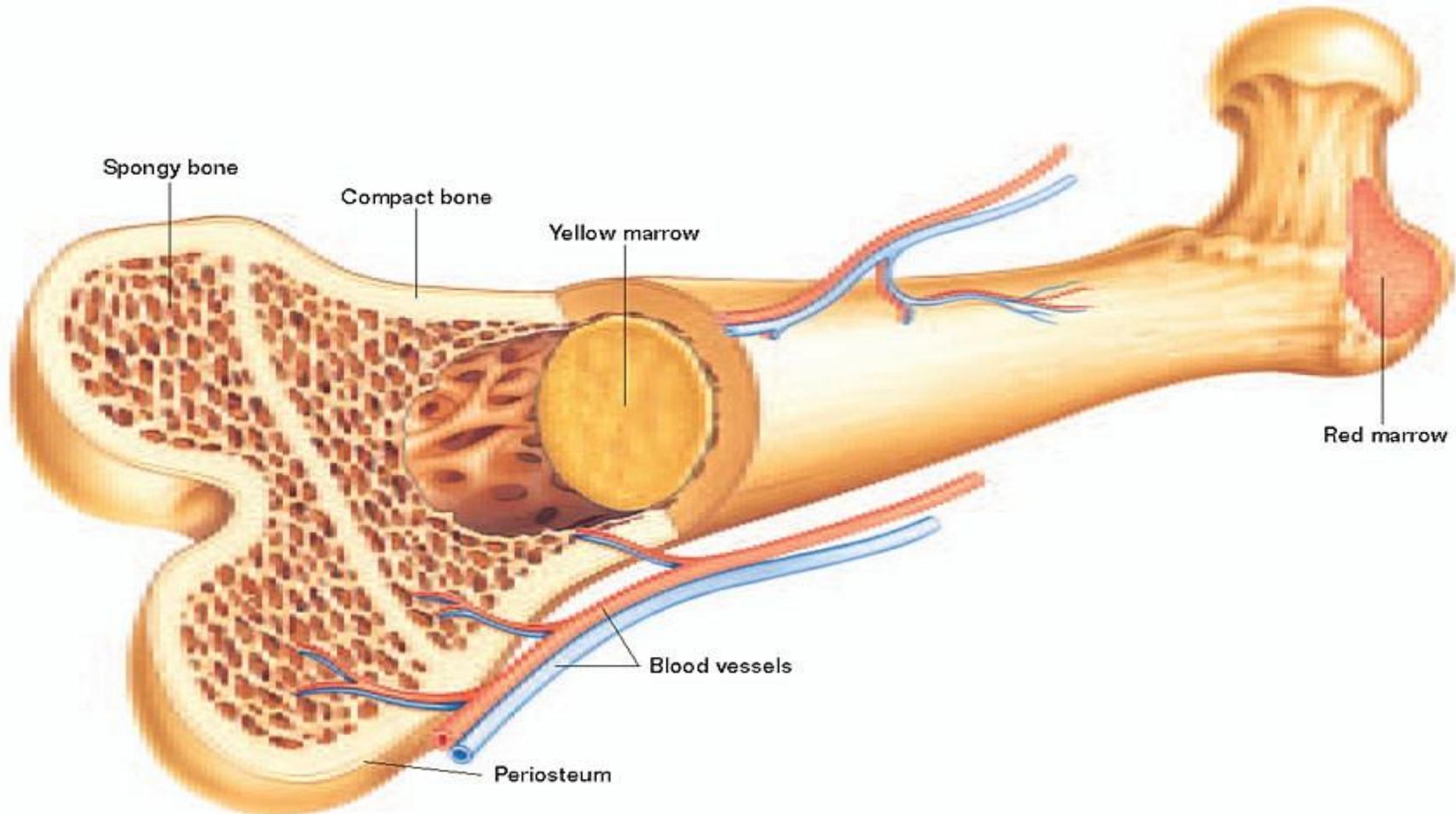
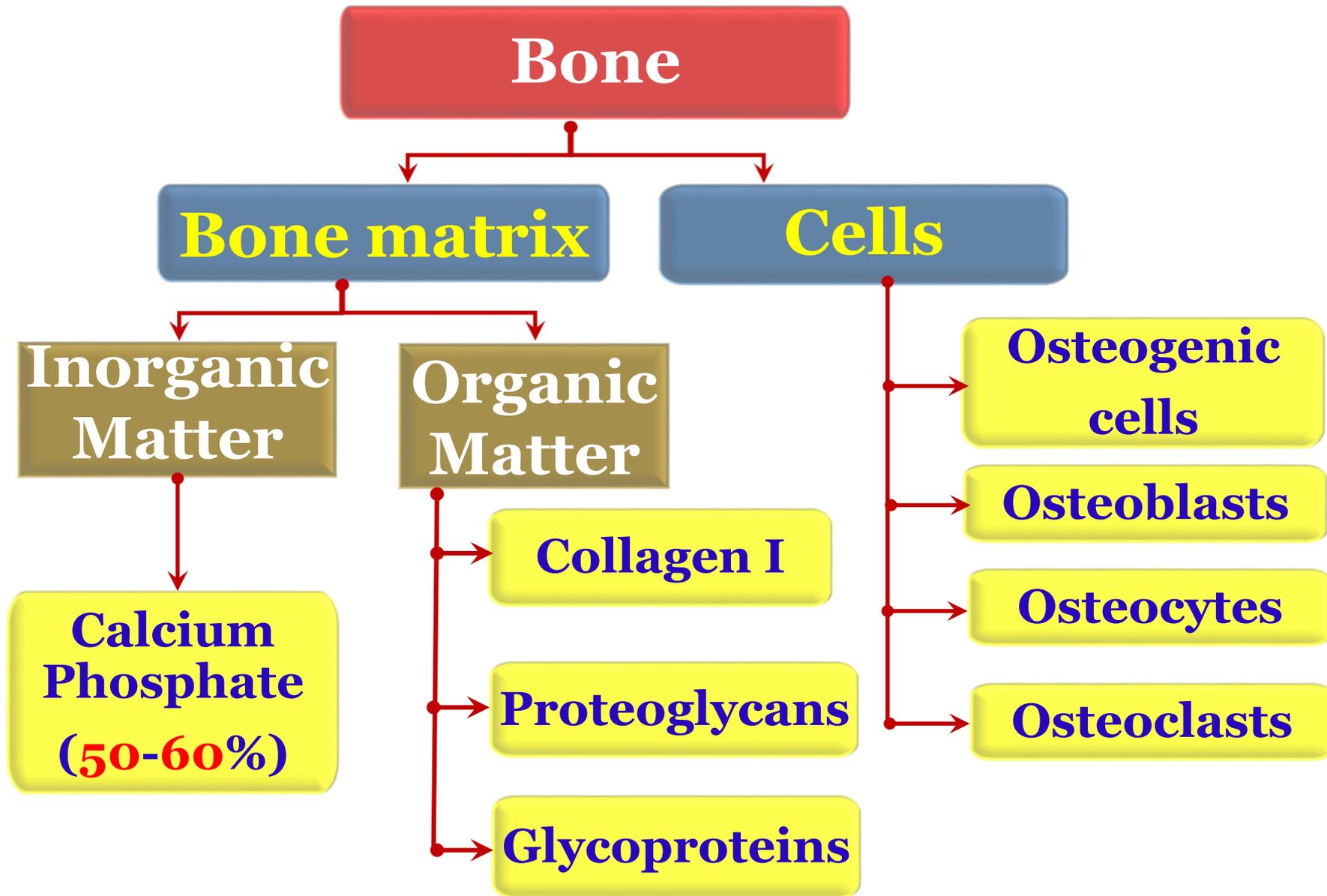


Bone





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.

