

Connective Tissues

General characteristics of connective tissues

1- Many functions are attributed to connective tissues such as: connect, hold, support and protect other tissues.

2- They are formed of cells, fibers and matrix (intercellular substance).

*The cells are separated from one another, and have different types and functions.

* The fibers are collagenous, elastic and reticular. These fibers are products of cells and not cells.

*The matrix is either watery and soft (loose connective tissue), rubbery and firm (cartilage), hard and calcified (bone) or even liquid (blood)

3- The connective tissue may be vascular (loose Conn. T.), highly vascular (bone), or avascular (cartilage).

A-Connective tissue proper

Connective tissue proper is formed of many types of cell, fibers, and jelly-like ground matrix. It act as a kind of packing material between other tissues and organs.

A- Cells of connective tissues proper

The cells of connective tissue are assigned to two categories,

Fixed cells and free cells.

a- The fixed cells

- 1- They are a relatively stable population of long lived cells.
- 2- They include, fibroblast, fixed macrophages, adipose cells, mesenchymal cells, pericytes, endothelial cells and reticular cells.

b- The free cells

- 1- They are a changing population of motile cells that enter the Connective tissue from the blood and wander through its ground substance.
- 2- Most of these are short lived.
- 3- They include free macrophage, plasma cells, mast cells, pigment cells and leukocytes.

Fibroblasts

- 1- Is an elongated cell with cytoplasmic projections, an ovoid nucleus with sparse chromatin, and one or two nucleoli.
- 2- Produce fibers and ground substances that form the matrix of the tissue.
- 3- They found in the periodontal ligament.
- 4- The **fibrocyte** is a more mature, smaller spindle-shaped cell without cytoplasmic projections; the nucleus is similar but smaller than that in the fibroblast.



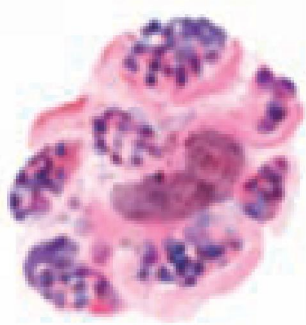
Adipocytes (Fat cells)

- 1- These cells exhibit a narrow rim of cytoplasm and a flattened, eccentric nucleus.
- 2- Store fat (lipid) and provide protective packing material in and around numerous organs.
- 3- It can be found isolated or in groups.
- 4- There are two types of adipose cells:
 - a- White adipose cell.**
 - b- Brown adipose cell.**
- 5- In histologic sections, the large fat globules of adipose cells have been dissolved by different chemicals, leaving a large empty space.



Macrophages

- 1- Most numerous in loose connective tissue.
- 2- Have irregular surface with an eccentrically located, oval or kidney shaped nucleus.
- 3- Ingest bacteria, dead cells, cell debris, and foreign matter.
- 4- Are antigen-presenting cells to lymphocytes for immunologic response.
- 5- Derived from circulating blood monocytes.
- 6- Called **Kupffer cells** in liver, **osteoclasts** in bone, and **microglia** in central nervous system.



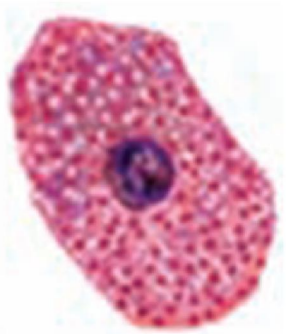
Plasma Cells

- 1- Characterized by chromatin distributed in radial pattern (clock face).
- 2- The large, ovoid cells with spherical eccentrically nuclei location.
- 3- Derived from lymphocytes exposed to antigens.
- 4- Produce antibodies to destroy specific antigens.
- 5- Plasma cells are only seen in the walls of the intestine and in inflamed tissue.



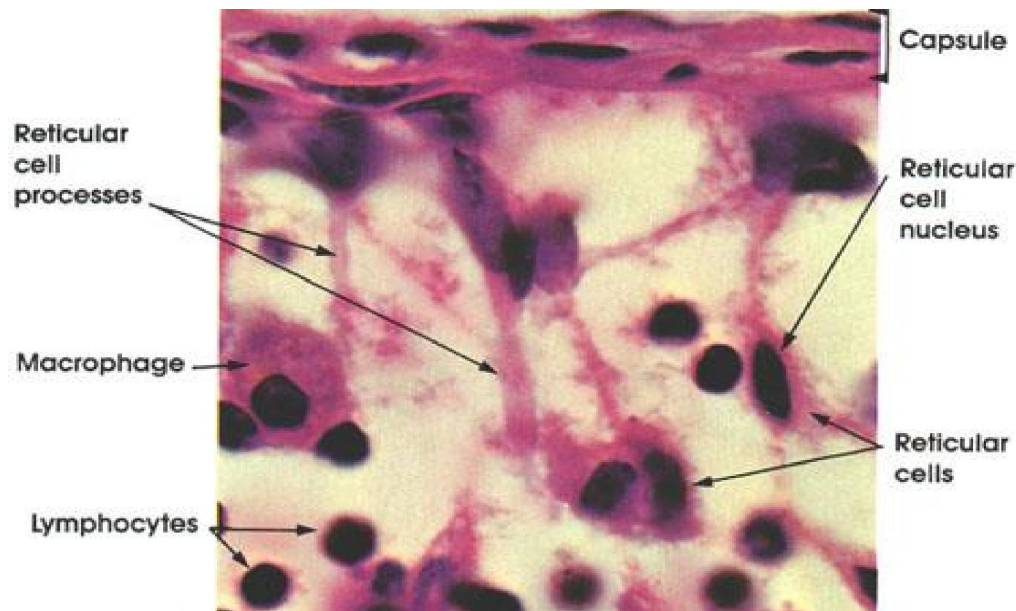
Mast Cells

- 1- Closely associated with blood vessel.
- 2- Found in skin, respiratory, and digestive system Conn. T.
- 3- Are oval or irregularly shaped cells with centrally located nuclei.
- 4- The cytoplasm is filled with regular basophilic secretory granules.
- 5- Synthesize and release histamine when exposed to allergens, causing allergic reactions.
- 6- Release heparin that act locally as an anti-coagulant.



Reticular cells

These are specialized fibroblasts, they are dispersed along the framework of the reticular fibers and ground substance with their cytoplasmic processes. (lymph node)



Melanocytes (pigment cells)

Are melanin-producing cells located in the bottom layer (the stratum basal) of the skin's epidermis.



B- Fibers of connective tissue proper(extracellular fibers)

There are three types of fibers:

White (collagen) fiber.

Yellow (elastic) fiber.

Reticular fibers.

Each type of fiber is formed by proteins made of long peptide chains

Types	Characters	Component	Location
White (collagen) fibers	They are seen as wavy bundles of various thickness.	Alpha polypeptide chain	Tendon, ligament, skin, cornea, cartilage, bone, blood vessel, gut, and intervertebral disc.
Yellow (elastic) fiber.	These are usually single thin and branched. They can be stretched.	Elastic micro fibril and elastin	Elastic ligaments, some cartilage (elastic cartilage) and large arteries (elastic arteries).
Reticular fibers	They are arranged in a mesh-like pattern form a delicate supporting network around cells.	Type III collagen	Liver, bone marrow, lymphatic organs.

C- Ground matrix of connective tissue proper

1- The ground substance is found between the different types of cells and fibers.

2- It allows the diffusion of tissue fluid, nutrients and waste products, between blood and lymphatic capillaries and the cells.

3- The ground substance is formed of acid mucopolysaccharide.

Fibroblasts are responsible for the formation of this matrix.

Classification of connective tissues

A- Embryonic connective tissues.

1- Mesenchymal connective tissues.

