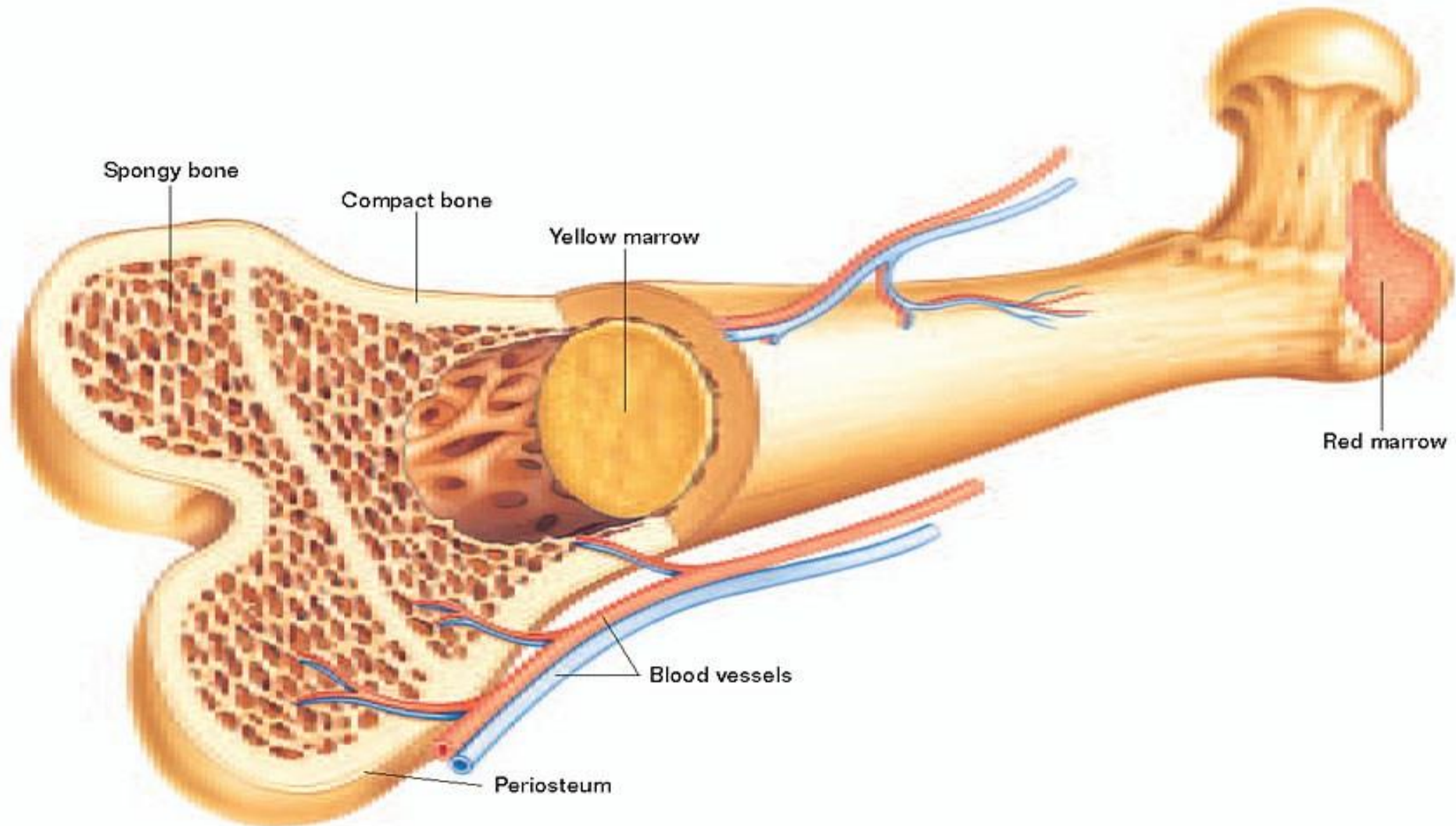
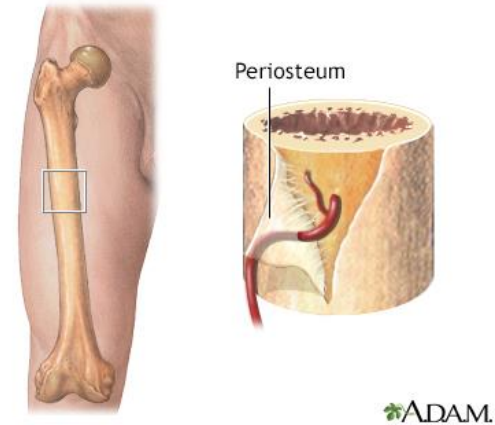