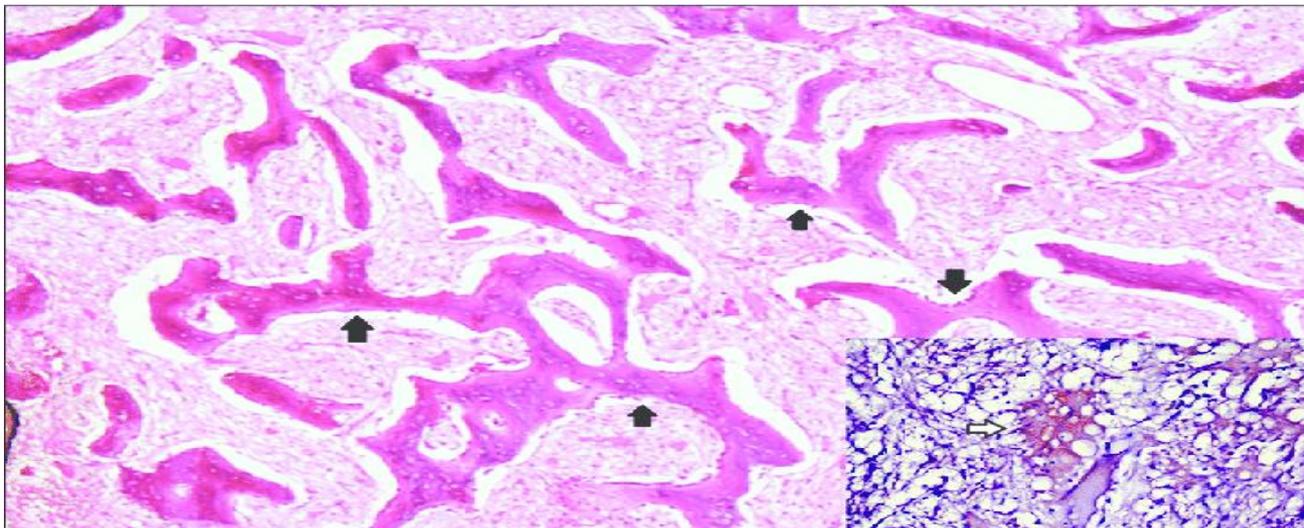
- *Types of bone tissue:*

(I) Microscopic types:

- Two types are detected:

1. primary bone: [immature or woven bone]

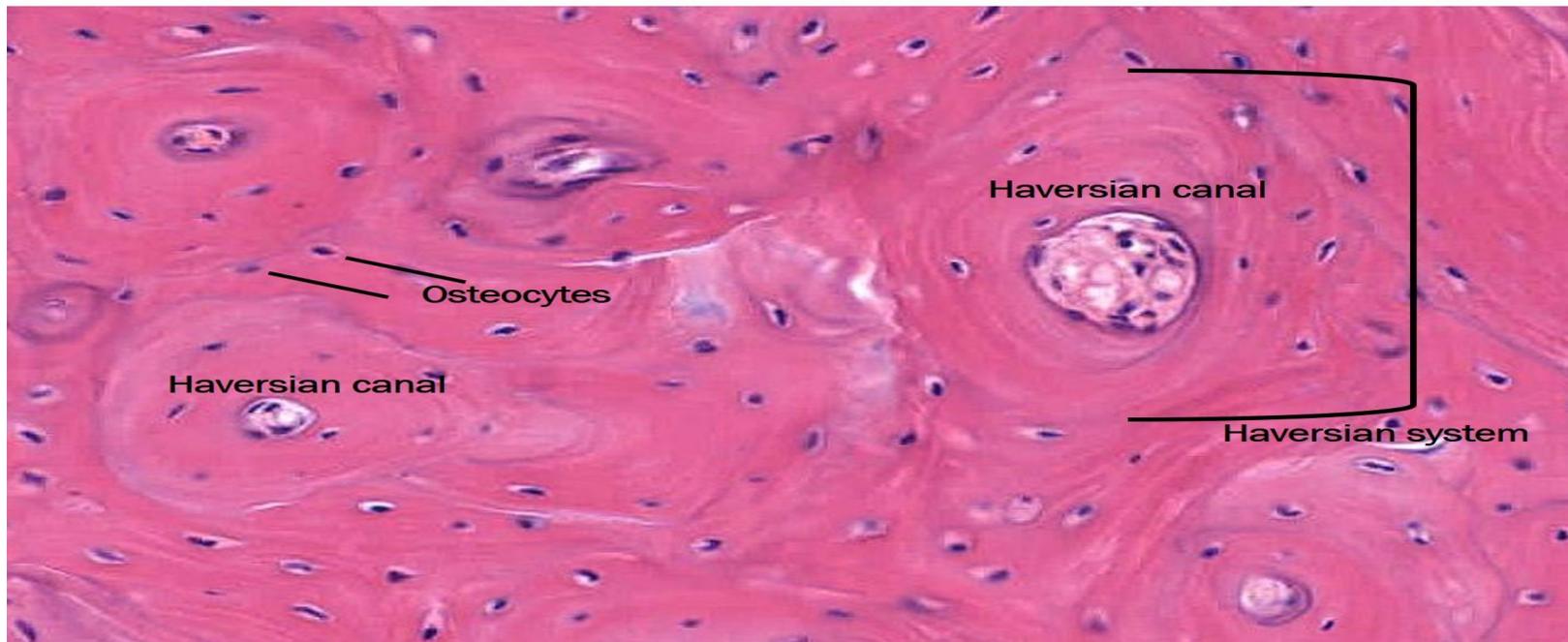
- It is the first bone formed during fetal development and during bone repair.
- It has abundant osteocytes and irregular bundles of collagen.
- Its mineral content (ca salts) is **much less** than that of secondary bone.



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



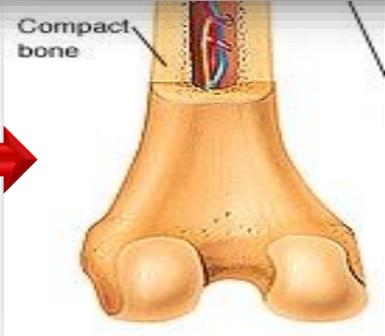
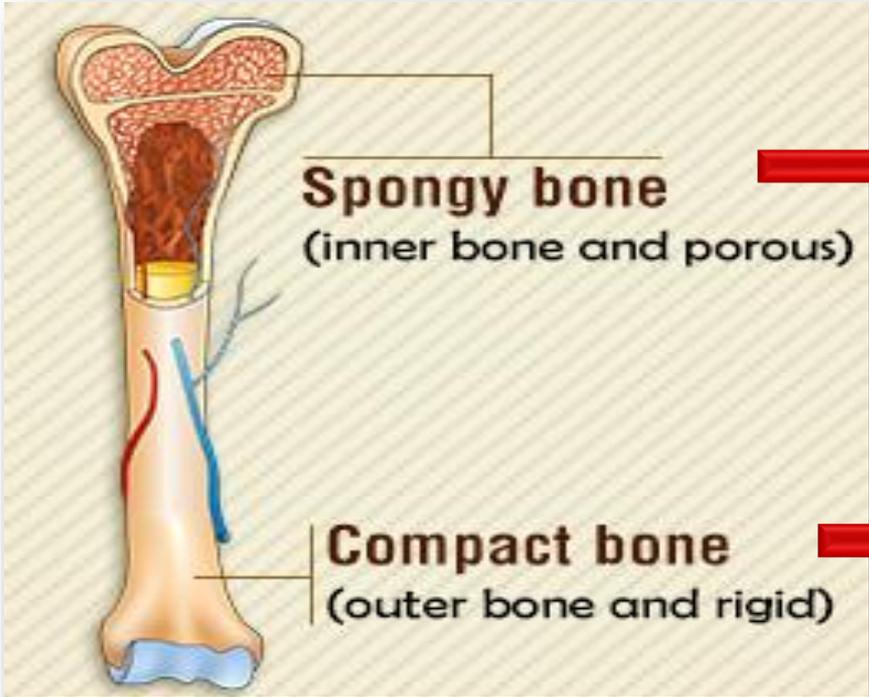
II-Macroscopic Types of Bone

