BONE

By

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ILOs

1. Describe the structure of bone tissue.
2. Recognize different types of bone cells.
3. Illustrate functions of different types of bone cells.
4. Recognize the histological structure of different types of bone.

Bone

Is a specialized connective tissue (supporting) whose extracellular matrix is calcified (hard).

Function:

- Bone supports soft tissues and protects vital organs of the body e.g. brain & thoracic cage.
- Bone serves as levers for the muscle attached to them, allows movement of the body .
- Bone serves as storage site for calcium and phosphate (maintains blood calcium level).
- Bone contains bone marrow, which act as a haemopoietic organ (blood cells formation).

Structure of bone tissue

Covering layers

- Periosteum
- Endosteum

Extracellular matrix

- Inorganic component
- Organic component
  - Collagen fibers (type I)
  - Ground substance

Bone cells: 4 cells

- osteogenic cells
- osteoblasts
- osteocytes
- osteoclasts

Bone covering

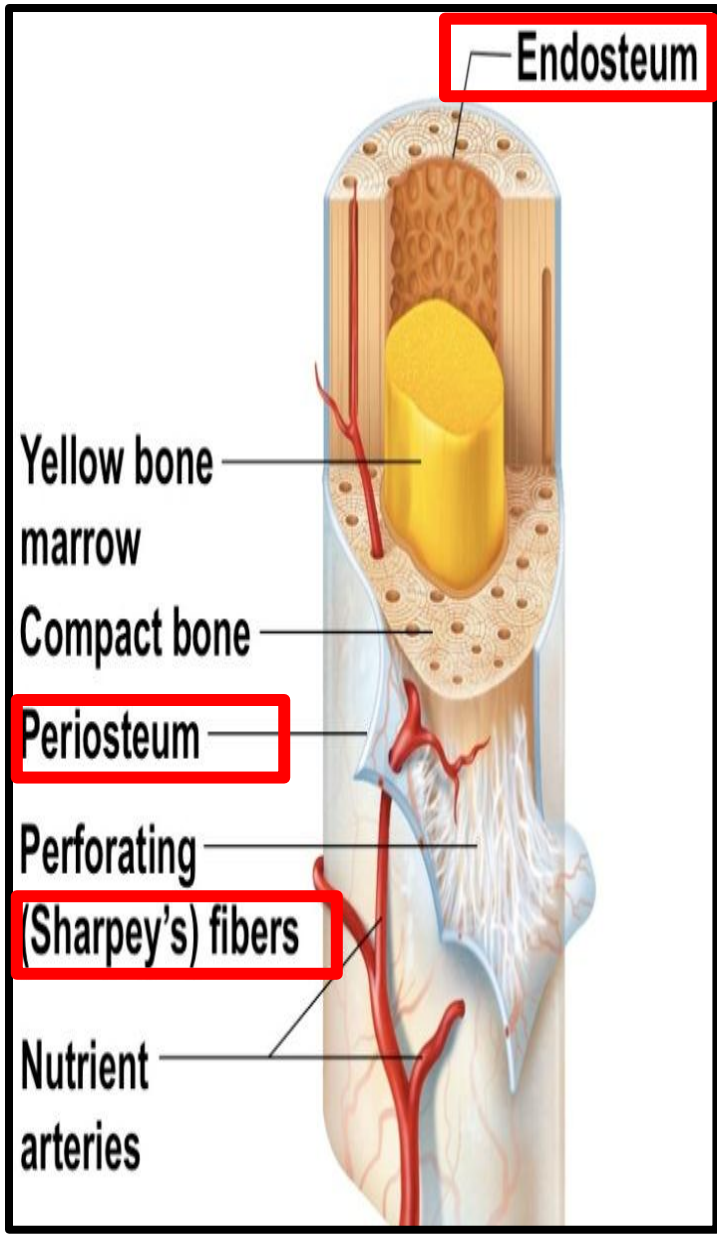
❑ Periosteum

cover the outer surface of bone. It is composed of 2 layers:

Outer fibrous layer:

- Formed of dense C.T (collagen fibers with fibroblasts & blood vesseles).
- Bundles of collagen called perforating or ***Sharpey's fibers*** *e*xtend from the fibrous layer of periosteum and penetrate the bone matrix binding the periosteum to bone and prevent its separation.

Inner cellular layer :composed of **osteoprogenitor** (osteogenic) cells that differentiate into osteoblasts.



❑ Endosteum

- It lines all the *internal surfaces or cavities* within the bone.
- It is composed of a single layer of osteogenic cells and little connective tissue.

Functions: Bone nutrition, growth & repair.

Bone matrix

Inorganic Components:

It constitutes about 50% of the dry weight of bone.

It is composed :

- **calcium salts** mainly **(ca hydroxyapatite**)
- calcium phosphate.

Organic Components:

it is composed of:

❑ ***Fibers :***

Collagen type I forms 90% of the organic portion so the bone matrix is *highly acidophilic.*

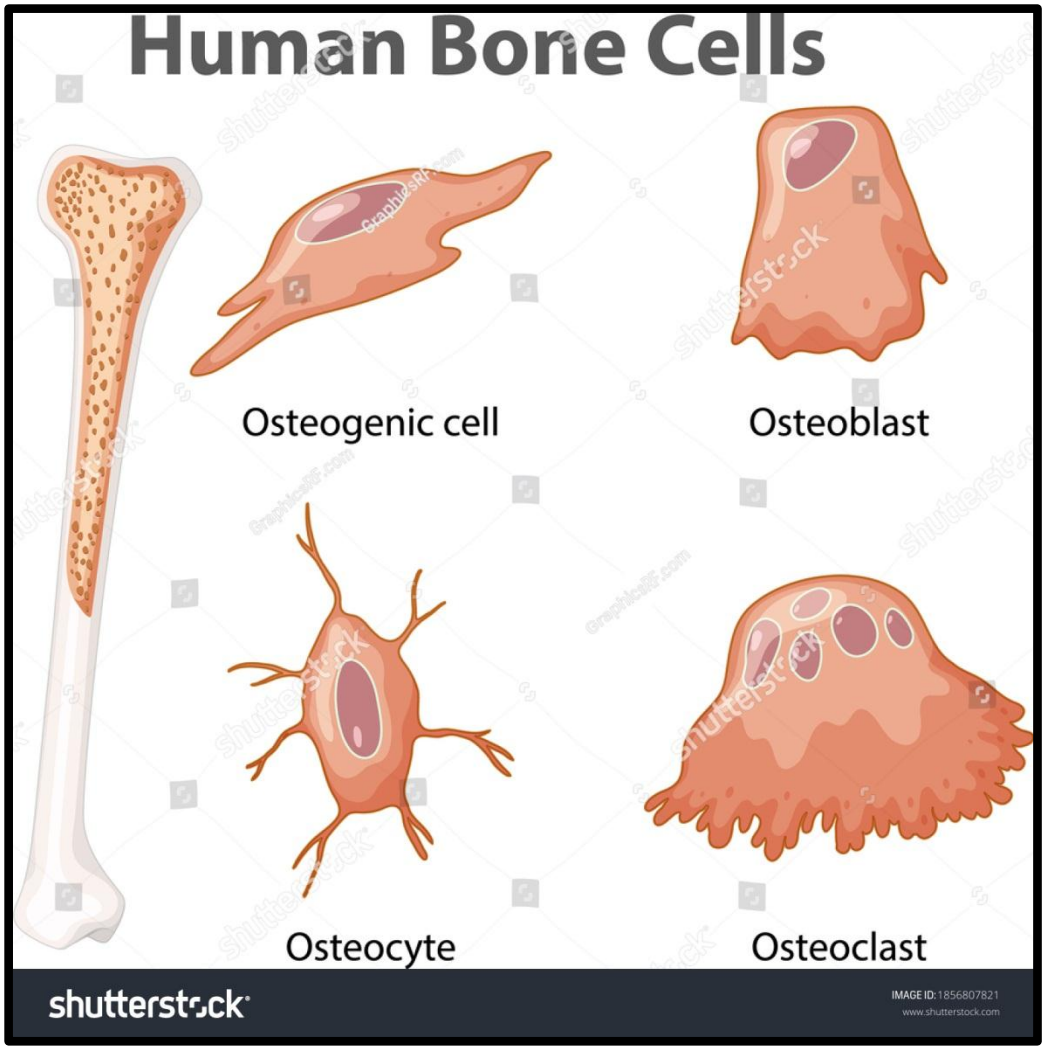
❑ ***Ground substance***

- Glycosaminoglycans
- Proteoglycans.
- Glycoproteins (**osteonectin)**.

➢ The **association** of minerals with collagen fibers during calcification is responsible for the *hardness* and resistance of bone tissue.

Bone cells

1. Osteo**genic** cells
2. Osteo**blasts**
3. Osteo**cytes**
4. Osteo**clasts**



Osteoprogenitor (osteogenic) cells

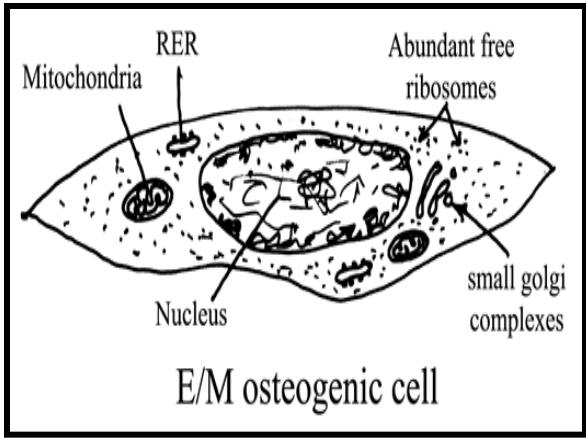
Origin: undifferentiated mesenchymal cells (UMC).

Site: They are present on bone surfaces *within* the periosteum and endosteum.