2- Mucous connective tissues.

B- Connective tissue proper

C- Specialized connective tissues.

B- Connective tissue proper.

According to the density of ground substance and to the main cells and fibers found, connective tissue proper is classified into:

1- Loose connective tissue.

a- Areolar connective tissue.

b- Reticular connective tissues.

c- Adipose connective tissues.

2- Dense connective tissue.

a- Dense irregular connective tissues.

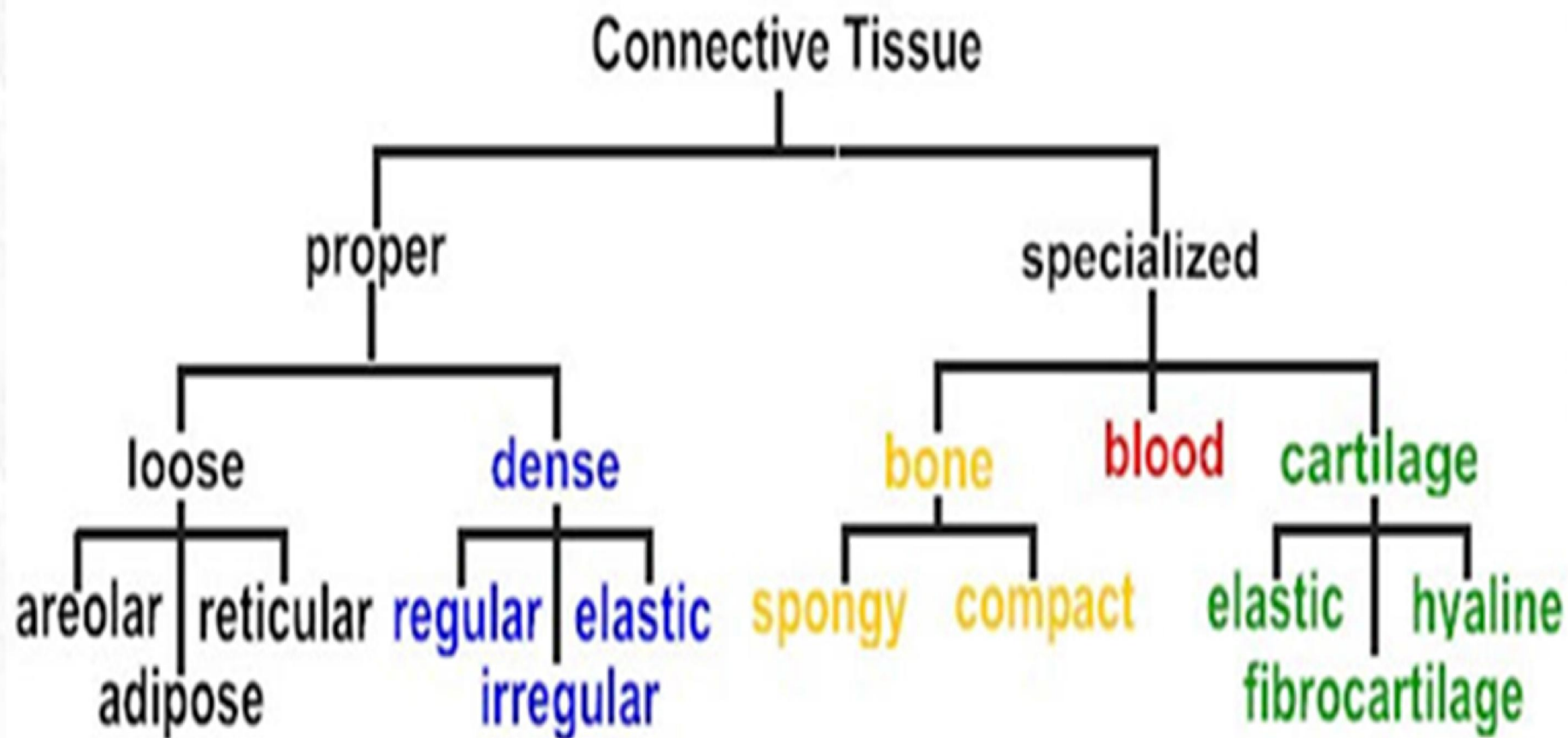
b- Dense regular connective tissues.

1- Collagenous. 2- Elastic.

- **C- Specialized connective tissues.**
- **Cartilage.**
- **Bone.**
- **Blood.**
- **Hemopoietic.**

TISSUES:

Connective Tissues



- **Loose connective tissues (areolar)**

- **1- It is the packing and anchoring material and the embedding medium of many structures, including nerves and blood as well as lymphatic vessels.**
- **2- It binds other tissues, organ components, and organs together.**
- **3- It is consist of a meshwork of collagen, elastic, and reticular fibers.**
- **4- Fibroblast, plasma cells, adipocytes, mast cells and macrophages are embedded within the areolar connective tissue.**
- **5- It is found in the papillary layer of the dermis and in the hypodermis.**

1 Mast cell

2 Fibroblasts

3 Collagen fibers

4 Plasma cell

5 Elastic fibers

6 Small lymphocyte

7 Capillary with erythrocytes

8 Large lymphocyte

9 Mast cell

10 Elastic fibers

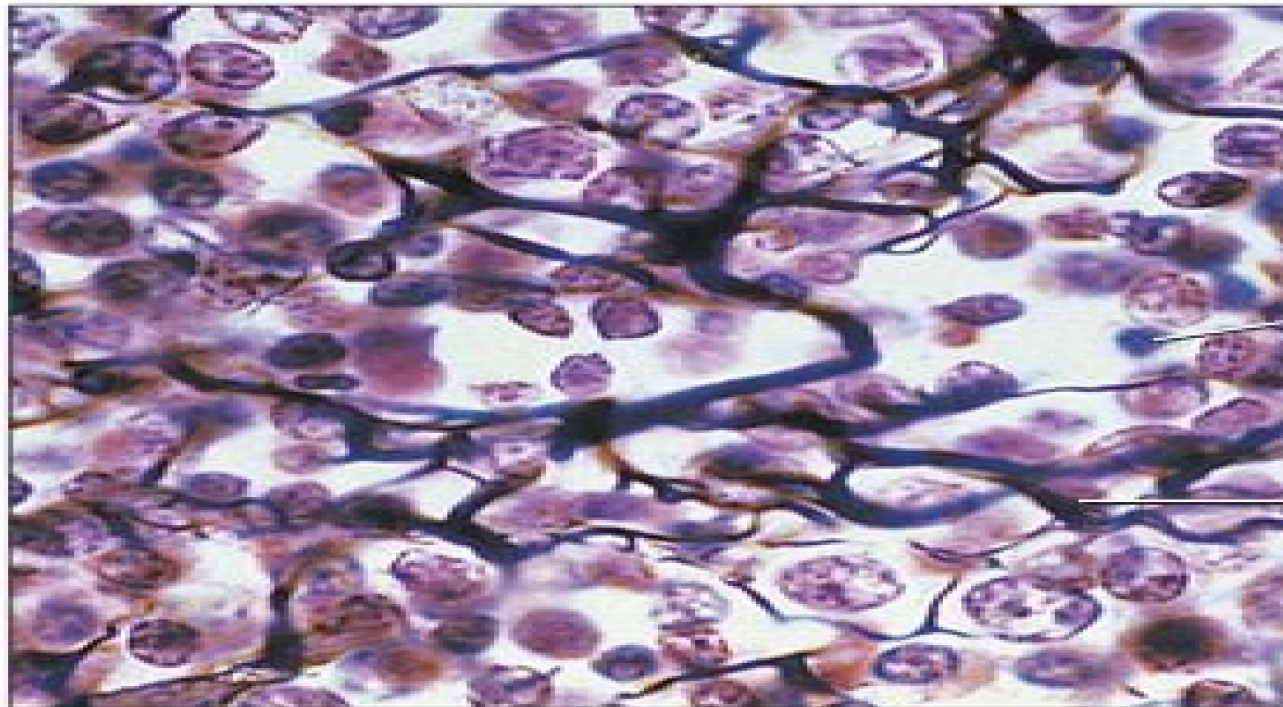
11 Plasma cells

12 Macrophage with ingested particles



- **Reticular connective tissues**

- 1- it is a primitive type of connective tissue that is characterized by the presence of a network of reticular fibers associated with primitive reticular cells (mesenchymal like cells).
- 2- It is form the framework of solid organs e.g., lymphoid organs , bone marrow and liver.