Compact

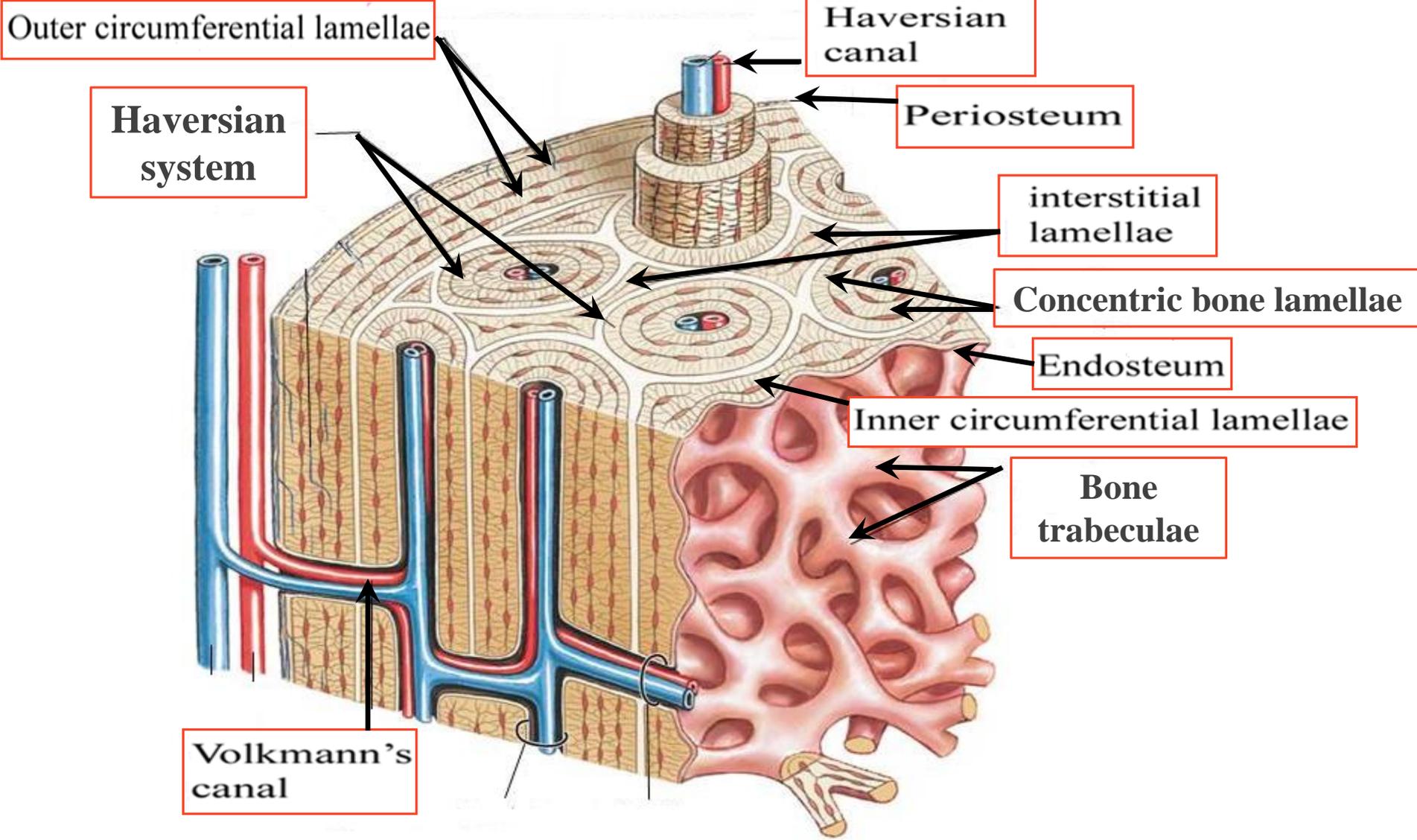
Cancelous (Spongy)

Solid very dense mass of bone tissue without cavities.

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.**

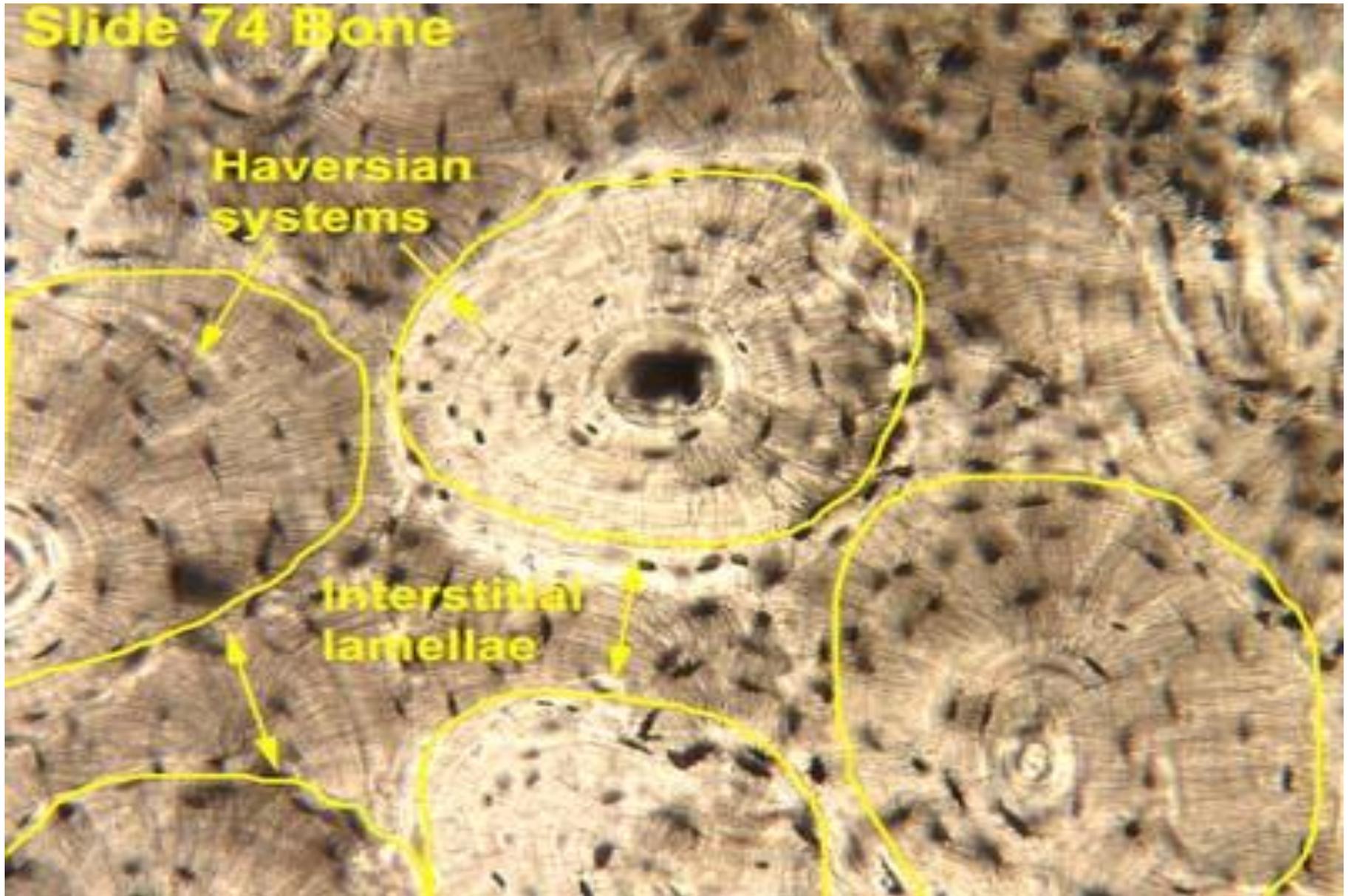
-Haversian canal run parallel to the long axis of the bone and connected with each other, with periosteum and with endosteum by transverse or oblique canals known as **Volkman's canals**.

-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.

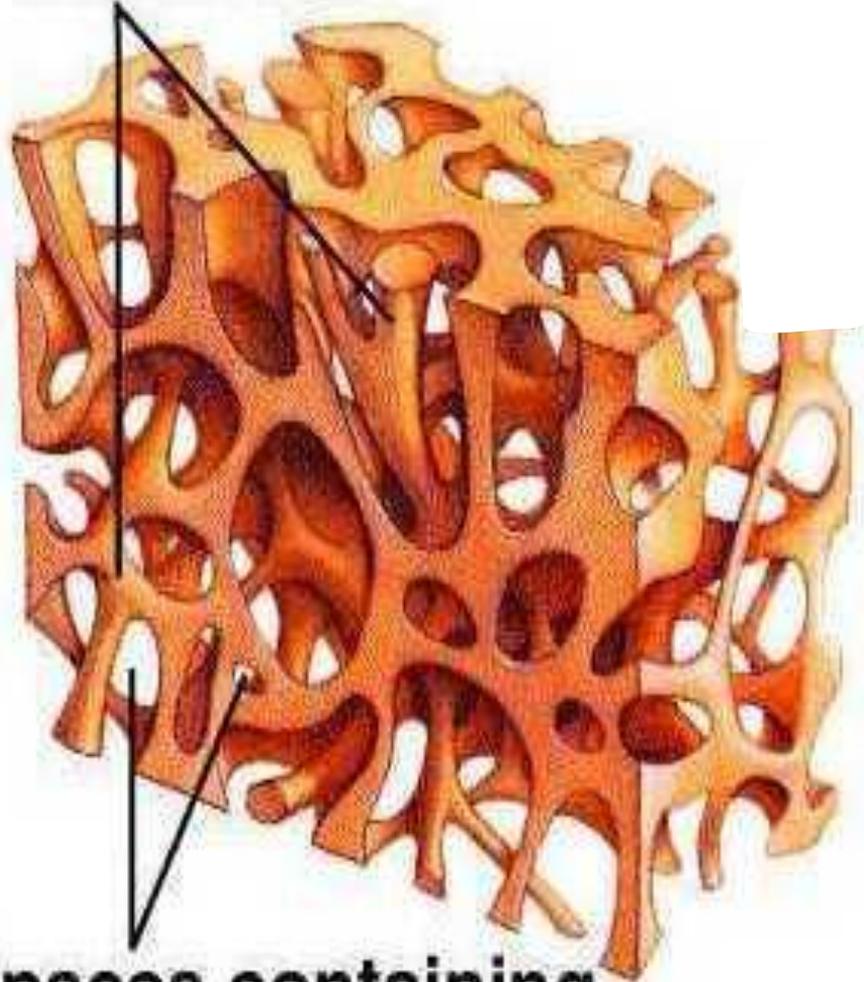
iv- Interstitial lamellae: They are the lamellae of bone present between Haversian systems

