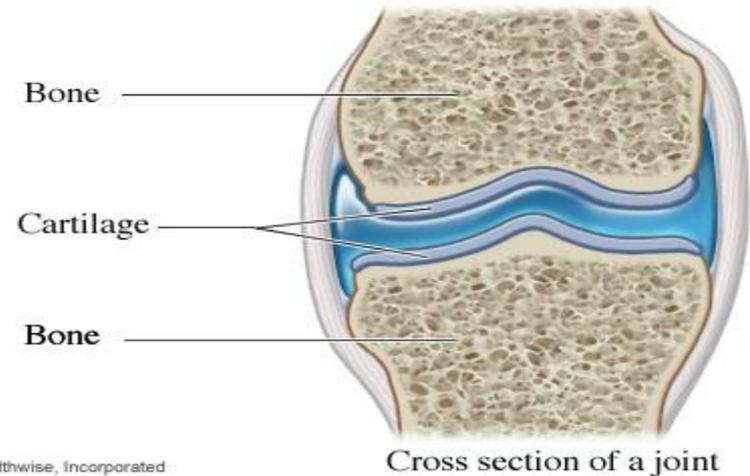


Cartilage & Bone

Ass. Prof Dr. Heba Hassan Abd El-Gawad

CARTILAGE

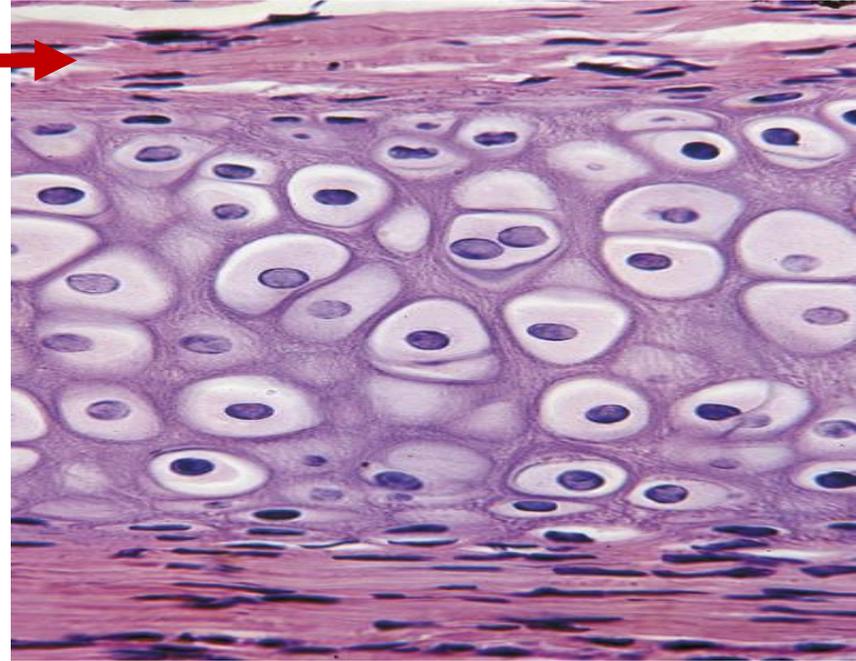
- Cartilage is a supportive type of connective tissue & has a firm consistency.
- The firm consistency of the cartilage allows the tissue to bear mechanical stresses without permanent distortion.
- Most cartilages are surrounded by a dense connective tissue called **perichondrium** except articular cartilage
- Cartilage lacks nerves, blood and lymphatic vessels and nourished by blood vessels in perichondrium.



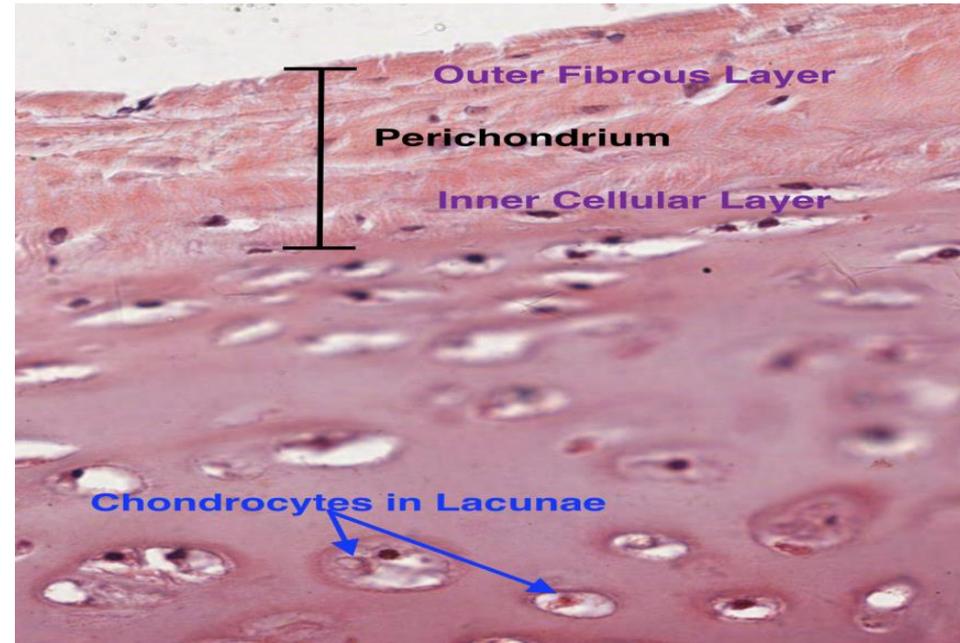
■ The perichondrium is a sheath of dense C.T formed of

- 1) outer fibrous layer
- 2) inner cellular layer

- The perichondrium consists largely of collagen type I fibers and fibroblasts.
- Among these fibroblasts in the inner layer of the perichondrium are progenitor cells for chondroblasts that divide and differentiate into chondrocytes.



- the perichondrium, is essential for the growth and maintenance of cartilage.
- Nutrients from the blood diffuse from the perichondrium to reach the deeper chondrocytes. Transport of water and solutes in the matrix is promoted by the pumping action of intermittent cartilage compression and decompression. Because of the limits of diffusion, the maximum thickness of the hyaline cartilage is limited and it usually exists as small, thin plates.