White blood cell
(lymphocyte)

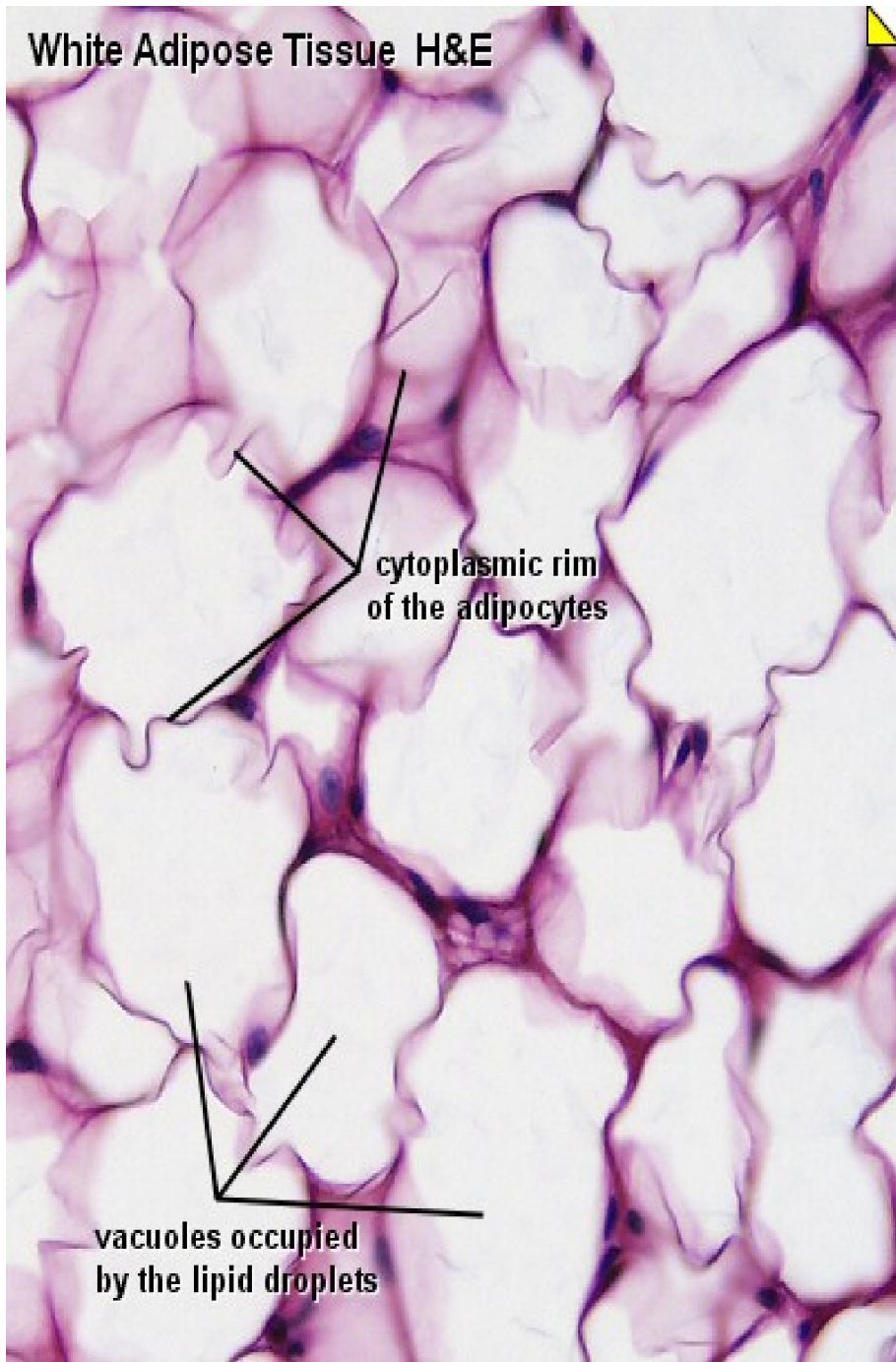
Reticular
fibers

- **Adipose connective tissues**

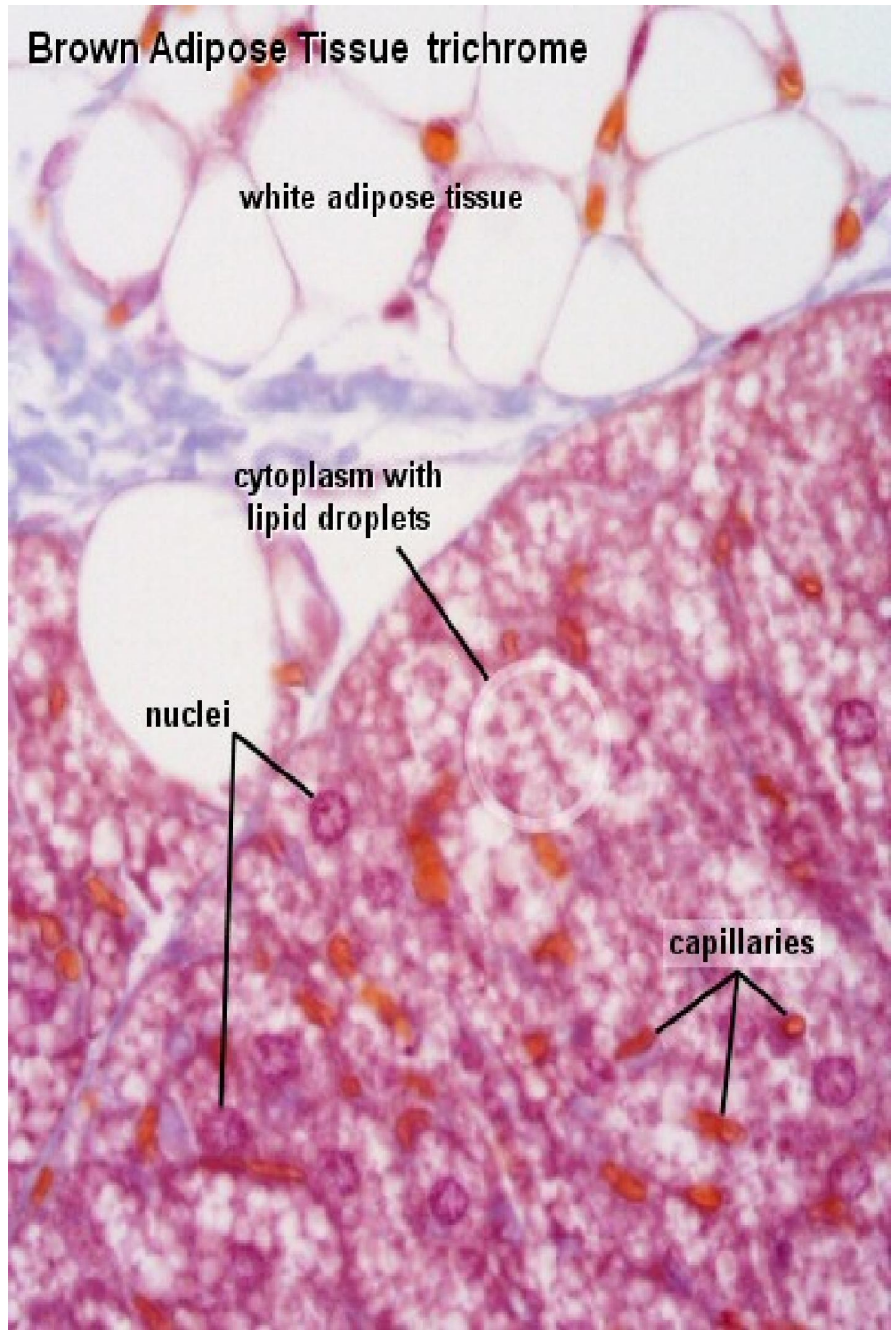
- 1- According to the vascularity and the function, there are two types of adipose connective, white and brown.
- 2- White adipose connective tissue **A-** represents the primary site of fat metabolism and storage in the body. **B-** Is composed of unilocular fat cell. **C-** This tissue have a rich blood supply. **D-** It is found in the subcutaneous layers throughout the body.
- 3- Brown adipose connective tissue **A-** plays an important role to provide heat. **B.** It is composed of multilocular fat cells. **C-** The tissue appear reddish brown because of its abundant mitochondria and large numbers of blood capillaries. **D-** - It is present in small amount in adult and in large amount in fetuses and neonates and then it is gradually replaced by white fat