Compact Bone



cancellous Bone

Trabeculae

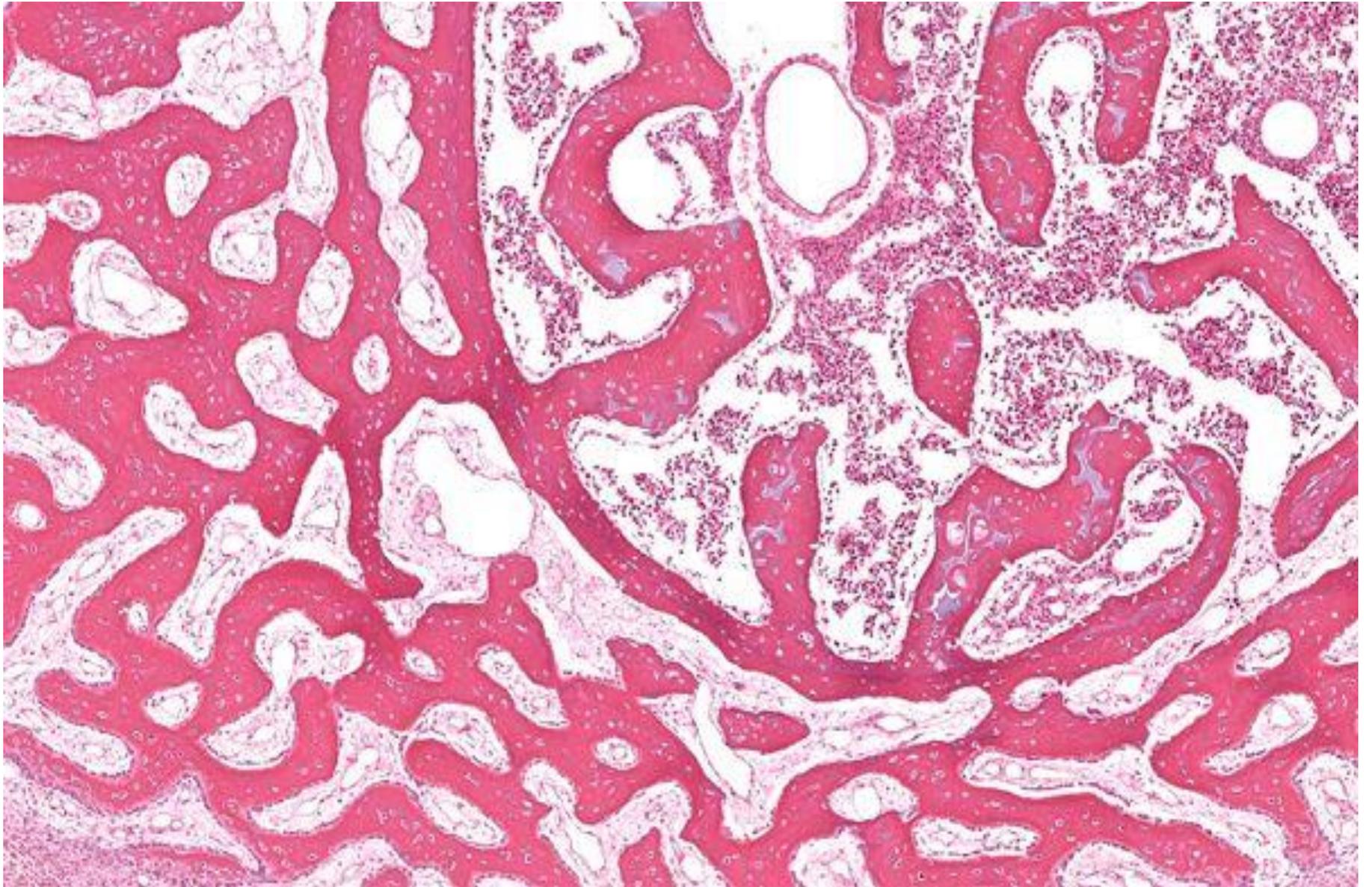


Spaces containing
bone marrow and
blood vessels

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.

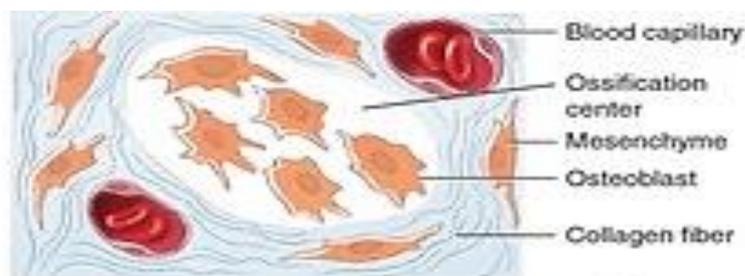
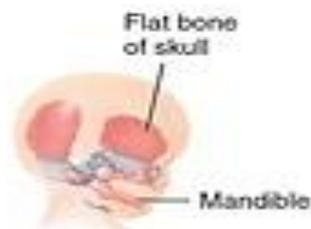
Cancellous Bone



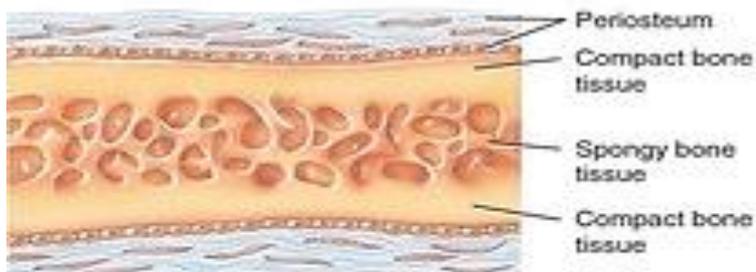
OSTEOGENESIS

I) Intramembranous ossification:

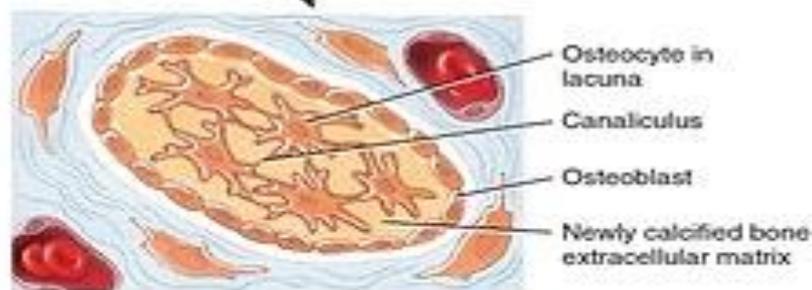
- The frontal and parietal bones of the skull—as well as parts of the occipital and temporal bones and the mandible and maxilla—are produced initially by intramembranous ossification.
- Mesenchymal cells differentiate into osteoprogenitor cells which proliferate and form incomplete layers of osteoblasts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



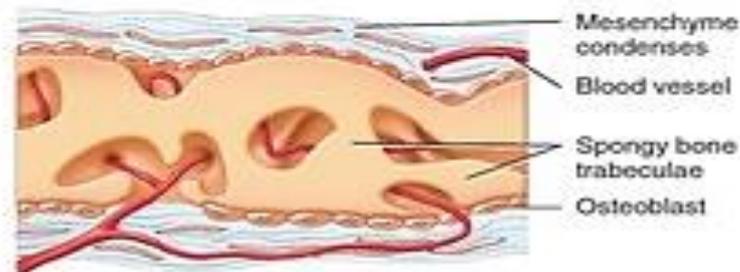
1 Development of ossification center: osteoblasts secrete organic extracellular matrix.