Bone



Bone coverings

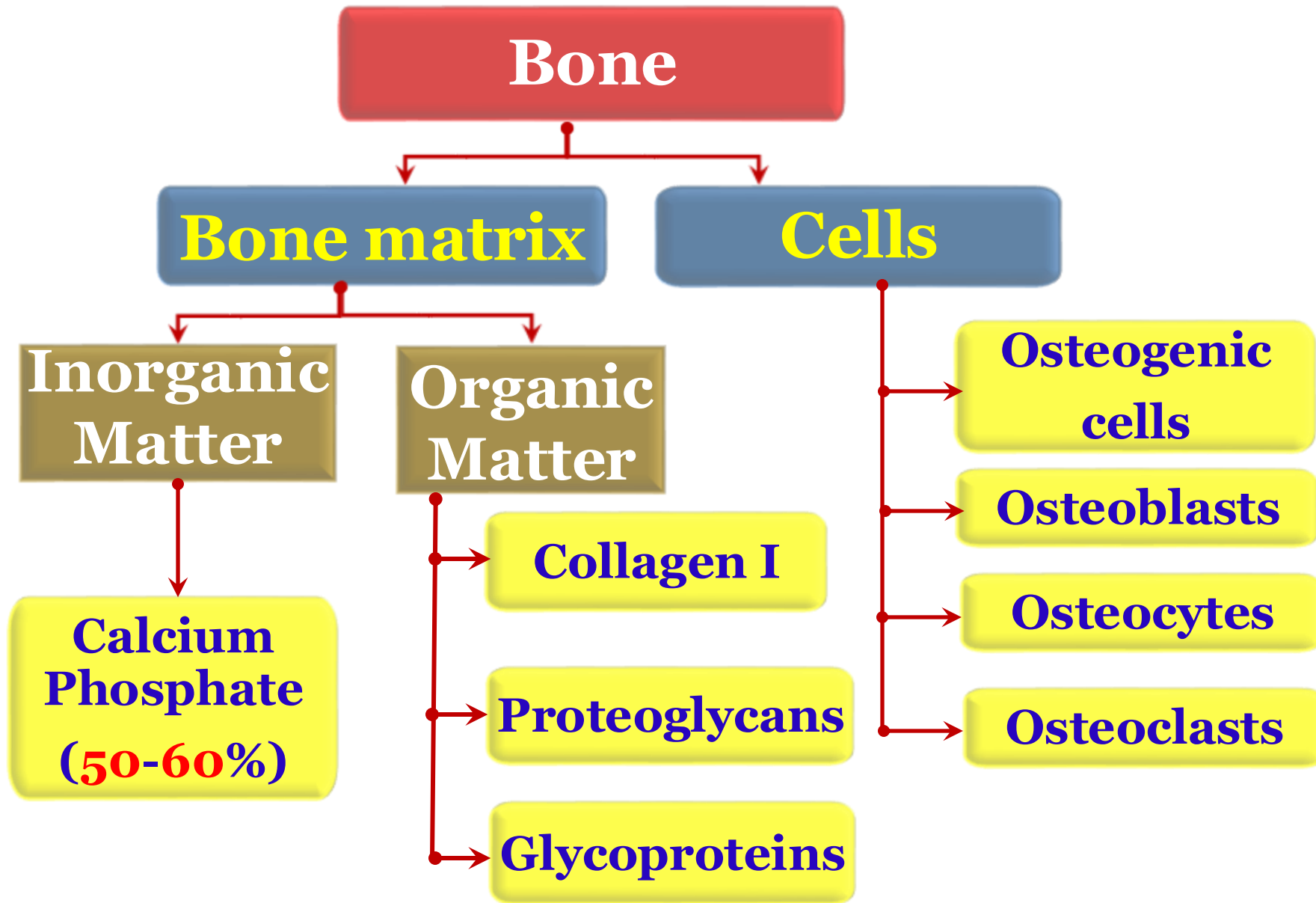


- **Periosteum**

- It is the outer covering of bone.
- It is composed of thin C.T sheath formed of an **outer fibrous layer** of dense fibrous connective tissue and an **inner cellular layer** containing osteogenic cells.
- Bundles of periosteal collagen fibers, called perforating (or Sharpey) fibers, penetrate the bone matrix, binding the periosteum to bone

- **Endosteum:**

- Cover the inner surface of bone.
- It is thin C.T. layer composed of osteogenic cells and osteoblasts.



Bone matrix: [extracellular matrix]

- Bone matrix has inorganic and organic components:-

- **Inorganic Components:**

- It constitutes about 50% of the dry weight of bone.
- It is composed mainly of calcium salts (ca hydroxyapatite) and phosphate.

- **Organic Components:**

- It constitutes about 50% of the dry weight of bone.
- it is composed of:
 - Collagen fibers type I in the form of collagen fibers.
 - Ground substance which contains:-

- a. Glycosaminoglycans [chondroitin sulphate & Keratan Sulphate].
- b. Proteoglycans.
- c. Glycoproteins.

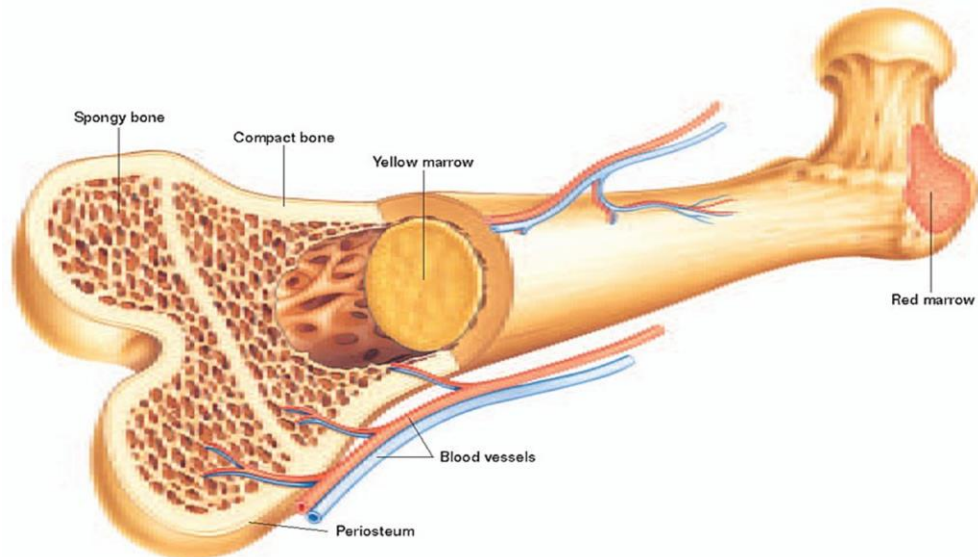
-The matrix is stained acidophilic (collagen) in Hx &E sections and it is PAS +ve.

- **Types of bone tissue:**

(I) Macroscopic types:

- Gross observation of bone tissue reveals two types.

1. Spongy (cancellous) bone: which consists of irregular bone trabeculae that branch and unit with one another enclosing spaces filled with bone marrow.
2. Compact bone: appears as solid very dense mass of bone tissue without cavities.

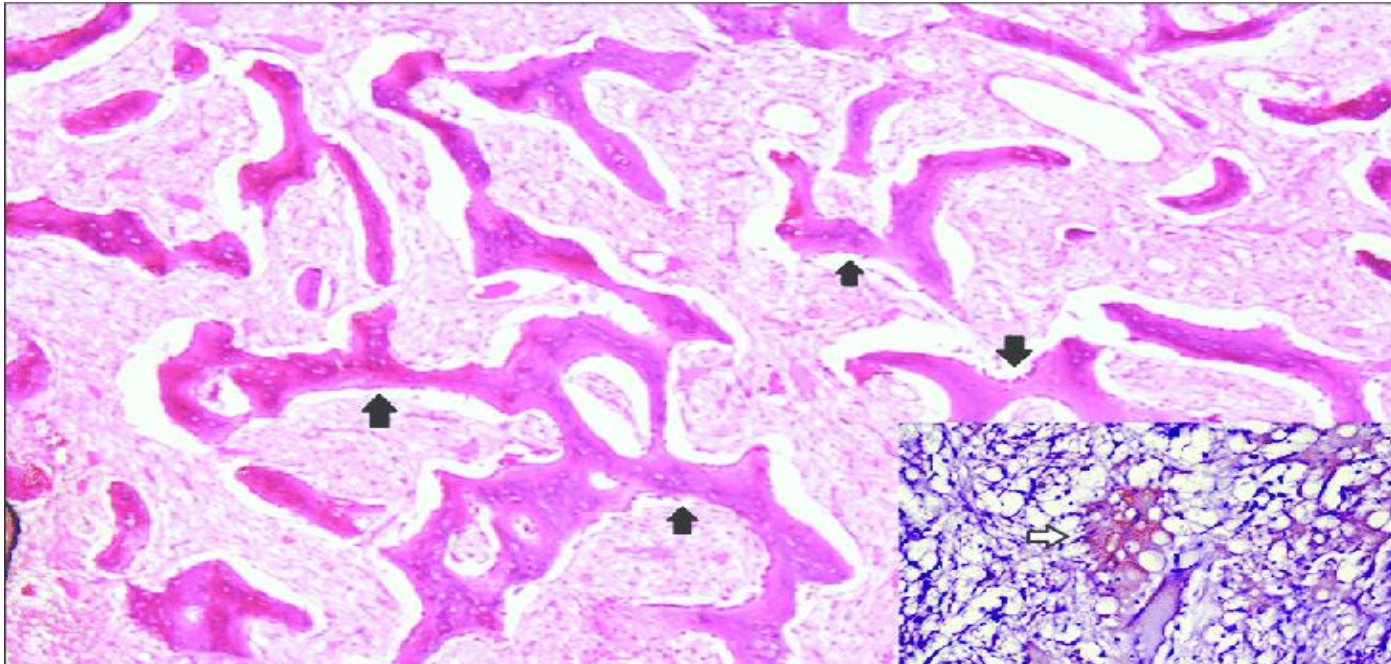


(II) Microscopic types:

- Two types are detected:

1. primary bone: [immature or woven bone]

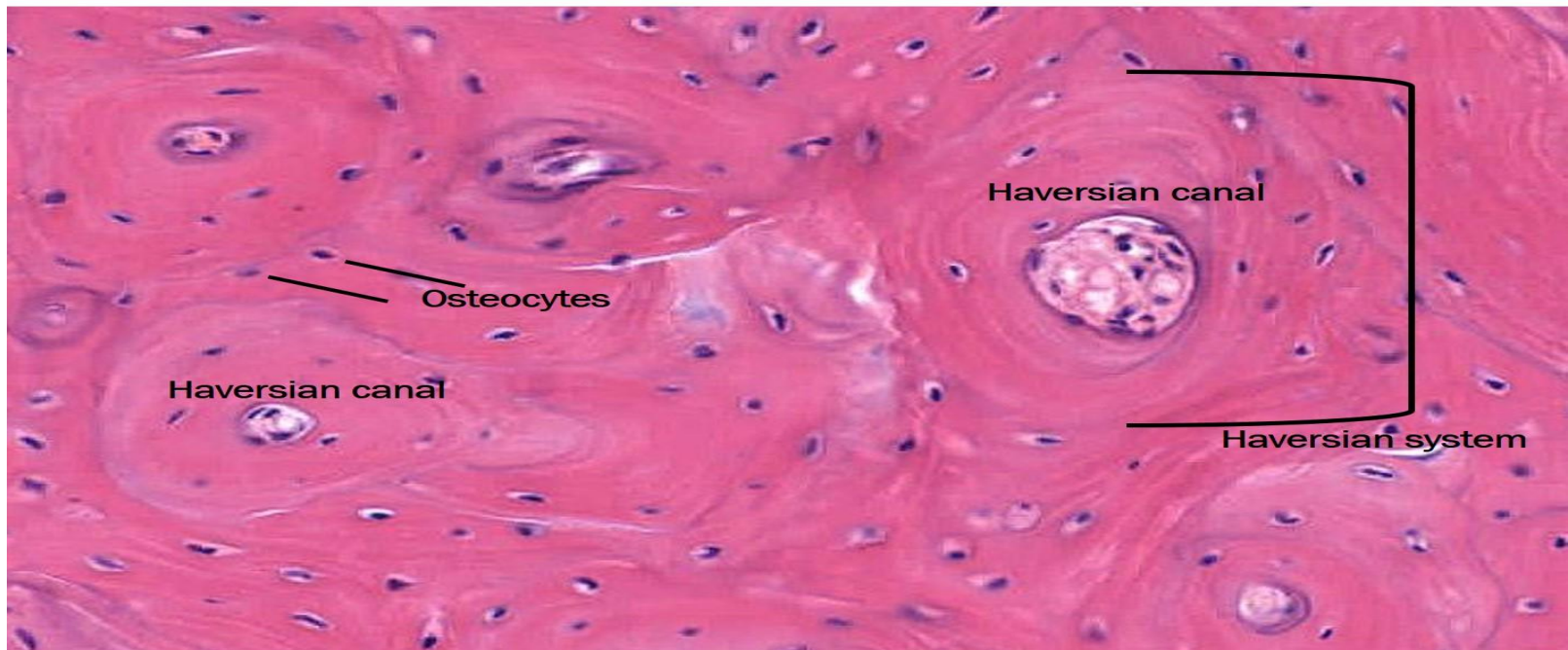
- It is the first bone formed during fetal development and during bone repair.
- It has abundant osteocytes and irregular bundles of collagen.
- Its mineral content (ca salts) is **much less** than that of secondary bone.



2- secondary bone: [mature or lamellar bone]

- - It is found in adult.
- Collagen fibers are regularly arranged in concentric lamellae which are parallel to each other around a vascular canal (Haversian canal).
- Osteocytes in their lacunae are dispersed between or within lamellae.
- The matrix of secondary bone is more calcified so it is stronger than primary bone.

Decalcified Compact Bone



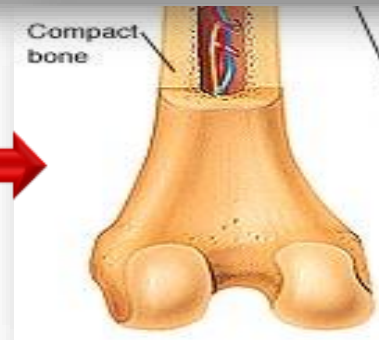
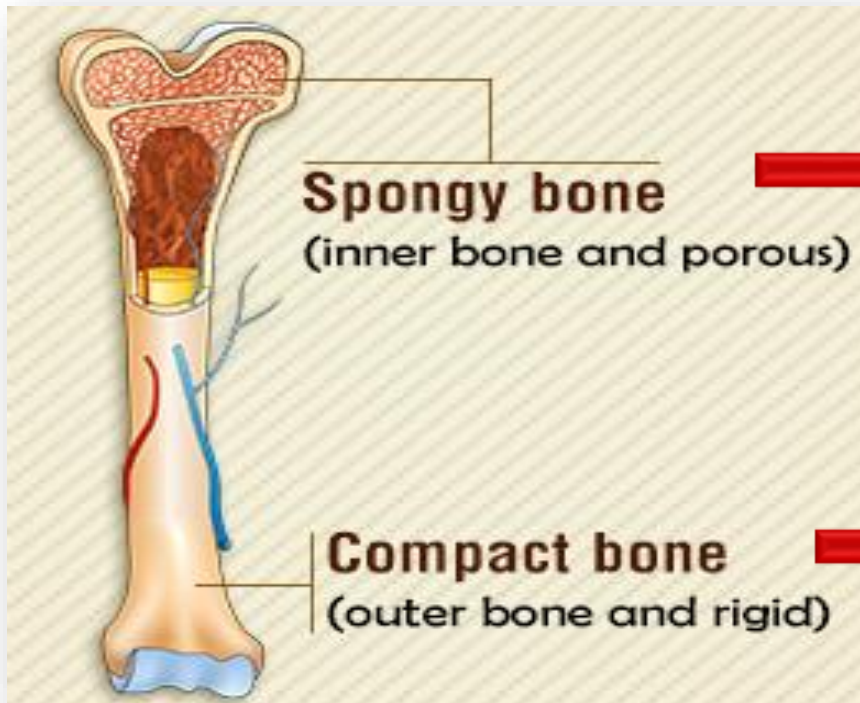
Types of Bone