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White Adipose Tissue H&E



Brown Adipose Tissue trichrome



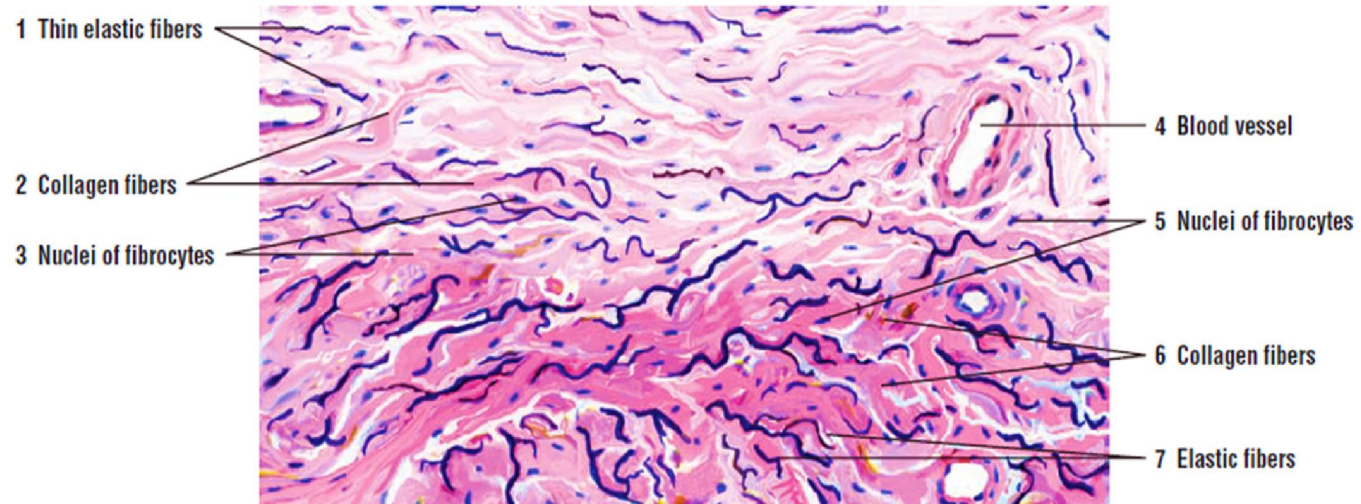
- **Dense connective tissue**

- Dense connective tissue is characterized by
- 1- The close packing of their fibers, few cells (fibroblasts and fibrocytes) and only small amount of intercellular material.
- 2- There are two types of dense Connective tissue:

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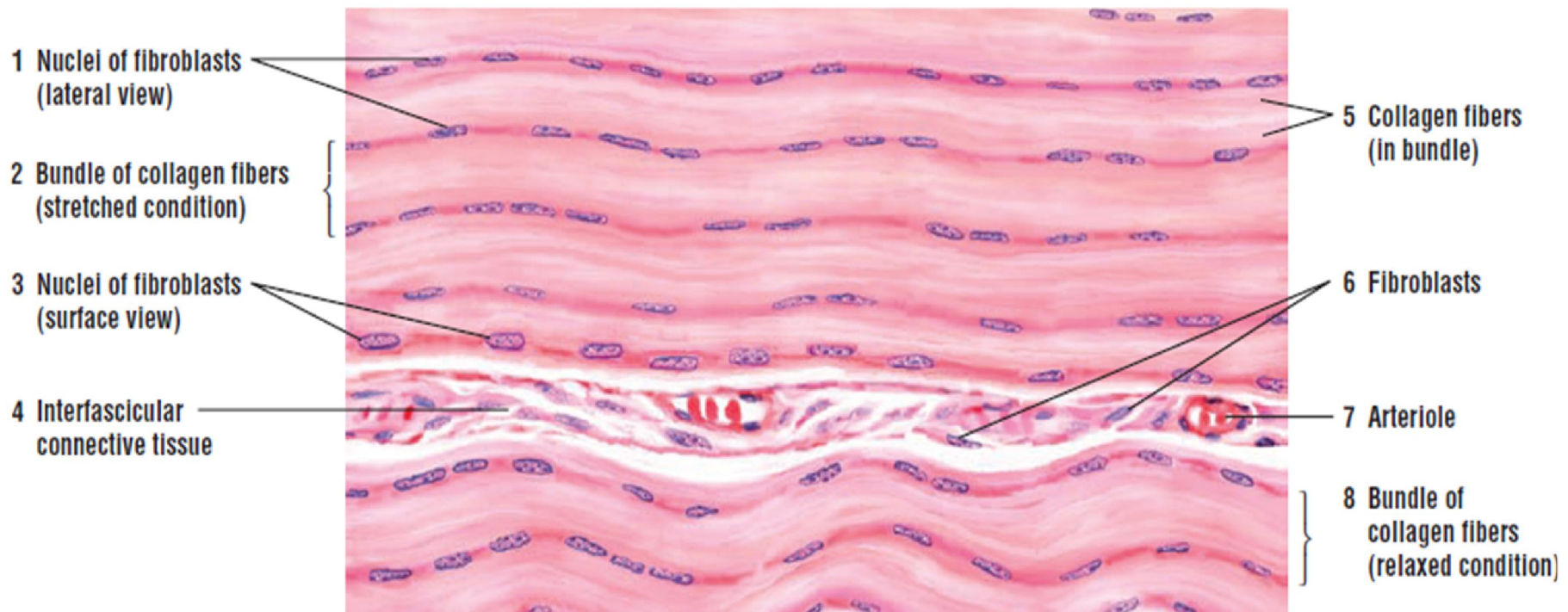
- **A- Dense Irregular Connective Tissue**

- • Consists primarily of fibroblasts, and thick and densely packed collagen fibers.
- • Fewer other cell types and minimal ground substance.
- • Collagen fibers exhibit random orientation and provide strong tissue support.
- • Concentrated in areas where resistance to forces from different
- directions is needed. (e.g., dermis of skin, in capsules of different organs, and in areas that need strong support).

