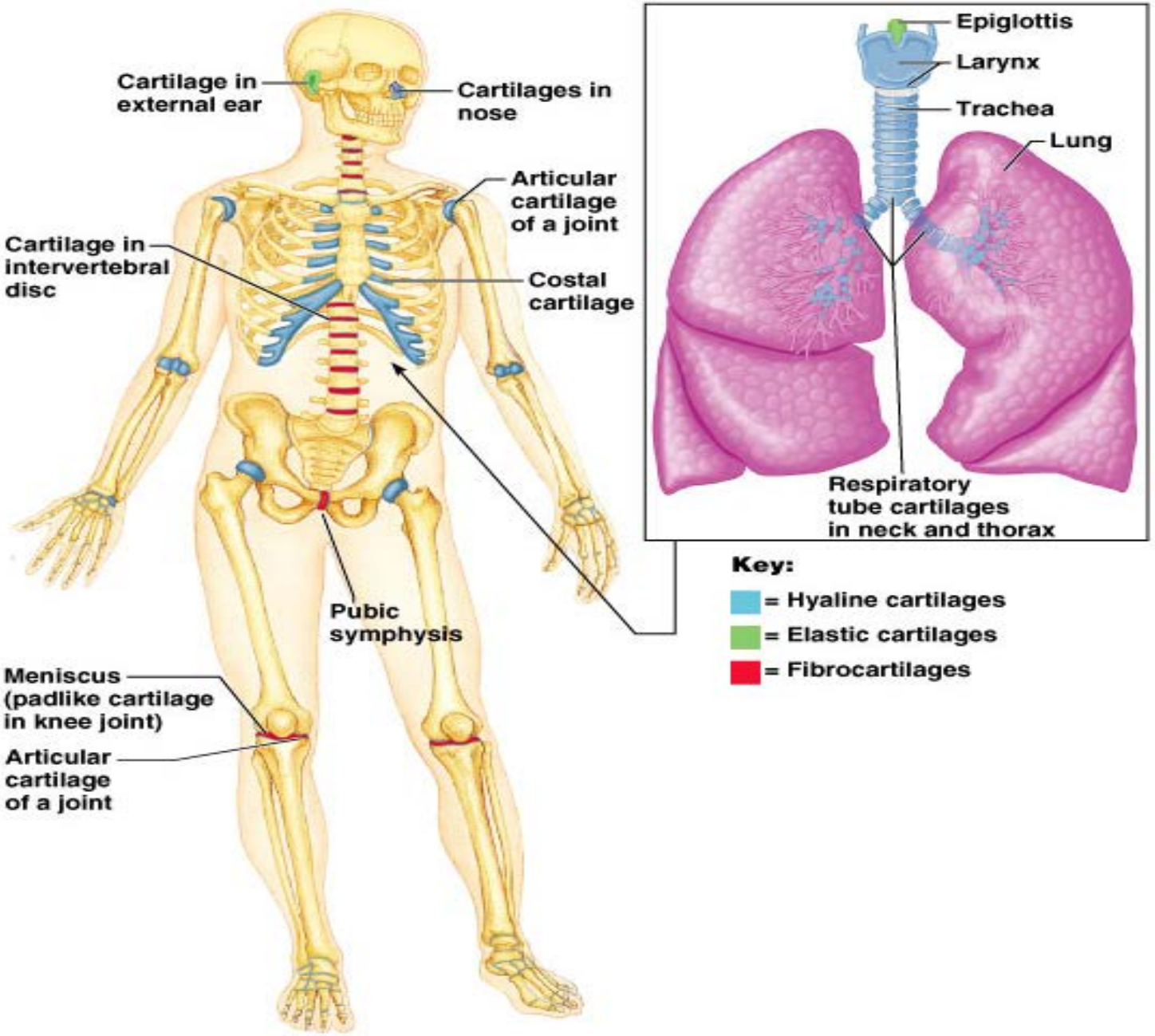
Biology

The cartilage

- Cartilage is a specialized type of connective tissue (supporting connective tissue).
- Consists, like other connective tissues, of cells and extracellular matrix composed of connective tissue fibers and ground substance.
- Does, unlike other connective tissue, not contain vessels or nerves.
- Cartilage consists mainly of cells called chondrocytes and chondroblasts that synthesize the extracellular matrix.
- Is surrounded by a layer of dense connective tissue, the perichondrium.
- Cartilage is rather rare in the adult humans, but it is very important during development because of its firmness and its ability to grow rapidly. In developing humans, most of the bones of the skeleton are preceded by a temporary cartilage.