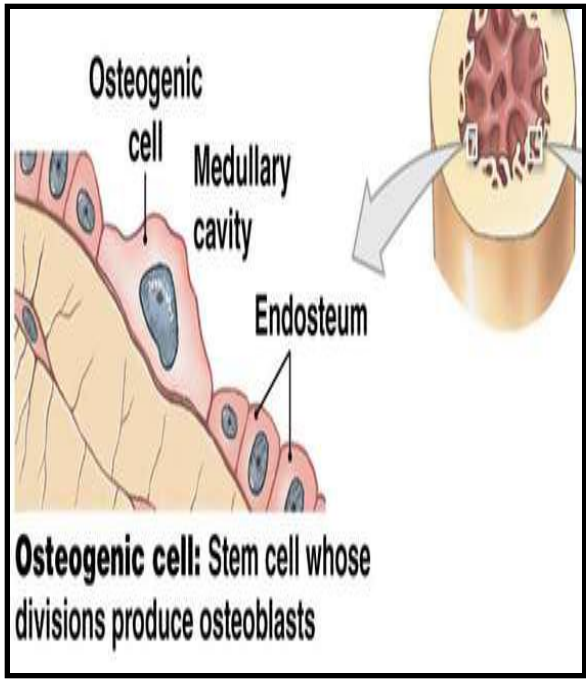
L/M: small spindle-shaped cells *with* pale-stained nuclei and basophilic cytoplasm.

E/M: The cytoplasm contains many mitochondria and free ribosomes and polyribosomes.

Function: They are the **stem cells** of bone & give rise to osteoblasts when stimulated for growth and repair of bone.



E/M osteogenic cell

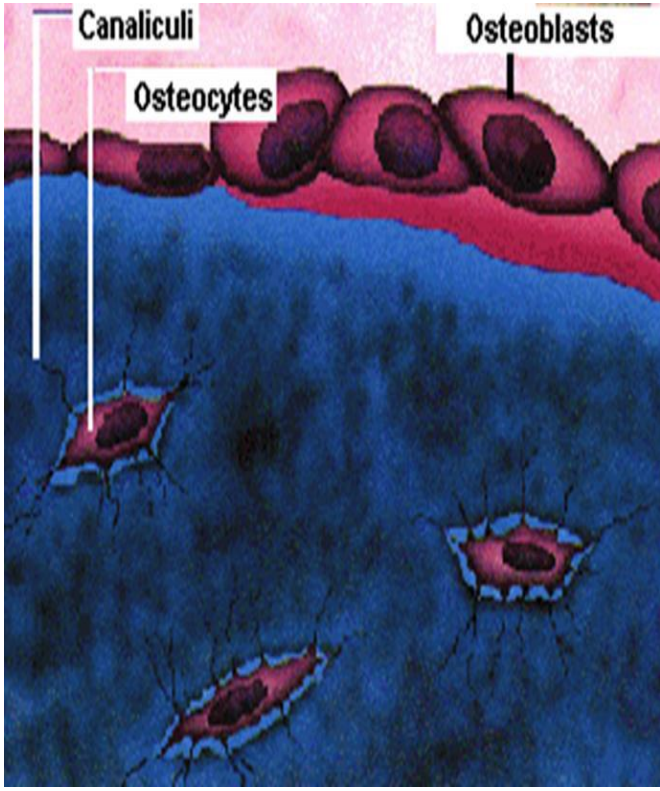


Osteogenic cell: Stem cell whose divisions produce osteoblasts

Osteoblasts

Origin: Osteogenic cells.

Site: present on the surface of bone, side by side resembling the epithelium.



L/M:

Shape:

-Cuboidal or columnar

-Have cytoplasmic processes connecting them together.

Cytoplasm:

Deeply basophilic (rich in rER)

Nucleus:

Rounded, pale, and eccentric.

Osteoblasts

E/M:

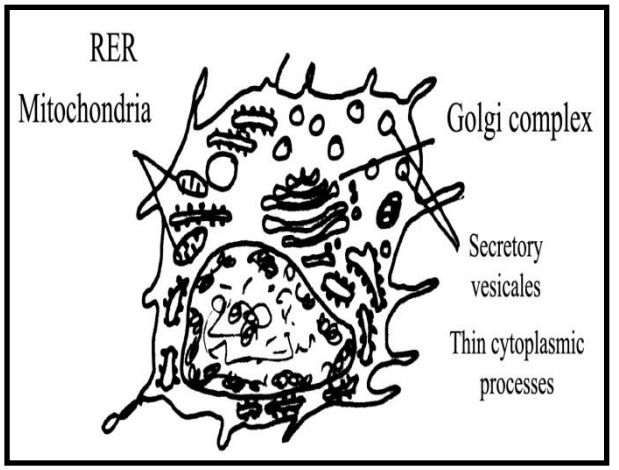
have the **characters of protein synthesizing cells** containing:

-many rER

- mitochondria

-prominent Golgi near the nucleus

-nucleus with mostly extended chromatin

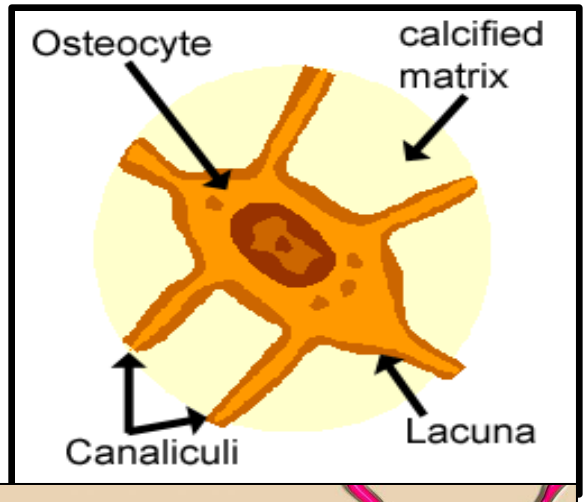


Function (bone formation):

- Responsible for synthesis of organic components of bone matrix which including **type 1 collagen**, proteoglycans, and glycoproteins.
- Secretion of high alkaline phosphatase enzyme which precipitates calcium salts in the matrix.

Osteocytes

Main &mature cell



Origin: from osteoblasts.

L/M:

- Shape:

-Oval and smaller

-Flattened than osteoblasts

- Cytoplasm:

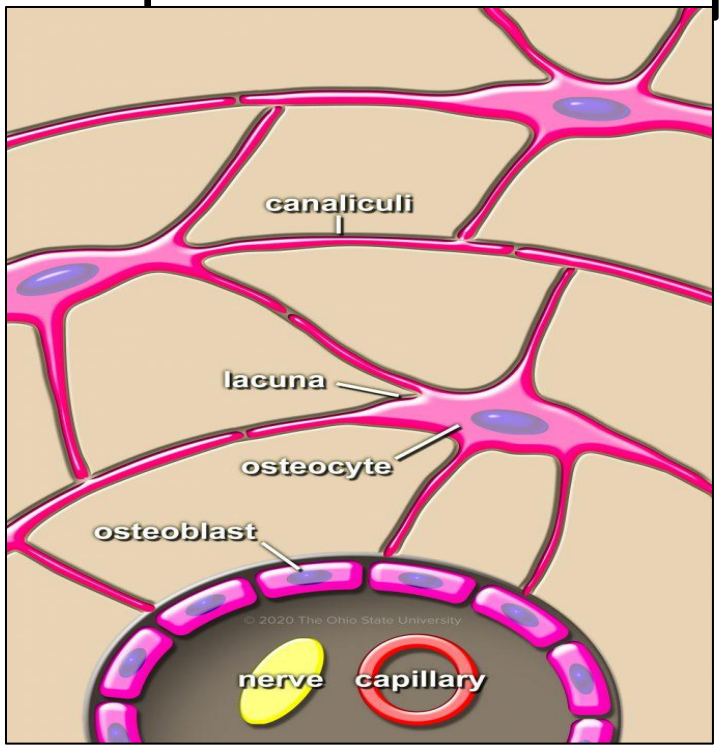
-Less basophilic (less active than osteoblast)

-low alkaline phosphatase activity.

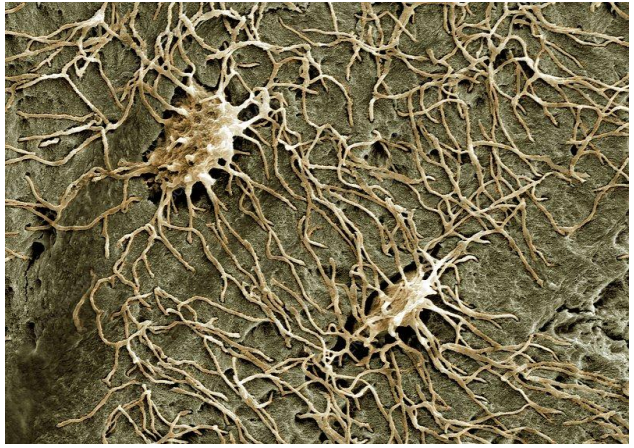
- Nucleus darker

Site: lacunae within matrix.

There is one osteocyte in each lacuna that sends its processes to extend inside thin, cylindrical spaces called **canaliculi** between adjacent lacunae.



Osteocytes



E/M:

- Has less rER
- Nucleus: more condensed chromatin.
- Cytoplasmic processes of adjacent osteocytes contact with each other inside the canaliculi by **gap junctions** through which nutrients can pass from a cell to the other.

- There is a **small amount of extracellular substance** between cells (and their processes) and bone matrix, through this, exchange can occur between cells and blood in the nearest blood vessels.

Function:

Osteocytes are involved in **maintenance of bone matrix.**

Osteoclasts

Bone macrophages

Origin: fusion of blood monocytes.

Site: present against the surfaces of bone in shallow depressions in the matrix called **Howship's lacunae**.

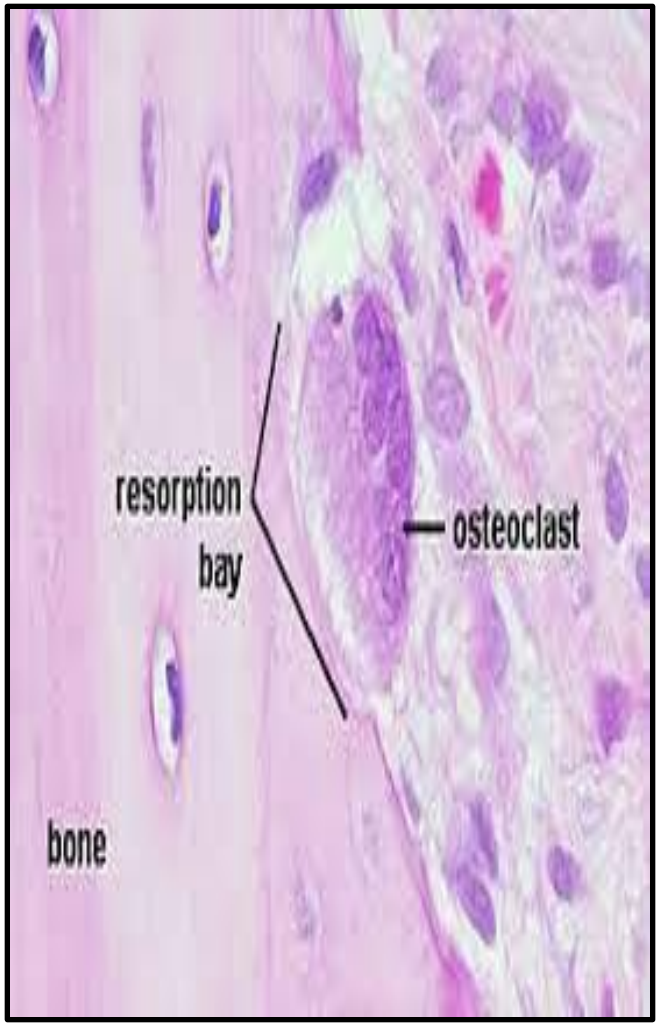
Shape: large, branched, and motile cells

L/M:

- Nuclei: multinucleated cell (5 -50 nuclei).
- Cytoplasm:

-Acidophilic.