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).

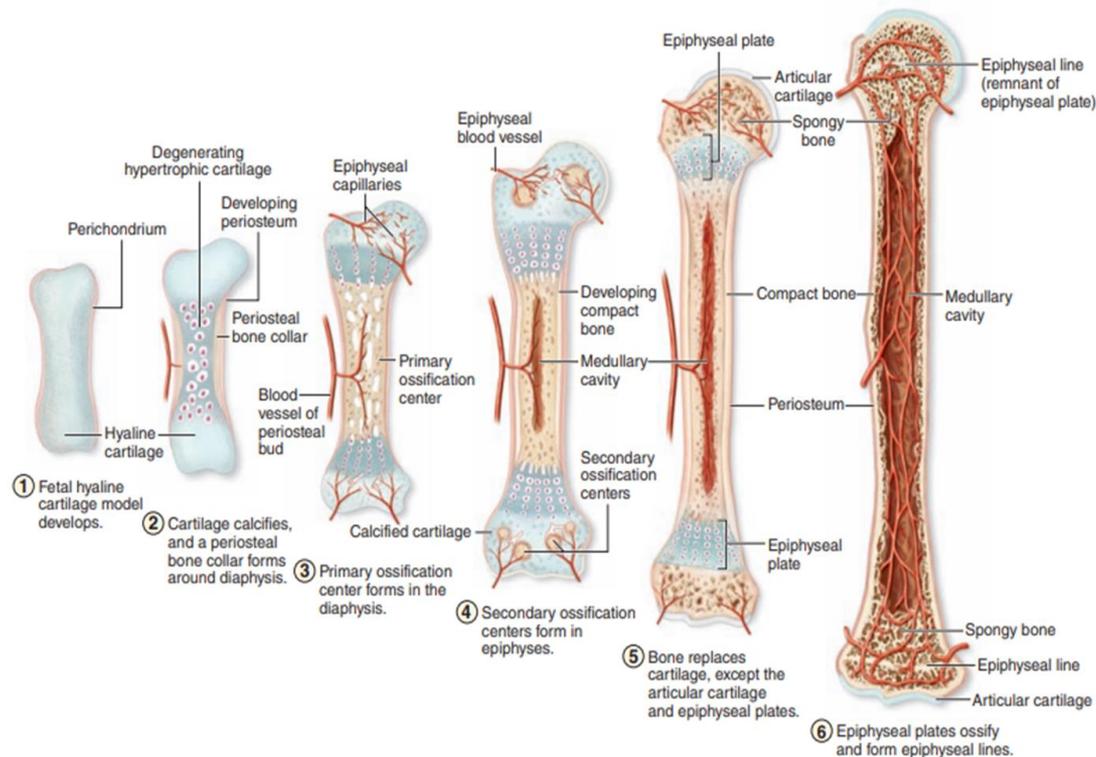


3 Formation of trabeculae: extracellular matrix develops into trabeculae that fuse to form spongy bone.

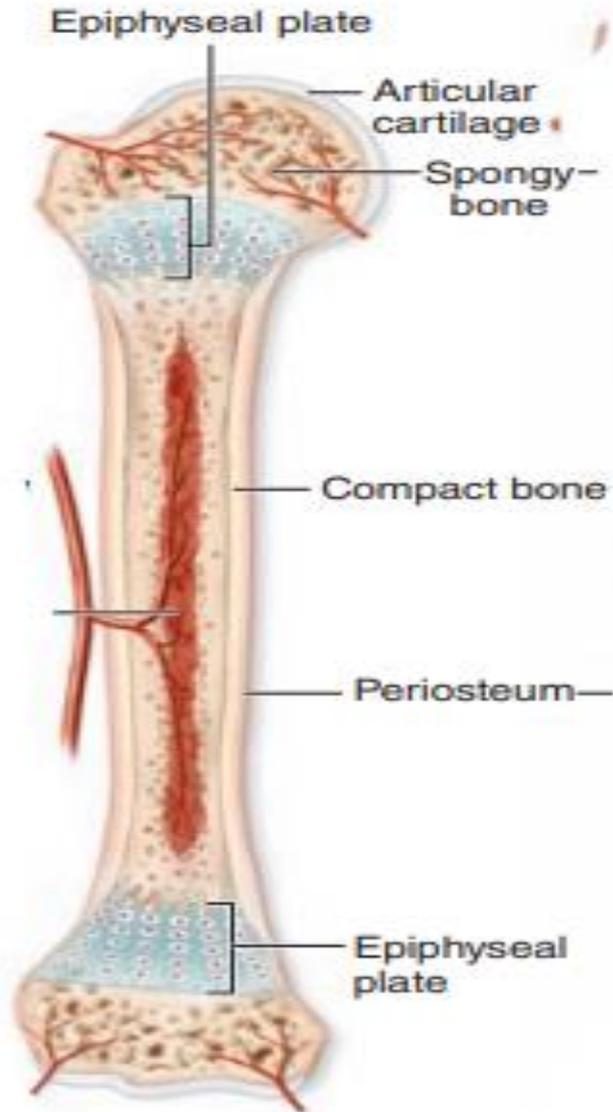
- The osteoblasts secrete the osteoid components that calcify and form trabeculae of woven bone.
- osteocytes enclosed within matrix lacunae. Continued matrix secretion, calcification, and trabecular growth lead slowly to the fusion of neighboring ossification centers and gradually produce layers of 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.

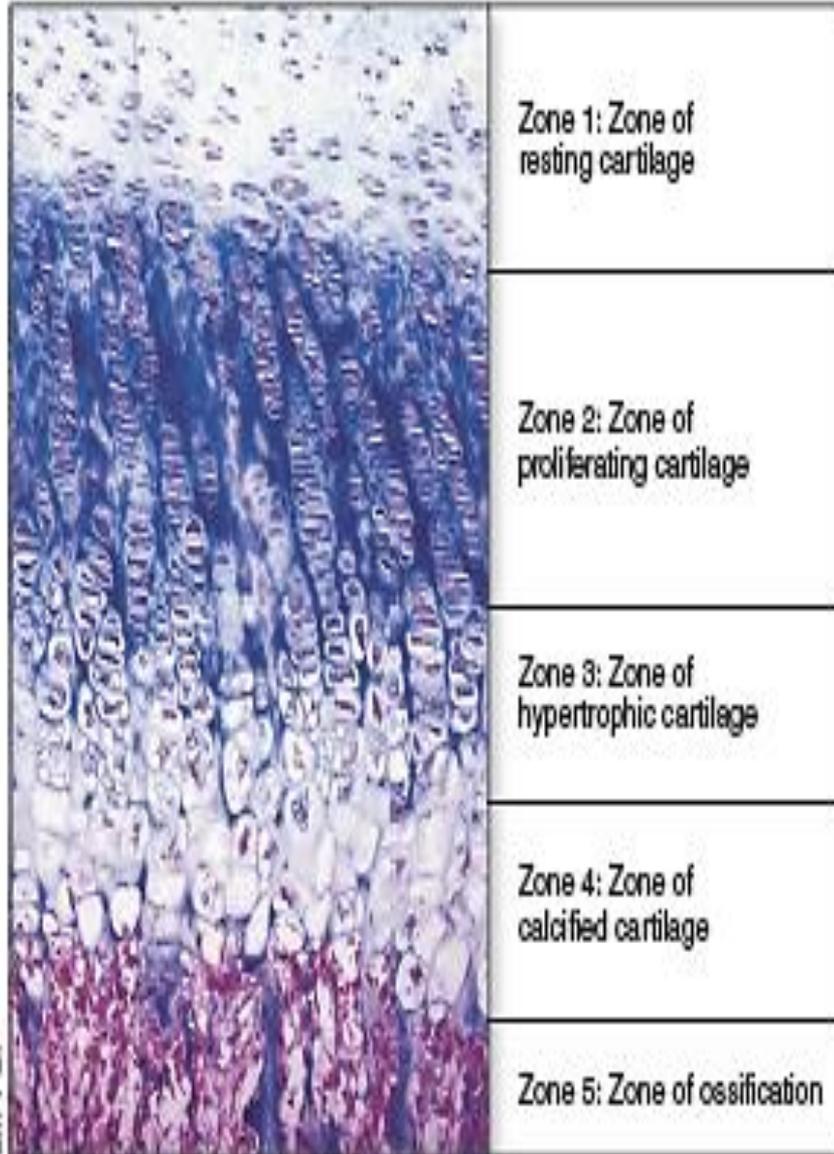


- Two regions of cartilage remain:
 - **The layer of articular cartilage** within joints , which usually persists through adult life and does not contribute to bone growth.
 - **The epiphyseal cartilage** (also called epiphyseal plate or growth plate), which connects each epiphysis to the diaphysis. 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.