Cartilage in external ear
Cartilages in nose
Articular cartilage of a joint
Cartilage in intervertebral disc
Costal cartilage
Pubic symphysis
Meniscus (padlike cartilage in knee joint)
Articular cartilage of a joint
Epiglottis
Larynx
Trachea
Lung
Respiratory tube cartilages in neck and thorax
Key:
= Hyaline cartilages
= Elastic cartilages
= Fibrocartilages

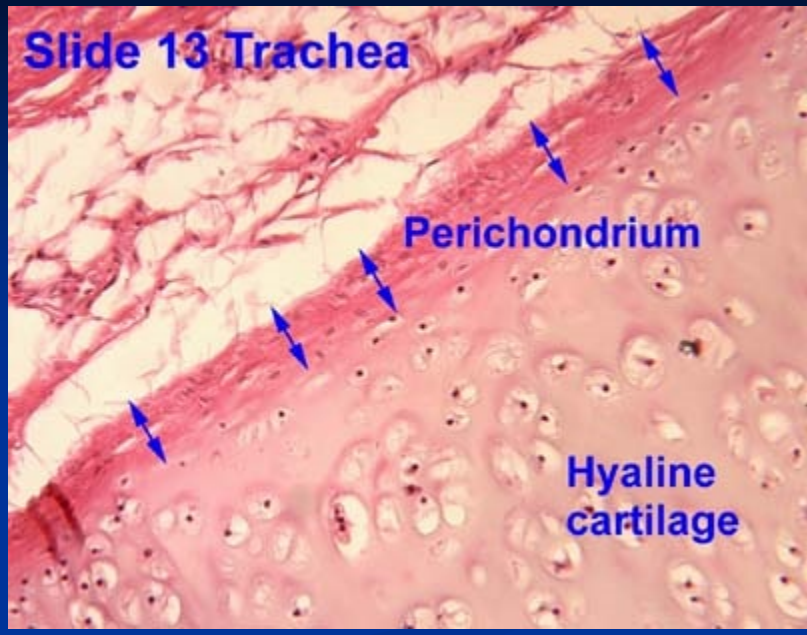
Perichondrium

- The perichondrium is a sheath of dense irregular connective tissue that surrounds most of hyaline and elastic cartilage, forming an interface between the cartilage and the tissue supported by the cartilage.

- Perichondrium contains blood vessels, nerves and lymphatic vessels.

Perichondrium composed of 2 layers:

- the outer one which is fibrous containing type I collagen fibers and fibroblasts.



- inner layer which is cellular containing flat cells called chondrogenic cells which are differentiated from mesenchymal cells, this layer called chondrogenic layer, the inner portion of this layer is rich with chondroblast which secrete the cartilage matrix and differentiate into chondrocytes.

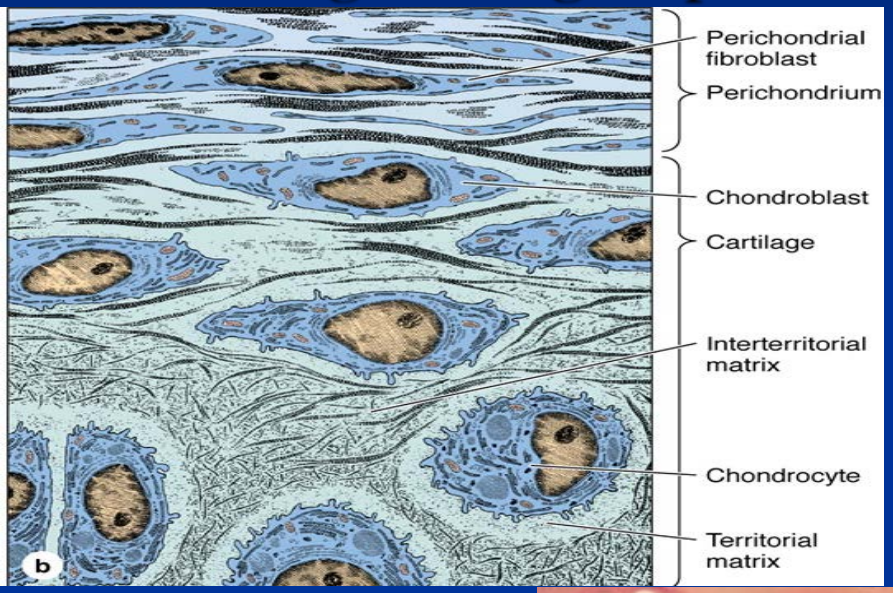
Functions of the perichondrium:

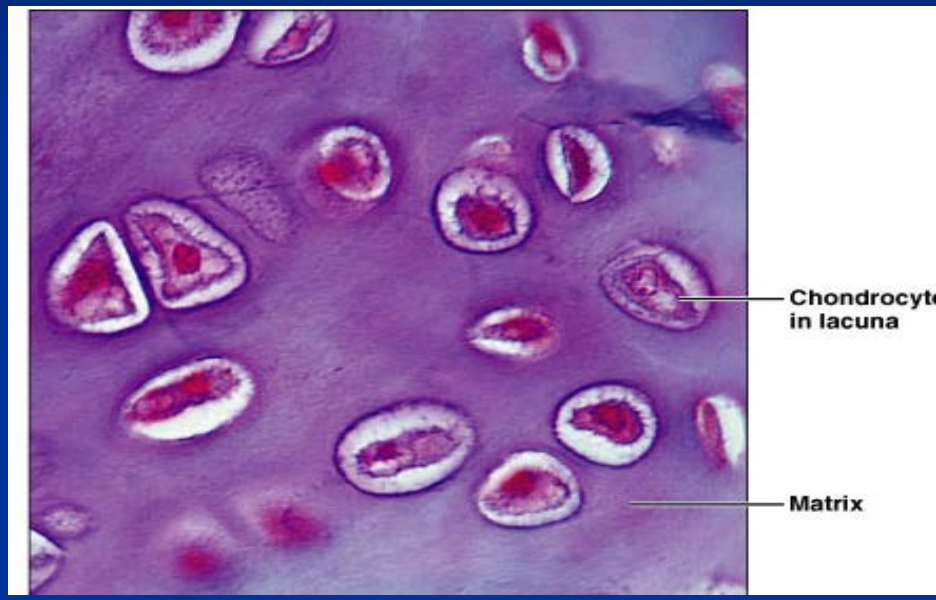
- **growth of cartilage.**
- **nutrition** (because the cartilage is devoid of blood vessels so the perichondrium pass the blood from connective tissue through the matrix to the chondrocytes).

Hyaline cartilage on the articulating surfaces of bones and fibrocartilage is not lined by perichondrium.