-The surface facing the bone is irregular



Osteoclasts

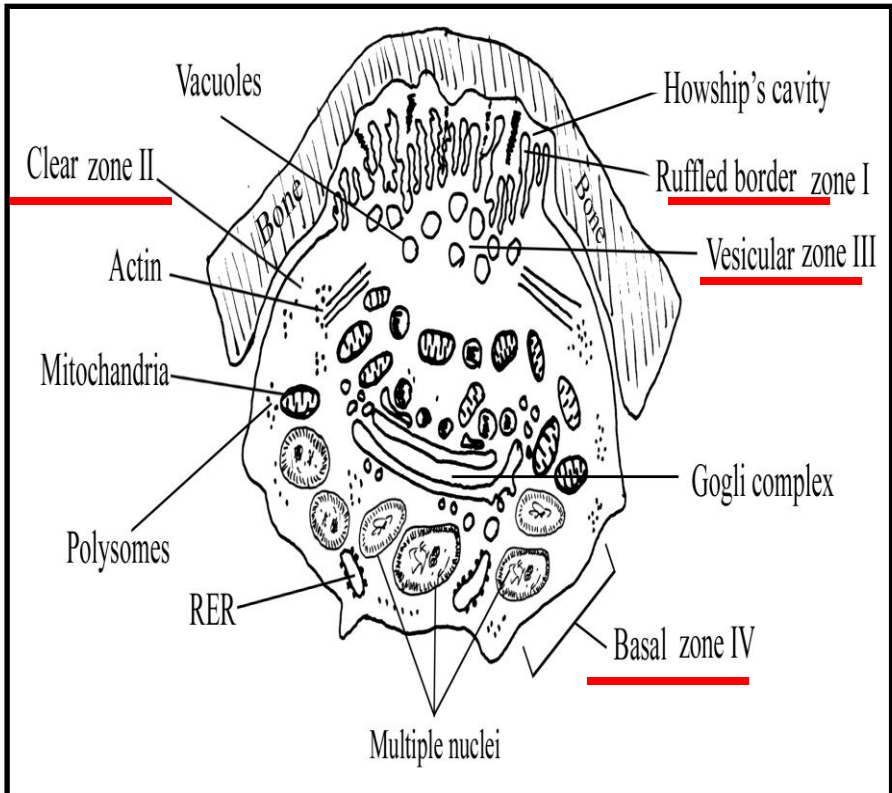
E/M: 4 zones:

1- Ruffled Border: It is **deep enfolding** of the cell membrane of the surface of the cell **facing the bone.**

2- Clear Zone: It is a **smooth ring-shaped** area of the cell surrounding the ruffled border.

3- Region of vesicles and vacuoles: just deep to the ruffled border. .It contains **lysosomes**

4- The basal zone:
contains the **nuclei** of the cell and **other cell organelles**



Function:

- ❑ **Bone resorption** (break down or erode bone matrix).

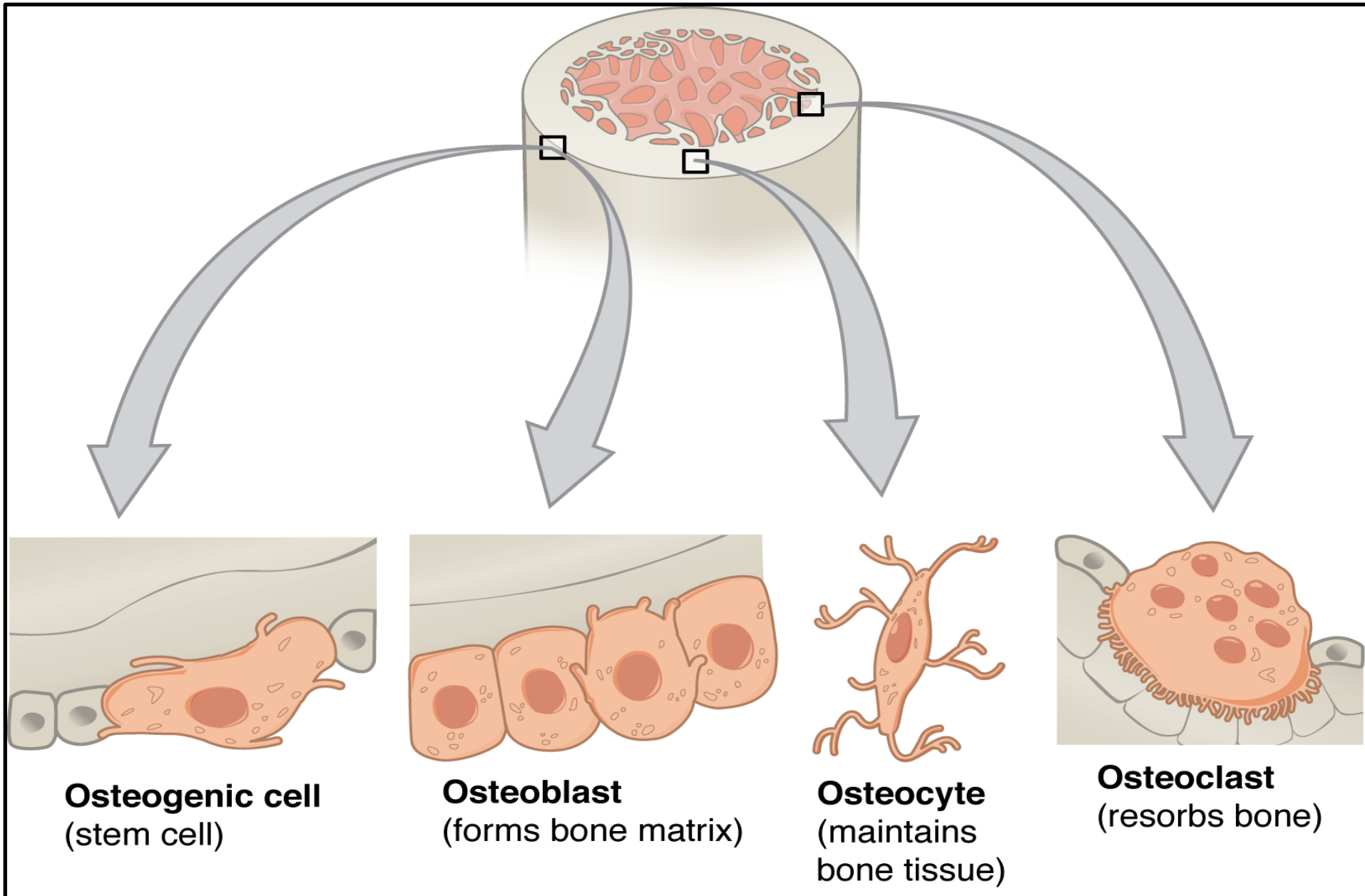
- They secrete acid *collagenase* and other *proteolytic enzymes* that attack bone matrix

- ❑ **Bone remodeling** (continuous destruction and rebuilding of bone)

Bone cells

	Osteogenic cell	Osteoblast	Osteocyte	Osteoclast
Origin	UMC	Osteogenic cells	Osteoblasts	Blood monocytes
Sites	-Periosteum -Endosteum	Bone surface	In lacunae	Howship's lacunae
Structure	-Small -Pale nucleus -Basophilic cytoplasm	-Pale nucleus -Basophilic Cytoplasm	-Dark nucleus -Less basophilic cytoplasm	-Many nuclei -Acidophilic cytoplasm -Ruffled border
Function	Mather cell (stem cell)	Bone formation	Maintenance of bone matrix.	-Bone resorption -Bone remodeling

Bone cells



Osteogenic cell
(stem cell)

Osteoblast
(forms bone matrix)

Osteocyte
(maintains bone tissue)

Osteoclast
(resorbs bone)

Types of bone

There are two types of bone recognized microscopically:

1- Primary bone (Immature or woven):

- The first bone to appear in development, fracture, and repair.
- ***It is characterized by:***

a. More cellular content (osteocytes)

b. Less mineral content.

c. Irregular arrangement of collagen fibers.

- It is temporary and is replaced by secondary bone tissue except in few places (e.g. near the sutures of skull bone).

