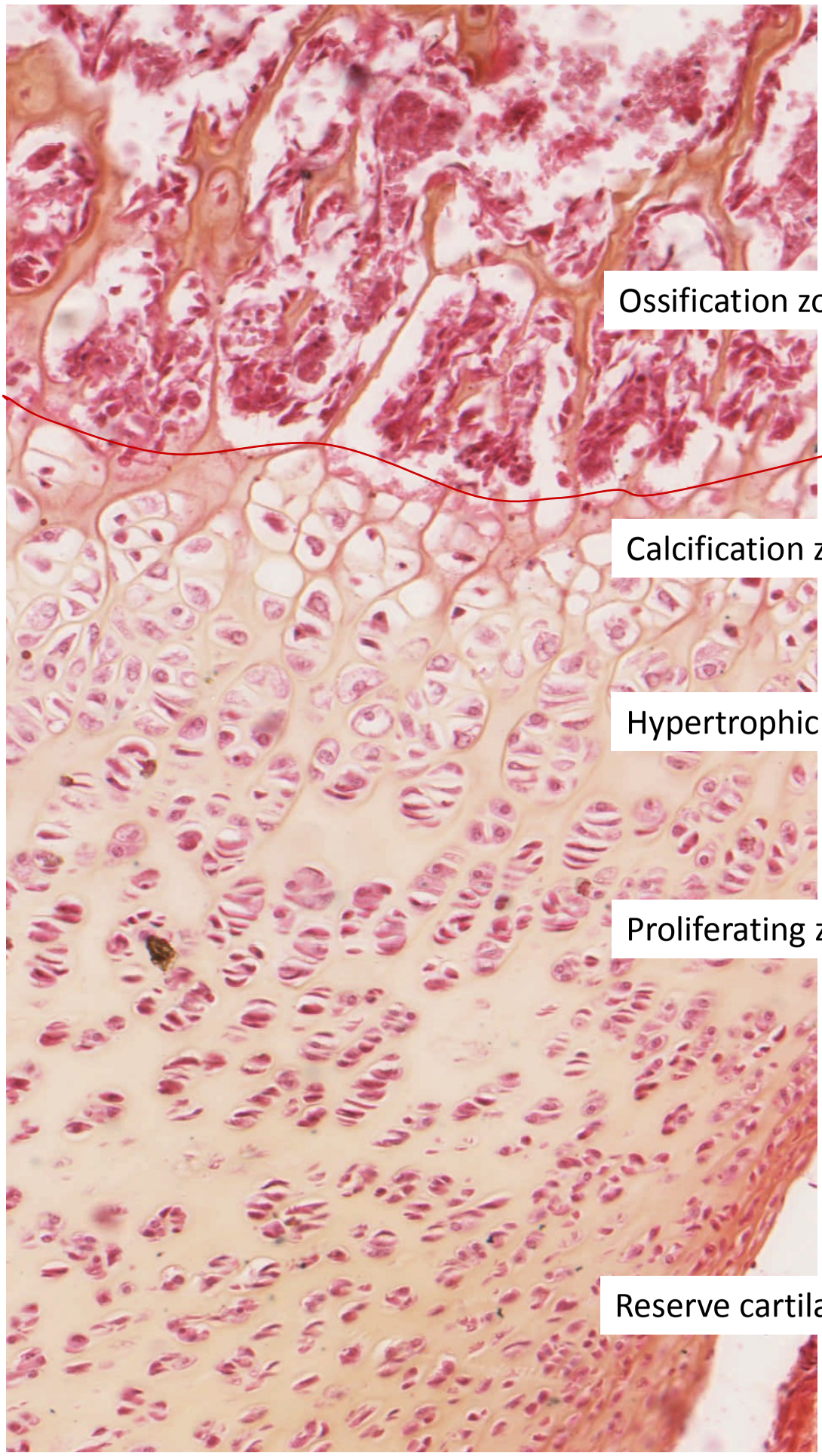
ZONE of HYPERTROPHY: Chondrocytes are hypertrophying and secreting **alkaline phosphatase**.

CALCIFICATION ZONE: Matrix around the hypertrophied cells calcified, trapping the chondrocytes in the matrix. Chondrocytes are dying here (due to no nutrients.).