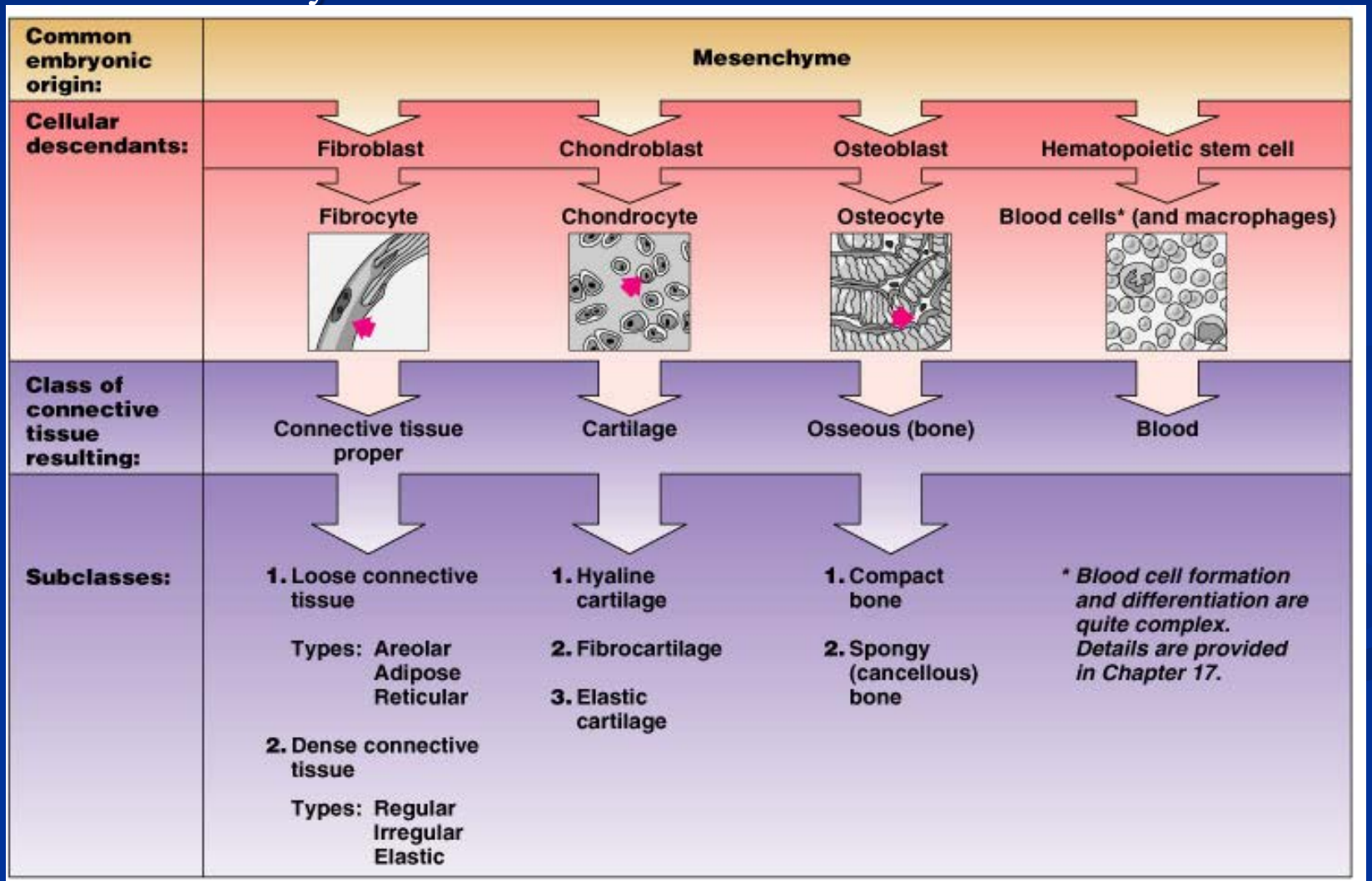
Cartilage cells

- mesenchyme cells ⟶ chondroblasts ⟶ chondrocytes ⟶ isogenous groups.