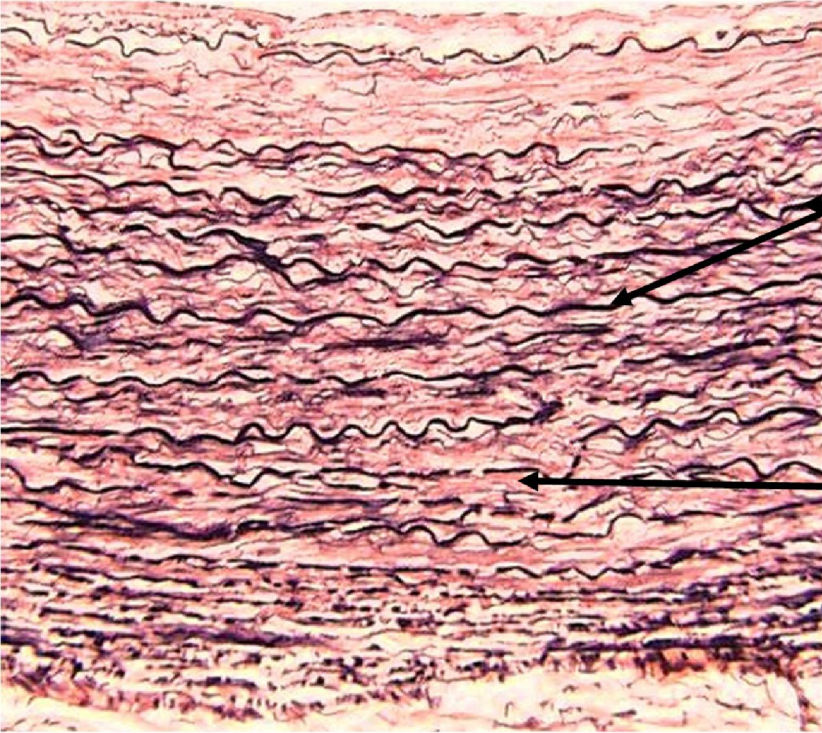


- **B- Dense Regular Connective Tissue**

- **1-• Fibers densely packed with regular, parallel orientation.**
- **• Present in tendons and ligaments that are attached to bones.**
- **• Great resistance to forces pulling along single axis or direction.**
- **• Minimal ground substance; predominant cell is fibroblast.**



- 2- According to the type of fibers, dense regular connective tissue can be divided into:
 - **White collagenous connective tissue.**
 - **Yellow elastic connective tissue.**
- Both of these types can be arranged in two ways - ***a: cord arrangement b: sheet arrangement.***
- 4- In cord arrangement, bundles of collagen and matrix are distributed in regular alternate patterns.
- 5- In sheet arrangement, collagen bundles and matrix are distributed in irregular patterns, sometimes it is found in the form of a network.
- 6-It is similar to areolar tissue but in areolar tissue, elastic fibers are completely absent.



Elastic fibers

White fibers

- **C- specialized connective tissue**

- **1- Cartilages**

- Cartilage is a specialized connective tissue in which intercellular substance is hardened to provide rigidity, support and attachment for the tissues.
- The cartilage is firm, flexible and strong connective tissue.
- The cartilage is formed of
- **a- cells, b- fibers c- intercellular substance (matrix).**

- **a- Cells**

- **1- Chondroblast**

- They are cartilage forming cells.

- **2- Chondrocytes**

- They are embedded in the matrix inside space called lacunae.
- They are responsible for the formation of collagen fibers and the protein of cartilage matrix.

- **b- Fibers**

- the collagen and elastic fibers could be found in the ground substance of cartilage.

- **c- Ground substance (matrix)**

- The intercellular substance produce by cartilage cells (chondroblast and chondrocytes)

•Types of cartilage

- According to the type of fibers embedded in the matrix, cartilage is classified into:

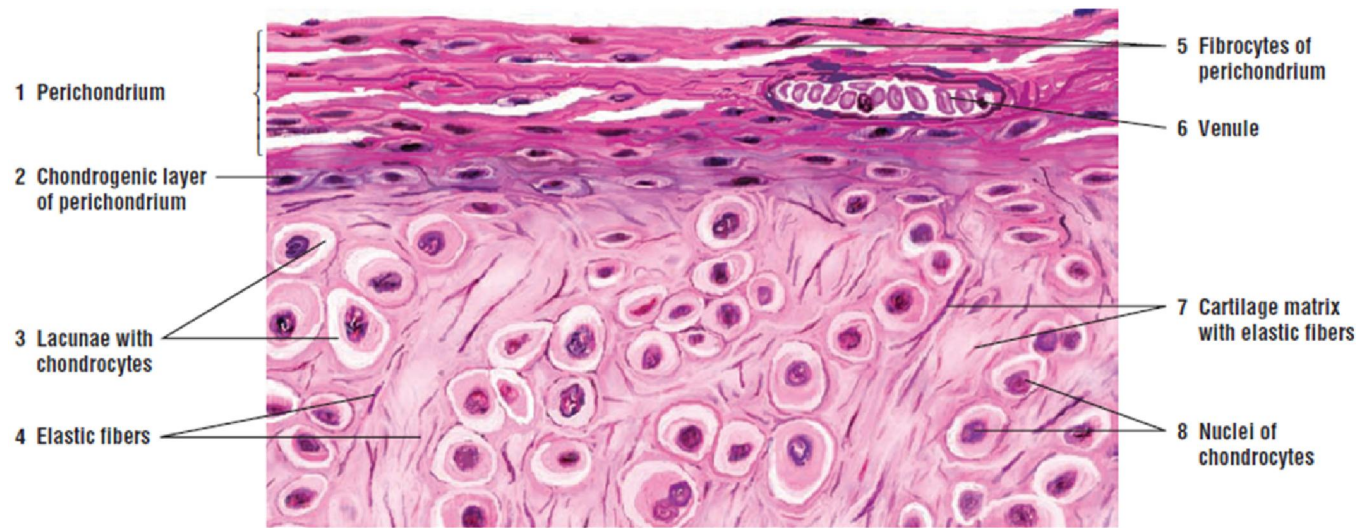
•A- Hyaline cartilage

- 1- The most common type of cartilage.
- 2- This type of cartilage is covered by a dense connective tissue called perichondrium.
- 3- The chondrocytes are seen in clusters, called isogenous groups or cell nest.
- 4- It has two layers, an outer white collagen (vascular layer) and an inner layer of chondroblast.
- 5- the matrix contains both collagen and elastic fibers.
- 6- Function and sites:
 - Development of bones.
 - Growth of bones.
 - Articulation of bones.
 - Maintains airways in respiratory passages.