Type of Cartilage

Hyaline

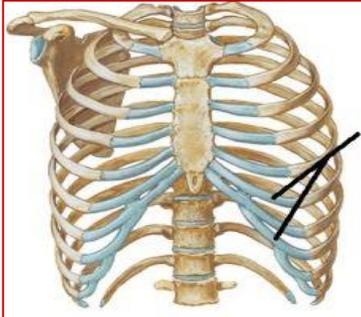
Elastic

Fibrocartilage

Articular cartilage



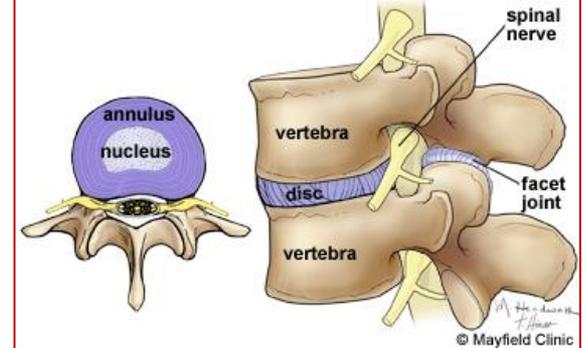
Costal cartilage



Ear pinna



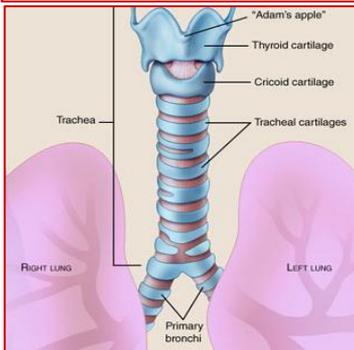
Intervertebral disc



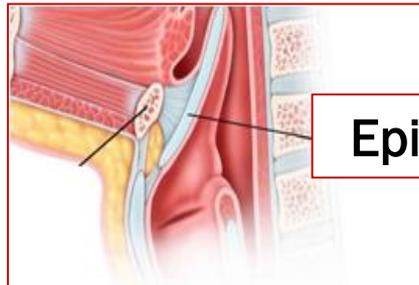
Fetal Skeleton



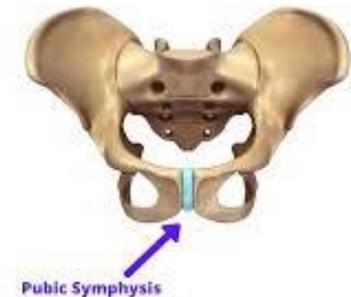
Trachea



Epiglottis



Symphysis pubis



Hyaline cartilage

- It is the most common type of cartilage in the body.
- It is covered by perichondrium.
- When fresh, it is **bluish white** and translucent.
- Site: In adults hyaline cartilage is located in the articular surfaces of movable joints, in the walls of larger respiratory passages (nose, larynx, trachea, bronchi), in the ventral ends of ribs, where they articulate with the sternum, and in the epiphyseal plates of long bones, where it makes possible longitudinal bone growth. In the embryo, hyaline cartilage forms the temporary skeleton that is gradually replaced by bone.

Hyaline Cartilage

Extracellular substances

Cells

Chondroblast

Chondrocyte

Collagen II

Amporphous ground substance (Basophilic)

Fibers

Glycosaminoglycans

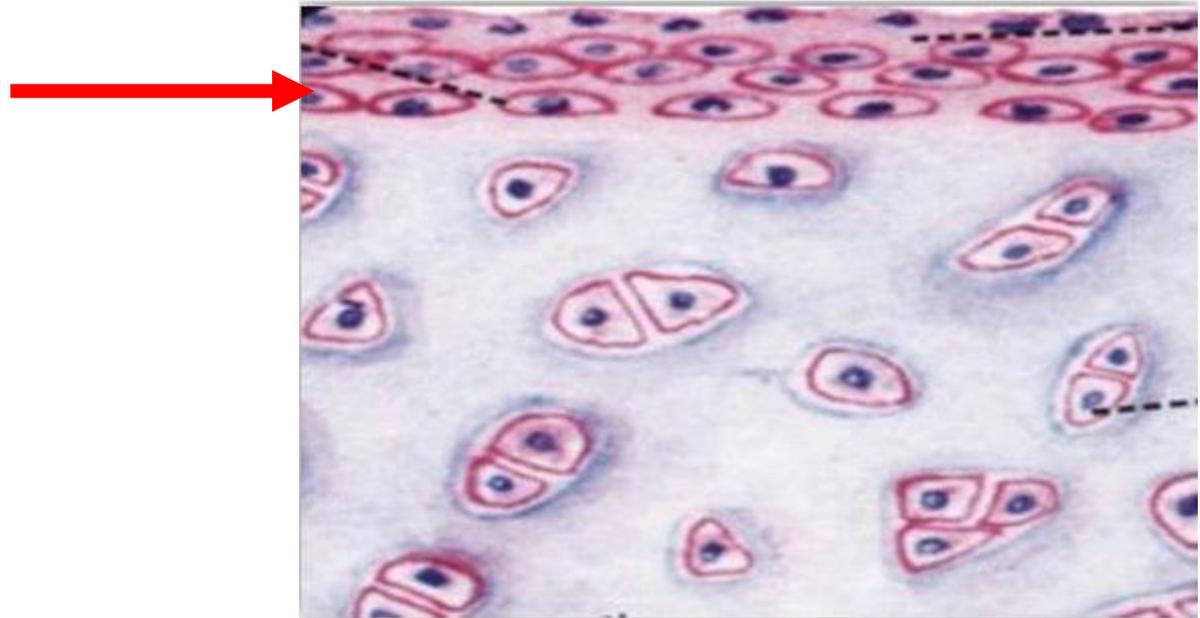
Proteoglycans

Glycoproteins

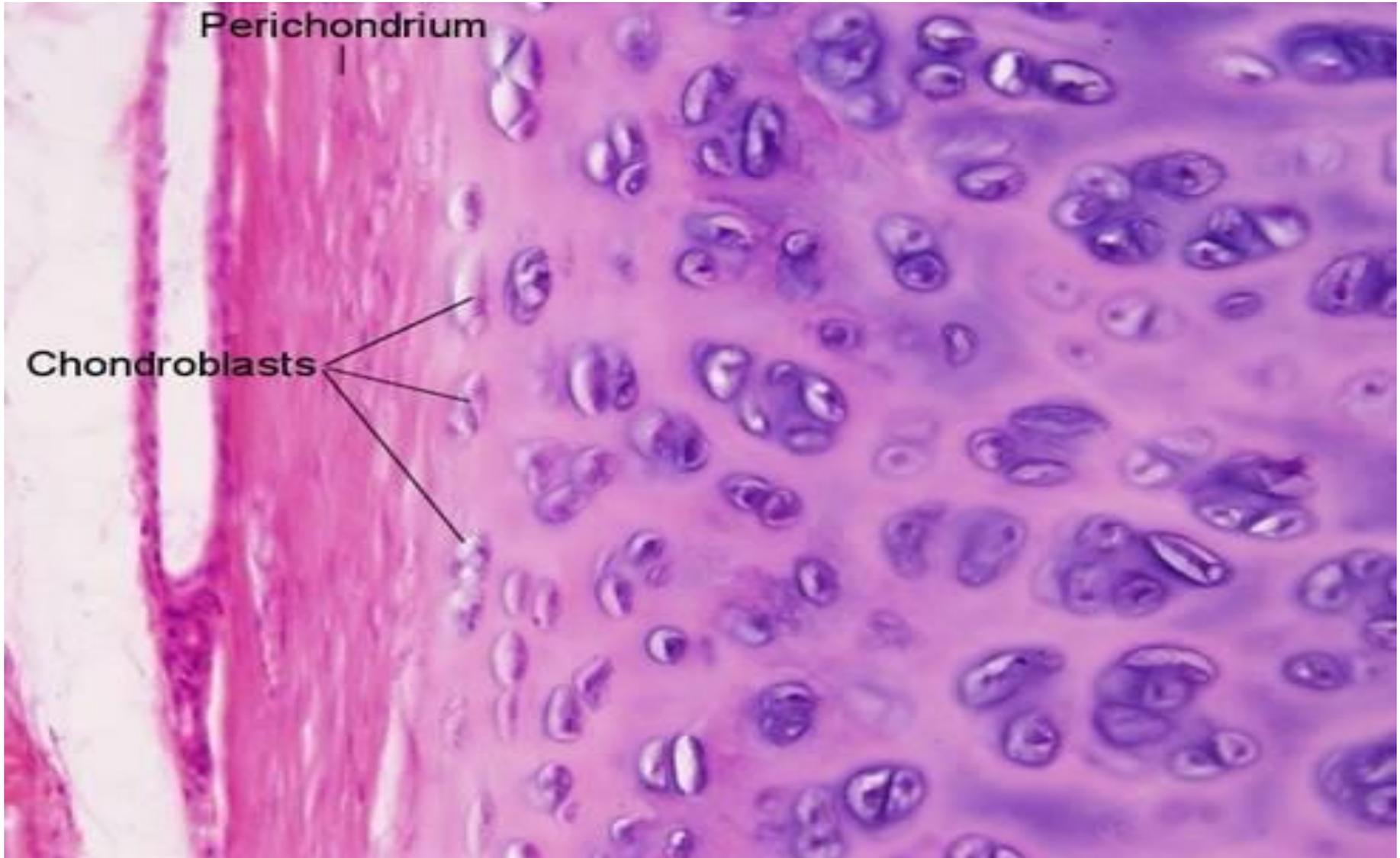
Chondroitin sulphate

a) The chondroblasts

- It is present under the perichondrium at the periphery of the cartilage called young chondrocytes or chondroblasts
 - Cells occupy relatively little of the hyaline cartilage mass.
- L.M: They are oval or spindle in shape with basophilic cytoplasm and pale nucleus with the long axis parallel to the surface.