2-Secondary bone (lamellar)

- It is usually present in adults.
- ***It is characterized by:***

- High calcium content so it is stronger
- Less osteocytes
- Regularly arranged collagen fibers in the form of lamellae which are either**:**

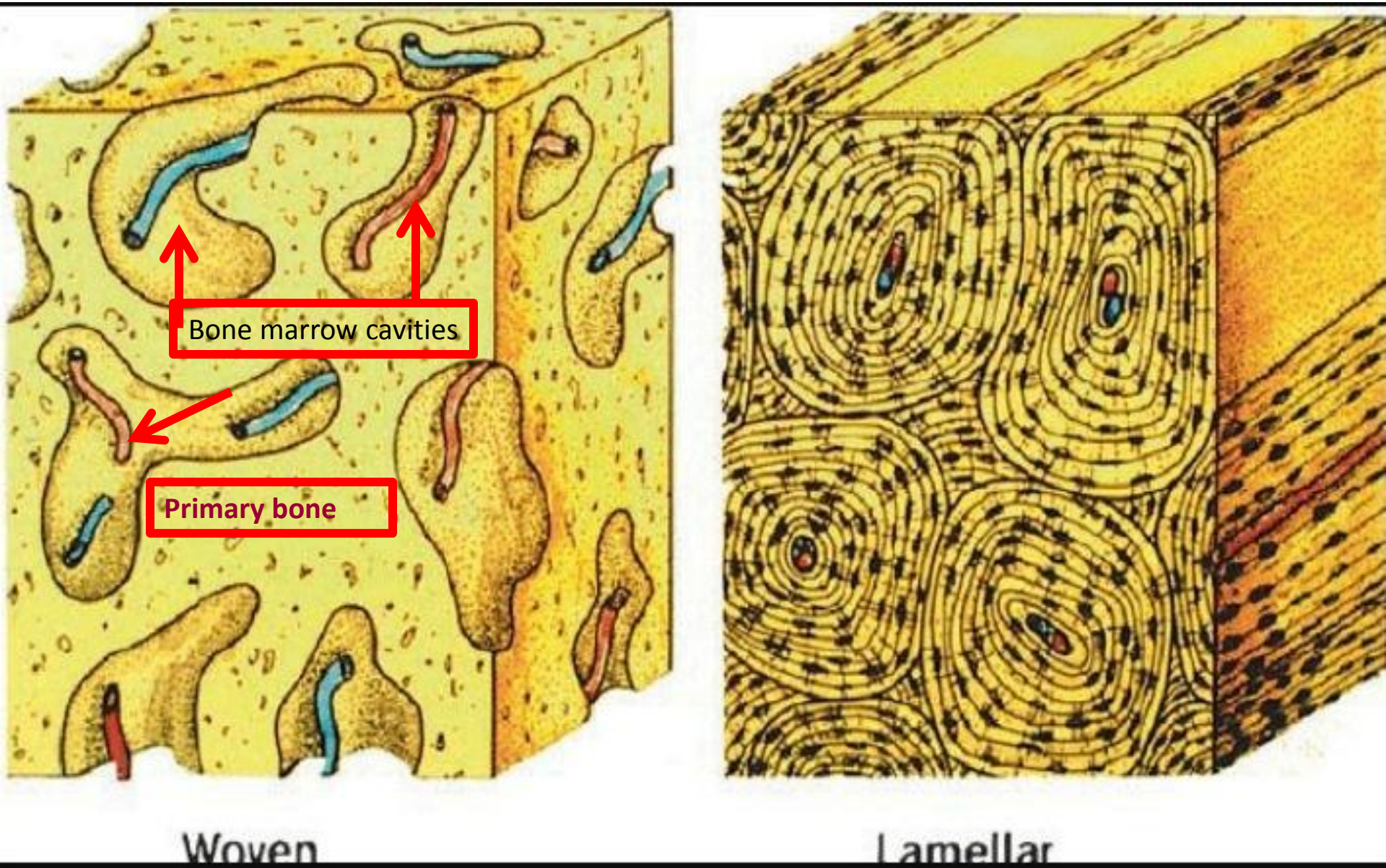
a. Parallel to each other.

b. Concentrically organized around a central canal.

- Secondary bone tissue is organized as either **compact bone** or **cancellous bone.**

Primary bone (Immature or woven)

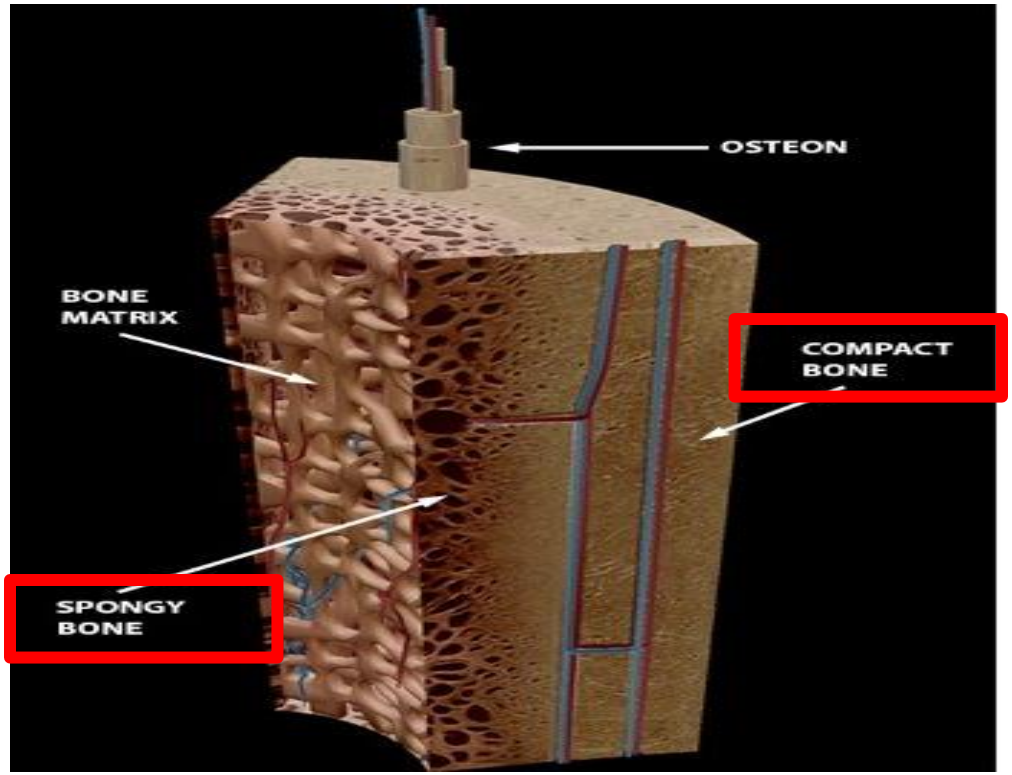
Secondary bone (lamellar)



Secondary bone tissue

Compact bone
(lamellar-dense-Ivory)

Cancellous bone
(spongy)

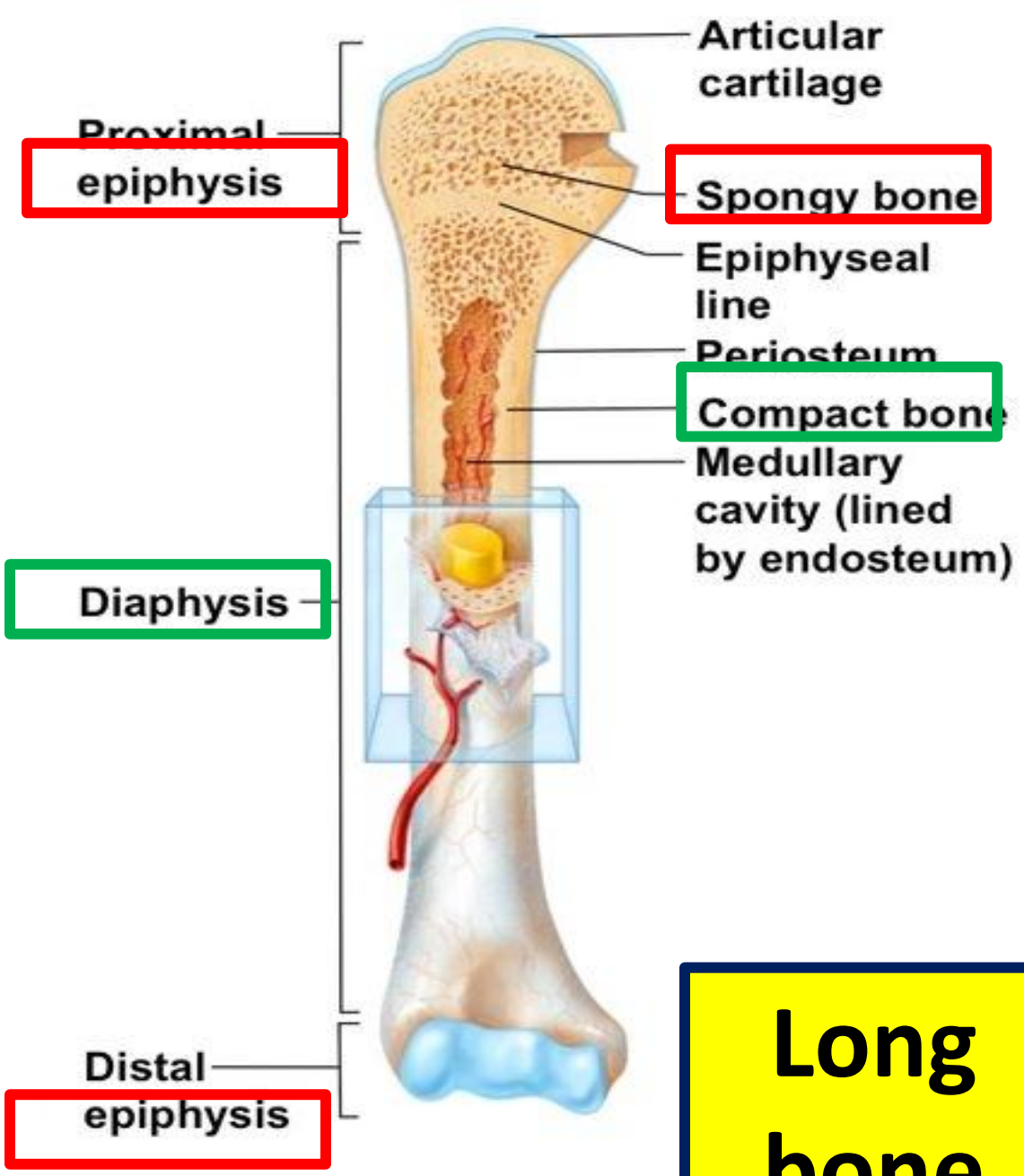


Articular Cartilage
-cover the epiphysis
- hyaline cartilage.

