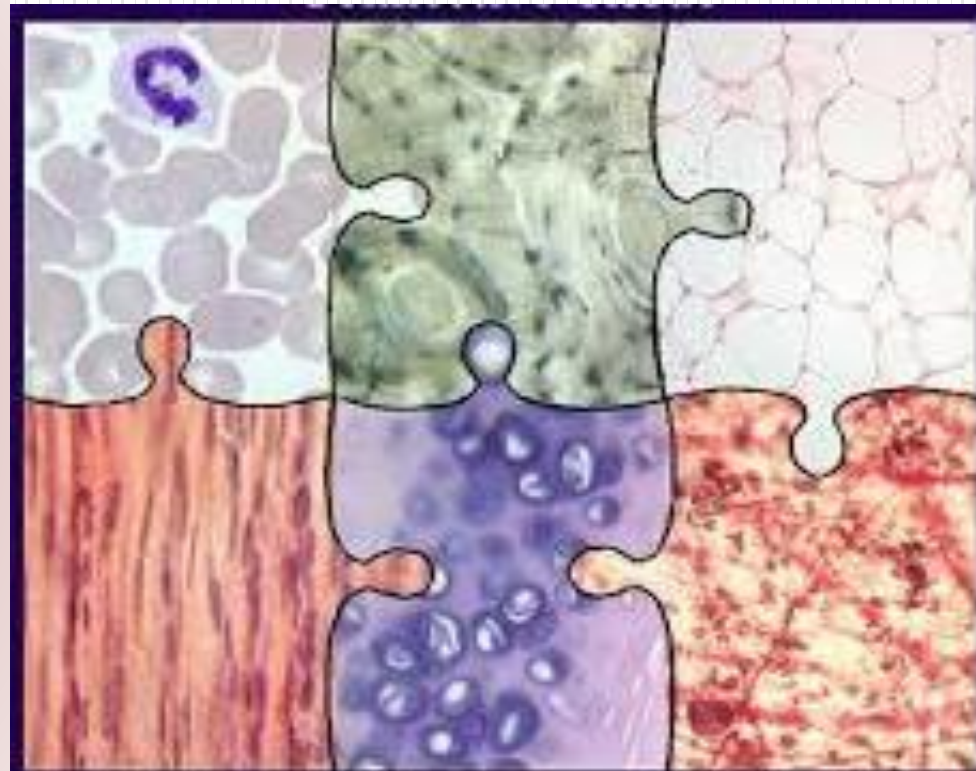


# Cartilage & Bone

By

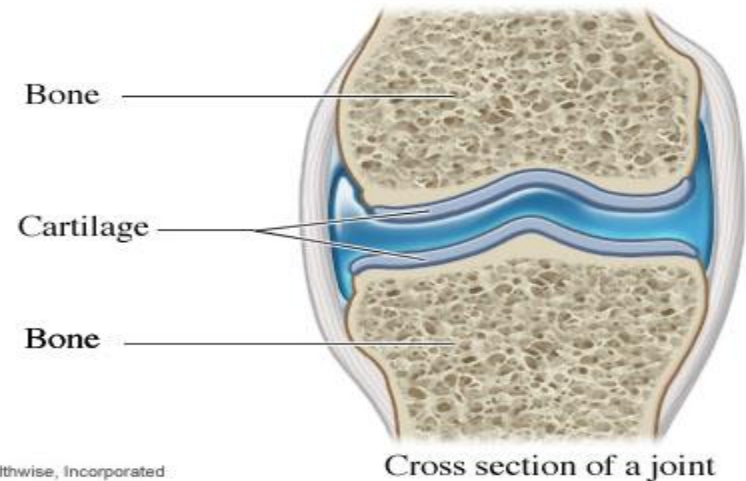
Heba Hassan Abd Elgawad

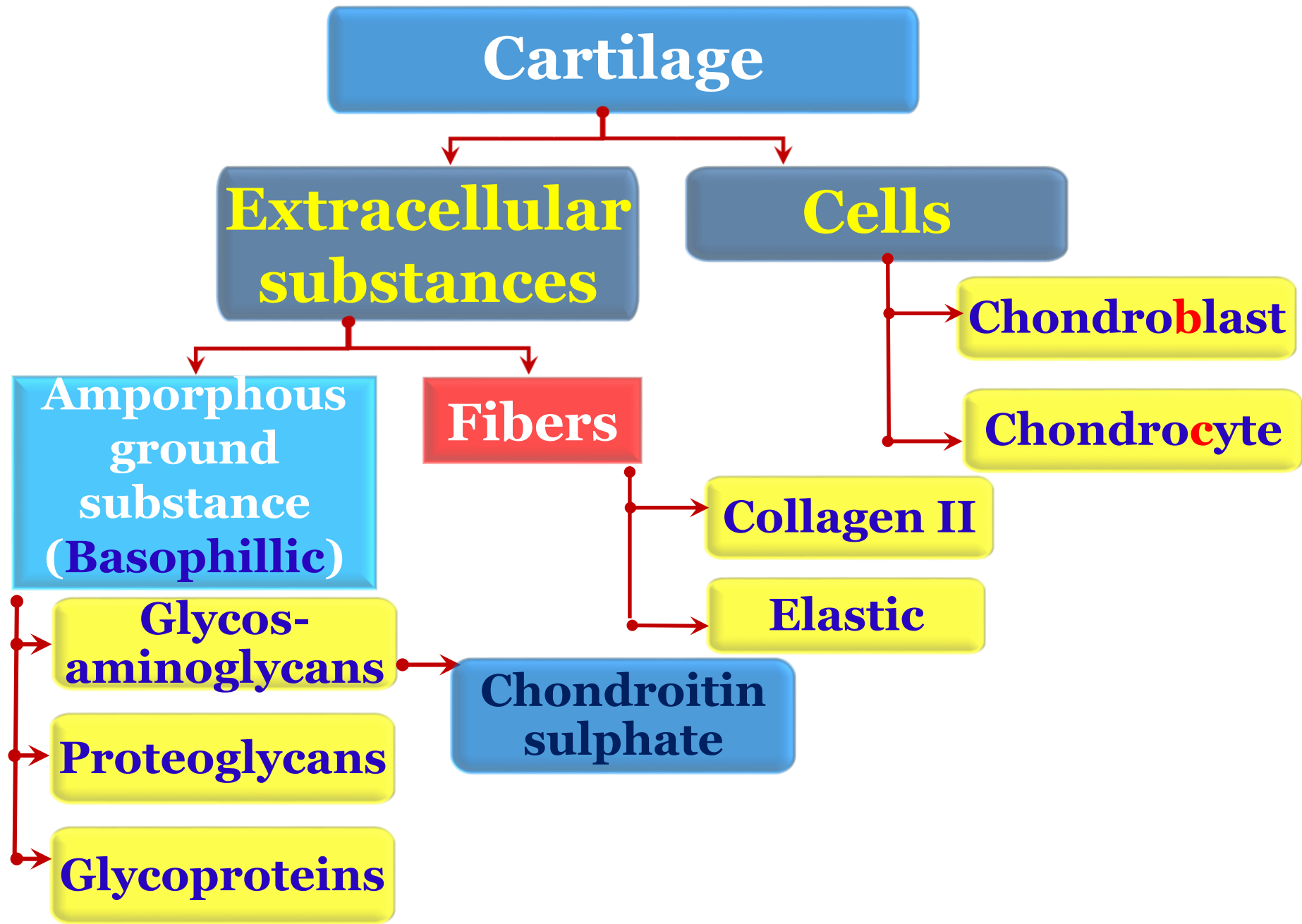
**Ass. Prof of  
Histology**



# 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**
- Cartilage lacks nerves, blood and lymphatic vessels and is nourished by blood vessels in perichondrium.