Hyaline cartilage



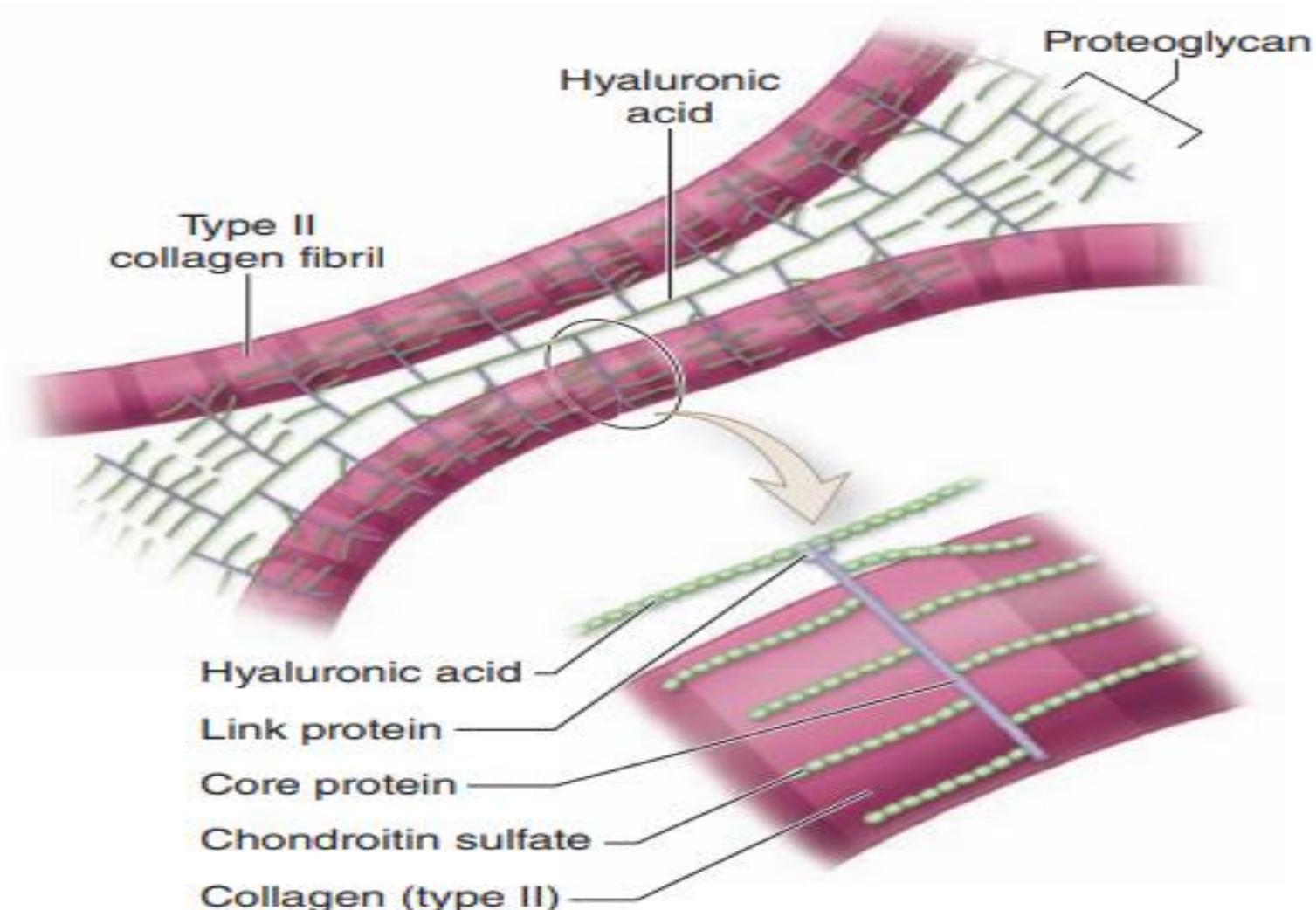
- E/M: The cytoplasm contains organelles concerned with protein synthesis e.g. RER, a well developed Golgi complex, numerous mitochondria and abundant secretory vesicles.
- Chondroblasts change into **chondrocytes** when they are trapped inside **lacunae**.
- **Function:** They synthesize proteins and fibers of the matrix.
- Synthesis of sulfated GAGs and secretion of proteoglycans are accelerated by many hormones and growth factors. A major regulator of hyaline cartilage growth is pituitary derived growth hormone or somatotropin. This hormone acts indirectly, promoting the endocrine release from the liver of insulin-like growth factors, or somatomedins, which directly stimulates proliferation of cartilage.

b) The chondrocytes

- It is present within spaces called **lacunae** either single or in-groups (up to 8 cells in the same lacuna) called **cell nest** that originate from mitotic divisions of a single chondrocyte and are called isogenous aggregates.
- The lacunae are surrounded by rigid intercellular substance formed of fibers and matrix.
- Their cytoplasm is less basophilic, and their nuclei are deeply stained.
- They are less active than chondroblasts



Matrix (Extracellular substances)



a

Matrix (Extracellular substances)

1-Ground substance which contains:-

-**Aggrecan** is the most abundant proteoglycan of hyaline cartilage.

It is composed of protein core with side chains of (GAG) chondroitin sulfate and keratan sulfate.

-Hundreds of these proteoglycans are bound by link proteins to long polymers of hyaluronic acid. These proteoglycan complexes bind further to the surface of type II collagen fibrils.

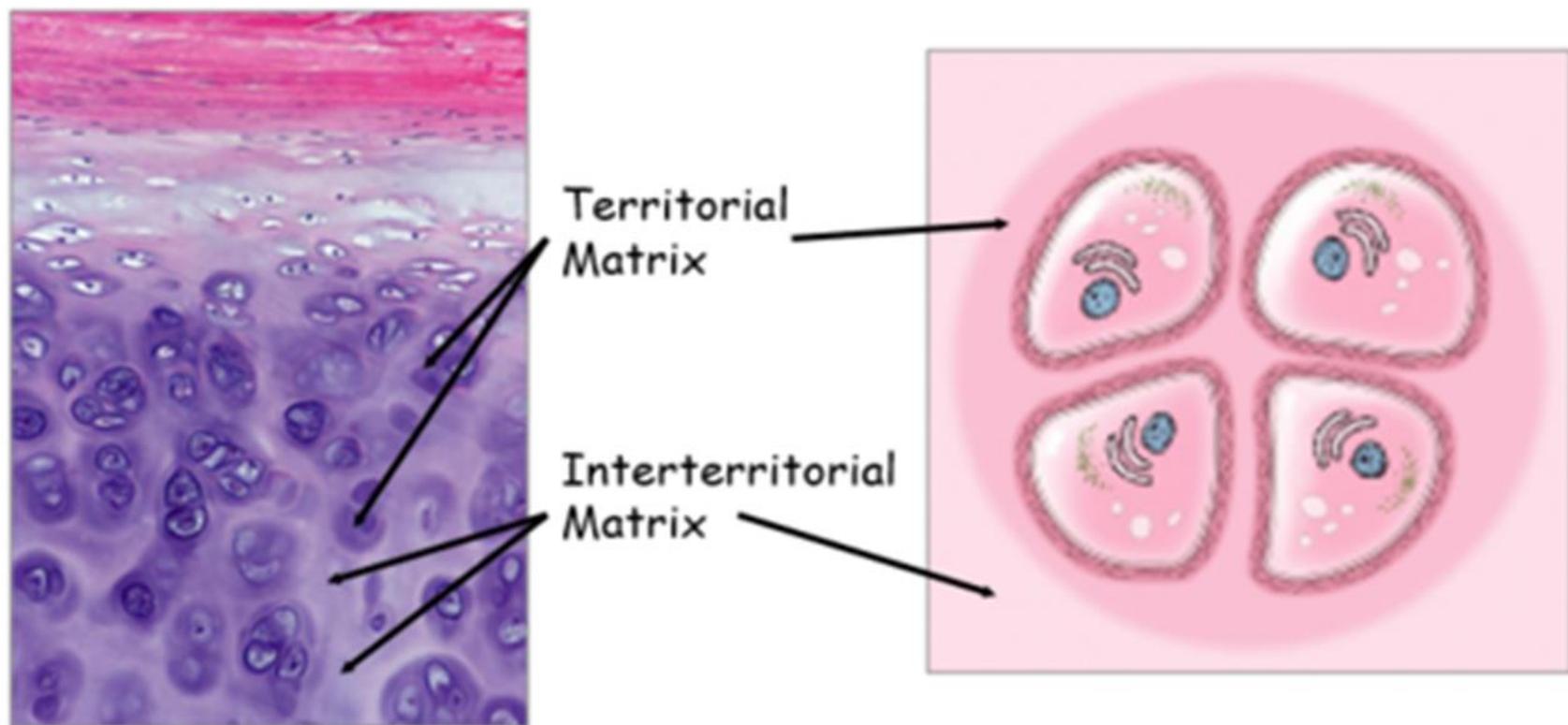
-**Glycoprotein:** chondronectin binds specifically to GAGs, collagen type II, and integrins, mediating the adherence of chondrocytes to the ECM.