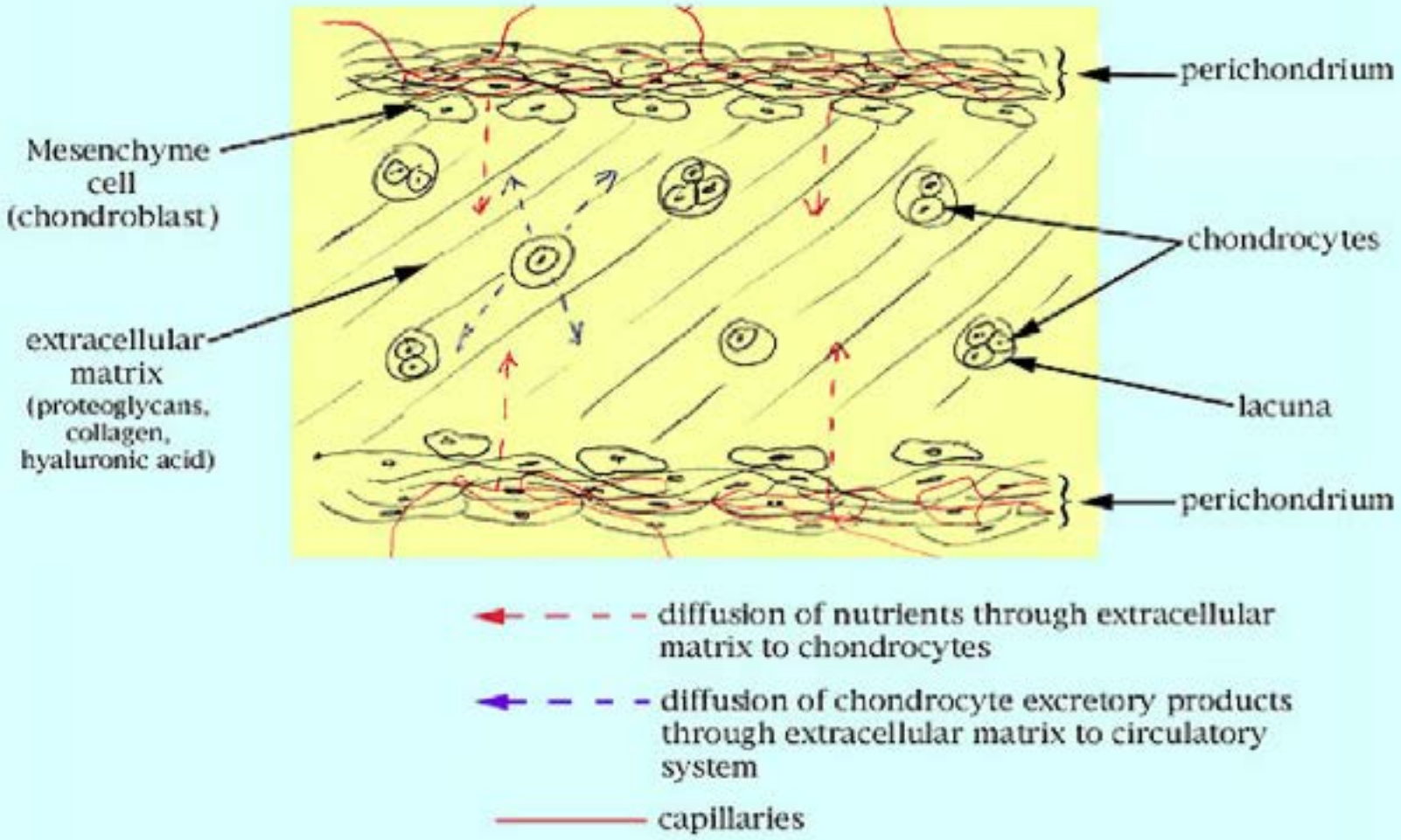




- Mesenchyme cells ⟶ fibroblasts
- chondrogenic cells ⟶ chondroblasts ⟶ chondrocytes.



Components of Cartilage



- Chondrocyte function is hormone dependent. Synthesis of sulfated GAGs is accelerated by growth hormone, thyroxin, and testosterone and is slowed by cortisone, hydrocortisone, and estradiol.

Cartilage matrix

- It is produced and maintained by chondrocytes and chondroblasts. It consists of:
- 1. Fibers: collagen or elastic fibers
- 2. Ground substance: contains sulfated glycosaminoglycans and hyaluronic acid that are closely associated with the elastic and collagen fibers within the ground substance. Cartilage matrix is highly hydrated because of its high water content (60%-80%), which allows for diffusion of molecules to and from the chondrocytes. Cartilage is a semirigid tissue and can act as shock absorber.

- Hyaline cartilage consists of only type II collagen fibers embedded in a firm amorphous hydrated matrix rich in proteoglycans and glycoproteins. In addition to type II collagen fibers, cartilage matrix contains adhesive glycoprotein called chondronectin, this provide adherence of chondroblasts and chondrocytes to collagen fibers of surrounding matrix.
- Type I collagen fibers is the only dominant fiber in fibrocartilage.
- While plenty of elastic fibers with few collagen fibers are present in elastic cartilage.