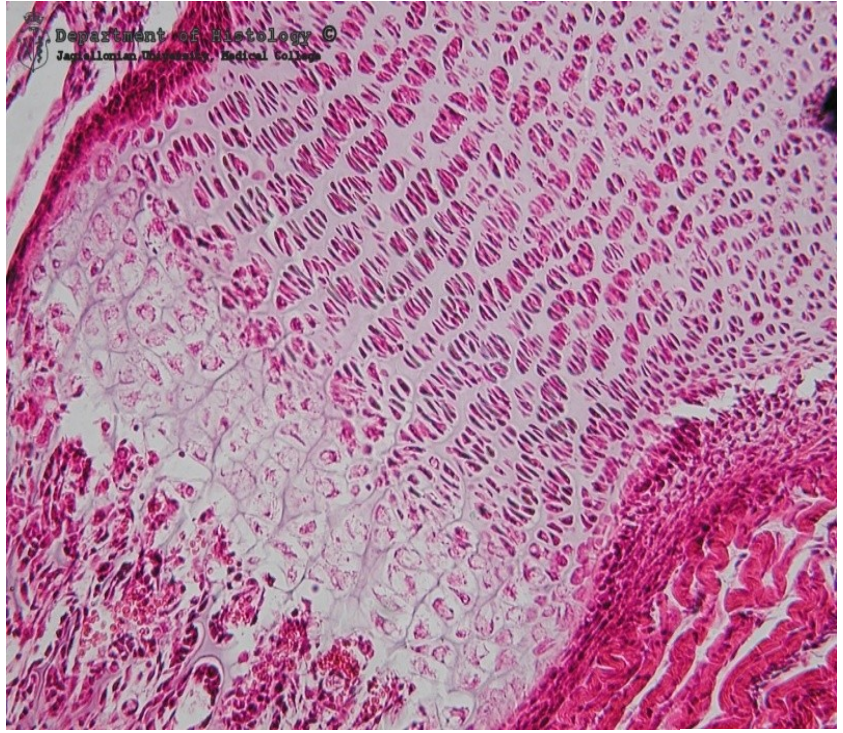
„LINE of errosion“

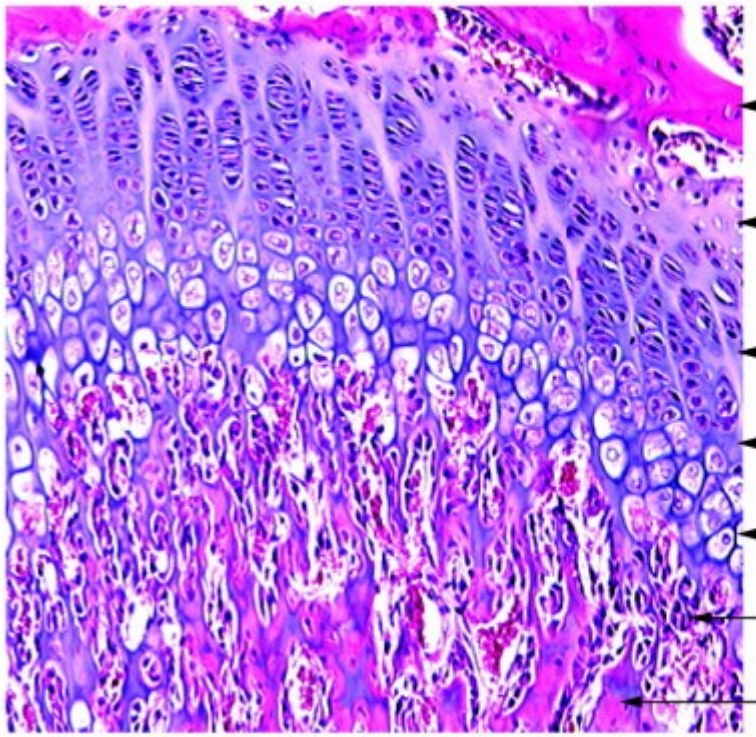
OSSIFORM ZONE: calcified cartilage matrix = spicules are covered with osteoblasts are recruited from the blind end of vascular bud. OSTEOBLASTS produce bone matrix = osteoid, which is later calcified trapping osteoblasts in mineralized matrix - ossein.