Epiphysis
-end of the long bone
-spongy bone
-multiple marrow cavities

Epiphyseal line
-growth site

Diaphysis
-shaft of the bone
-compact bone.
-one marrow cavity



Long bone

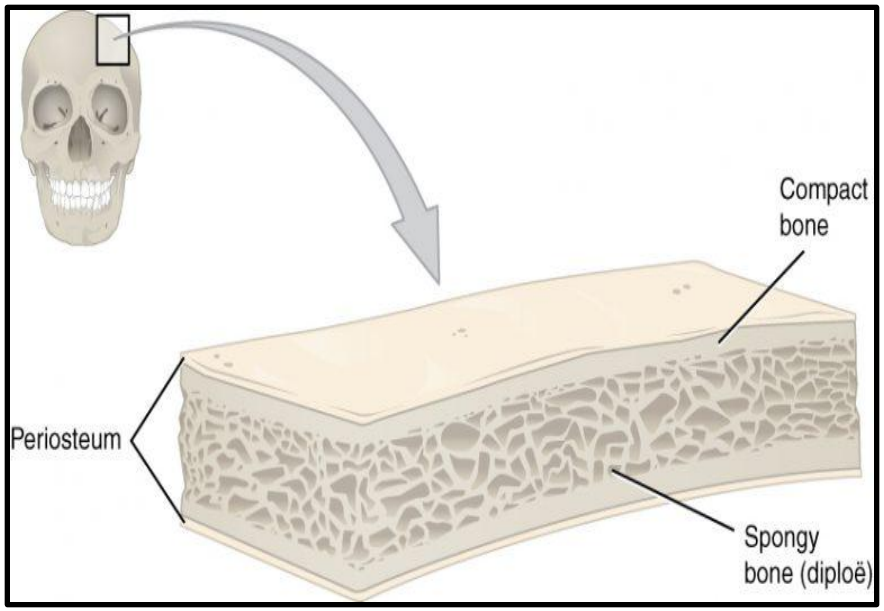
COMPACT BONE

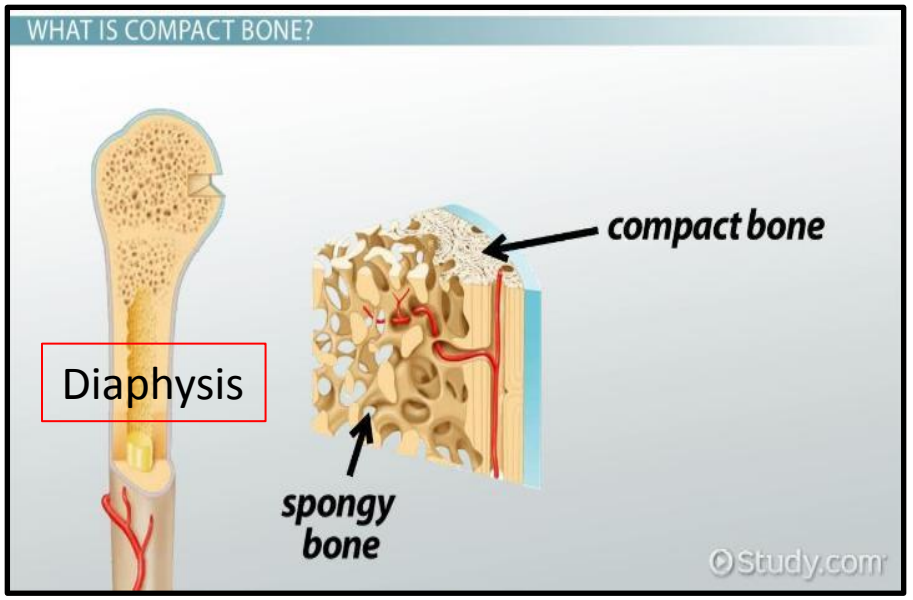
❑ Sites:

1. Diaphysis (shaft) of long bones.

2. *Covering* any cancellous bone, e.g. the outer and inner plates of the skull and short bones.

❑ Compact bone is covered *externally by* periosteum and lined *internally by* endosteum.





Microscopic structure of compact bone

It consists of thin layers of **bone lamellae.**

Lamella= (calcified matrix +collagen type I+ osteocytes trapped in lacunae)

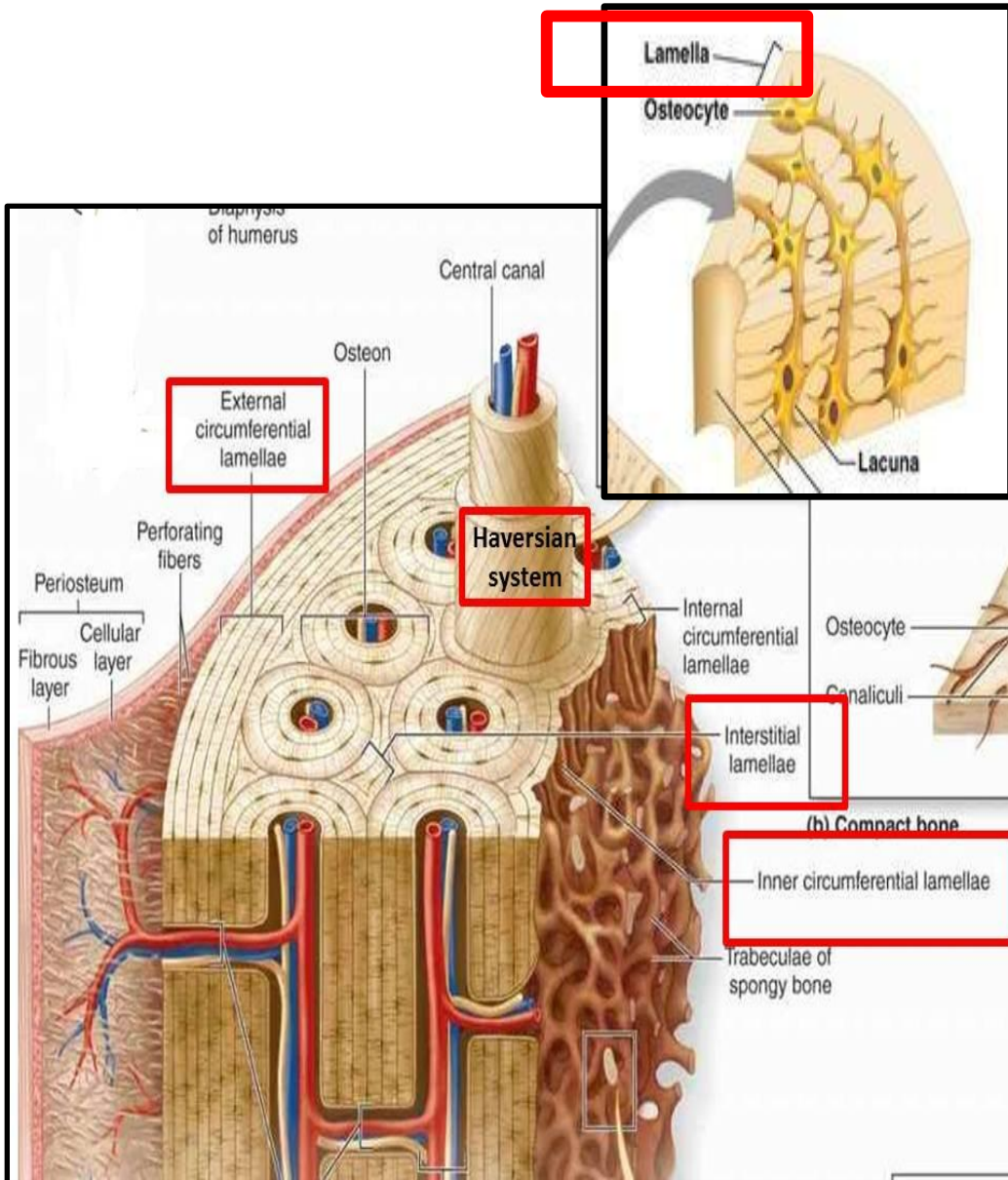
Arranged

a. Parallel to each other.

b. Concentrically organized around a central canal.

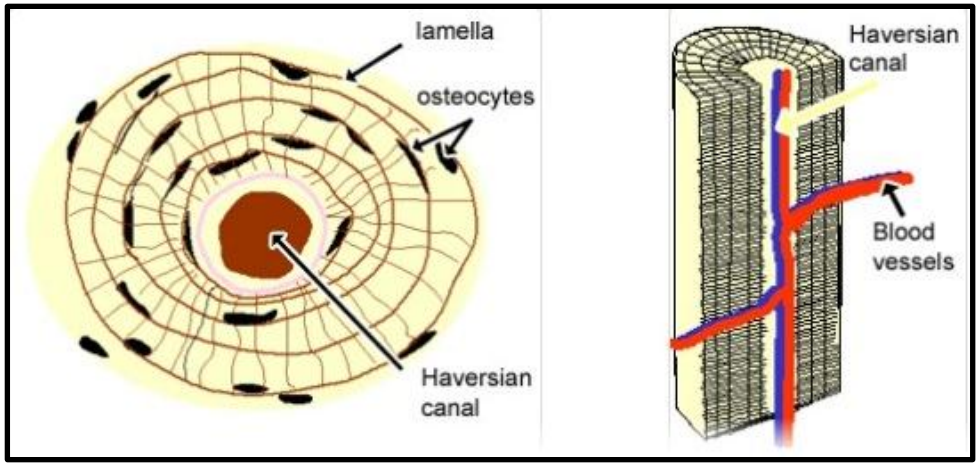
- **Lamellae are organized in the form of:**

1. **Outer circumferential lamellae.**
2. **The Haversian system (osteon)**
3. **Interstitial lamellae.**
4. **Inner circumferential lamellae.**