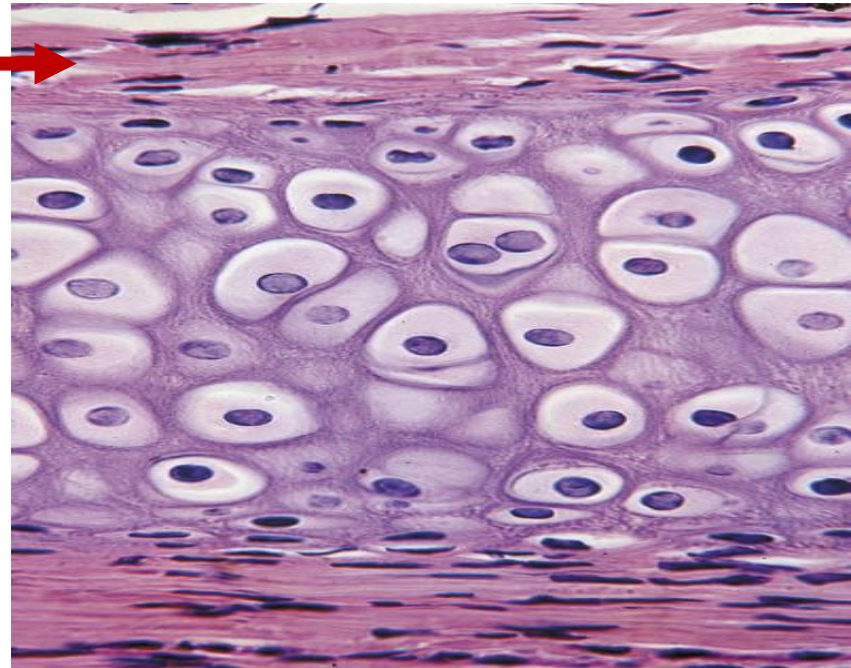




■ The perichondrium is a sheath of dense C.T formed of

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

- the perichondrium, is essential for the growth and maintenance of cartilage.
- 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.