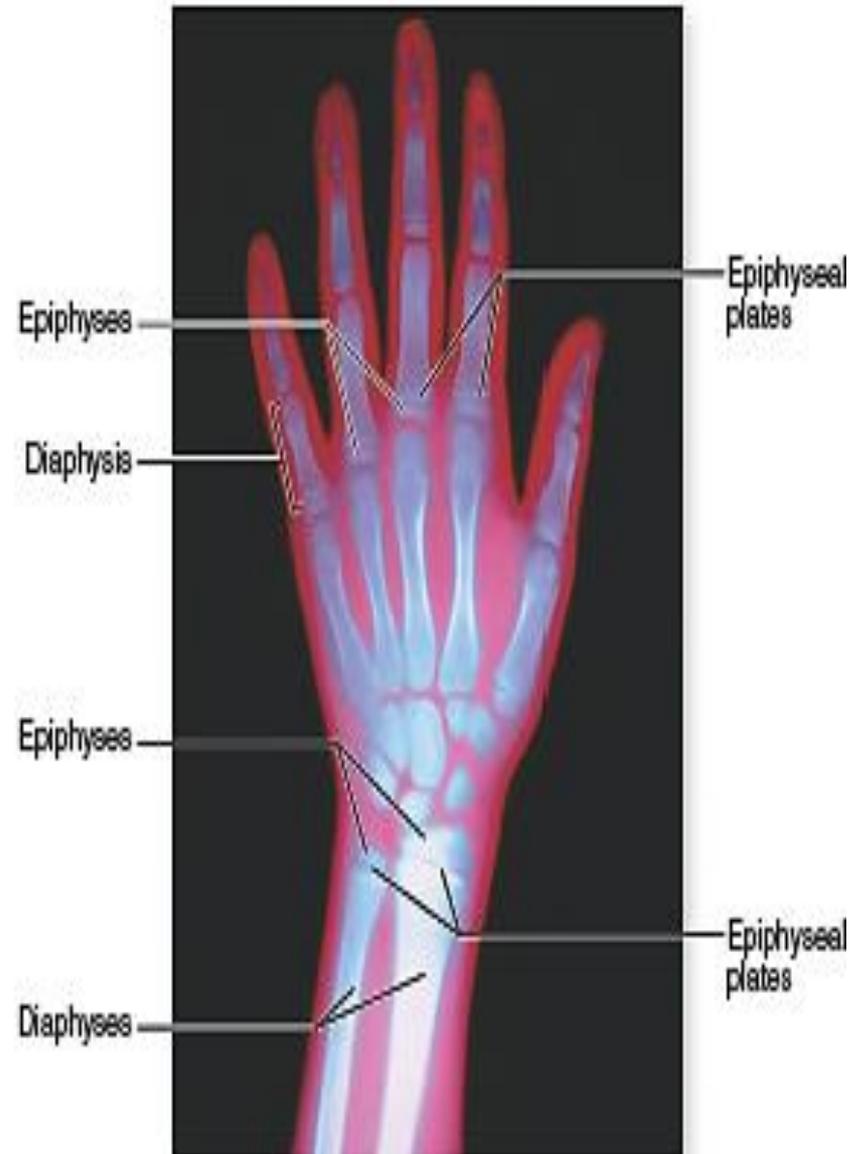


⑤ Bone replaces cartilage, except the articular cartilage and epiphyseal plates.

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.

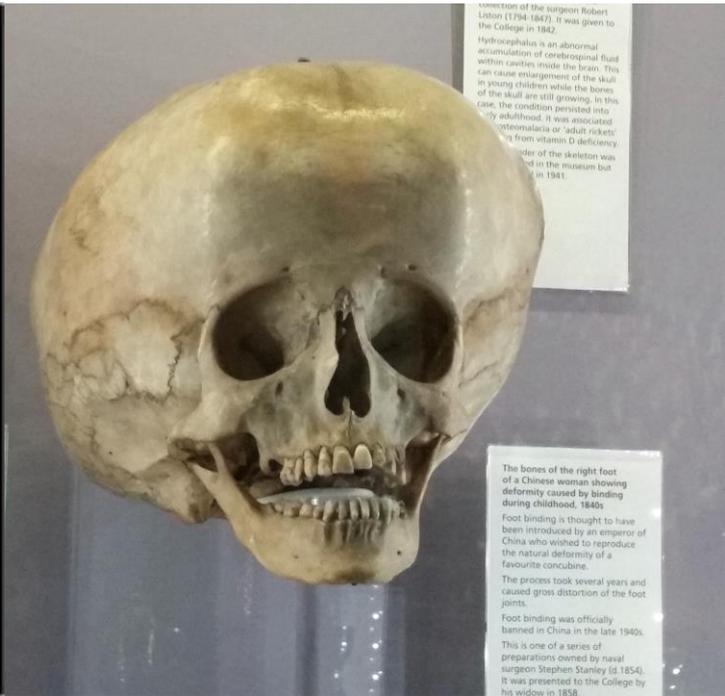
BONE GROWTH

- ❑ Osteogenesis and bone growth involves the partial resorption of bone tissue formed earlier, while simultaneously laying down new bone at a rate exceeding that of bone removal which maintains each bone's general shape while increasing its mass.
- ❑ The rate of bone turnover is very active in young children, where it can be **200 times** faster than that of adults. In adults the skeleton is renewed continuously in a process of bone remodeling that also involves coordinated linked cellular activities for bone resorption and bone formation.
- ❑ **Cranial bones:** grow mainly because of the formation of bone tissue by the periosteum between the sutures and on the external bone surface. At the same time, resorption takes place on the internal surface. The plasticity of bone allows it to respond to the growth of the brain and form a skull of adequate size. The skull is small if the brain does not develop completely and larger than normal in a person with hydrocephalus, a disorder characterized by abnormal accumulation of spinal fluid and dilation of the cerebral ventricles.