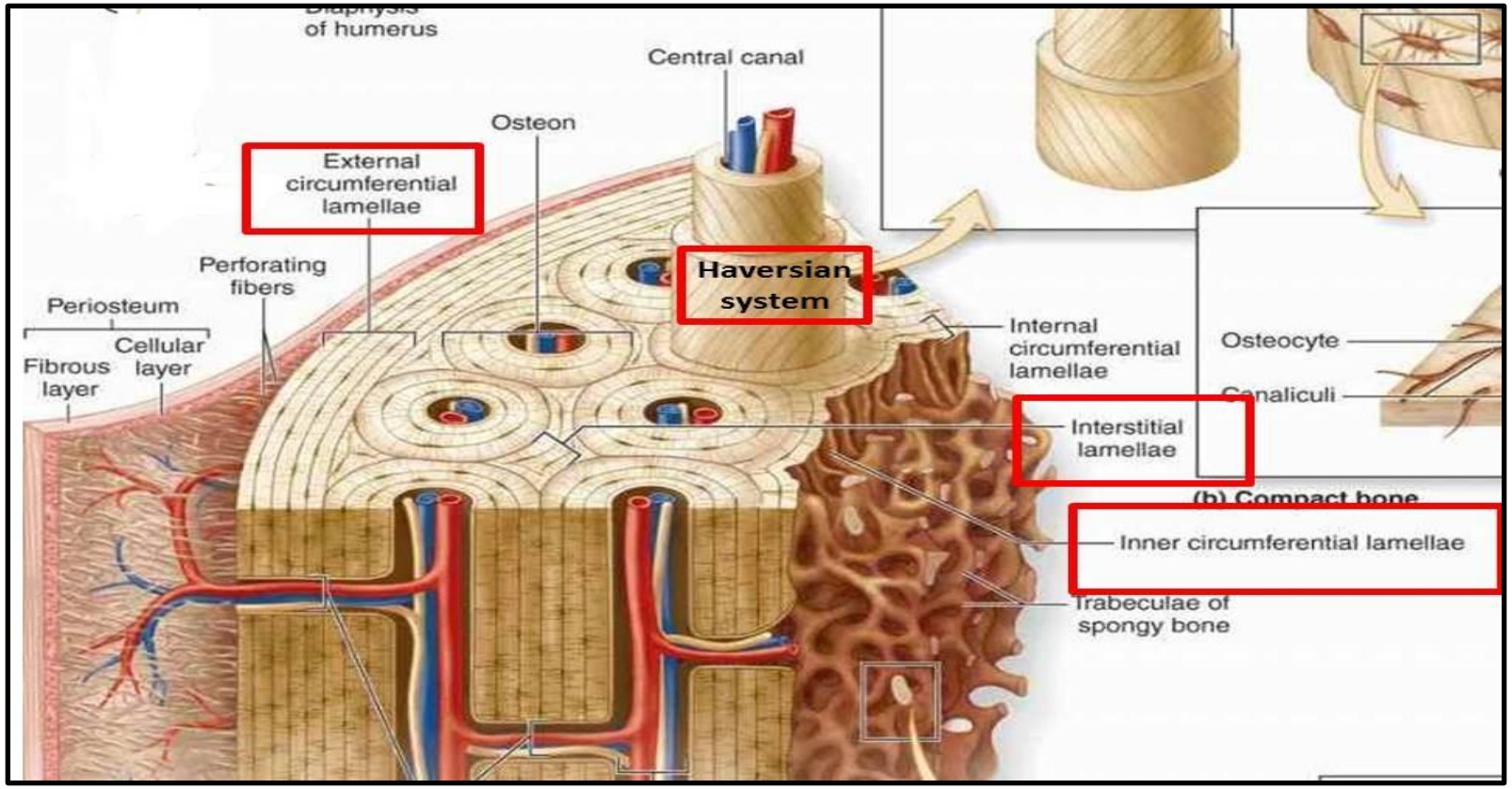


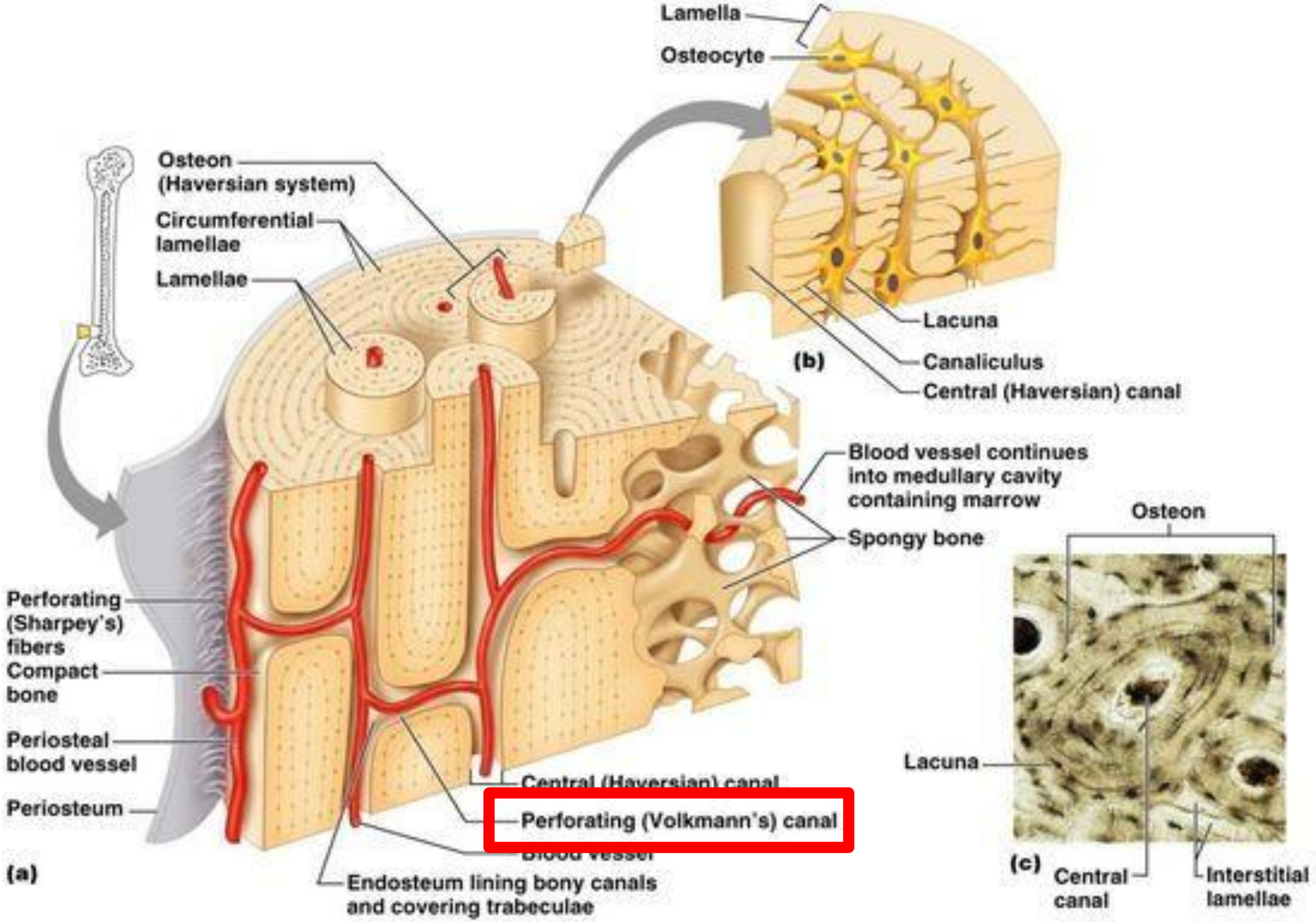
The Haversian system (osteon)

- **Structural unit of bone**
- It is a **long cylinder** parallel to the long axis of the diaphysis.
- It consists of a central canal ***(Haversian canal)*** surrounded by <u>4 to 20 concentric lamellae of bone tissue.</u>
- Each **canal** in lined by endosteum and contains blood vessels, nerves and loose connective tissue.
- Around *the* ***Haversian canal*** there are several lamellae, in each lamella, fibers are parallel to each other and **follow a helical course.**
- **Osteocytes** are present inside lacunae between or within lamellae.
- *"**Volkmann's canals**" are* communicating canals that **<u>connect Haversian canals with each other's</u>**, with periosteum and with marrow cavities



- **The outer circumferential lamellae:** lie immediately beneath the periosteum, and parallel to it.
- **The inner circumferential lamellae:** are less, and lie parallel to the endosteum around the marrow cavity.
- **The interstitial lamellae:** are irregularly shaped groups of parallel lamellae located in between the Haversian systems.





Compact Bone

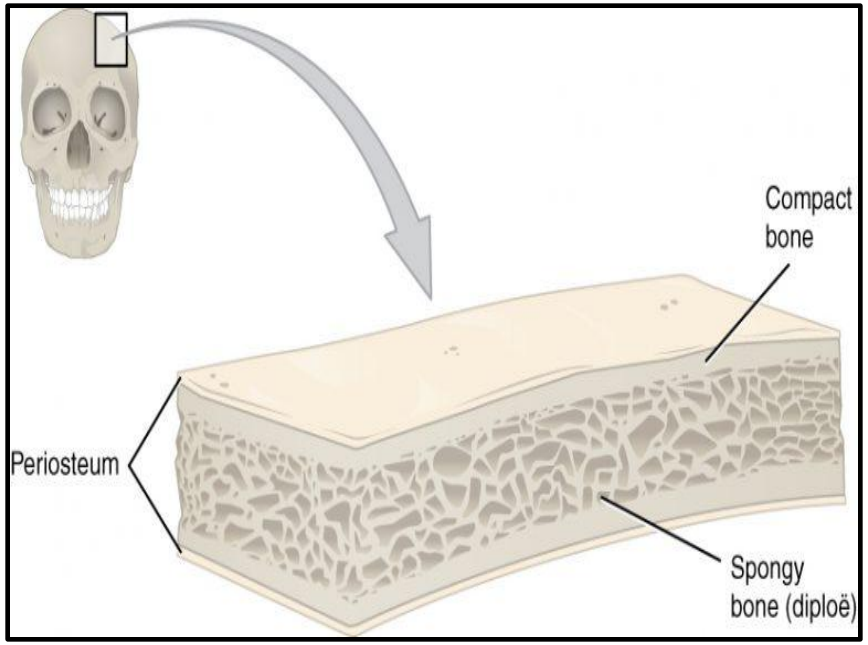
cancellous (spongy) bone

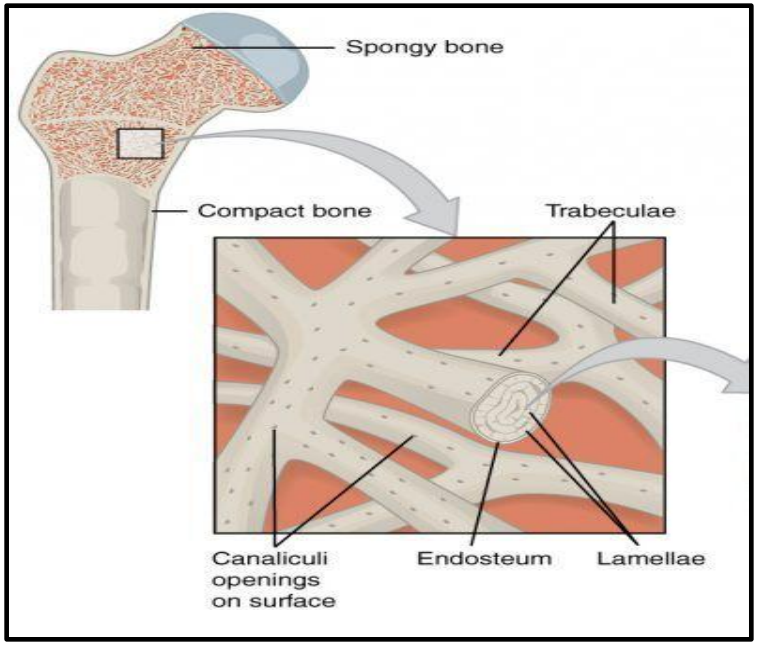
Sites:

1. Flat banes (e.g. diploe of skull, scapulae, and iliac bones).

2. Irregular bones: (e.g. vertebrae)

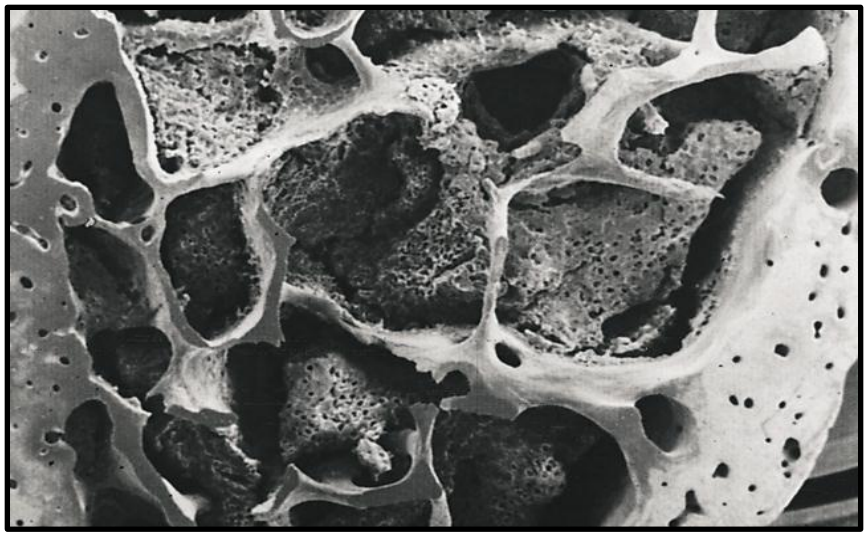
3.Epiphysis of long bones.

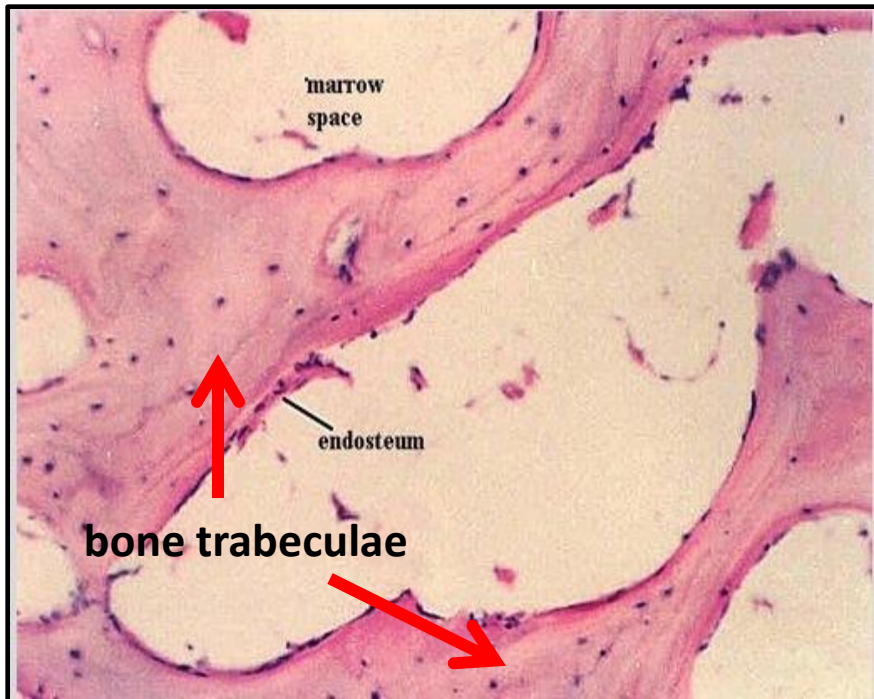




structure of Cancellous Bone

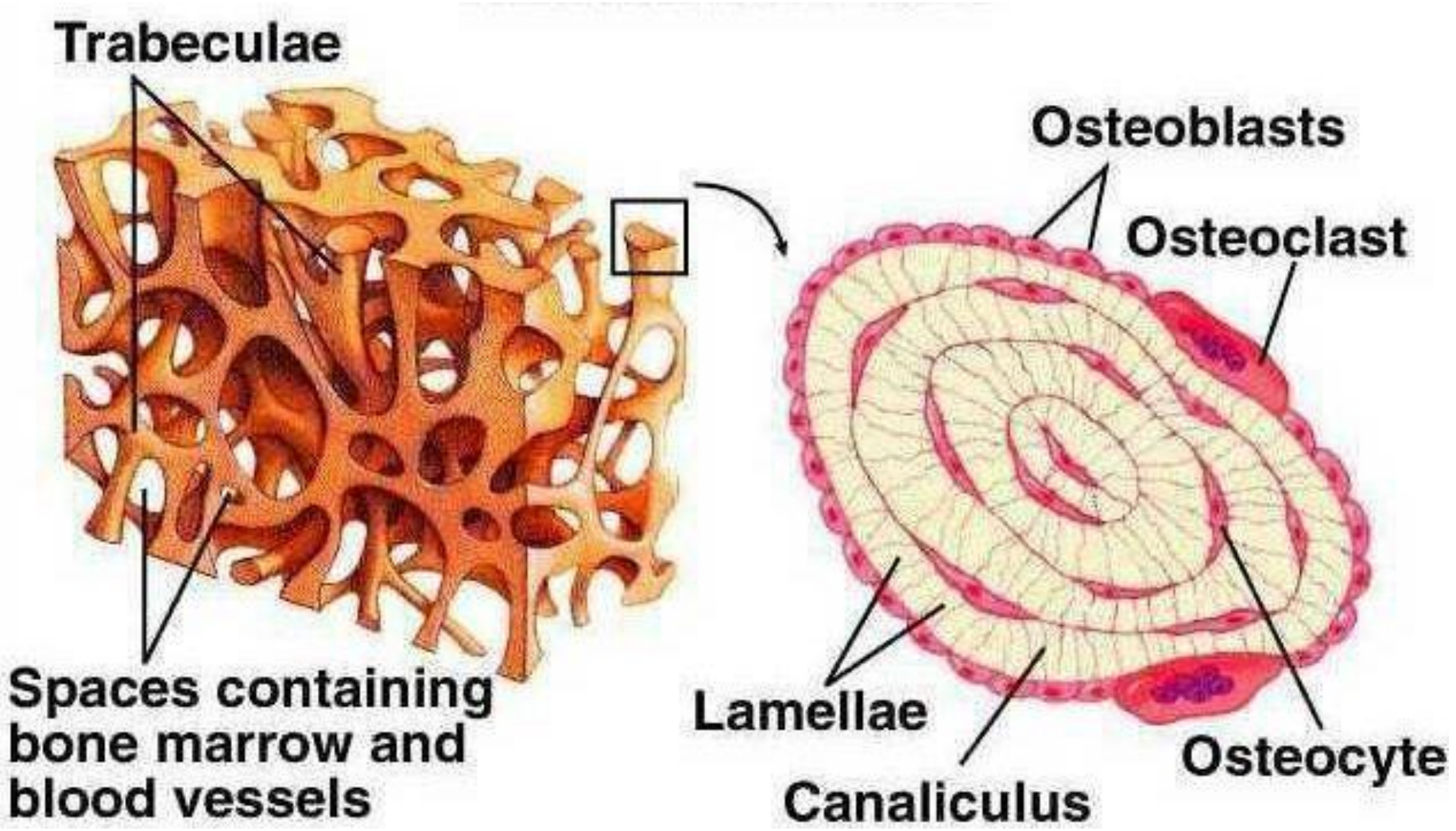
- It is composed of **branching and anatomizing bone trabeculae** with *multiple* bone marrow cavities in between them.
- The **bone trabeculae** are formed of irregularly arranged bone lamellae with osteocytes inside lacunae in between.
- The **bone marrow cavities** are lined by *endosteum.*
- Haversian systems are absent in the thin trabeculae of cancellous bone.
- - Cancellous bone is surrounded and protected by a layer of compact bone covered by periosteum.