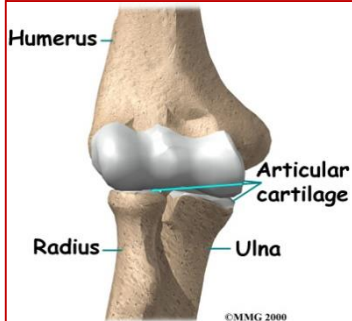
# Type of Cartilage

## Hyaline

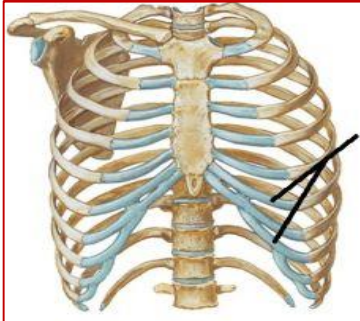
## Elastic

## Fibrocartilage

### Articular cartilage



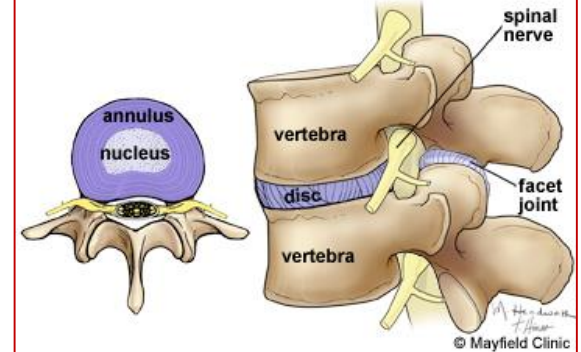
### Costal cartilage



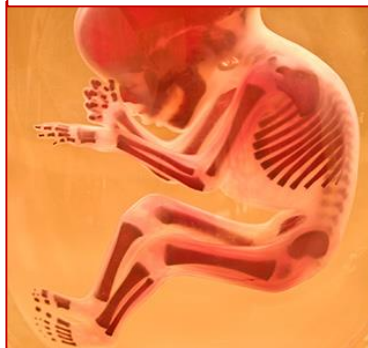
### Ear pinna



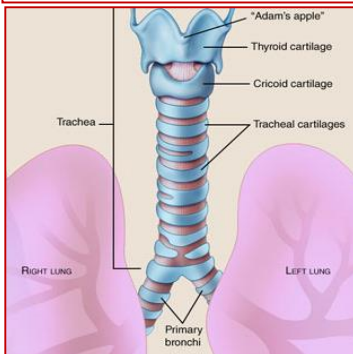
### Intervertebral disc



### Fetal Skeleton



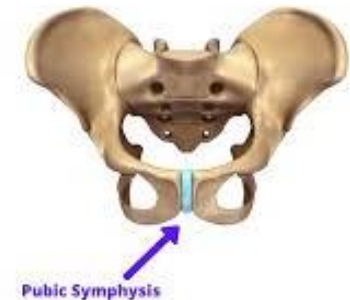
### Trachea



### 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**

**Fibers**

**Chondroitin sulphate**

**Amorphous ground substance (Basophilic)**

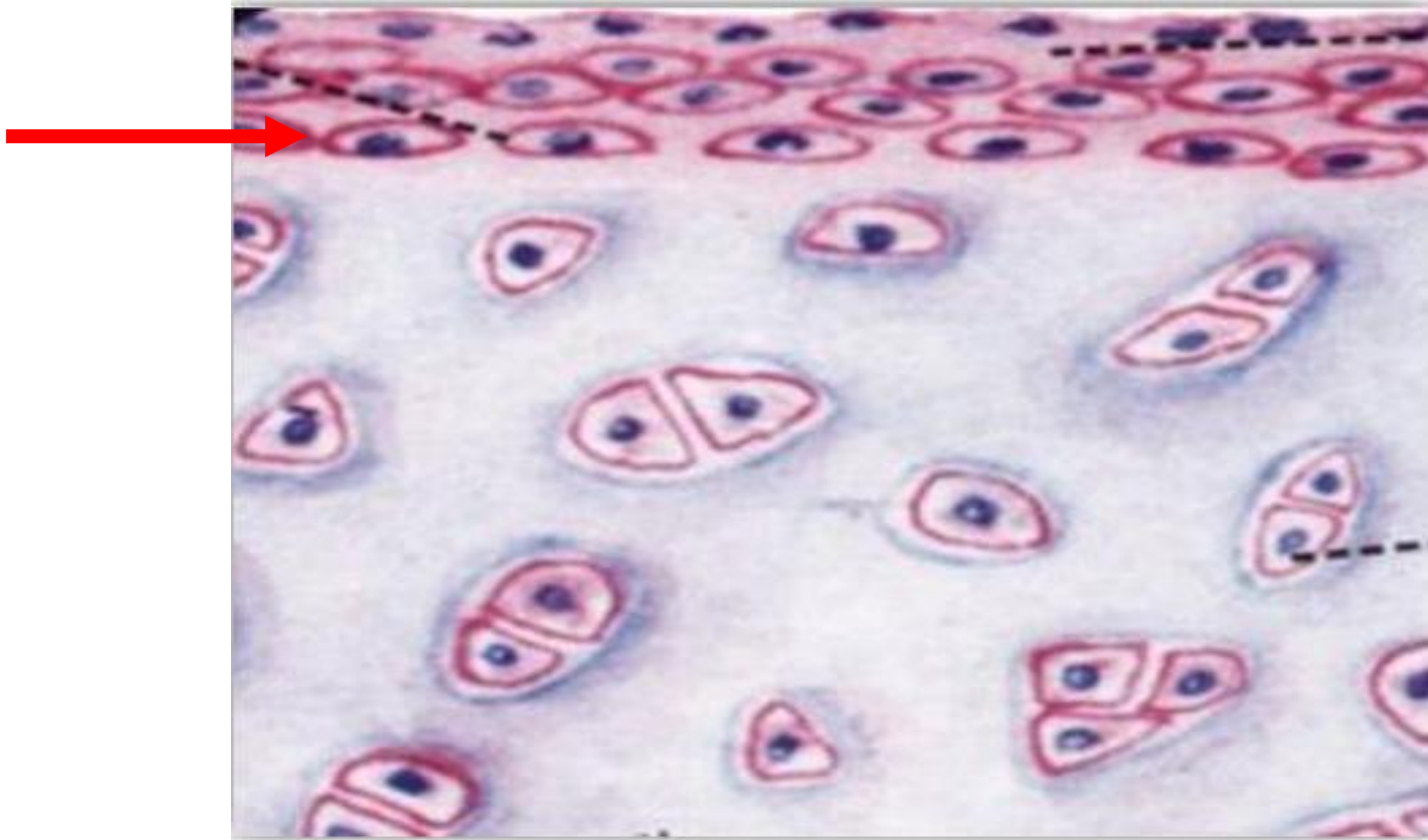
**Glycosaminoglycans**

**Proteoglycans**

**Glycoproteins**

## a) The chondroblasts

- It is present under the perichondrium.
- L.M: They are oval or spindle in shape with basophilic cytoplasm and pale nucleus.





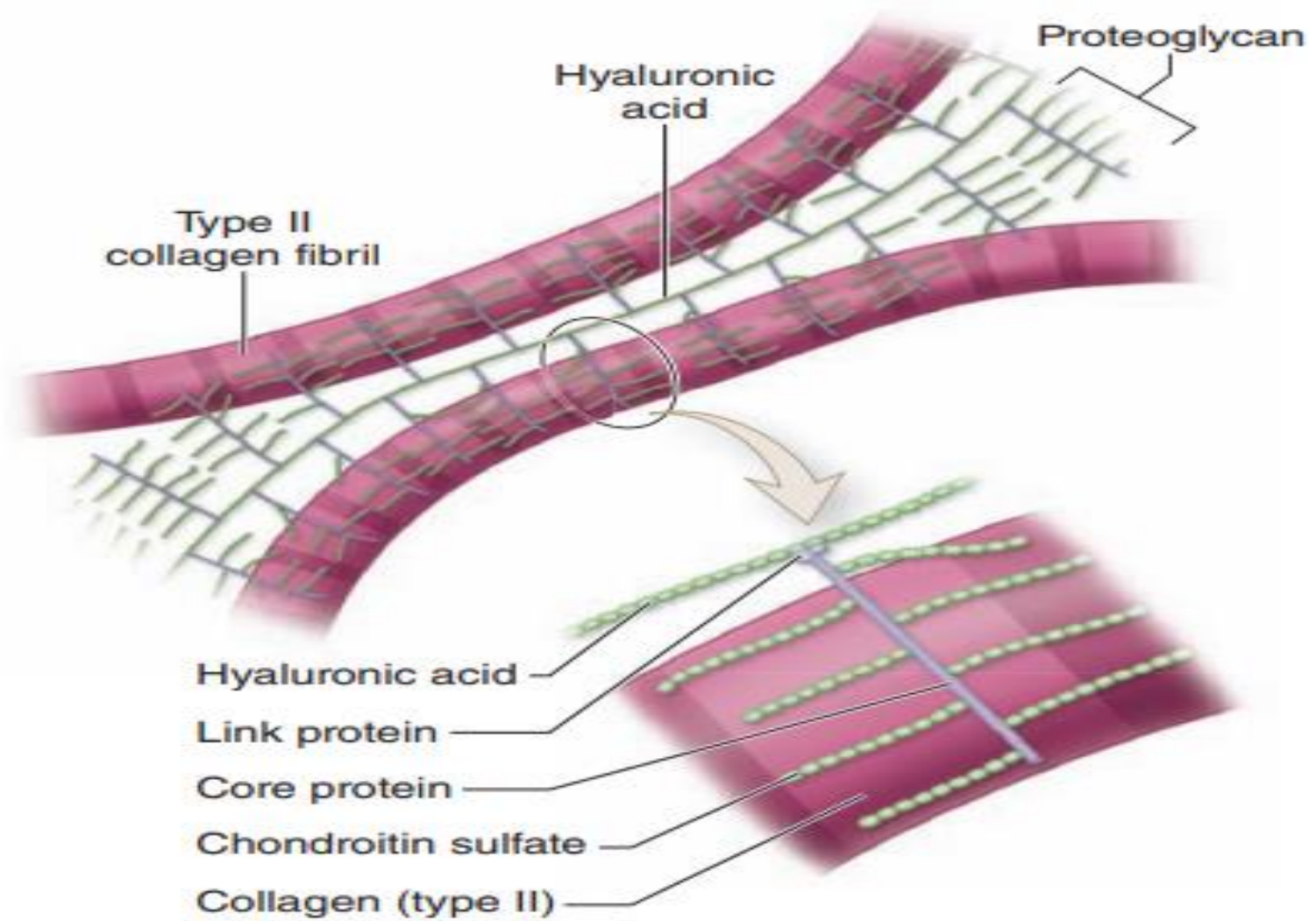
- E/M: The cytoplasm contains organelles concerned with protein synthesis e.g. RER, a well developed Golgi complex, numerous mitochondria and abundant secretory vesicles.
- Chondroblasts change into **chondrocytes** when they are trapped inside **lacunae**.
- **Function:** They synthesize proteins and fibers of the matrix.