2- Type II collagen fibrils:

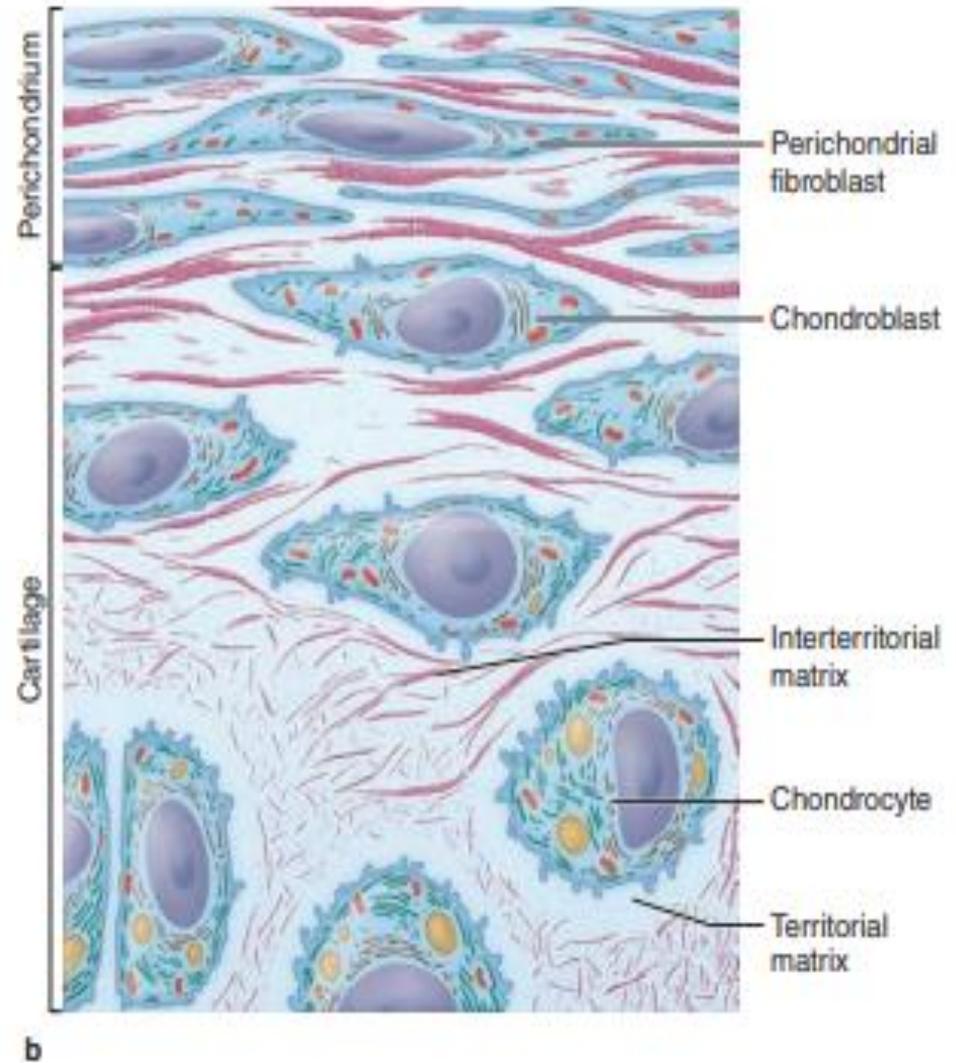
- The dry weight of hyaline cartilage is 40% collagen embedded in a firm, hydrated gel of proteoglycans and glycoproteins.
- Collagen fibrils cannot be seen with L/M because
 - A- The refractive index of the collagen fibrils and the ground substance is the same.
 - B- Type II collagen does not form bundles.
- The matrix is basophilic, PAS +ve and can be stained metachromatic with toluidine blue stain.

Territorial and Interterritorial Matrix

(Ross, Figs. 7.4; 7.7, pgs. 201 ; 203)



- Staining variations within the matrix reflect local differences in its molecular composition.
- Immediately surrounding each chondrocyte, the ECM is relatively richer in GAGs, often causing these areas of **territorial matrix** to stain differently (more basophilic) from the intervening areas of **interterritorial matrix** (Collagen is more abundant in the interterritorial parts of the matrix)



Growth & Repair of hyaline cartilage

Cartilage is capable of two kinds of growth:

1- **Appositional growth:** It is the process that forms new cartilage from outside by proliferation of progenitor cells present in the perichondrium.

2- **Interstitial growth:** The process that forms new cartilage within the cartilage. The new cartilage cells arise from pre-existing chondroblasts within the substance of the cartilage.

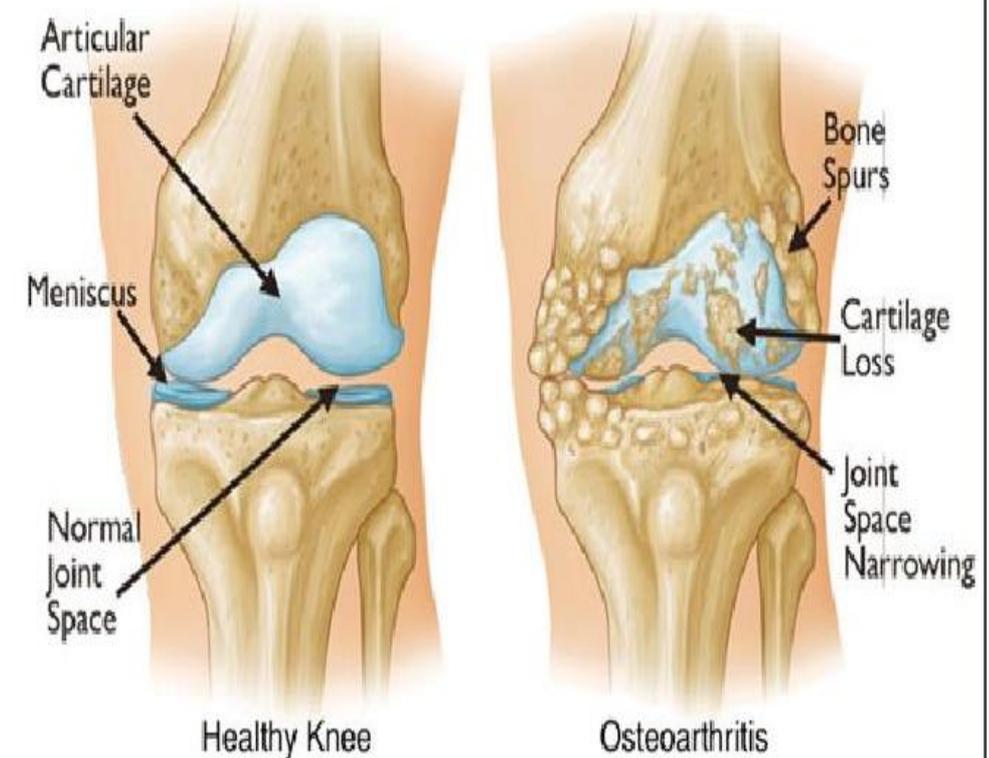
❖ In extensively damaged areas the perichondrium produces a scar of dense connective tissue instead of forming new cartilage. The poor capacity of cartilage for repair or regeneration is due to the avascularity of this tissue.