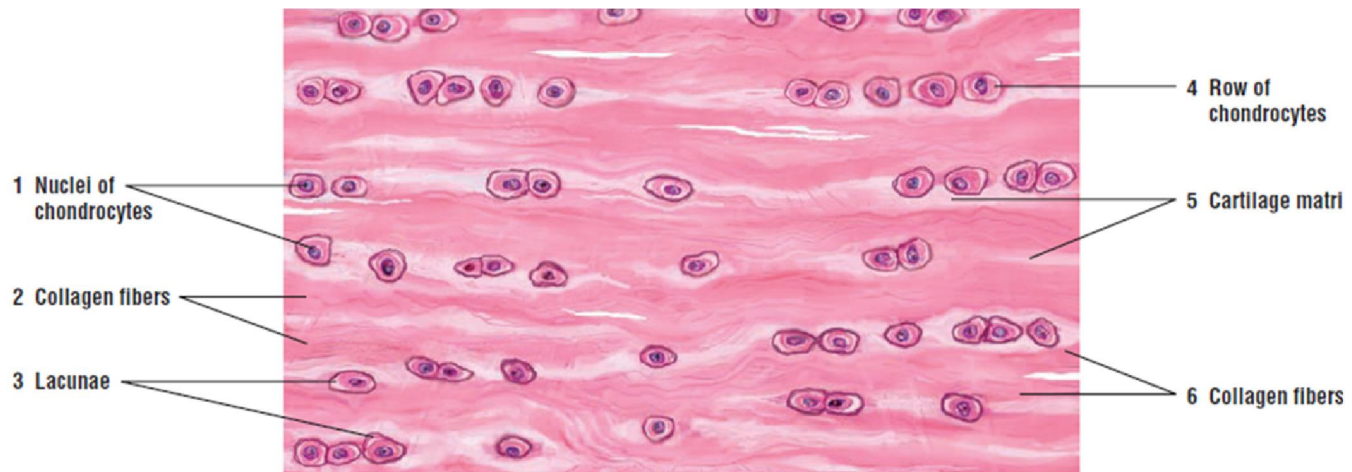
• **B- Elastic cartilage**

- 1- Elastic cartilage is covered by **perichondrium**.
- 2- It has two layers, an outer white collagen fibrous vascular layer and an inner cellular layer of chondroblast.
- 3- Matrix has many elastic fibers and few collagen type II fibers embedded in a small amount of intercellular matrix.
- 4- Chondrocytes are located inside lacunae and form cell nests.
- 5- Function and sites
- It is a very flexible type of cartilage. It can return to original shape after being deformed.
- It is found in **the a- external ear (pinna). b- Auditory (Eustachian tube). c- Epiglottis. d- Some cartilages of larynx (where recoil is needed).**



•C- Fibrocartilage

- 1- There is no perichondrium in collagenous fibrocartilage.
- 2- The intercellular matrix is full of parallel dense collagen fibers.
- 3- They appear in a regular bundles chondrocytes inside lacunae which are seen as rows between collagen fibers.
- 4- function and sites
- Fibrocartilage is strong enough to resist stretching even under extern tension.
- It attaches bone to bone and provides restricted mobility under great mechanical stress.
- It is found in intervertebral discs and pubic symphysis.



2- Bone

- Bone is a strong, hard and rigid specialized form of connective tissue.
- It is formed of matrix (ground substance and fibers) and cells.
- In most areas bone is covered by **Periosteum** (outer surface) and lined by **endosteum** (inner surface).
- There are two different types of bone structure:
 - ***Compact bone.**
 - ***Spongy or cancellous bone.**

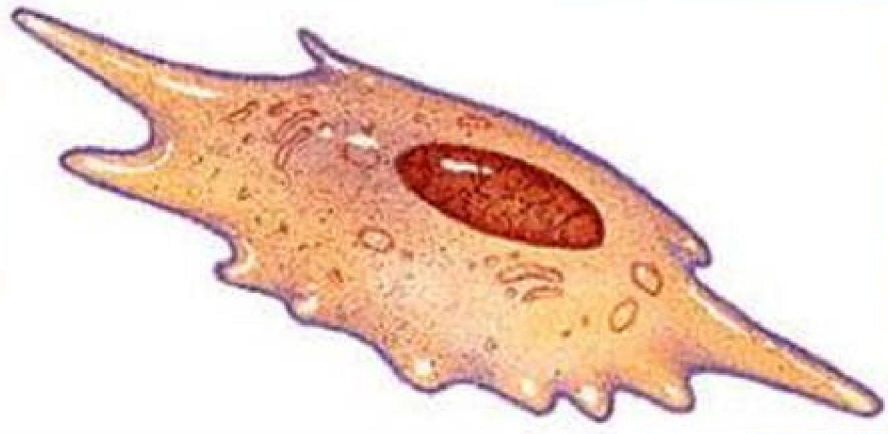
* **Matrix of bone**

- * The matrix is consist closely packed layers or lamellae of classified collagen fibers embedded in intercellular substance rich in proteins and carbohydrate.
- * Bone matrix consist of:
 - * a- Organic components or osteoid (35% of bone dry weight)
 - * It is composed of collagen fibers, protein and carbohydrates
 - * b- Inorganic components or bone minerals (65% of bone dry weight,)
 - * It is formed mainly of calcium phosphate, which is the cause of hardness of bone.
- * Bone matrix is formed and produced by osteoblast and maintained by osteocytes.

* Bone cells

* 1- Osteogenic cells

- * Osteogenic or osteoprogenitor cells are mesenchymal stem cells found in the periosteum and endosteum.
- * These cells are most active during the growth of bones but are reactivated in adult life in the repair of bone fractures.
- * These cells are the only cell of the bone that can divide.
- * They have a capacity for mitosis and further differentiation.
- * They are small oval or elongated in shape with pale cytoplasm and oval nuclei.



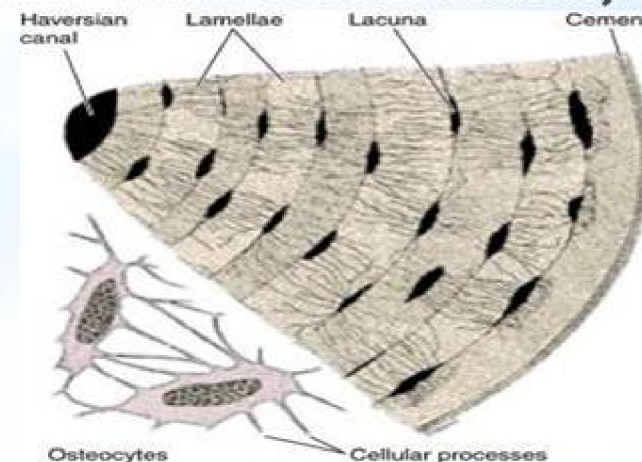
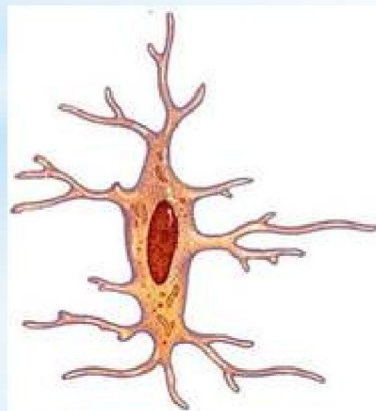
* 2- Osteoblasts:

- * They are bone forming cells, found in the growing surface of the bone.
- * They are dividing cells that synthesize the organic components of bone matrix.
- * They are large rounded branched cells, with deep basophilic cytoplasm, and eccentric nucleus.
- * They are found in the periosteum and endosteum
- * The osteoblasts secrete alkaline phosphate which stimulates deposition of calcium salts in the matrix and around the cells and their processes.