## 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 GAG with side chains of chondroitin sulfate and **keratan sulfate**, is the most abundant proteoglycan of hyaline cartilage.

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

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

## 2- Type II collagen fibrils:

- Collagen fibrils cannot be seen with L/M because

A- The refractive index of the collagen fibrils and the ground substance is the same.

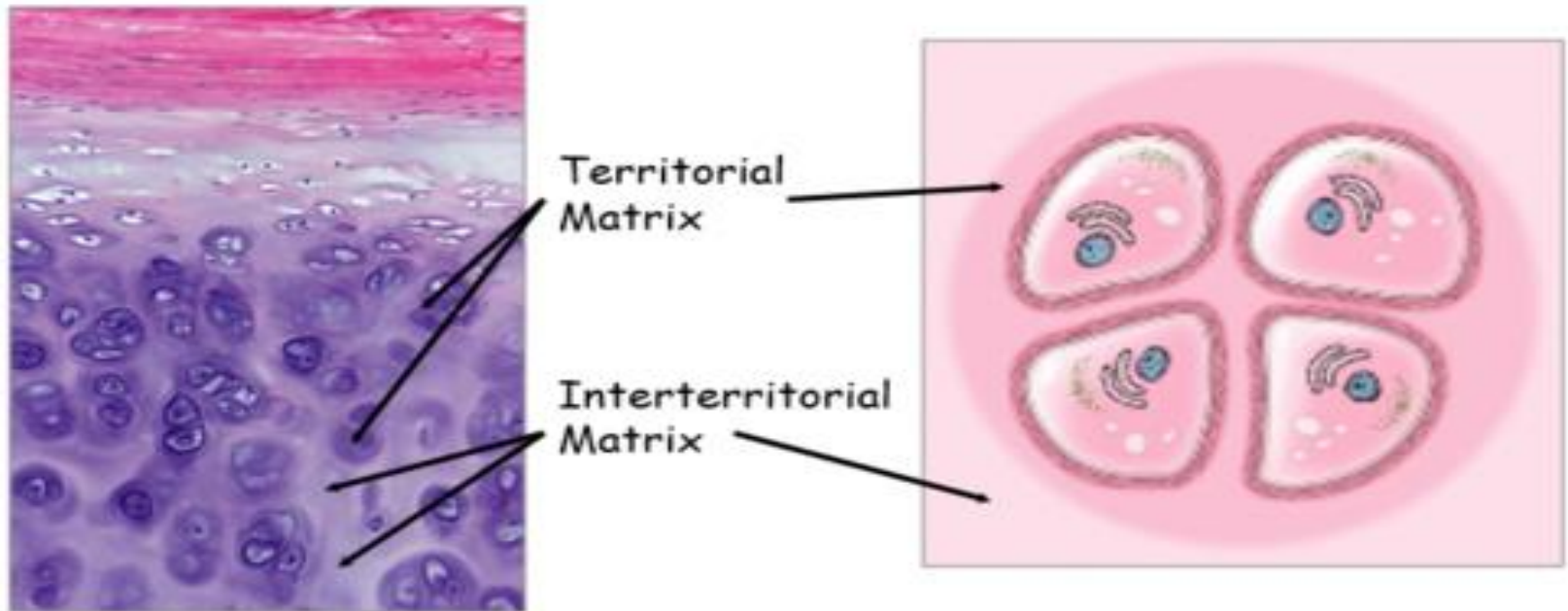
B- Type II collagen dose not form bundles.

- The matrix is basophilic (GAG), PAS +ve and can be stained metachromatic with toluidine blue stain.



# Territorial and Interterritorial Matrix

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



- Immediately surrounding each chondrocyte, the ECM is relatively richer in GAGs, often causing these areas of **territorial matrix** to stain differently from the intervening areas of **interterritorial matrix**