Compact

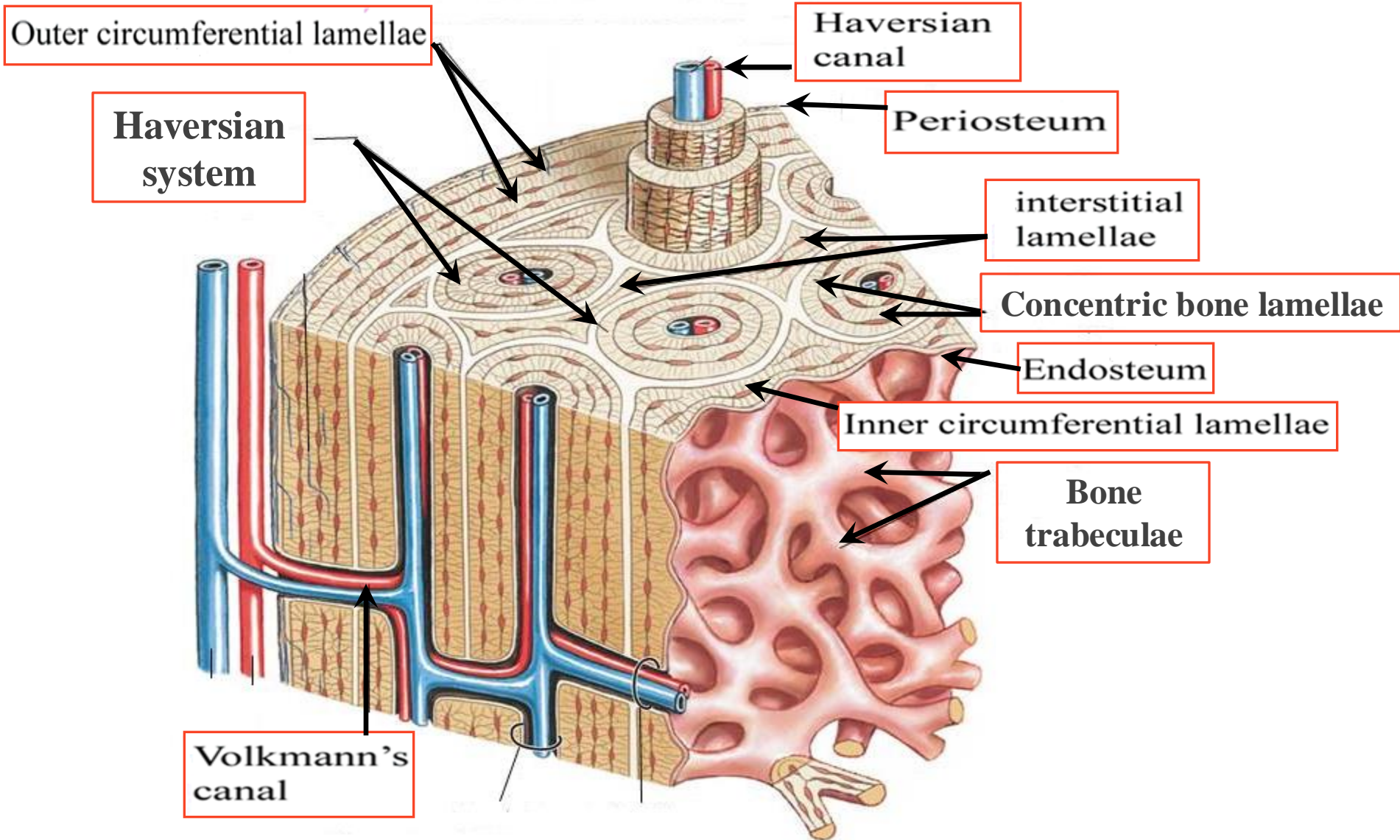
Solid very dense mass of bone tissue without cavities.

Cancellous (Spongy)

Irregular bone trabeculae that enclosing numerous cavities filled with bone marrow.



Compact Bone



Compact or decalcified compact bone

- Compact bone is composed of four lamellae arranged in the diaphysis of long bones.

i-Outer circumferential lamellae: They are just beneath the periosteum and they contain Sharpy's fibers.

ii- Haversian system (osteon):

- Each Haversian system is composed of concentric lamellae of regularly arranged collagenous fibers concentric around a vascular canal known as Haversian canal.

- Each Haversian canal is lined with endosteum (osteoblasts & osteogenic cells).

- Haversian canals contain blood vessels and nerves as well as associated C.T. **The outer boundary of each osteon** is a more collagen-rich layer called **the cement line**.

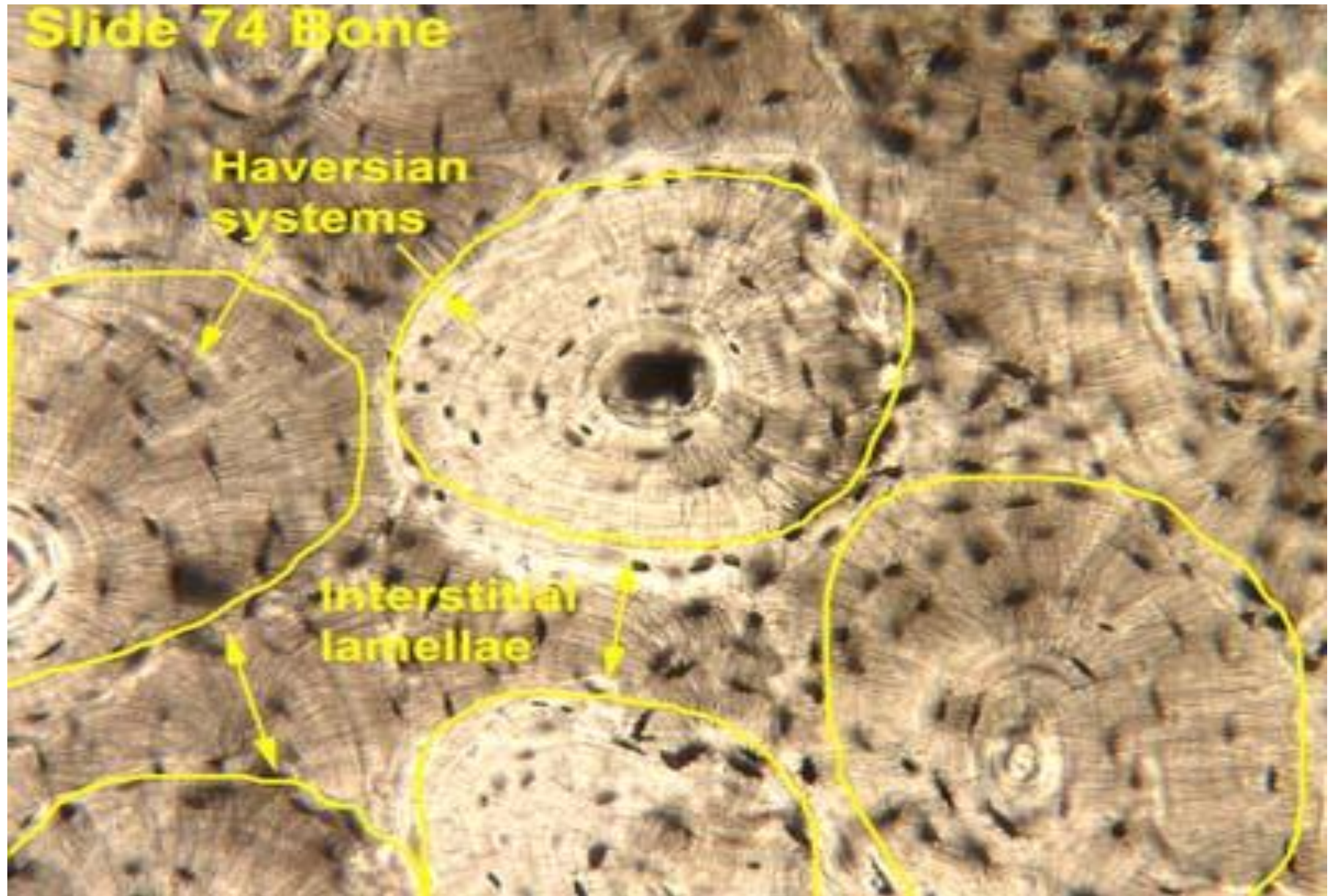
-Haversian canal run parallel to the long axis of the bone and connected with each other, with periosteum and with endosteum by transverse or oblique canals known as **Volkman's canals**.