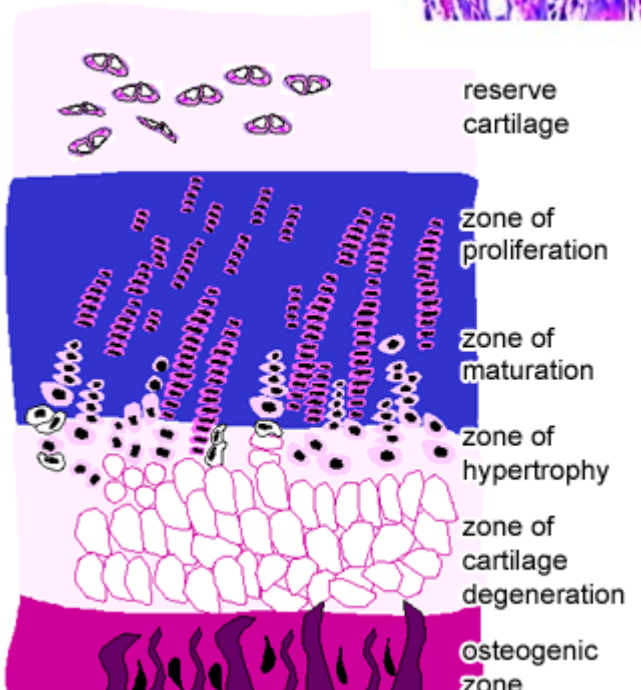


Intracartilaginous ossification (HES)





Current Biology



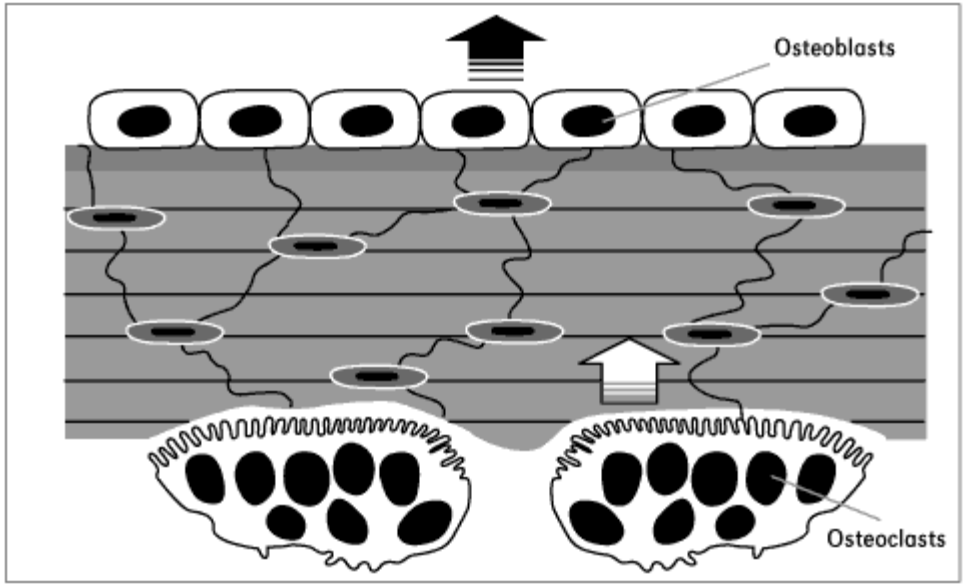
Bone remodeling

The process of BONE-REMODELING, which occurs during growth and in mature bone. It explains relationship between osteoclastic and osteoblastic activity in bone-remodeling, which explains why osteoporosis is difficult to treat.

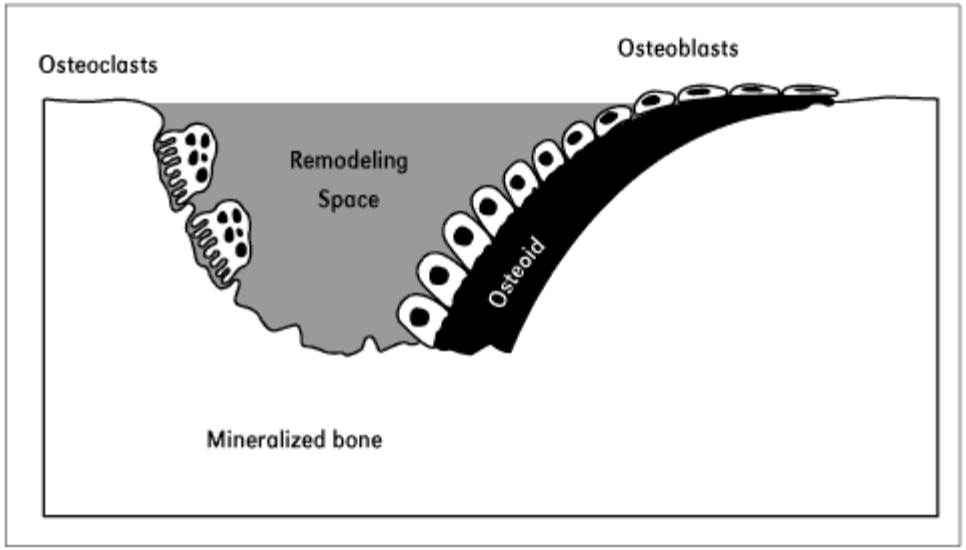
- **Activation:** Osteoclasts are activated and begin secreting acids to resorb bone.
- **Resorption:** Osteoclastic resorption occurs.
- **Reversal:** Resorption stops and osteoblasts take over.
- **Formation:** Osteoblasts form bone on the opposing surface to complete the bone reforming process.