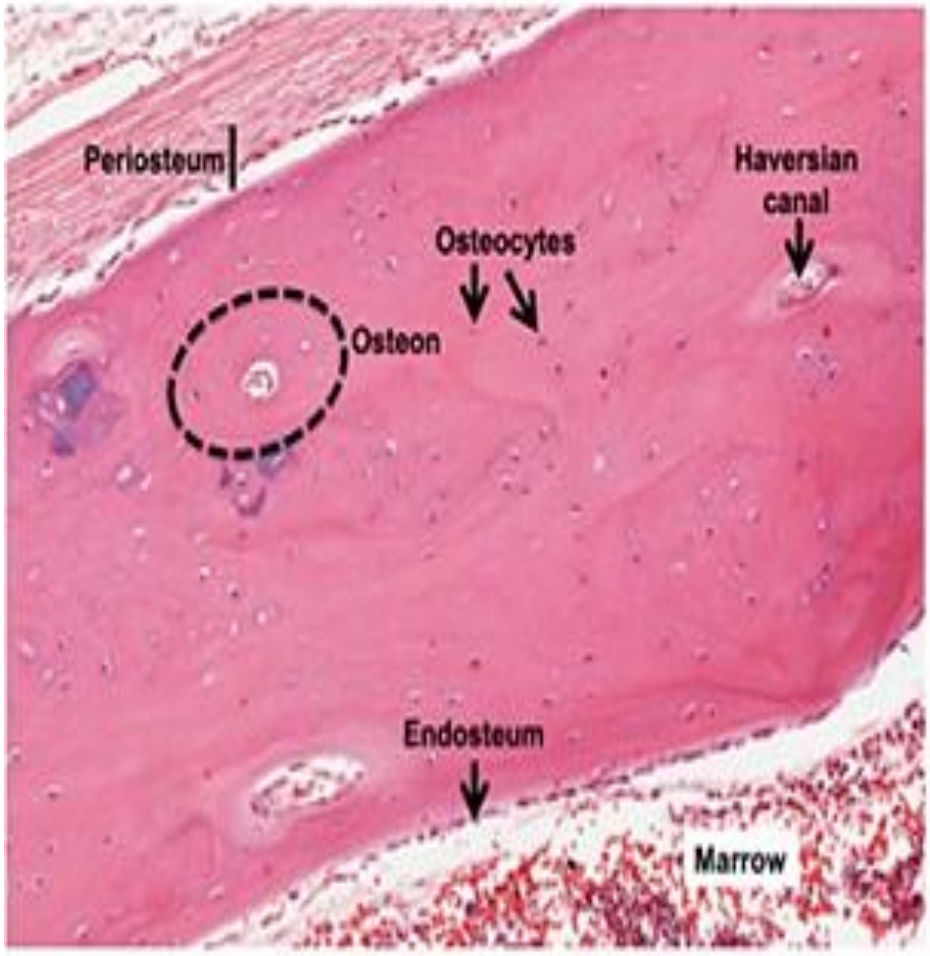
Cancellous bone

Compact bone

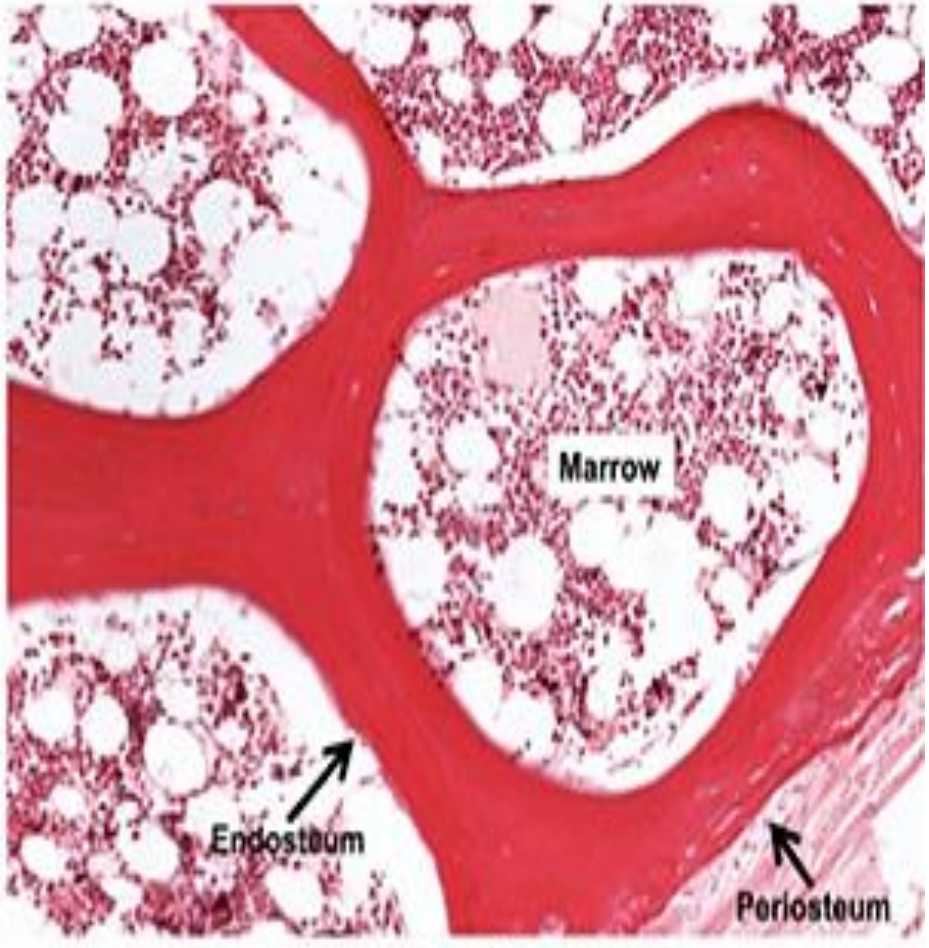


Compact bone

Cancellous bone



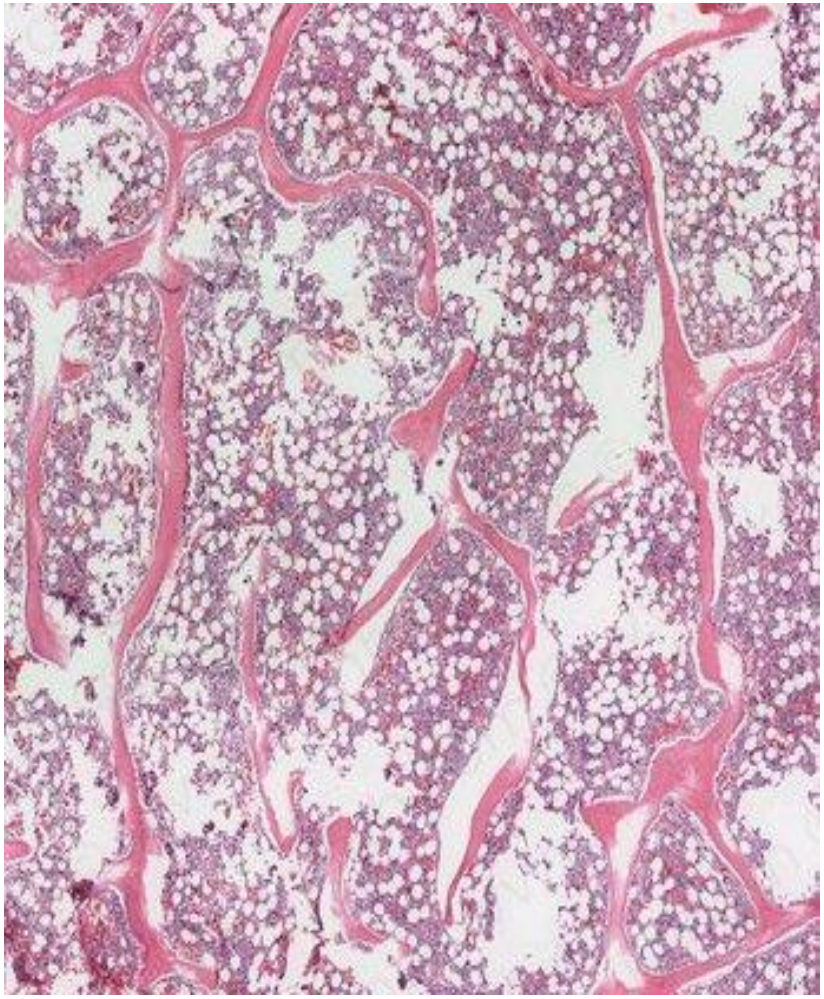
Compact bone



Trabecular bone

Compact bone

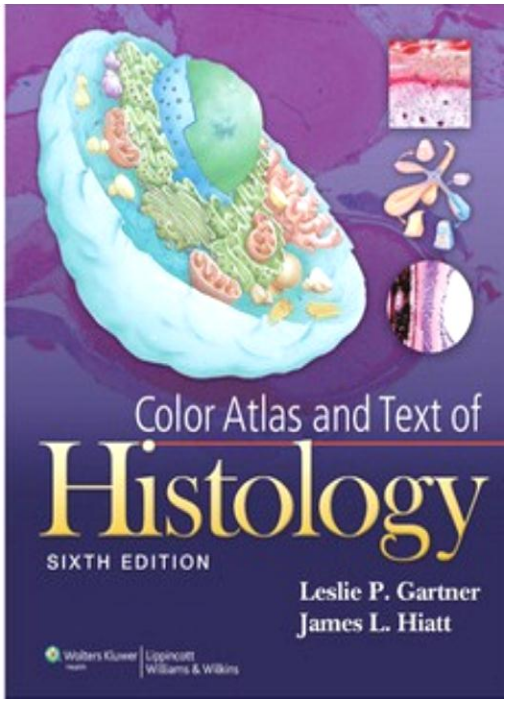
Cancellous bone

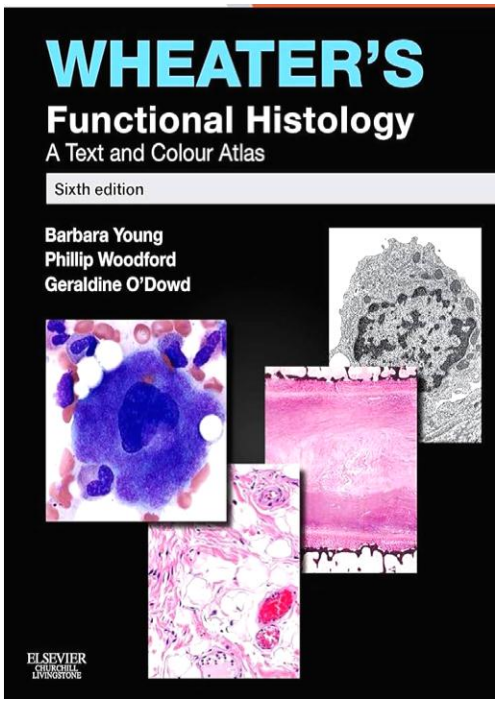


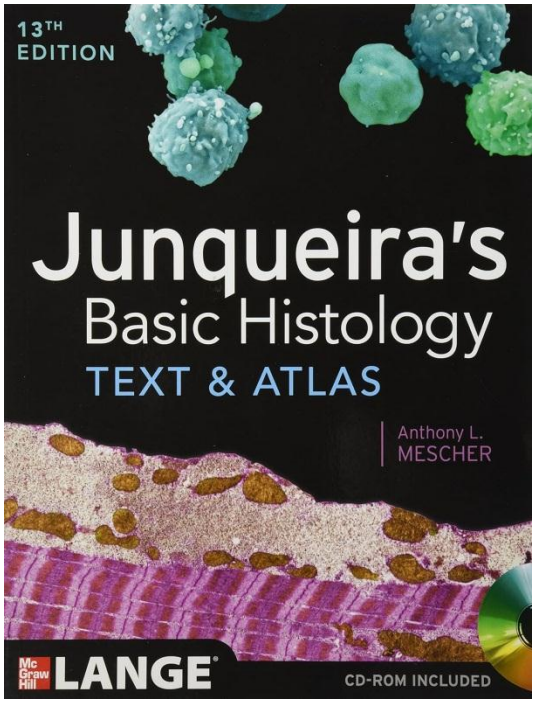
	Compact bone	Cancellous bone
Necked eye	No holes	Many holes
Sites	• Shaft of long bones • Outer and inner plates of flat bones	• Flat banes • Epiphysis of long bones.
Periosteum	Present	Present
Endosteum	Lines one central marrow cavity	Lines multiple marrow cavities
Marrow cavity	single	Multiple
Bone lamellae	Regular	Irregular
Haversian systems	present	Absent

References

Text books







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