❖ Calcification of the hyaline matrix, accompanied by degenerative changes in the chondrocytes, is a common part of the aging process.

Articular Cartilage

- Specialised form of hyaline cartilage covers articulating ends of the bones for:

- Lubrication
- slightly compressible
- exhibit very little friction.

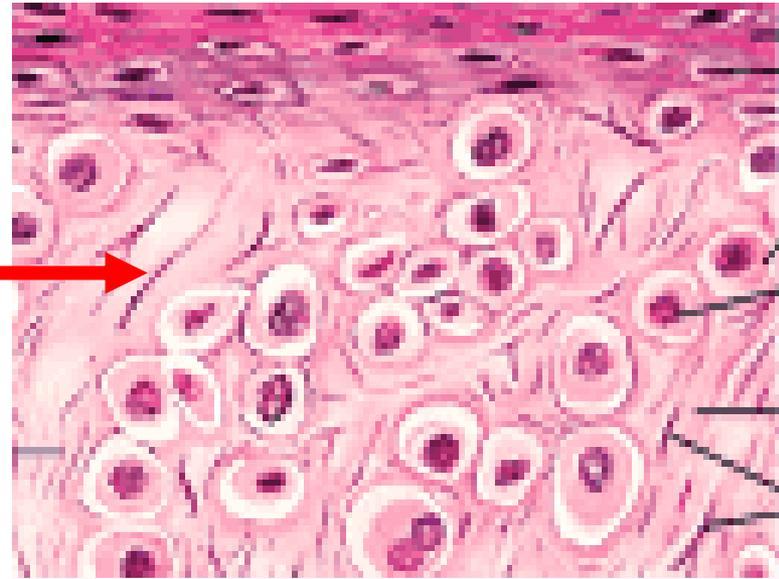


N.B: Articular cartilage lacks perichondrium and is sustained by the diffusion of oxygen and nutrients from the synovial fluid.

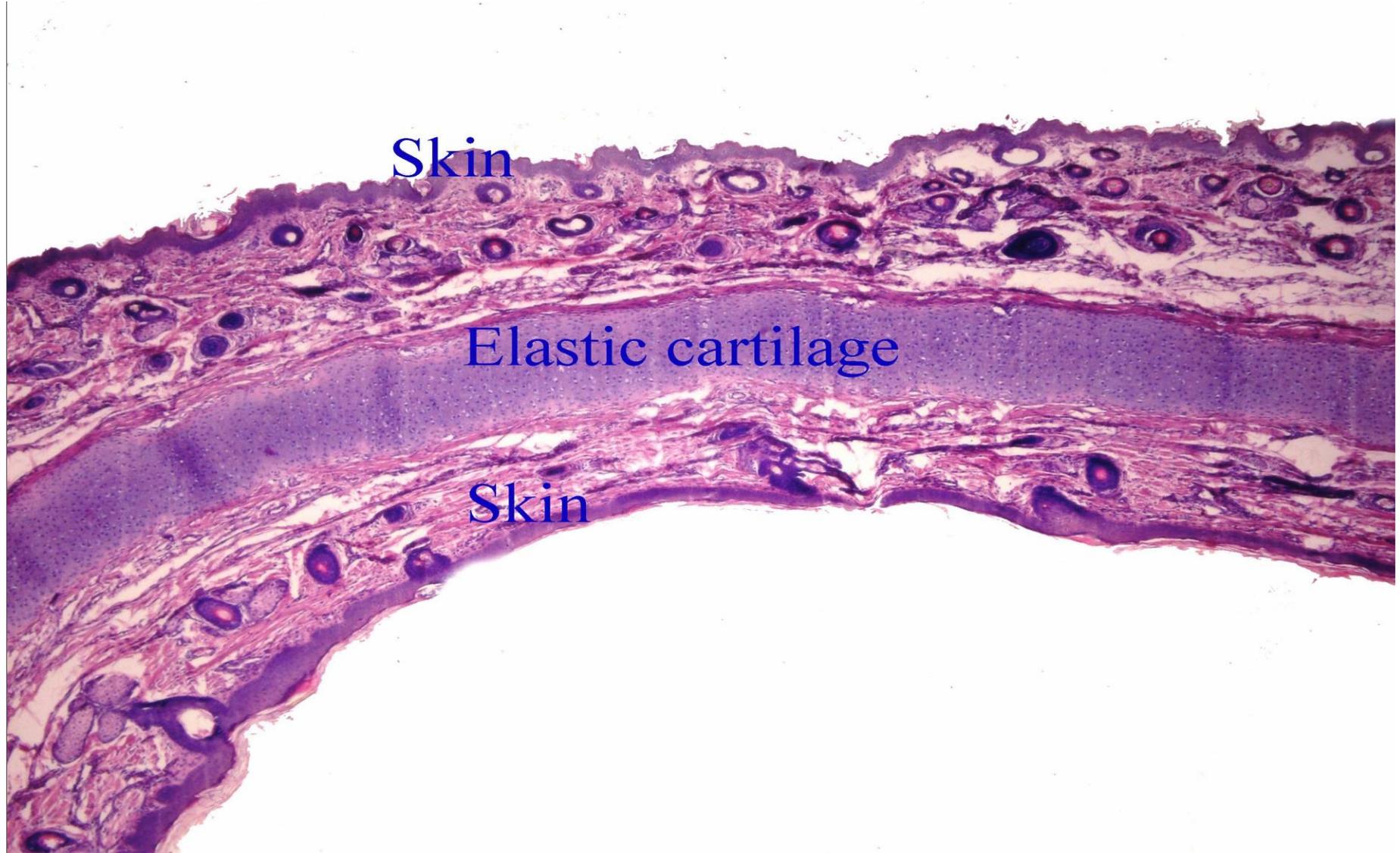
- **Osteoarthritis**, a chronic condition that commonly occurs during aging, involves the gradual loss or changed physical properties of the hyaline cartilage that lines the articular ends of bones in joints.
- Joints that are weight bearing (knees, hips) or heavily used (wrist, fingers) are most prone to cartilage degeneration. Fragments released by wear-and-tear to the articular cartilage trigger secretion of matrix metalloproteinases and other factors from macrophages in adjacent tissues, which exacerbate damage and cause pain and inflammation within the joint
- Injured cartilage is very slow and ineffective, due in part to the tissue's avascularity and low metabolic rate .

Elastic cartilage

- It is identical to hyaline cartilage except that its matrix contains abundant network of elastic fibers in addition to collagen II fibers.
- Elastic fibers give fresh elastic cartilage a yellowish color
- Site: the ear pinna, external & internal auditory tubes, epiglottis and larynx.