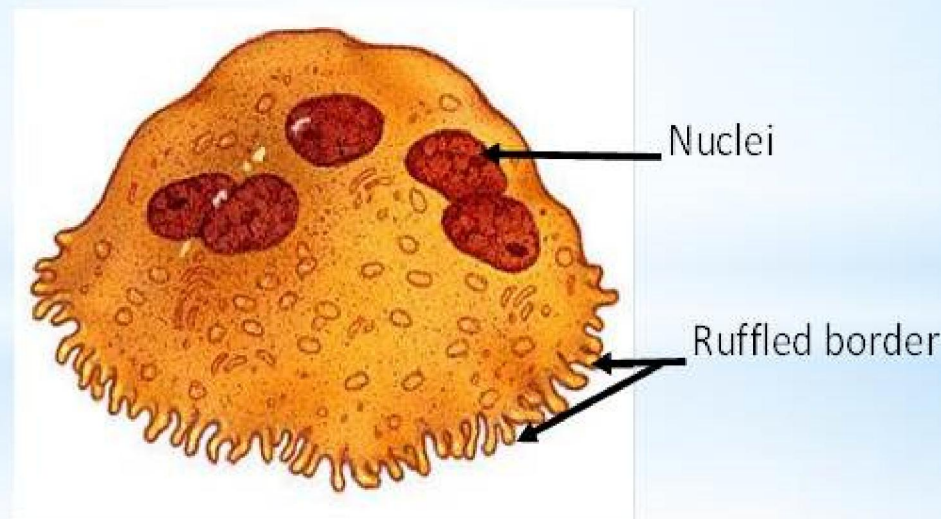
* 3- Osteocytes

- * They are the principal cells of mature bone.
- * They maintain bone matrix by sharing in the formation of the organic part of bone matrix, e.g., collagen fibers.
- * When osteoblasts embedded in hard matrix (calcified matrix) they are called **osteocytes**.
- * Osteocytes occupy small cavities called lacunae, and their processes (branches) extend into canaliculi in the hard matrix.
- * The cells are branched, smaller than osteoblasts, and not divide.



* 4- Osteoclasts

- * Osteoclasts are large multinucleated cells (~ 50 nuclei), with acidophilic cytoplasm, and brush border (Ruffled border) facing the bone marrow.
- * They are bone eating cells (resorption).
- * They are located in bony surfaces in shallow depression called HOWSHIP `S lacunae near bone marrow cavities.



* Anatomical classification of bone

* 1- Long bones

* They are found in the limbs.

* Each has two ends or "epiphyses" and shaft or "diaphysis" and "metaphysis" in between.

* 2- Irregular bones

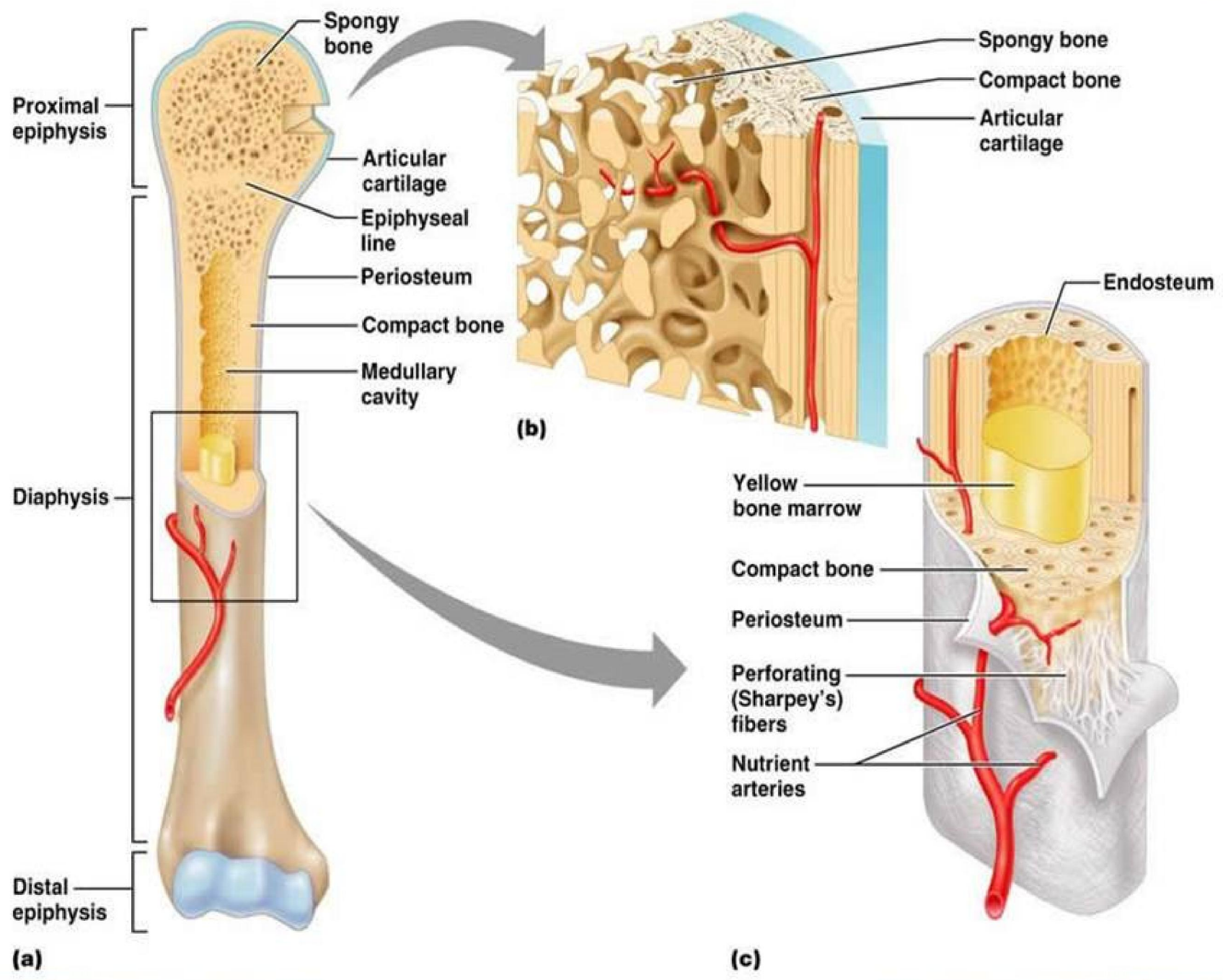
* They are found in the vertebrae.

* 3- Flat bones

* They are found in the skull and pelvis.

* **Histological classification of bone**

- * According to the arrangement of bone lamellae, bone can be classified into **compact bone** in which lamellae are regularly arranged and **spongy bone** in which lamellae are irregularly arranged.



* Compact bone

- * Compact bone is a solid mass, found mainly in the shaft of long bones.
- * Bone lamellae are regularly arranged.
- * **Periosteum** covers the shaft of long bone, and formed of two layers:-
 - * a- An outer **fibrous layer** of collagen fibers . Fibroblast, fibrocytes and blood capillaries are found in this layer.
 - * b- An inner **Osteogenic layer** of Osteogenic cells and osteoblasts.
- * **Endosteum**: a cellular layer lining the bone cavities, and formed of Osteogenic cells and osteoblasts.

* **Haversian system (osteone)**

- * 1- Bone lamellae are arranged concentrically around the blood vessels.
- * 2- The bone lamellae are formed of osteocytes inside lacunae and canaliculi embedded in calcified matrix.
- * 3- Each Haversian system consist of 5-20 lamellae that surround the central canal (**Haversian canal**) in which blood vessels and nerves are running longitudinally

* **Volkman `s Canals**

* They are transverse canals connecting blood vessels in the Haversian canals to each other and to those in the periosteum and in marrow cavities.

* **External circumferential lamellae**

* They are the bone lamellae which close to the periosteum surrounding the outer surface of the shaft of long bone.

* **Internal circumferential lamellae**

* They are the bone lamellae close to endosteum in the inner surface of bone toward bone marrow cavity.