# Growth 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.

# Elastic Cartilage

**Extracellular substances**

**Cells**

**Chondroblast**

**Chondrocyte**

**Collagen II**

**Elastic**

**Fibers**

**Chondroitin sulphate**

**Amporphous ground substance (Basophilic)**

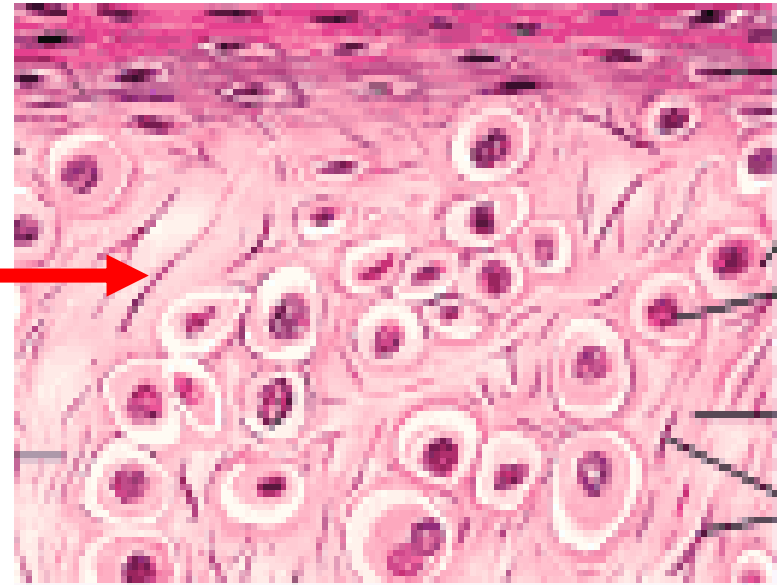
**Glycosaminoglycans**

**Proteoglycans**

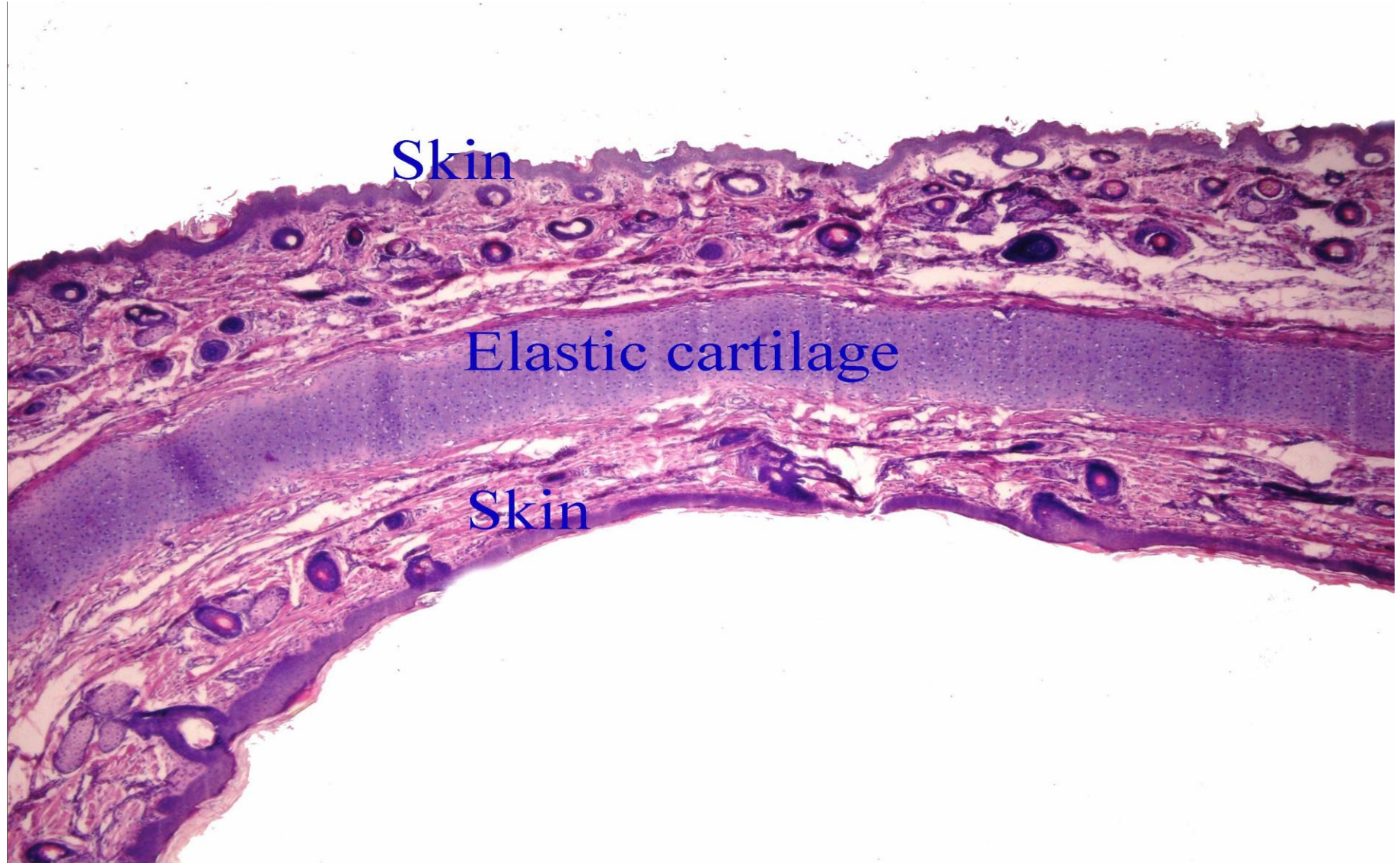
**Glycoproteins**

# Elastic cartilage

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



# Elastic cartilage

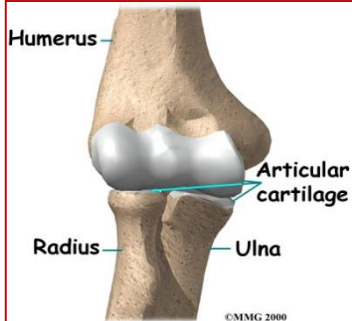




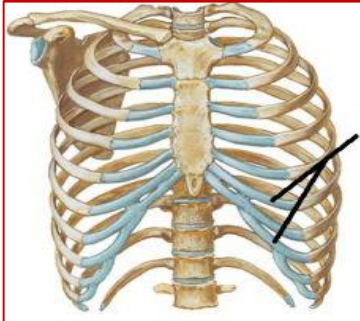