Figure 2–2. Modeling and Remodeling

Modeling

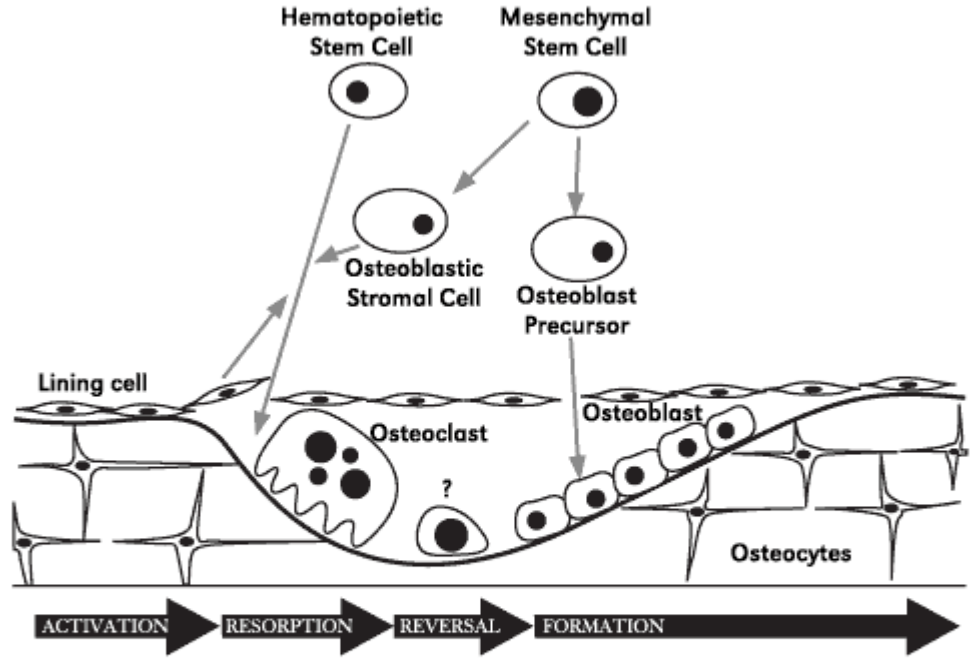


Remodeling



Note: In modeling, osteoblast and osteoclast action are not linked and rapid changes can occur in the amount, shape, and position of bone. In remodeling, osteoblast action is coupled to prior osteoclast action. Net changes in the amount and shape of bone are minimal unless there is a remodeling imbalance.

Figure 2–3. Bone Remodeling



Note: The sequence of *activation, resorption, reversal,* and *formation* is illustrated here. The activation step depends on cells of the osteoblast lineage, either on the surface of the bone or in the marrow, acting on blood cell precursors *(hematopoietic cells)* to form bone-resorbing osteoclasts. The resorption process may take place under a layer of lining cells as shown here. After a brief reversal phase, the osteoblasts begin to lay down new bone. Some of the osteoblasts remain inside the bone and are converted to osteocytes, which are connected to each other and to the surface osteoblasts. The resorption phases last only a few weeks but the formation phase is much slower, taking several months to complete, as multiple layers of new bone are formed by successive waves of osteoblasts.

CONNECTIVE TISSUE – II: bone.

Slides:
Lamellar bone (95. Bone – HE or Schmorl staining)
Endochondral ossification (96.)

Atlas EM:
Osteoblast (46)
Osteocyte (47)