-Volkman's canals are also lined with endosteum and contain blood vessel, nerves and C.T.

iii- Inner circumferential lamellae: They are located immediately beneath the endosteum and completely encircle the marrow cavity and have less lamellae than the outer circumferential lamellae.

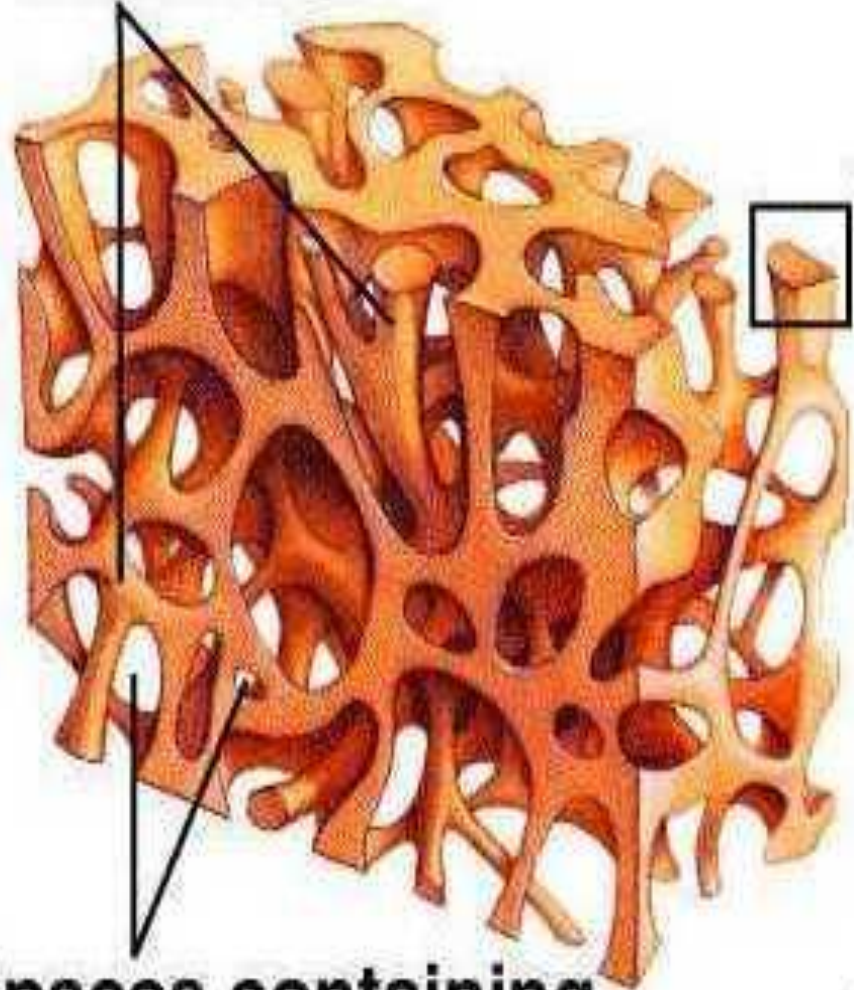
iv- Interstitial lamellae: They are the lamellae of bone present between Haversian systems