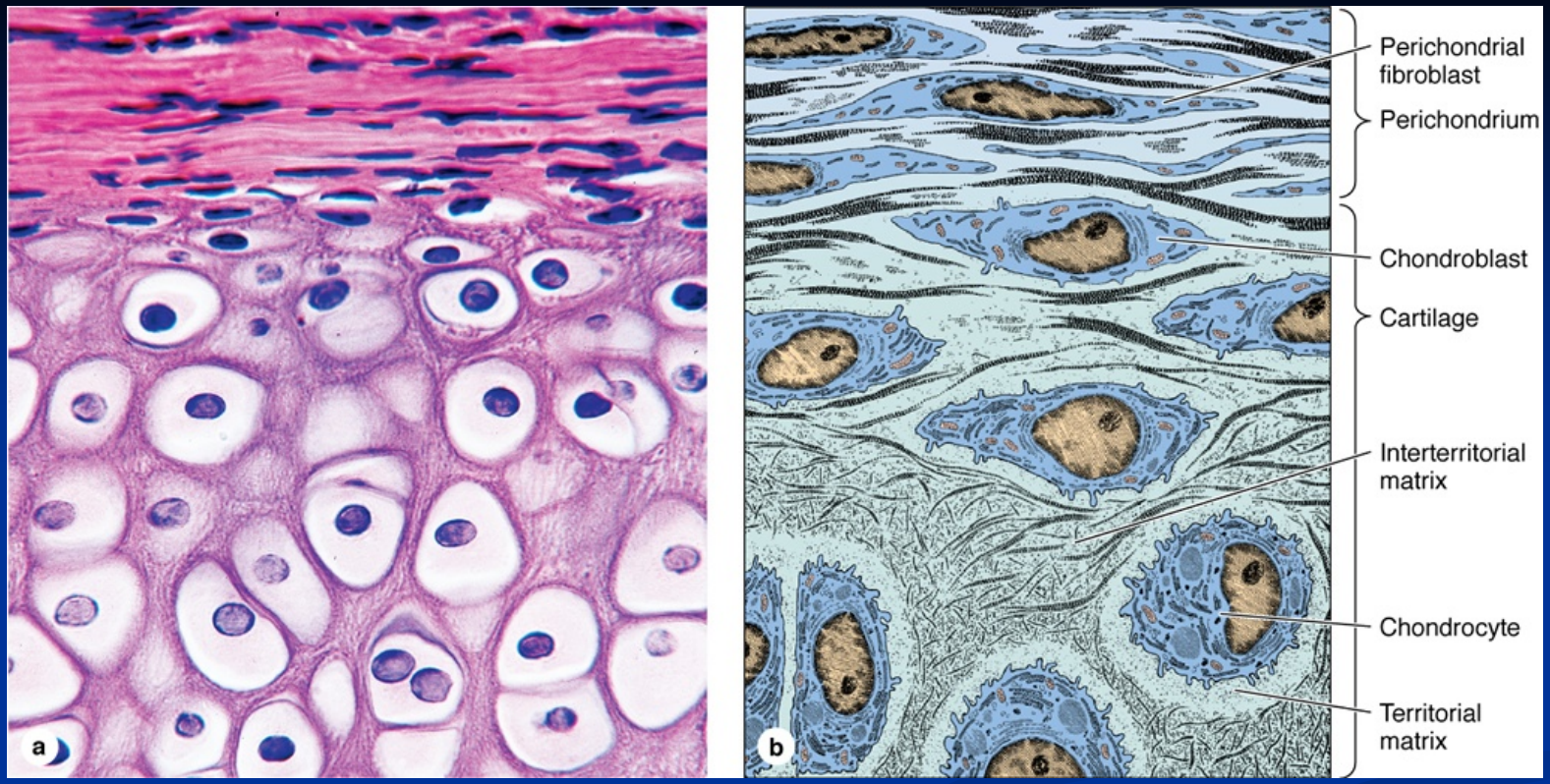
Types of cartilage

Classified into 3 types depending on the amount and types of connective tissue fibers that are present in the extracellular matrix:

- **Hyaline cartilage: flexible and resilient.**
- **Elastic cartilage: highly bendable.**
- **Fibrocartilage: resists compression and tension.**

hyaline cartilage:

- Hyaline cartilage is the most common. Fresh hyaline cartilage, is a bluish-gray, semi translucent, in the embryo, it serves as a temporary skeleton.
- In adult mammals, hyaline cartilage is located in the articulating surfaces of the movable joints, in the walls of larger respiratory passages (nose, larynx, trachea, bronchi), in the ventral ends of the ribs (costal cartilage) and in the epiphyseal plate, where it is responsible for the longitudinal growth of bone.



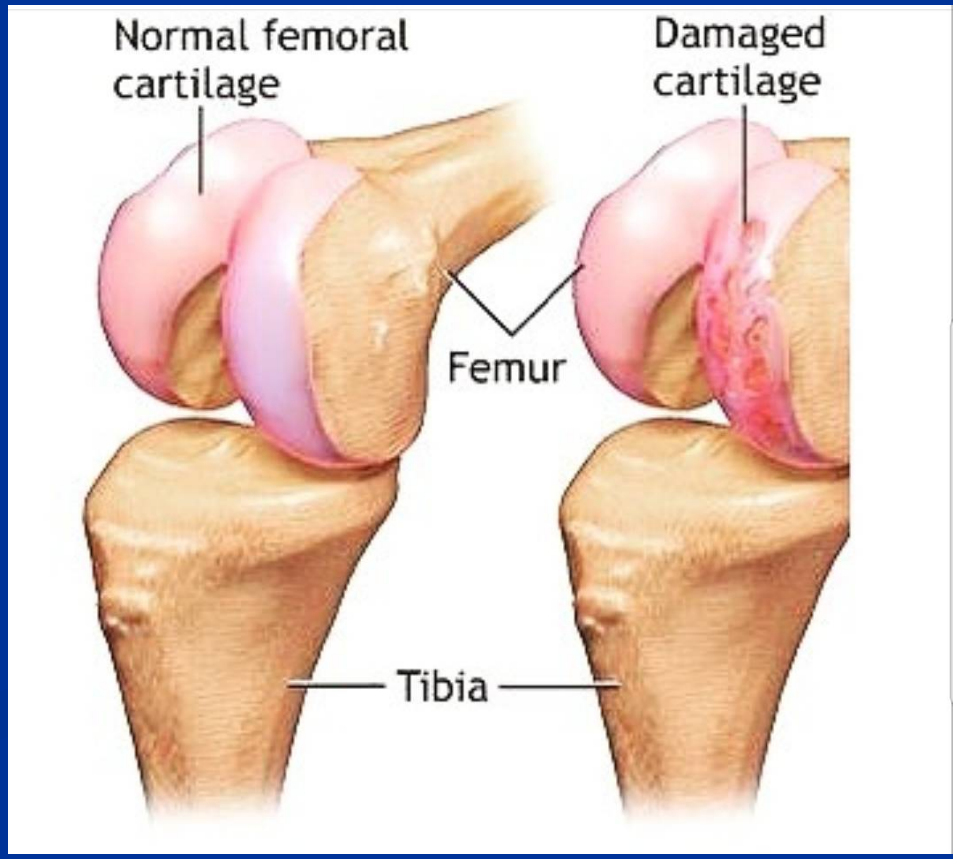
The matrix of hyaline cartilage is subdivided into 2 regions:

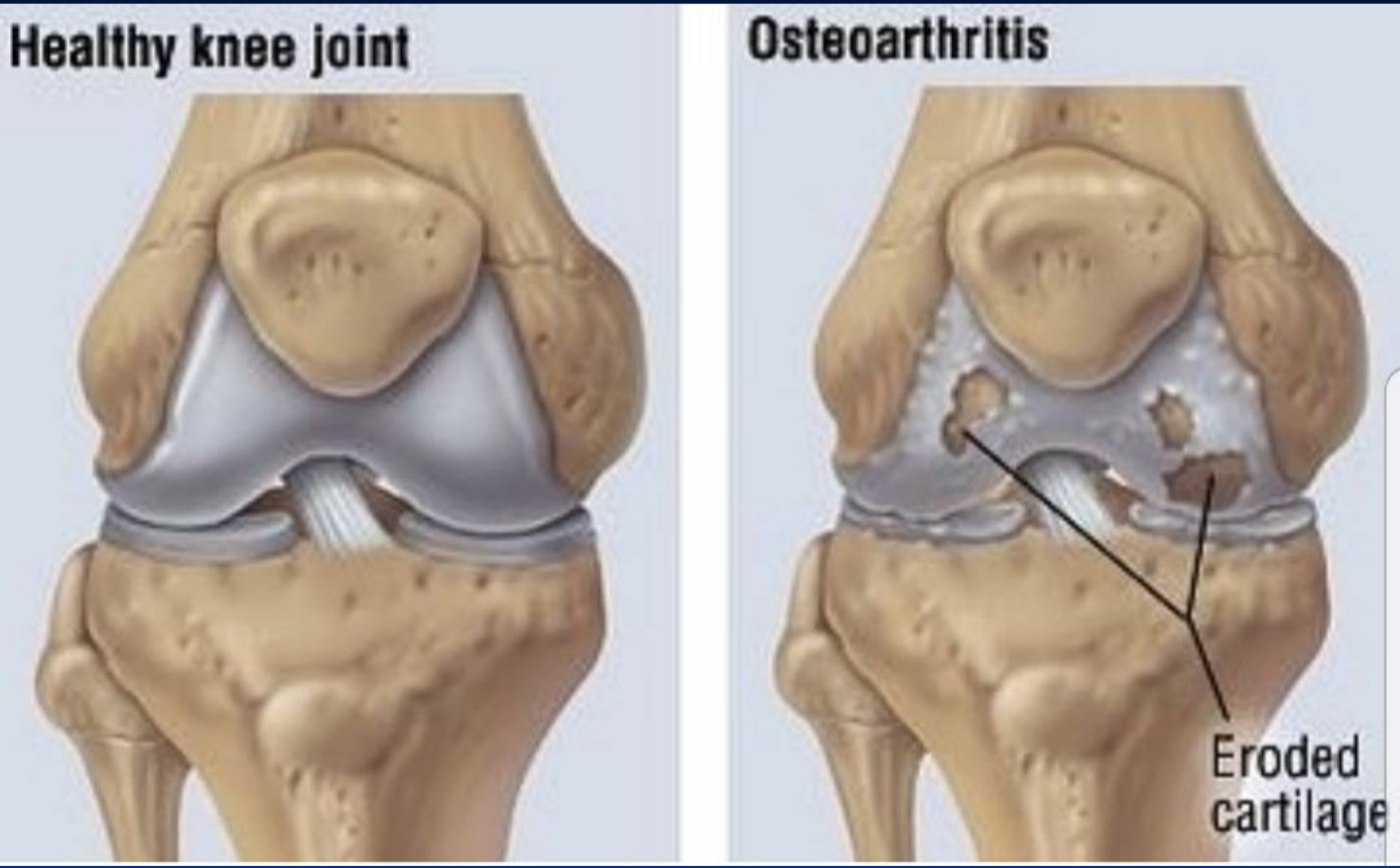
1.The darker staining matrix between chondrocytes is called interterritorial matrix.