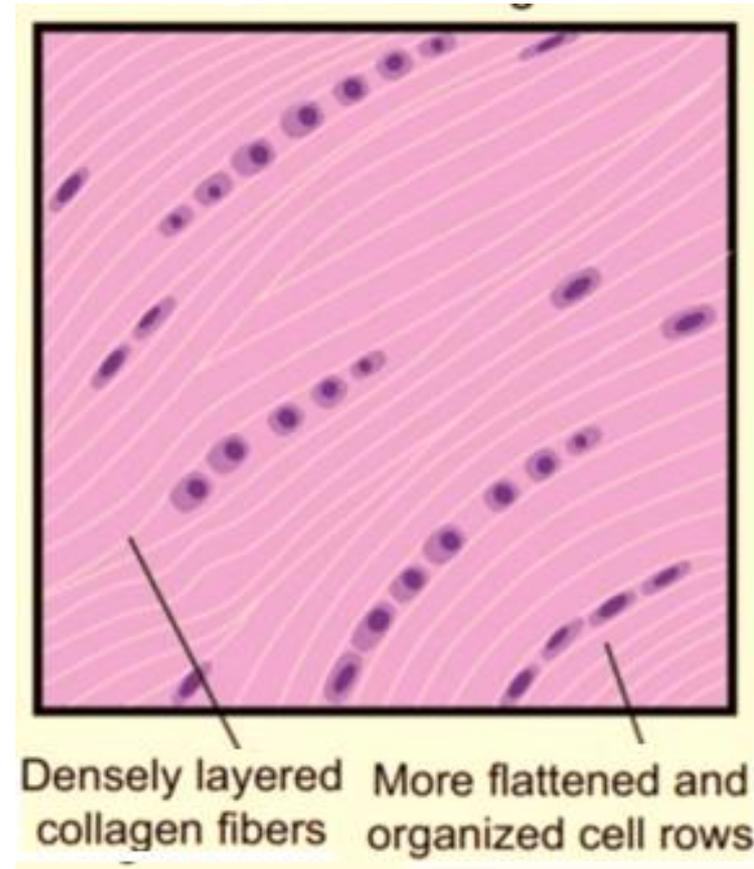


Elastic cartilage



Fibrocartilage

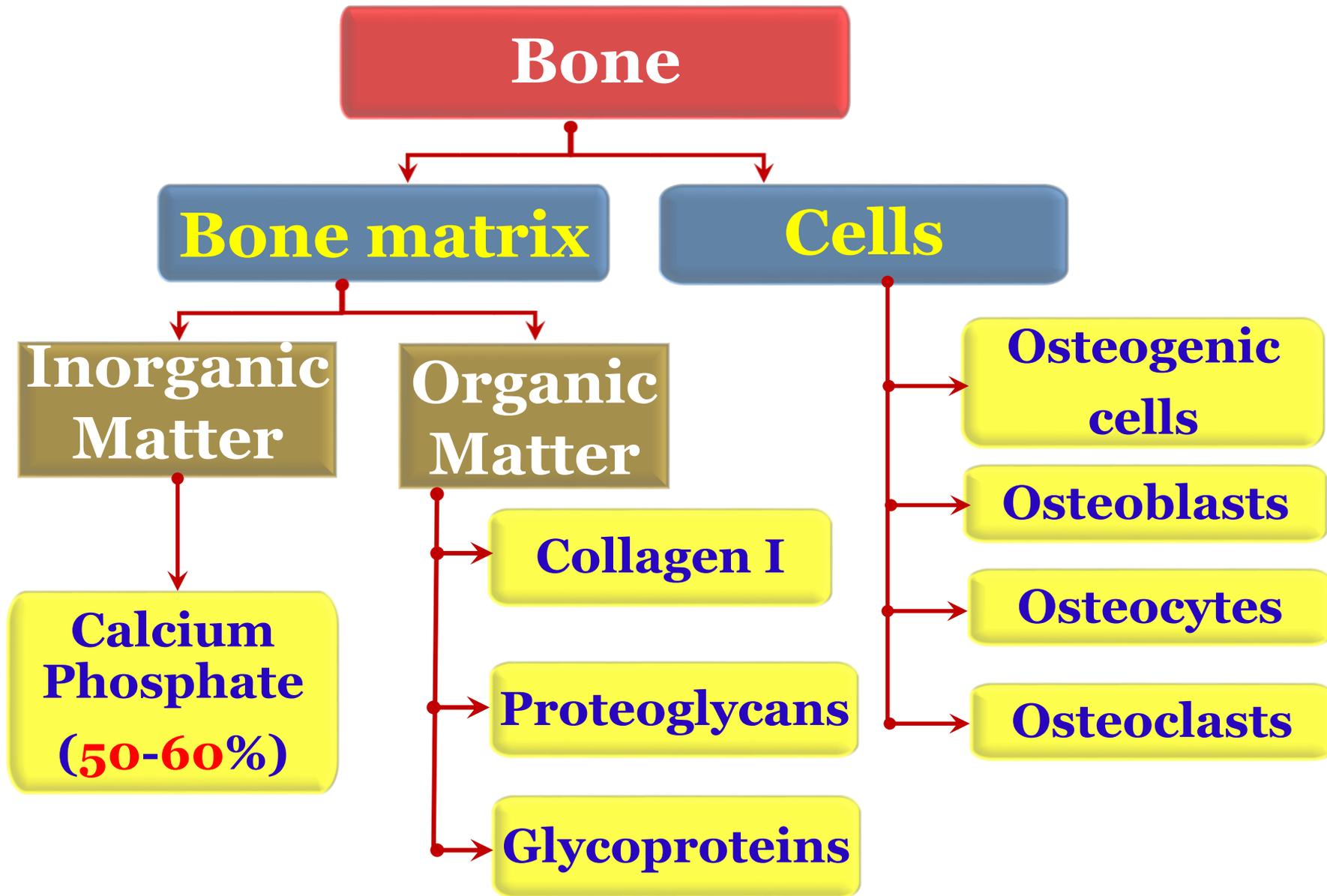
- It has no perichondrium
- Site: intervertebral discs, symphysis pubis,
- It is a combination of hyaline cartilage and dense connective tissue with gradual transitions between these tissues
- The chondrocytes inside lacunae are usually present in rows surrounded by **collagen I** bundles in great amount that give **acidophilia** to matrix.



Bone

Bone

- It is a specialized connective tissue whose extracellular matrix is calcified.
- It is covered from outside by **periosteum** (outer fibrous layer and inner cellular layer).
- It is lined from inside by **endosteum** (cellular layer).
- Bone cells and collagen fibers are arranged in **lamellae**.