Compact Bone



Cancellous Bone

Trabeculae



**Spaces containing
bone marrow and
blood vessels**

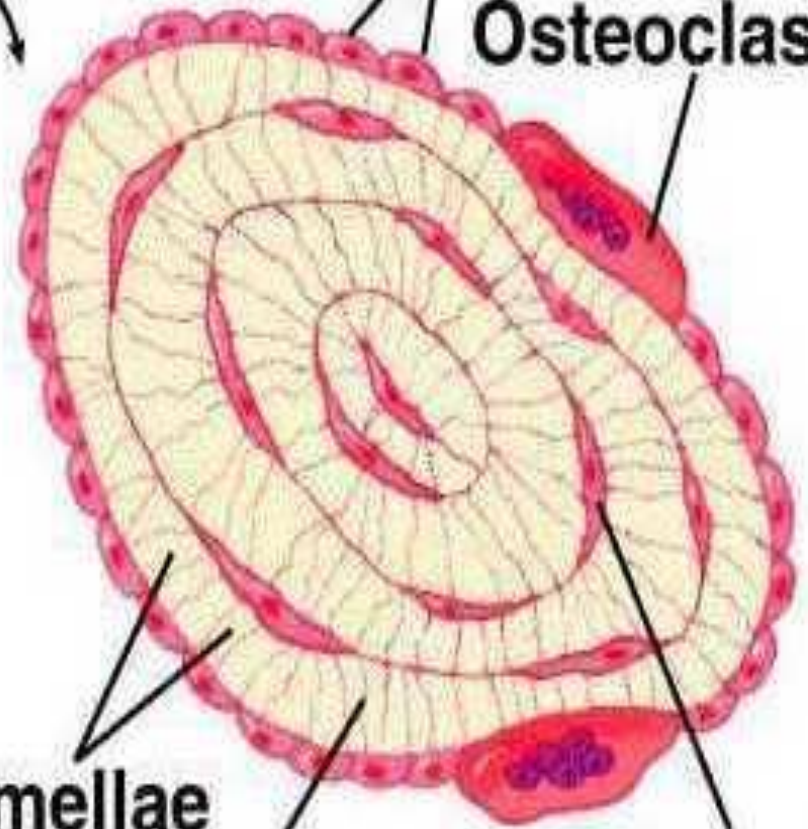
Osteoblasts

Osteoclast

Lamellae

Canaliculus

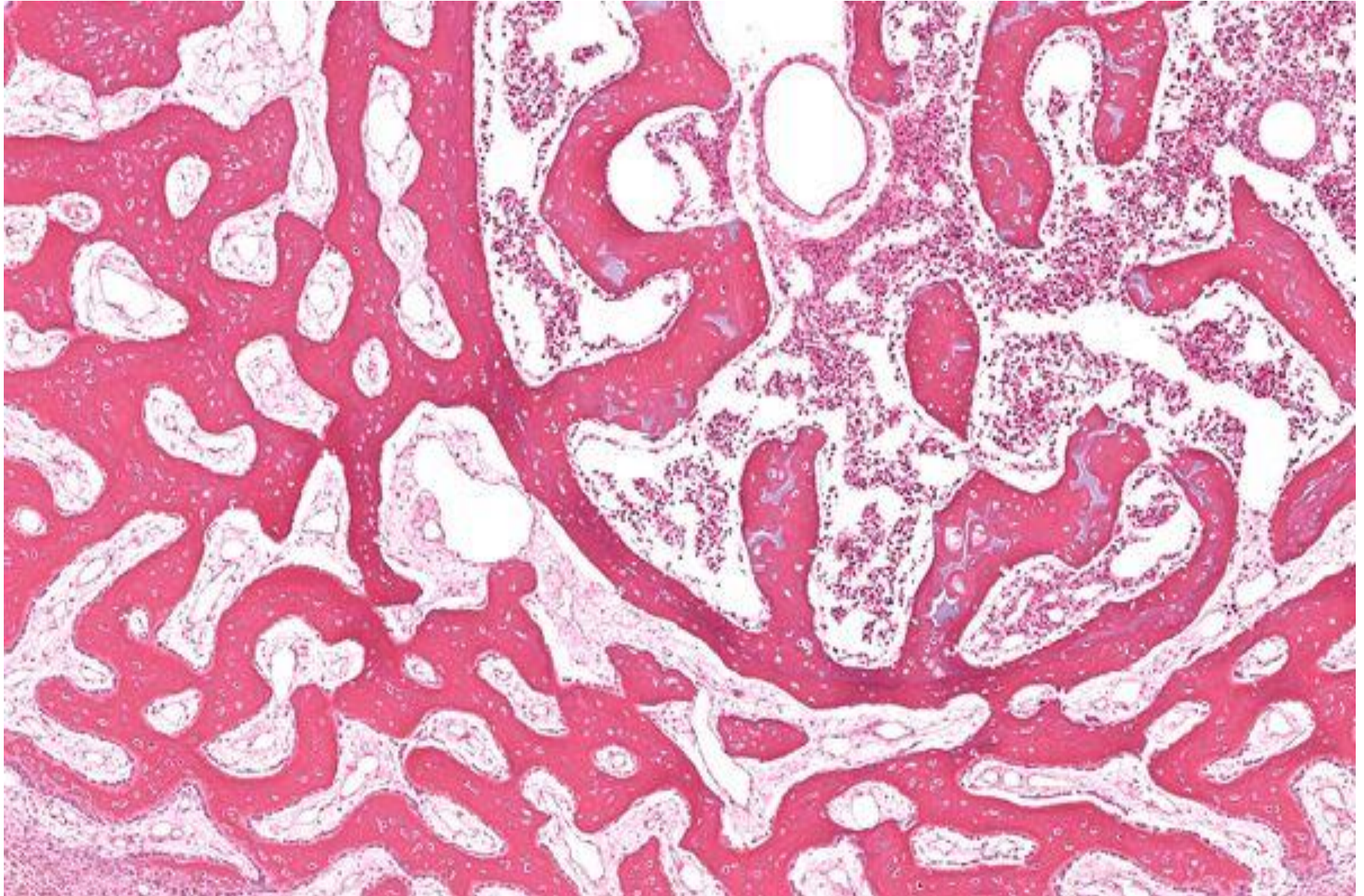
Osteocyte



cancellous bone

- They are present in flat bones as skull, sternum, ribs and ends of long bones .It is made up of branching trabeculae of spongy bone which are composed of irregularly arranged lamellae, but they do not have Haversian systems.
- Their bone cells are nourished by diffusion of tissue fluid through the canaliculi from the bone marrow cavities. The bone marrow cavities appear as irregular cavities in between bone trabeculae of spongy bone containing blood cells.

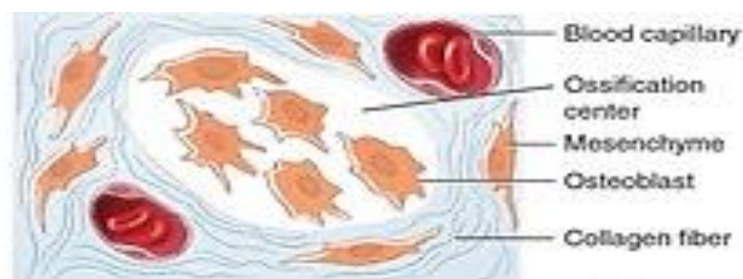
Cancellous Bone



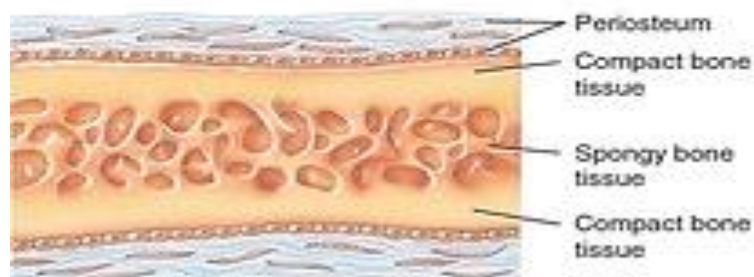
OSTEOGENESIS

I) Intramembranous ossification:

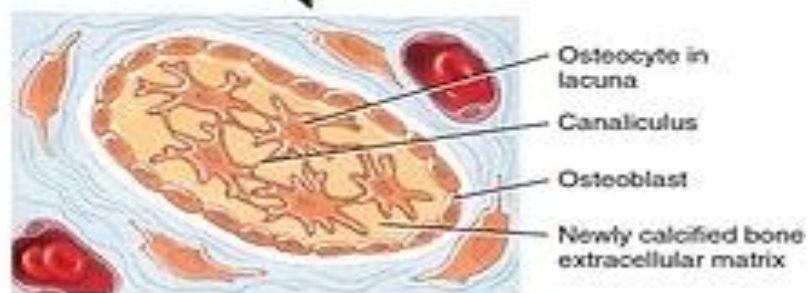
- The frontal and parietal bones of the skull—as well as parts of the occipital and temporal bones and the mandible and maxilla—are produced initially by intramembranous ossification.
- Mesenchymal cells differentiate into osteoprogenitor cells which proliferate and form incomplete layers of osteoblasts around a network of developing capillaries called **ossification centers**.



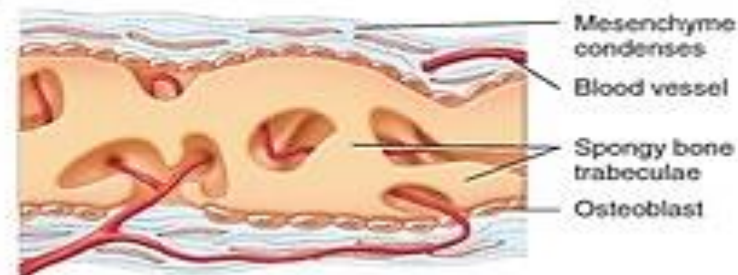
- 1** Development of ossification center: osteoblasts secrete organic extracellular matrix.



- 4** Development of the periosteum: mesenchyme at the periphery of the bone develops into the periosteum.