# Type of Cartilage

## Hyaline

### Articular cartilage



### Costal cartilage

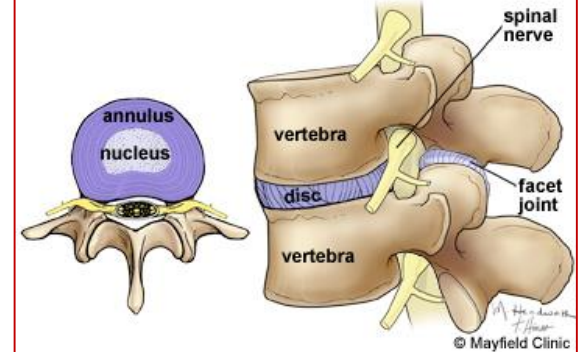


### Ear pinna

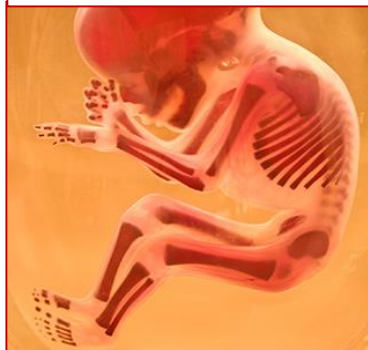


## Fibrocartilage

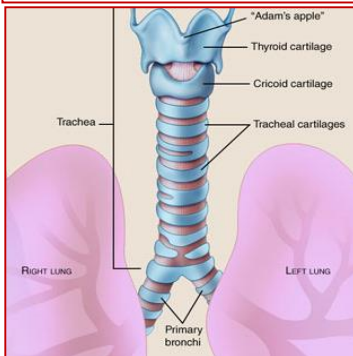
### Intervertebral disc



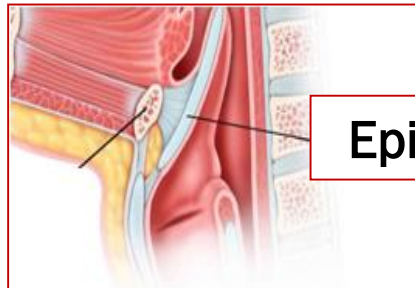
### Fetal Skeleton



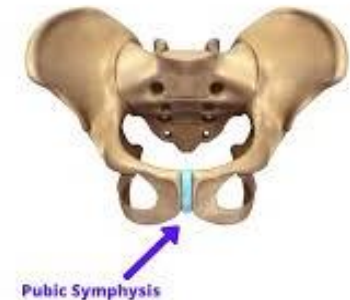
### Trachea



### Epiglottis

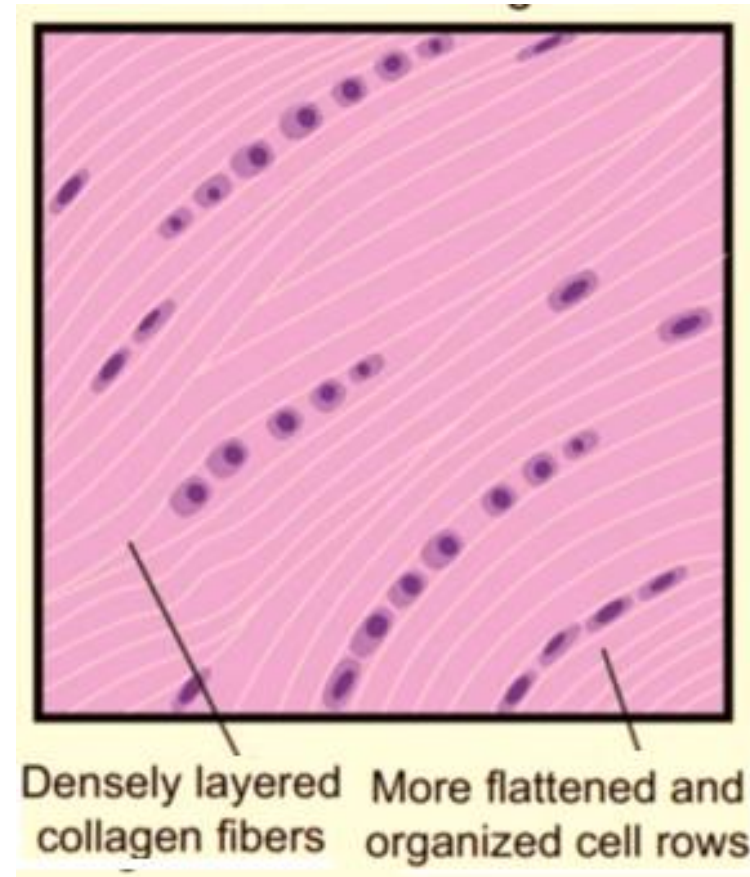


### Symphysis pubis

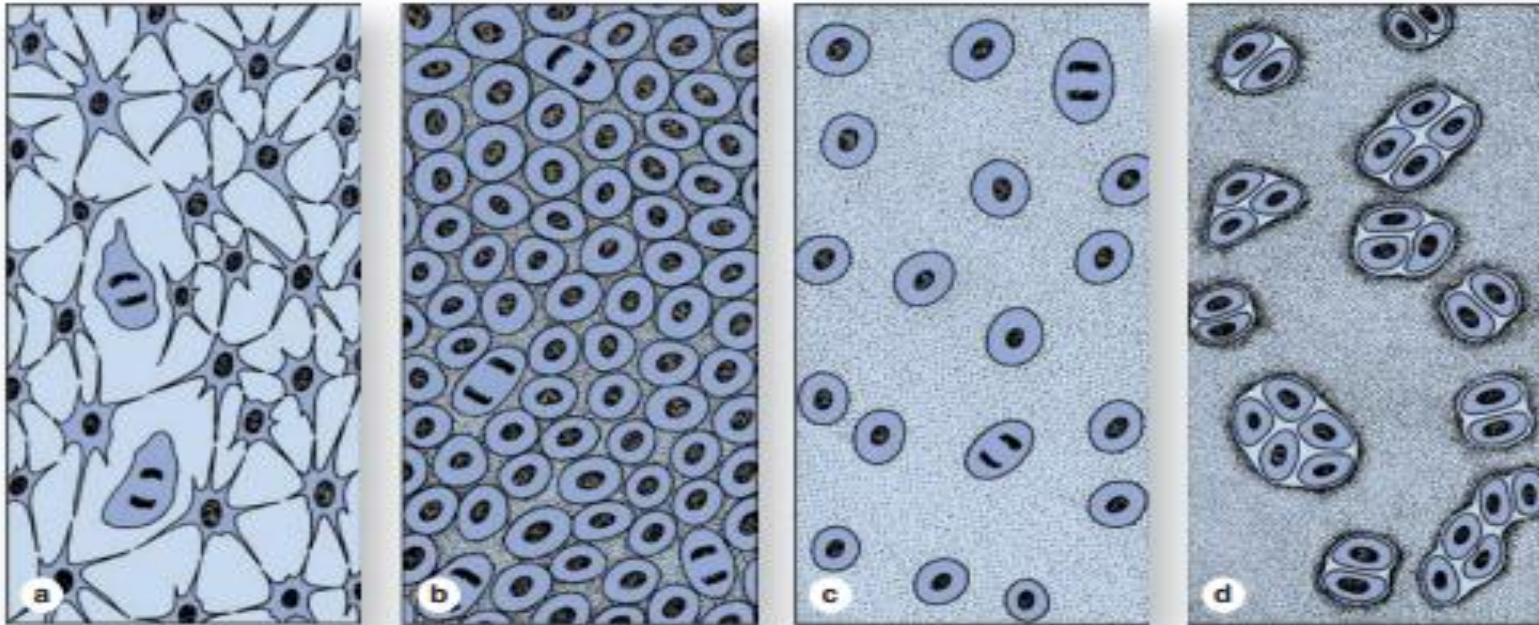


# Fibrocartilage

- 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.



# Chondrogenesis

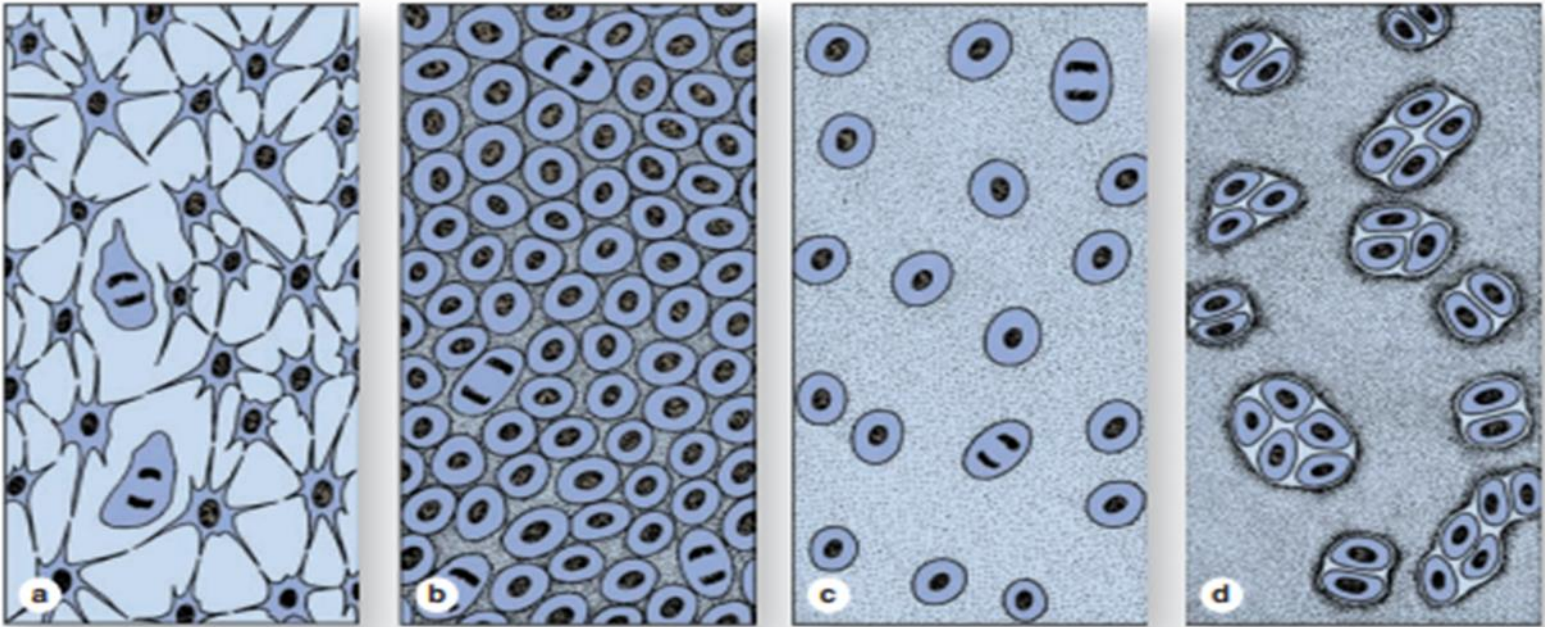


(a) Mesenchyme is the precursor for all types of cartilage.