Anencephalus

Normal skull

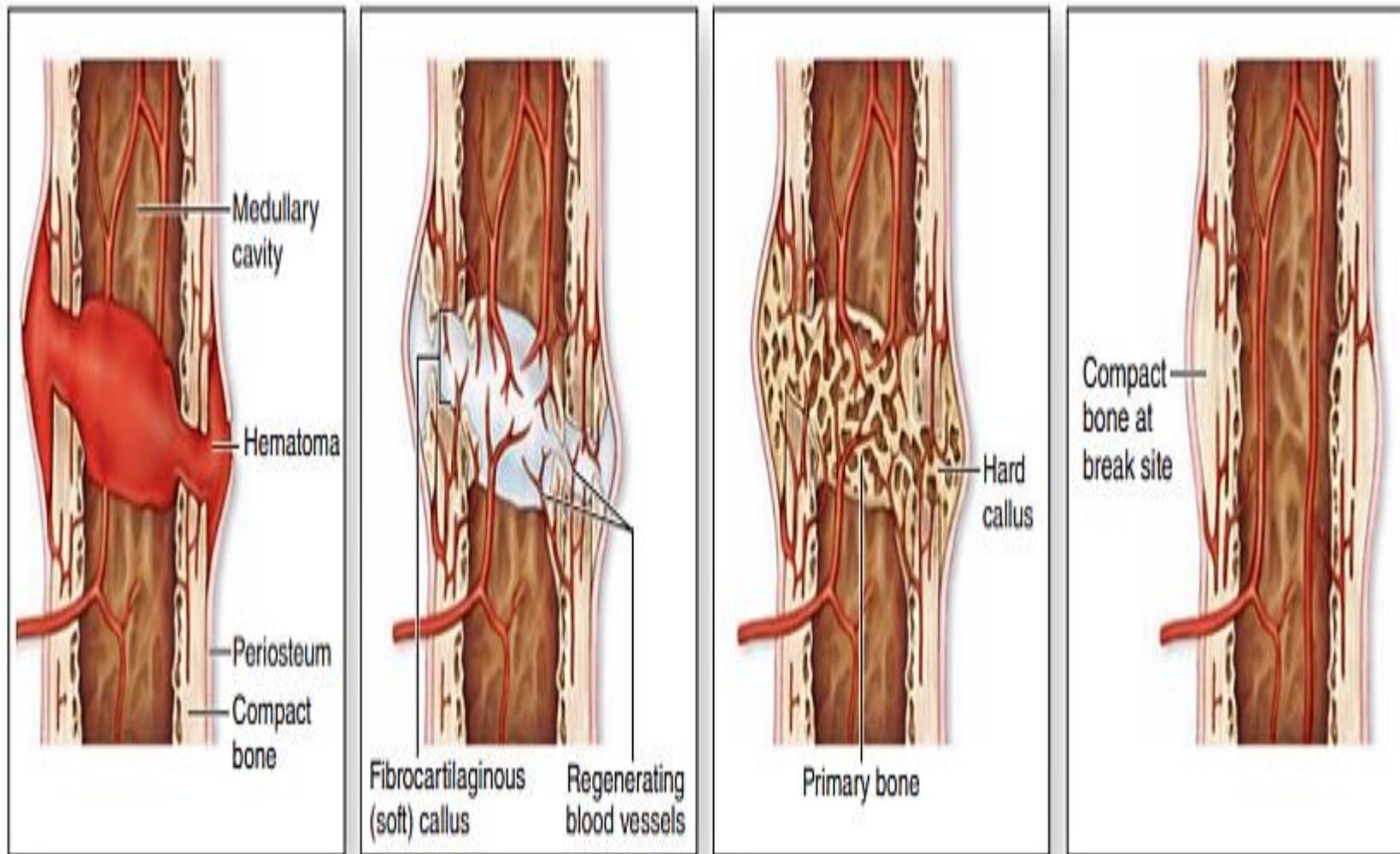


Hydrocephalus

BONE REPAIR

- ❑ Because bone contains osteoprogenitor stem cells in the periosteum, endosteum, and marrow and is very well vascularized, bone normally has an excellent capacity for repair.
- ❑ Repair of bone fractures and other damage efficiently uses cells, signaling molecules, and processes already active in bone remodeling. Surgically created gaps in bone can be filled with new bone, especially when periosteal tissue remains.

BONE FRACTURE REPAIR



(a) A fracture hematoma forms.

(b) A fibrocartilaginous (soft) callus forms.

(c) A hard (bony) callus forms.

(d) The bone is remodeled.

BONE FRACTURE REPAIR

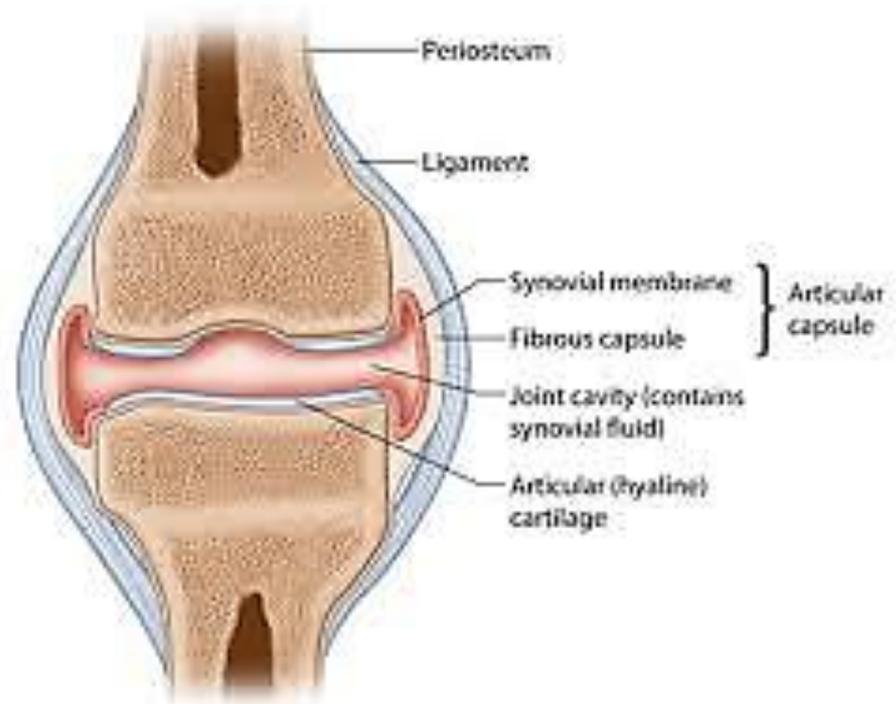
- a) Blood vessels torn within the fracture release blood that clots to produce a large fracture **hematoma**.
- (b) This is gradually removed by macrophages and replaced by a soft fibrocartilage-like mass of **procallus** tissue rich in collagen and fibroblasts. If broken, the periosteum reestablishes continuity over this tissue.
- (c) This soft procallus is invaded by regrowing blood vessels and osteoblasts. In the next few weeks the fibrocartilage is gradually replaced by trabeculae of woven bone, forming a **hard callus** throughout the original area of fracture.
- (d) The immature, woven bone of the callus is gradually resorbed and replaced by lamellar bone, then remodeling and restoring the **original bone structure** occur.

JOINTS

■ Joints with very limited or no movement are classified collectively as synarthroses and freely mobile joints are called diarthroses.

■ Diarthroses have a joint cavity filled with lubricant synovial fluid, enclosed within a tough, fibrous articular capsule; ends of the bones involved are covered with hyaline articular cartilage.

■ Specialized connective tissue of the synovial membrane lines the capsule, with folds extended into some areas of the joint cavity.

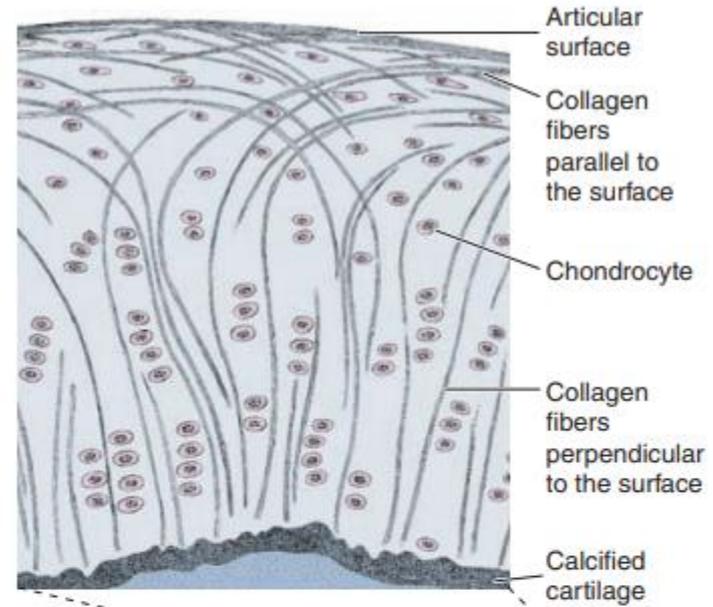
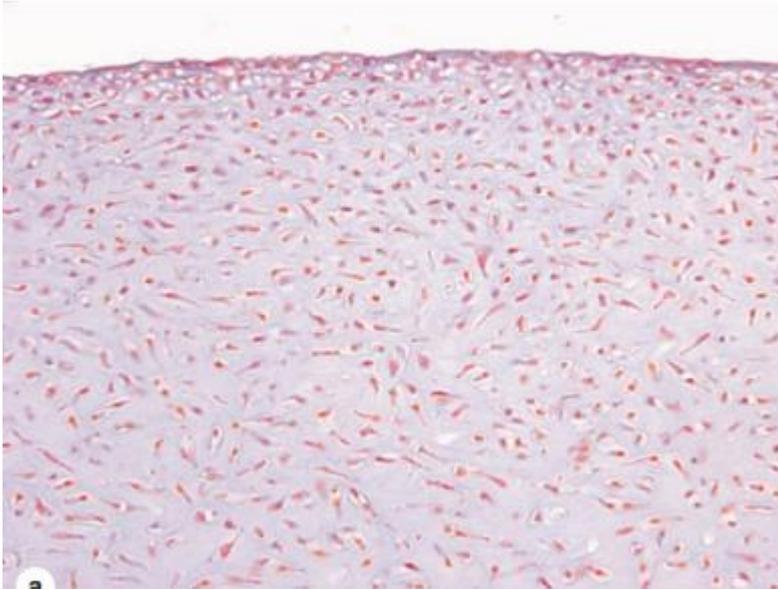


❖ **The synovial membrane in this area is characterized by two specialized cells:**

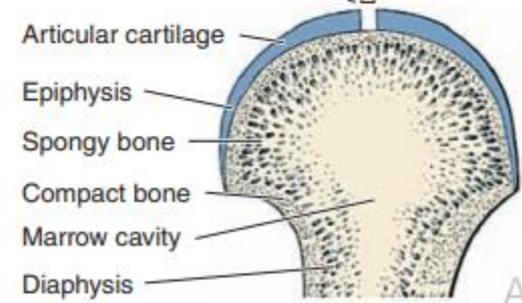
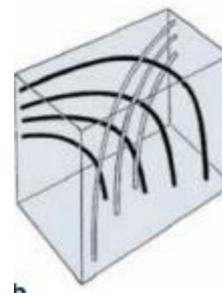
■ **Macrophage-like synovial cells**, also called **type A cells**, are derived from blood monocytes and remove wear-and-tear debris from the synovial fluid. These modified macrophages, which represent approximately 25% of the cells lining the synovium, are important in regulating inflammatory events within diarthrotic joints.