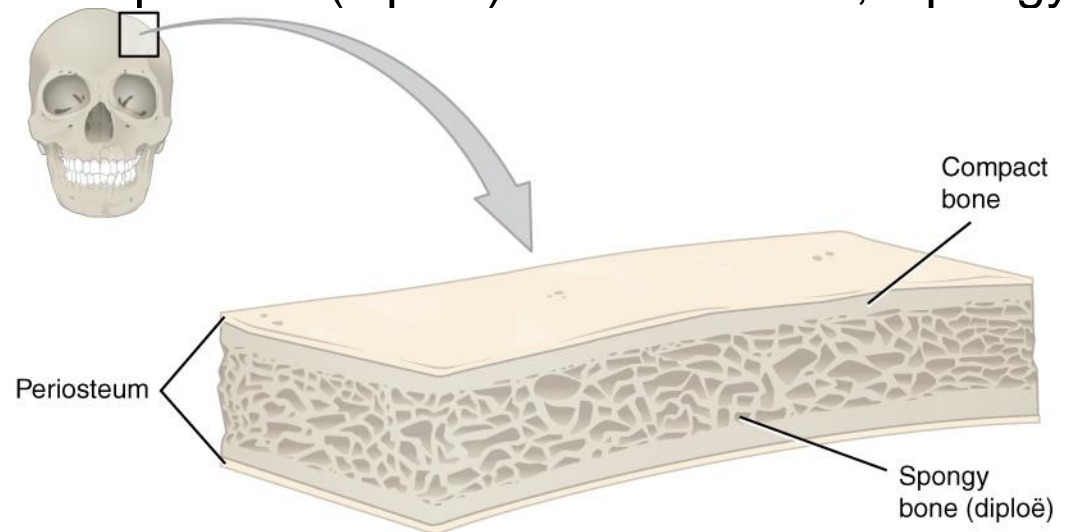


- 2** Calcification: calcium and other mineral salts are deposited and extracellular matrix calcifies (hardens).



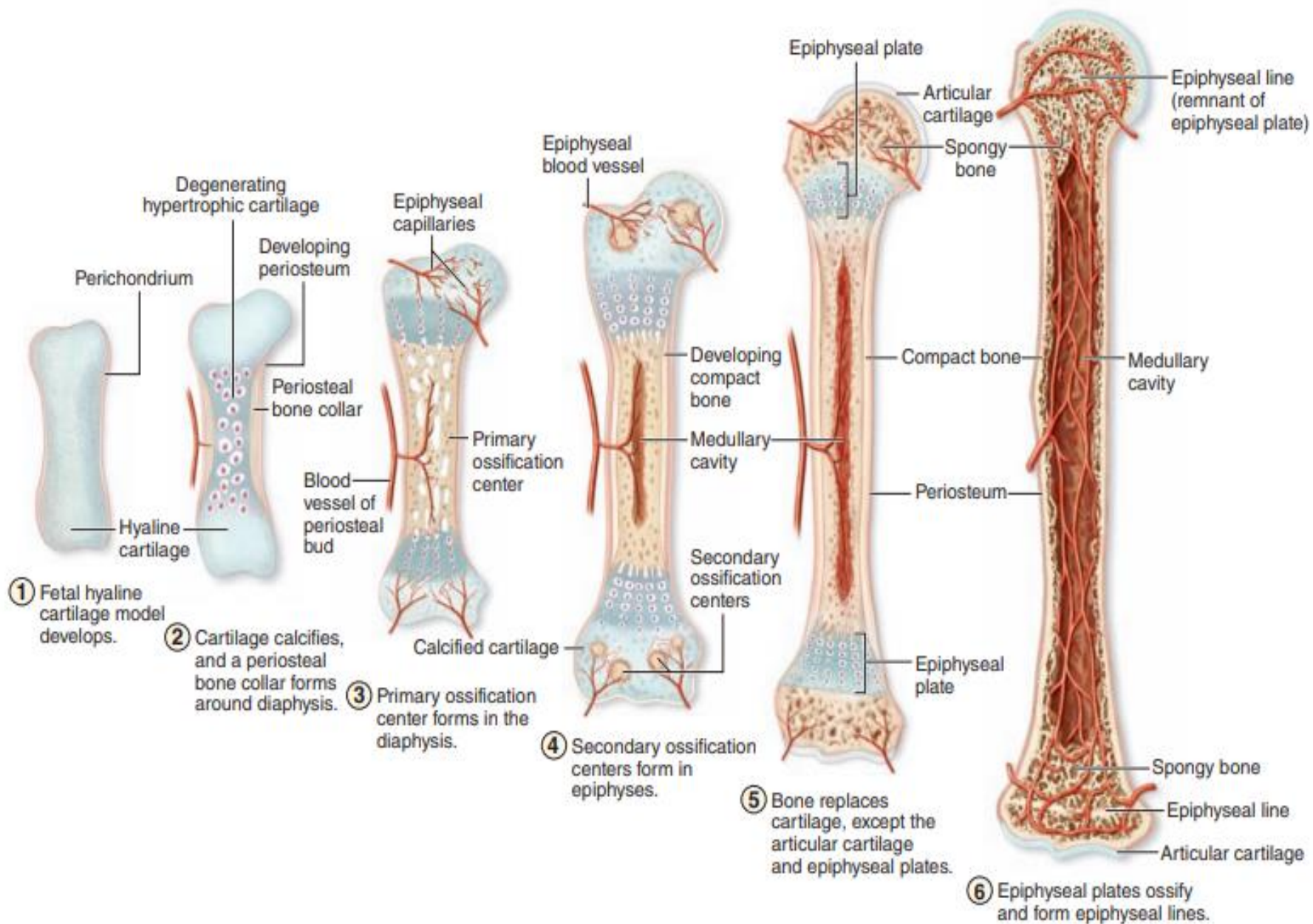
- 3** Formation of trabeculae: extracellular matrix develops into trabeculae that fuse to form spongy bone.

- The osteoblasts secrete the osteoid components that calcify and form trabeculae of woven bone.
- osteocytes enclosed within matrix lacunae. Continued matrix secretion, calcification, and trabecular growth lead slowly to the fusion of neighboring ossification centers and gradually produce layers of compact bone that enclose a region of cancellous bone with marrow and larger blood vessels.
- **In cranial flat bones:** two layers of compact bone (internal and external plates) arise, while the central portion (diploë) is cancellous, spongy nature.