(b) Mitosis and early differentiation produces a tissue with condensations of rounded cells called chondroblasts.

(c) Chondroblasts are then separated from one another again by their production of various matrix components, which collectively swell with water and form the very extensive ECM.





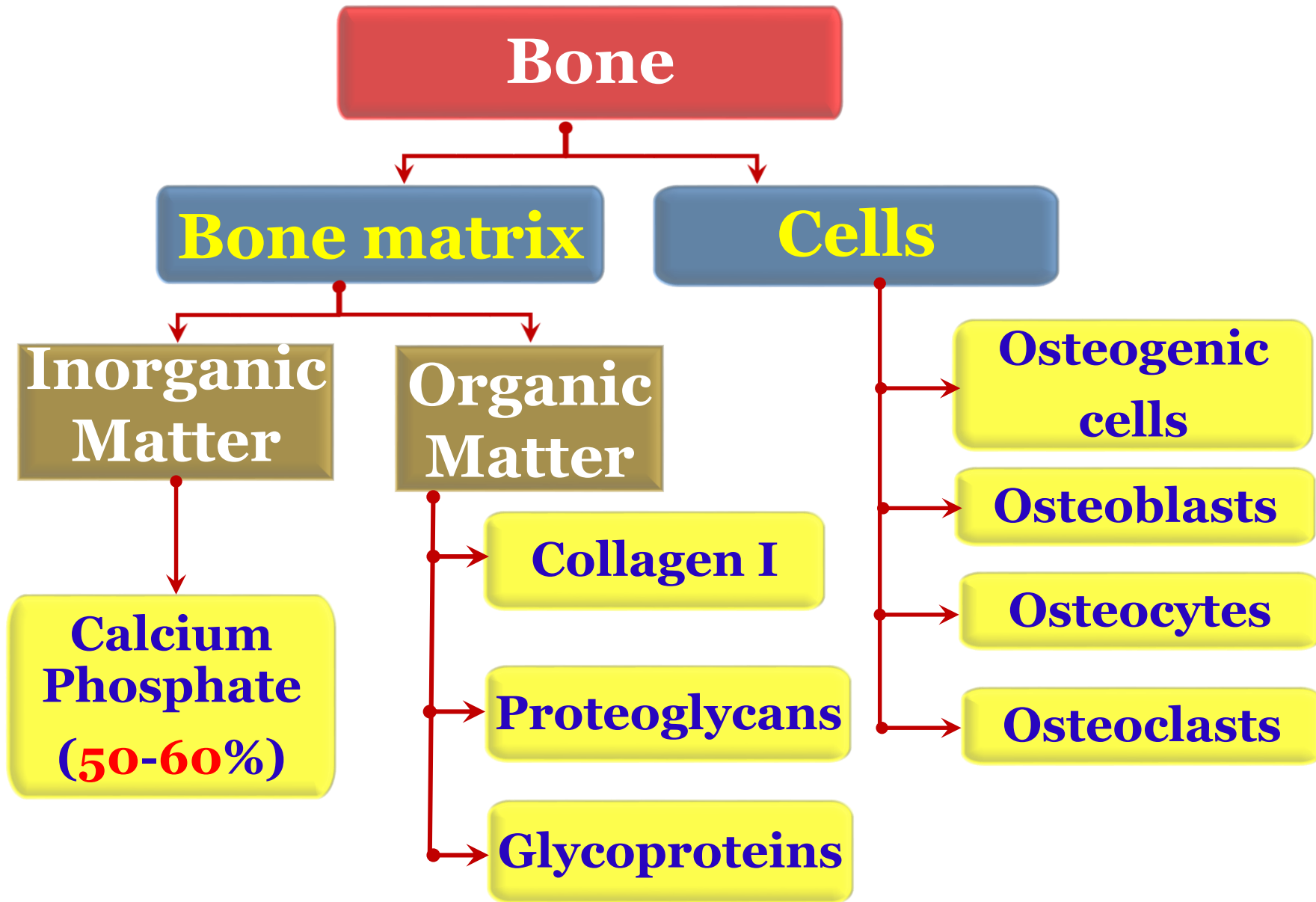
(d) Multiplication of chondroblasts within the matrix gives rise to isogenous cell aggregates surrounded by a condensation of territorial matrix.