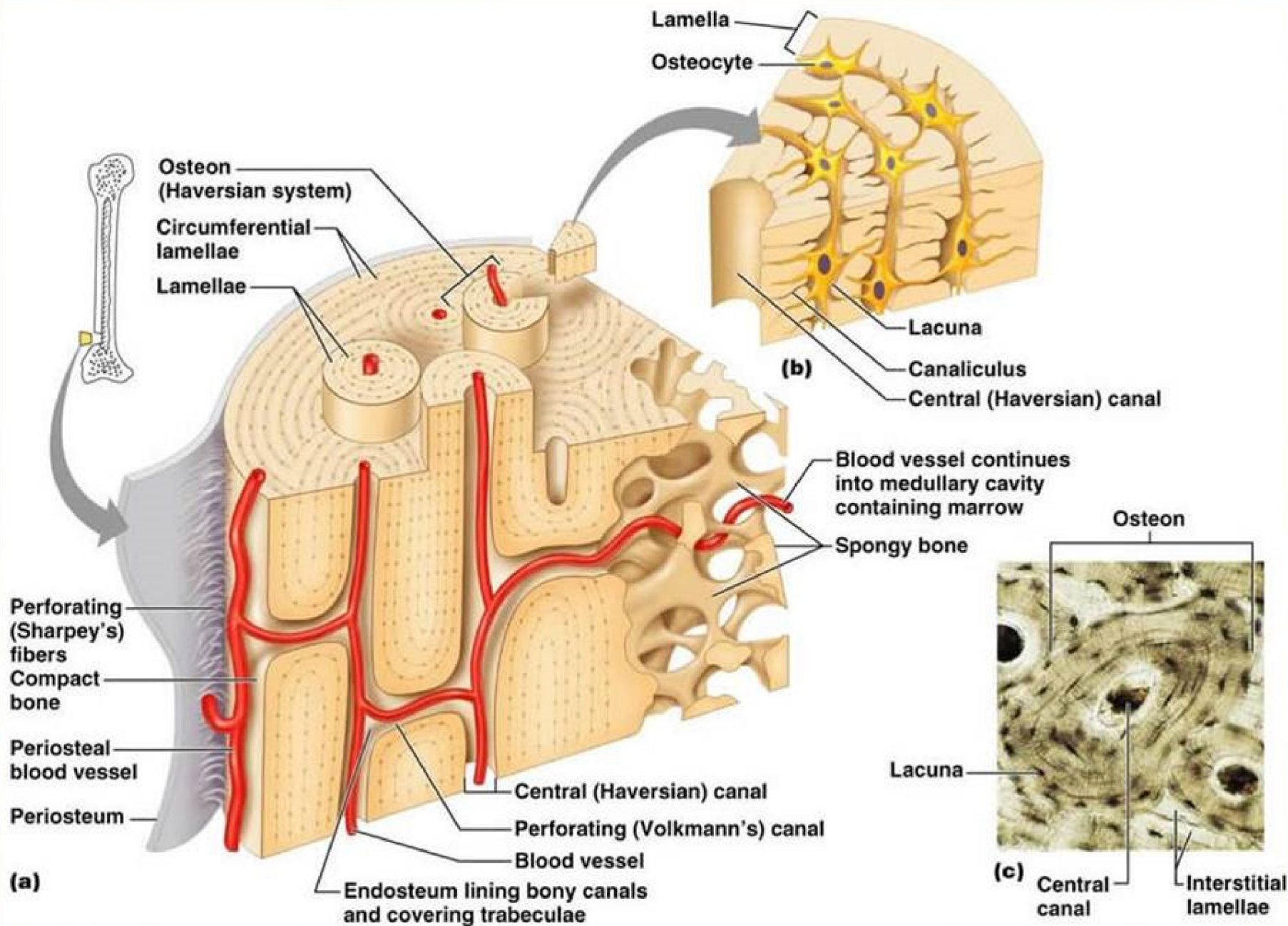
* **Interstitial lamellae**

* The irregular bone lamellae in-between Haversian system.

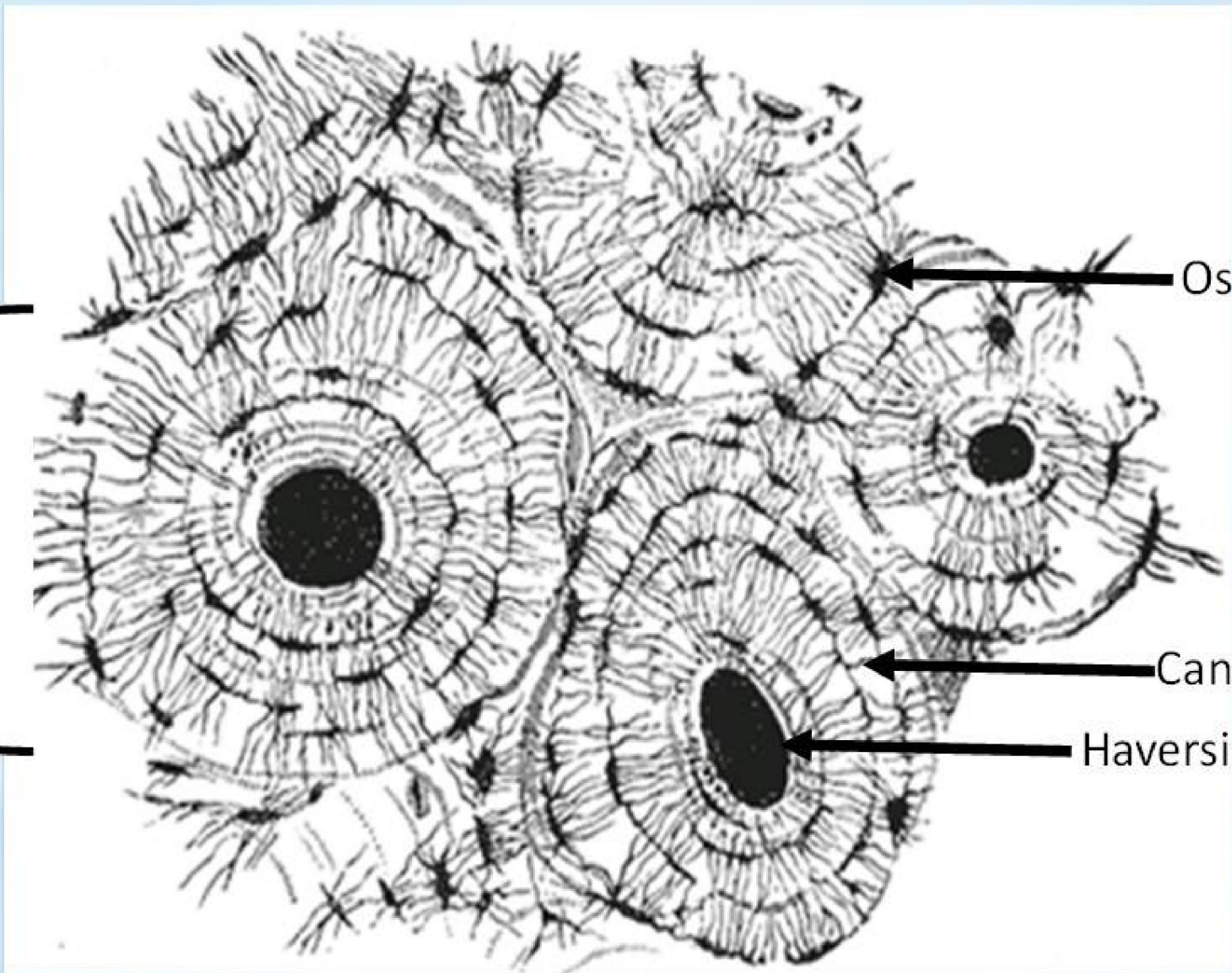
* **Sharpey`s fibers**

* 1- They are penetrating collagen fibers from outer layer of periosteum to Haversian systems.

* 2- They are found at the sites of attachment of tendons and ligaments.



Osteon



Osteocyte

Canaliculi

Haversian canal

*Spongy or cancellous bone

- *It is found at the ends of long bones and in the center of flat and irregular bones.
- *It is made up of branching Trabeculae, each of which is composed of irregularly arranged lamellae.
- *There are no Haversian systems.