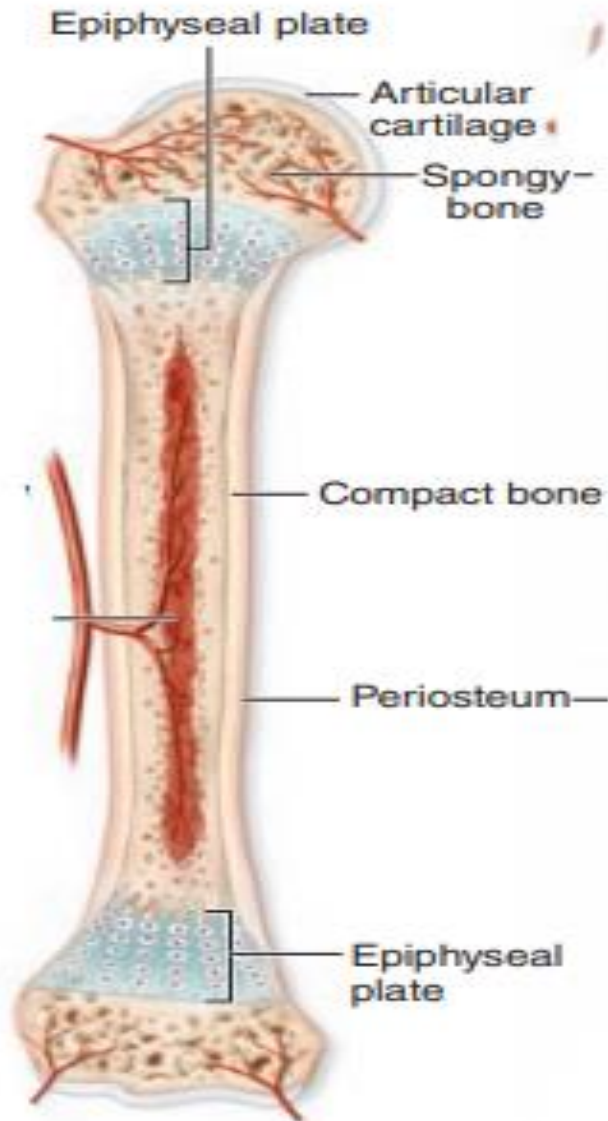
II) Endochondral Ossification

- Ossification takes place within a piece of hyaline cartilage whose shape resembles a small version, or model, of the bone to be formed. This type of ossification is principally responsible for developing long bones.
- The first bone tissue appears as a collar surrounding the diaphysis of the cartilage model. This bone collar is produced by activity of osteoblasts that form in perichondrium. The collar inhibits diffusion of oxygen and nutrients into the underlying cartilage, promoting degenerative changes there.



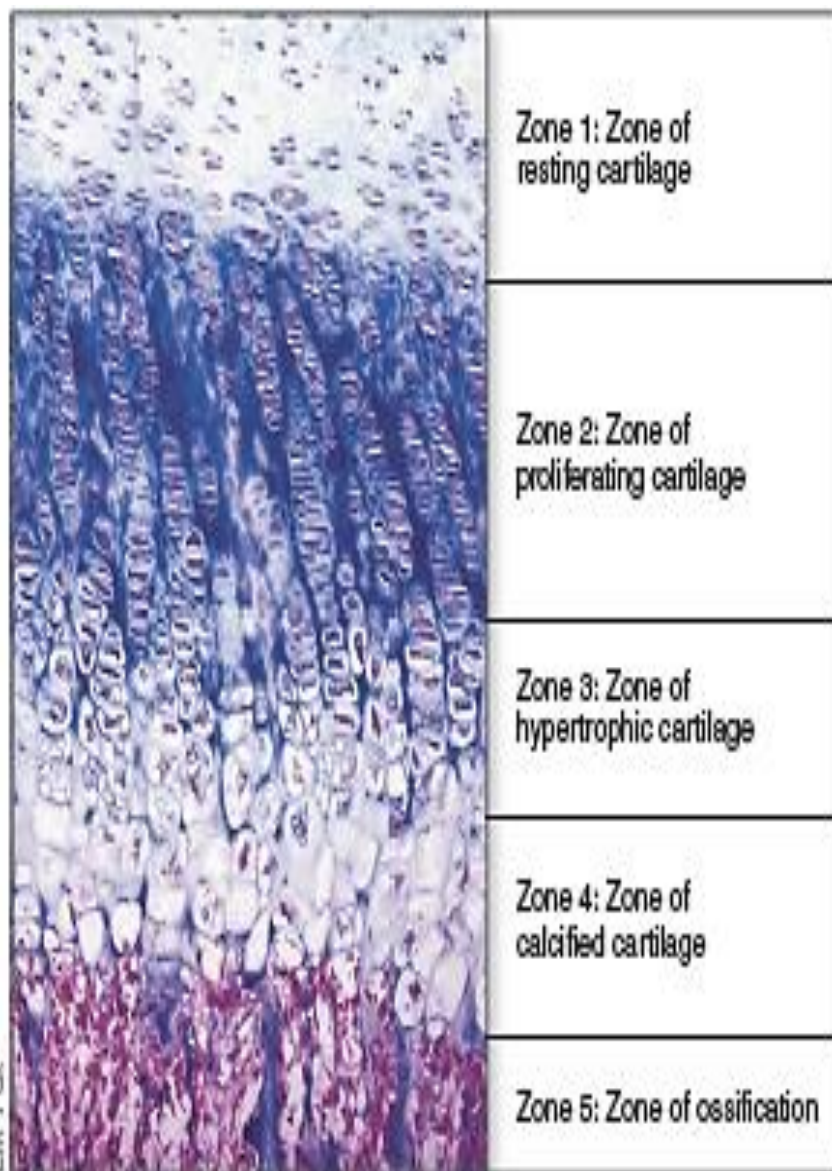
- The chondrocytes begin to produce alkaline phosphatase which leads to matrix calcification and death of the chondrocytes.
- Next, osteoblasts adhere to the remnants of calcified matrix and produce woven bone. Blood vessels from the perichondrium (now the periosteum) penetrate through the bone collar, bringing osteoprogenitor cells to the central region.
- This process in the diaphysis forms **the primary ossification center**, beginning in many bones as early as the first trimester.

- **Secondary ossification centers** appear later at the epiphyses of the cartilage model and develop in a similar manner. During their expansion and remodeling, the primary and secondary ossification centers produce cavities that are gradually filled with bone marrow and trabeculae of bone.
- With the primary and secondary ossification centers, two regions of cartilage remain:
 - **The layer of articular cartilage** within joints , which usually persists through adult life and does not contribute to bone growth.
 - **The epiphyseal cartilage** (also called epiphyseal plate or growth plate), which connects each epiphysis to the diaphysis. The epiphyseal cartilage is responsible for the growth in length of the bone and disappears at adulthood. (“epiphyseal closure”) occurs at different times with different bones and is complete in all bones by about age 20.



⑤ Bone replaces cartilage, except the articular cartilage and epiphyseal plates.

In forensics or through x-ray examination of the growing skeleton, it is possible to determine the “bone age” of a young person, noting which epiphyses are open and which are closed. Once the epiphyses have closed, additional growth in length of bones is no longer possible although bone widening may still occur.



(a) Epiphyseal plate



(b) X-ray of a hand

An epiphyseal growth plate shows distinct regions of cellular activity and is often discussed in terms of five zones starting from the thin region of normal cartilage:

1. The resting zone consists of hyaline cartilage with typical chondrocytes.

2. the proliferative zone, chondrocytes begin to divide rapidly and form columns of stacked cells parallel to the long axis of the bone.

3. The hypertrophic cartilage zone contains swollen, degenerative chondrocytes whose cytoplasm has accumulated glycogen. This hypertrophy compresses the matrix into thin septa between the chondrocytes.

4. the calcified cartilage zone, loss of the chondrocytes by apoptosis is accompanied by calcification of the septa of cartilage matrix by the formation of hydroxyapatite crystals.

5. the ossification zone, Capillaries and osteoprogenitor cells from the periosteum invade the cavities left by the chondrocytes. Osteoblasts secrete osteoid forming woven bone.

THANK YOU