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**



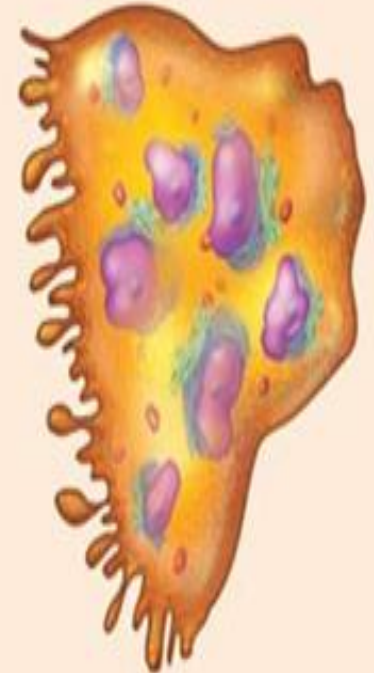
**(c) Osteocyte**

**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:





## 2-Osteoblasts:

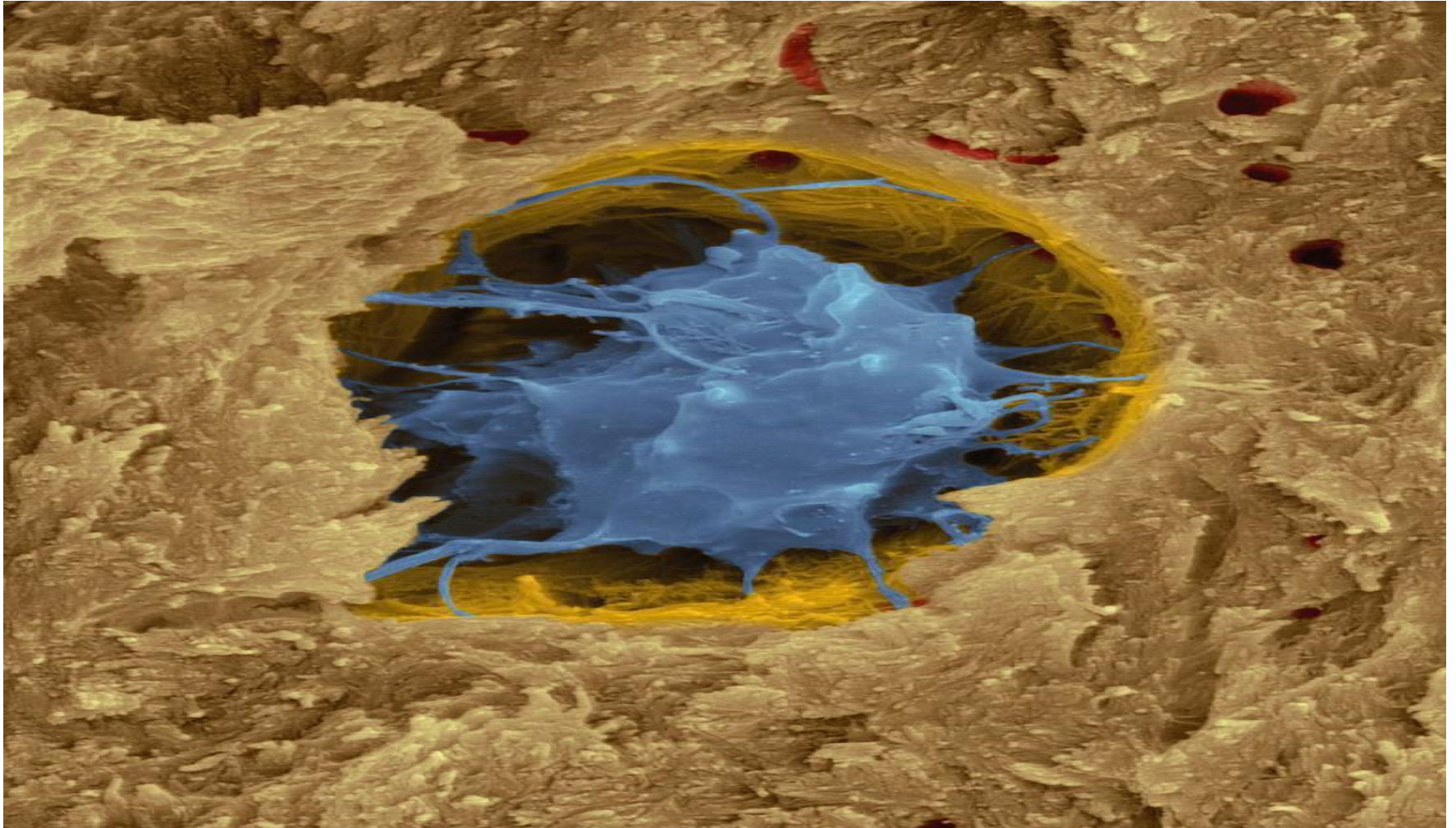
- Origin: they are developed from osteogenic cells.
- Site: They are located on the surfaces of the bone in a sheet-like arrangement of simple cuboidal cells.
- Shape: Osteoblasts show very thin cytoplasmic processes that extend to those of adjacent osteoblasts, and osteocytes.
- LM:
  - They are irregularly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

- 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:

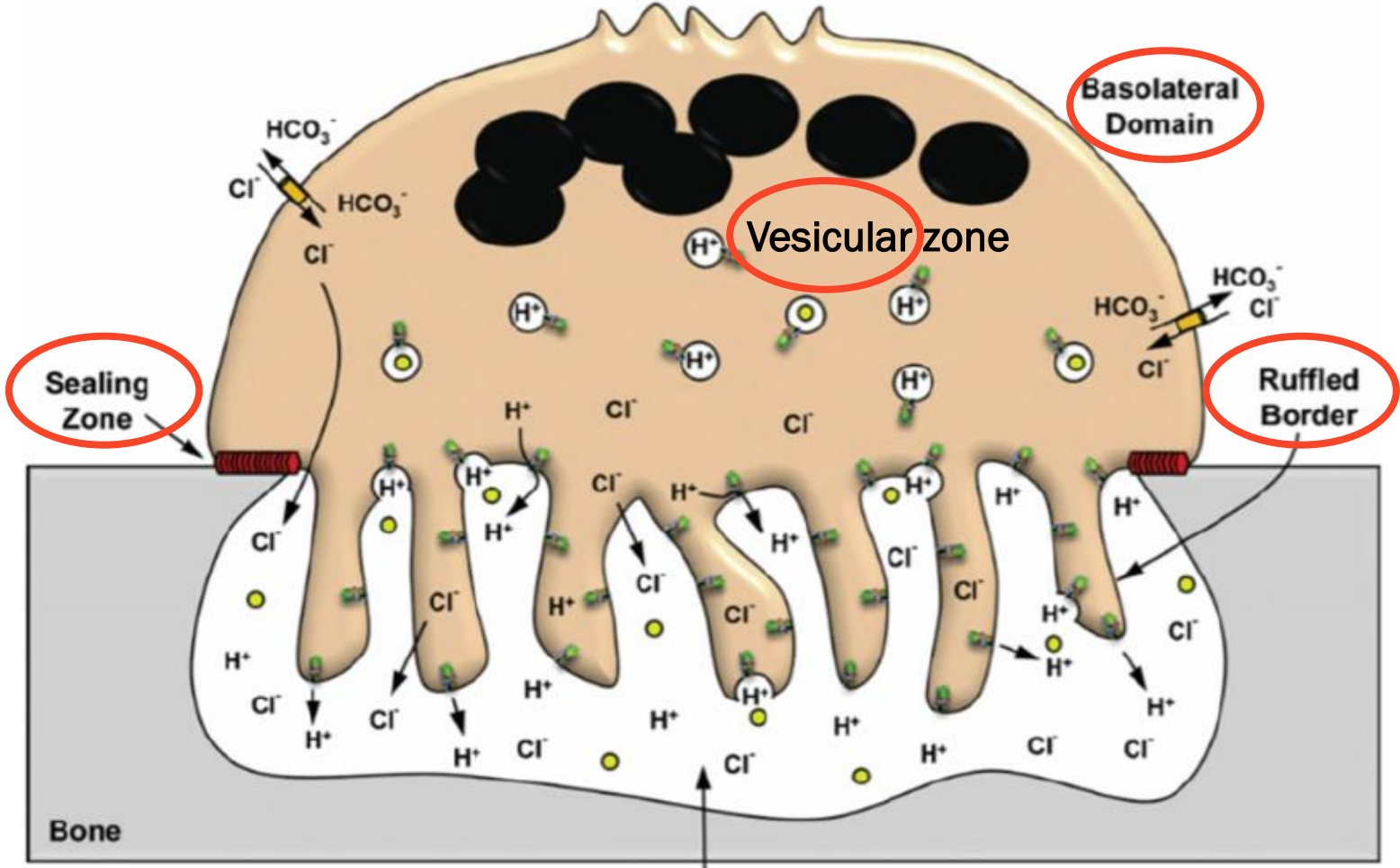


# 4-Osteoclasts:

- 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<sub>v</sub>β<sub>3</sub> Integrin
-  HCO<sub>3</sub><sup>-</sup>/Cl<sup>-</sup> 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) and parathormone (a parathyroid hormone (PTH))

**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 reflection of the same words, rendered in a lighter, semi-transparent purple color, creating a mirror-like effect on a white background.