■ **Fibroblastic synovial cells**, or **type B cells**, produce abundant hyaluronan and other extracellular components. Much of this material is transported by water from the capillaries into the synovial fluid, which lubricates the joint, reducing friction on all internal surfaces, and supplies nutrients and oxygen to the articular cartilage

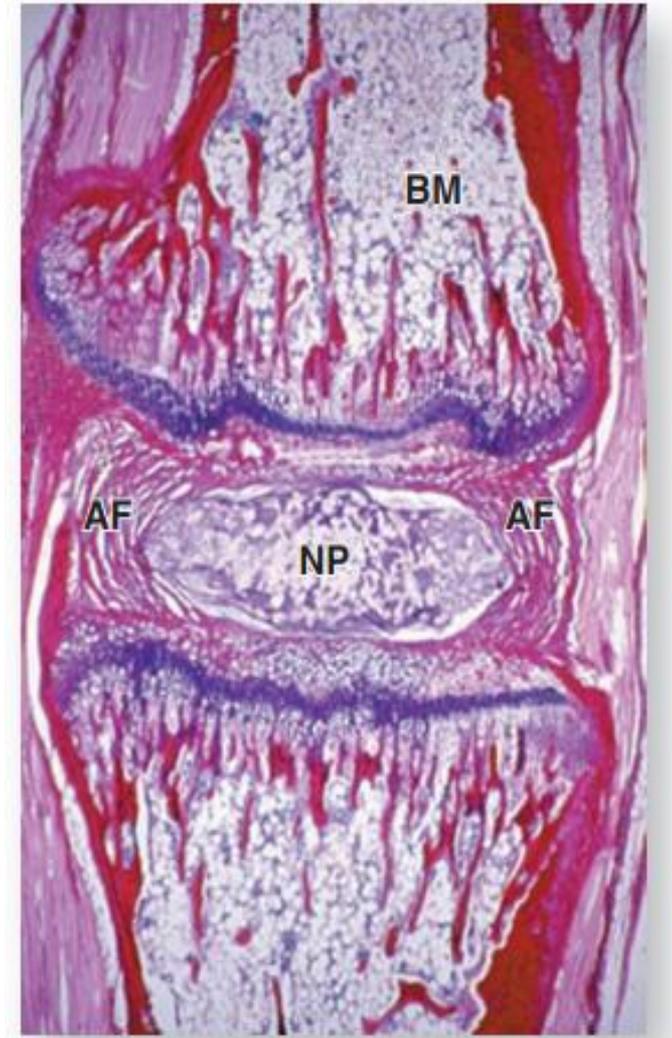
❖ **The collagen fibers of the hyaline articular cartilage are disposed as arches with their tops near the exposed surface, This arrangement of collagen helps distribute the forces generated by pressure on joints. Hyaline articular cartilage unlike most cartilage, is not covered by perichondrium.**

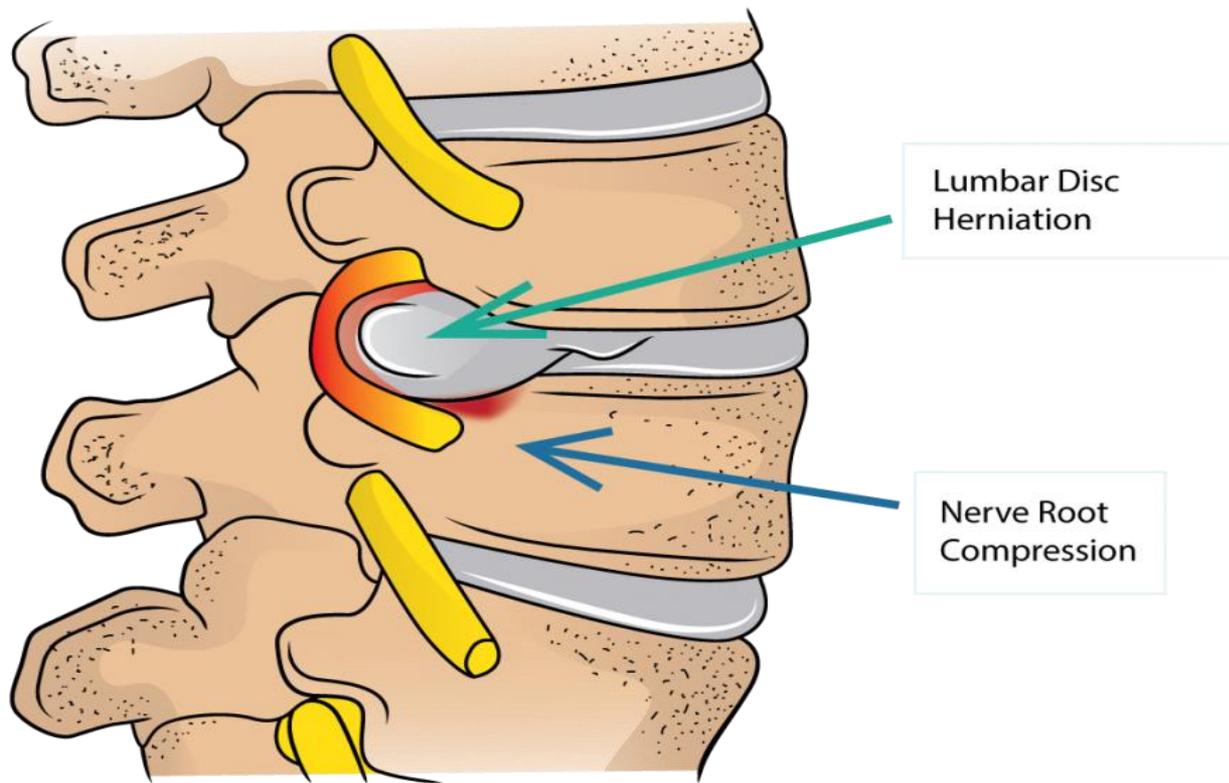


Articular surfaces of a diarthrosis are made of hyaline cartilage that lacks the usual perichondrium covering



- **Intervertebral discs** allow limited vertebral mobility and consist of large pads of fibrocartilage that cushion adjacent vertebrae.
- Each intervertebral disc consists mainly of a thick outer layer of fibrocartilage forming a tough annulus fibrosus (AF), and a shock absorbing inner, gel-like core, the nucleus pulposus (NP).
- **nucleus pulposus** typically contains scattered, vacuolated cells but it is largely composed of water in a gel-like matrix rich in hyaluronan and fibers of type II collagen. The nucleus pulposus is large in children, but these structures gradually become smaller with age and are partially replaced by fibrocartilage.





❖ Collagen loss or other degenerative changes in the annulus fibrosus are often accompanied by displacement of the nucleus pulposus, a condition variously called a slipped or herniated disc .

This occurs most frequently on the posterior region of the intervertebral disc where there are fewer collagen bundles. The affected disc frequently dislocates or shifts slightly from its normal position. If it moves toward nerve plexuses, it can compress the nerves and result in severe pain and other neurologic disturbances usually the lower lumbar region.

THANK YOU

The image features the words "THANK YOU" in a bold, purple, sans-serif font. The text has a slight 3D effect with a shadow on the bottom. Below the text is a reflection of the same words, rendered in a lighter, semi-transparent purple color, creating a mirror-like effect on a white background.