Bone cells

(a) Osteogenic cell

Stem cell



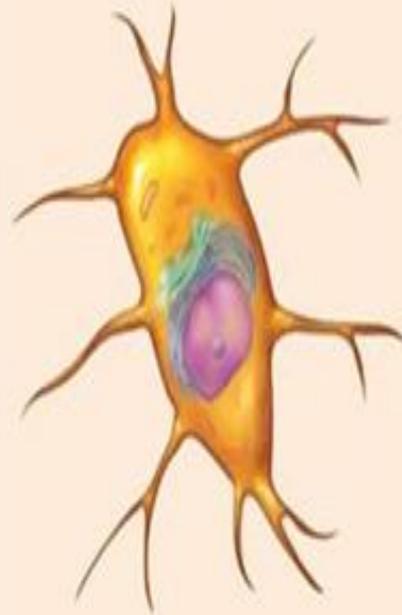
(b) Osteoblast

Matrix-synthesizing cell responsible for bone growth



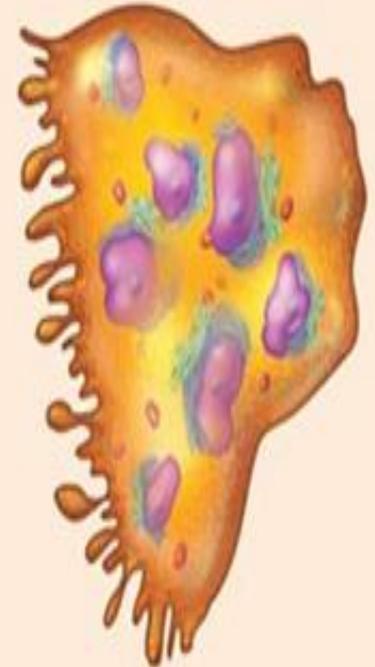
(c) Osteocyte

Mature bone cell that maintains the bone matrix



(d) Osteoclast

Bone-resorbing cell



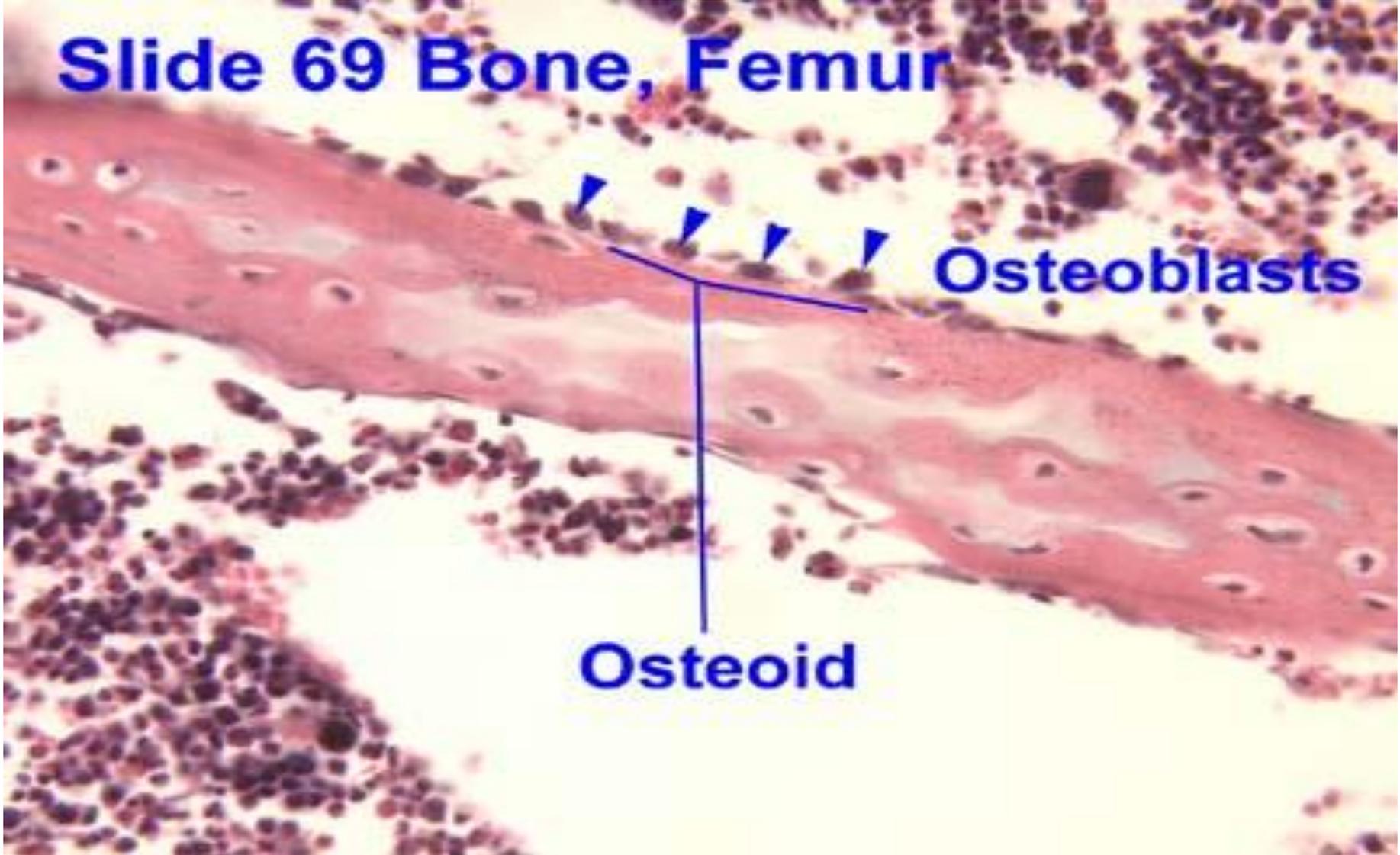
1-Osteogenic cells:

- It is the stem cells of bone.
- - Origin: It develops from mesenchymal cells.
- Site: found on the osteogenic layer of periosteum and endosteum.
- L/M: -They are spindle shaped, - Basophilic cytoplasm, - Pale oval nucleus.
- E/M: The cytoplasm has mitochondria, RER, poorly developed Golgi complex and abundant free ribosomes.
- Function: they can undergo mitotic division and can differentiate into osteoblasts.

2-Osteoblasts:

- **Origin:** they are developed from osteogenic cells.
- **Site:** They are located on the surfaces of the bone in a sheet-like arrangement of simple cuboidal cells.
- **Shape:** Osteoblasts show very thin cytoplasmic processes that extend to those of adjacent osteoblasts, and osteocytes.
- **LM:**
 - The cytoplasm: deeply basophilic with negative Golgi image.
 - The nucleus is large, pale and rounded.

2-Osteoblasts:

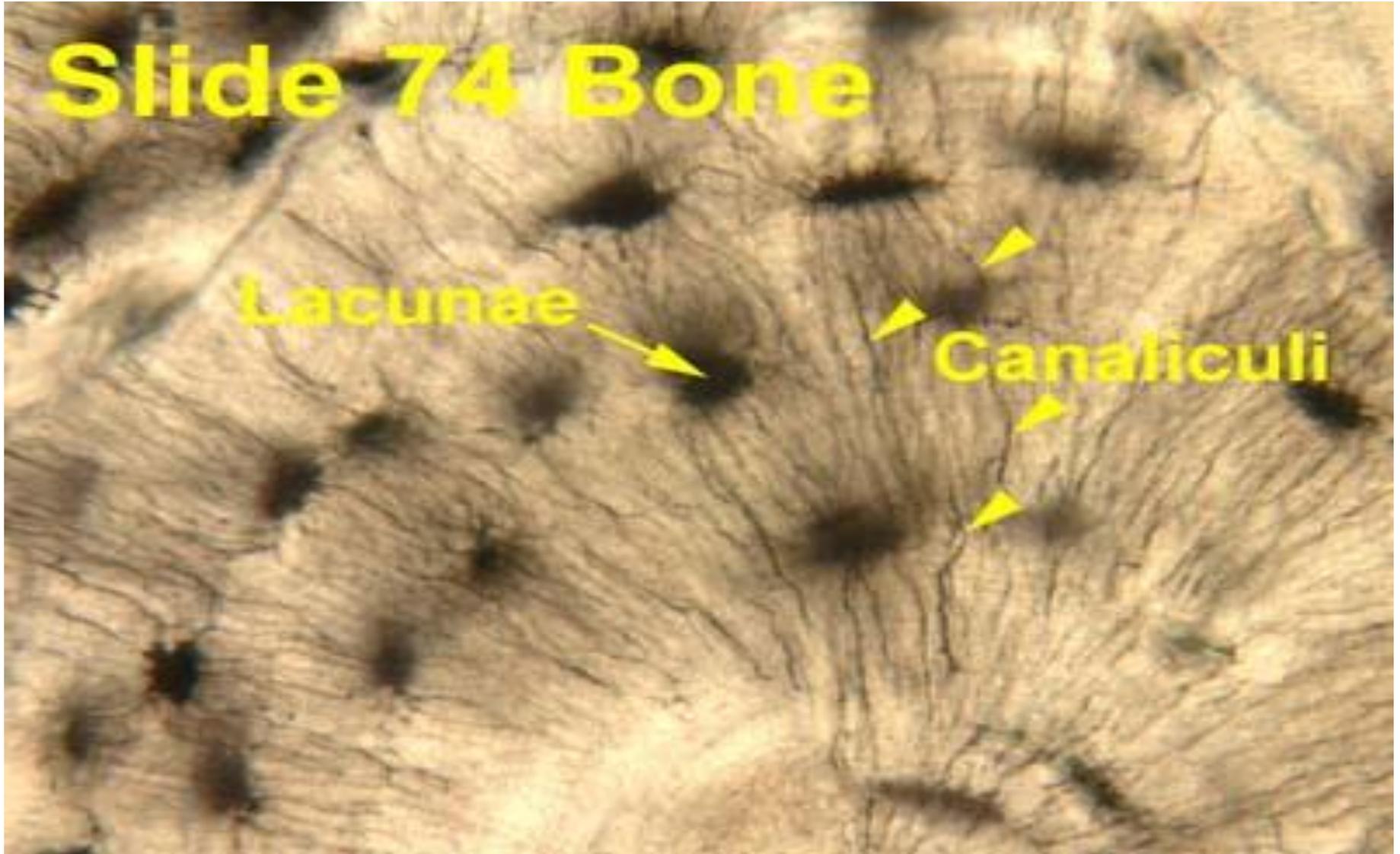


- E/M: Osteoblast shows all the ultrastructure features of actively secreting cells.
 - The cytoplasm contains abundant RER, well-developed Golgi complex, numerous secretory vesicles, many ribosomes & mitochondria.
 - The nucleus has extended chromatin.
- Function:
 - They are responsible for the synthesis of the organic components of bone matrix.
 - They secrete alkaline phosphatase enzyme which precipitate ca salts in the matrix. The matrix closest to the osteoblasts is not yet calcified and is known as **osteoid or prebone**.

3-Osteocytes:

- Osteocytes are flat cells with less basophilic cytoplasm and darker nucleus.
- They are present **singly** in a small cavity called **lacuna**. They have cytoplasmic processes that pass through canaliculi within the bony matrix to be in contact with the processes of the adjacent cells.
- They are responsible for maintaining bone matrix.

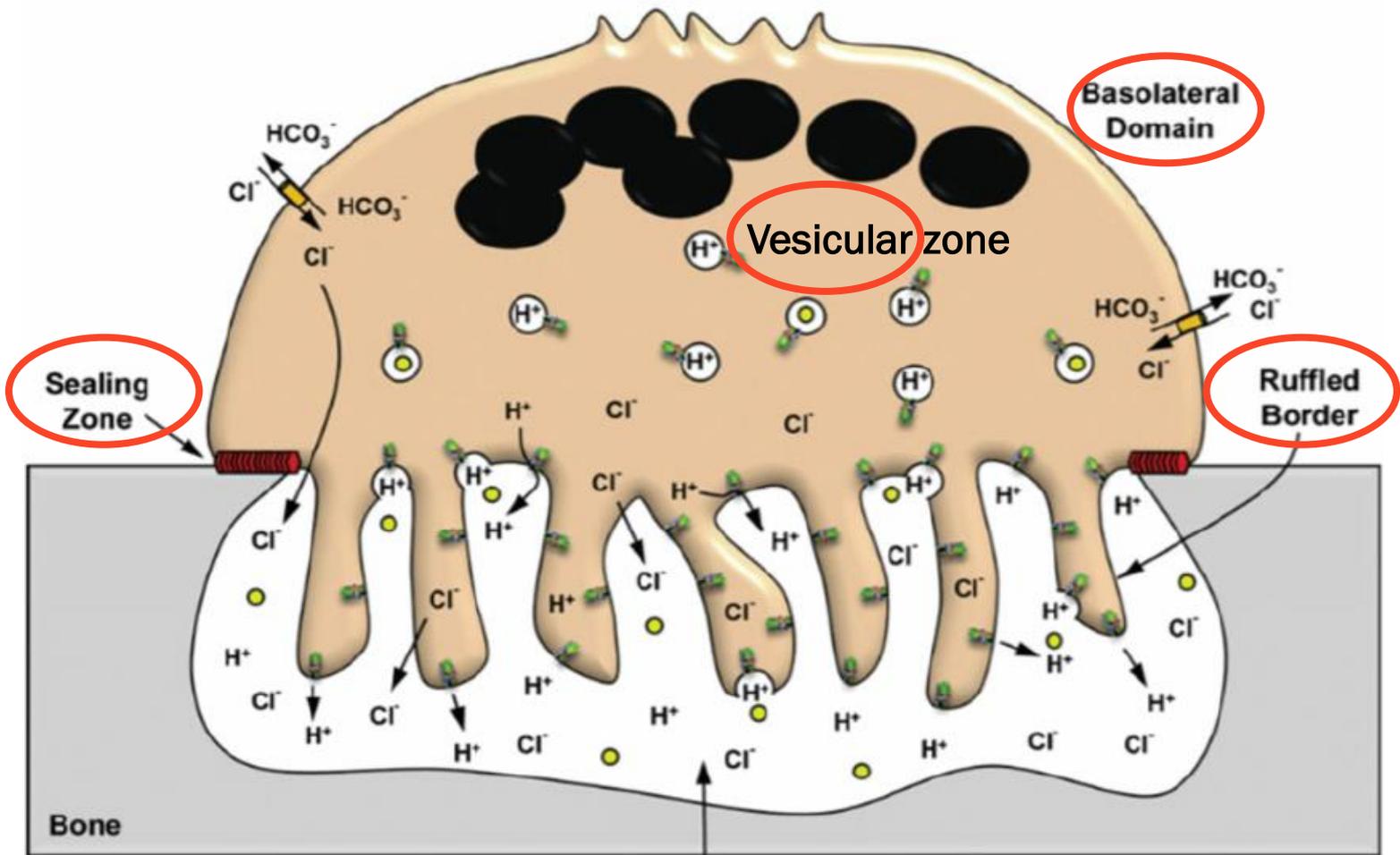
3-Osteocytes:



4-Osteoclasts:

- Originate from fusion of monocytes.
- L/M:
 - They are large, motile multinucleated giant cells; they contain up to 50 nuclei and have an acidophilic cytoplasm.
 - They are located in shallow depressions in the matrix called **Howship's lacunae**. They are present on the surfaces where bone resorption occurs

Functional Secretory Domain



Sealing Zone

Basolateral Domain

Vesicular zone

Ruffled Border

Bone

Resorption Lacunae (pH ~4.5)

-  V-ATPase
-  α_vβ₃ Integrin
-  HCO₃⁻/Cl⁻ Exchanger
-  Acidified Vesicles
-  Nucleus
-  Proteolytic Enzymes

E/M:

Four regions are recognized:

1- Ruffled border:

- It shows numerous plasma membrane enfolding forming microvilli like-structures.

2- Clear zone (sealing):

- It is the region of the cell that immediately surrounds the periphery of the ruffled border.

- It contains many actin microfilaments which holds the osteoclasts to bony surface.

3- Vesicular zone:

- It is region between the basal zone and ruffled border.
- It contains numerous endocytotic vesicles, large vacuoles and lysosomes (like acid phosphatase and collagenase). It also pumps protons to produce an acidic environment

4- Basal zone:

- It contains most of the organelles including the multiple nuclei, Golgi complexes and centrioles.
- Mitochondria, RER and polysomes are distributed throughout the cell.

• **Function:** -They are responsible for bone resorption and remodeling. the osteoclast secretes collagenase, cathepsin K, and other enzymes and pumps protons to produce an acidic environment locally for dissolving hydroxyapatite and promoting the localized digestion of matrix proteins.

-Osteoclast activity is controlled by local signaling factors and hormones. Osteoclasts have receptors for **calcitonin**, a thyroid hormone lowers blood calcium and preserves bone density by directly inhibiting osteoclasts and **parathormone**, a parathyroid hormone (PTH) which stimulate bone resorption to maintain serum calcium homeostasis.

4-Osteoclasts:



• *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.

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 underneath. Below the text is a faint, semi-transparent reflection of the same words, creating a mirror-like effect. The background is plain white.