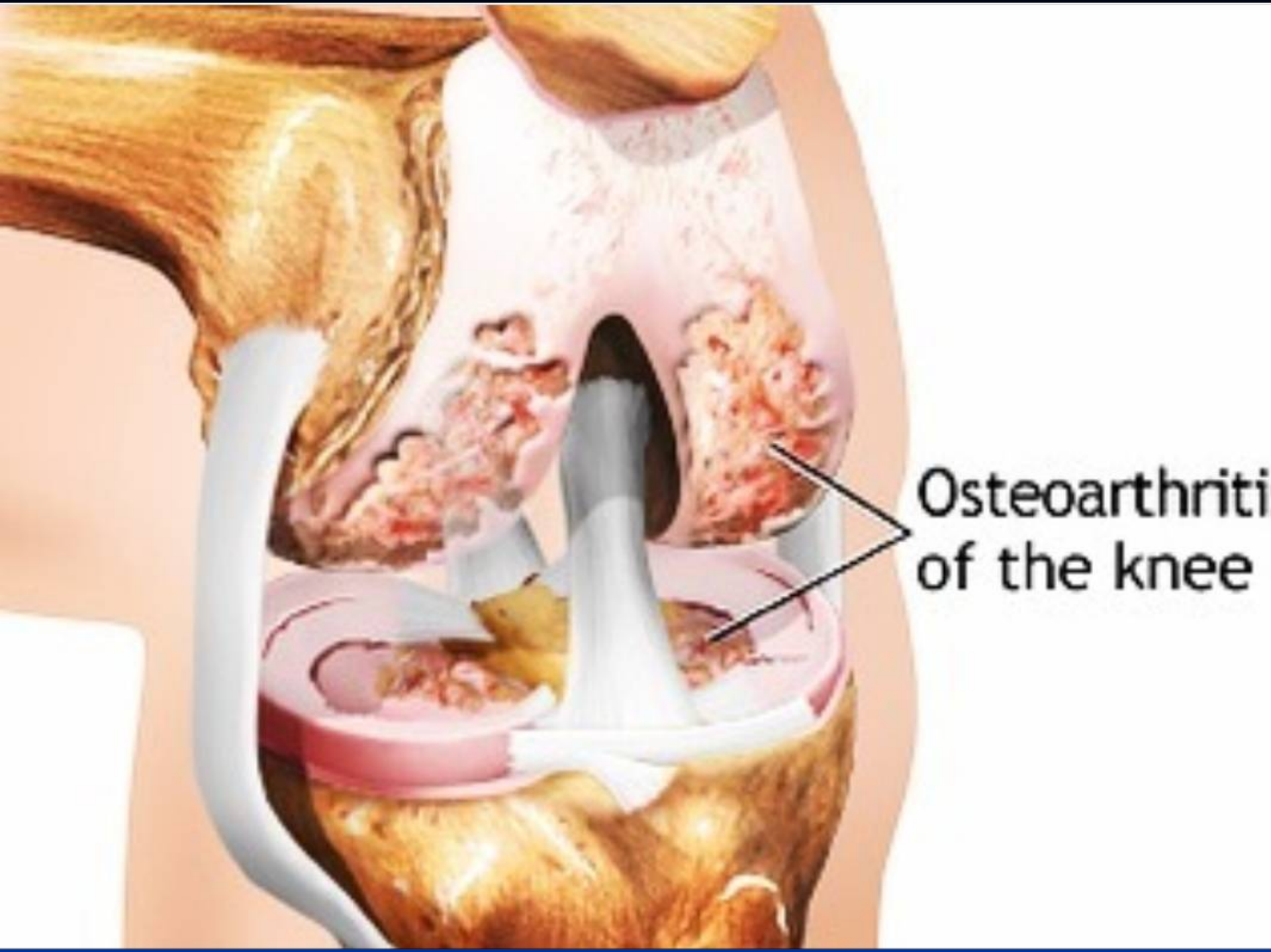
2.The lighter matrix adjacent to the chondrocytes (around lacunae) is the territorial matrix or **capsular** matrix is rich in glycosaminoglycan and poor in collagen.

Collagen fibers type II are the only fibers present in hyaline cartilage matrix.

Clinical notes: Osteoarthritis

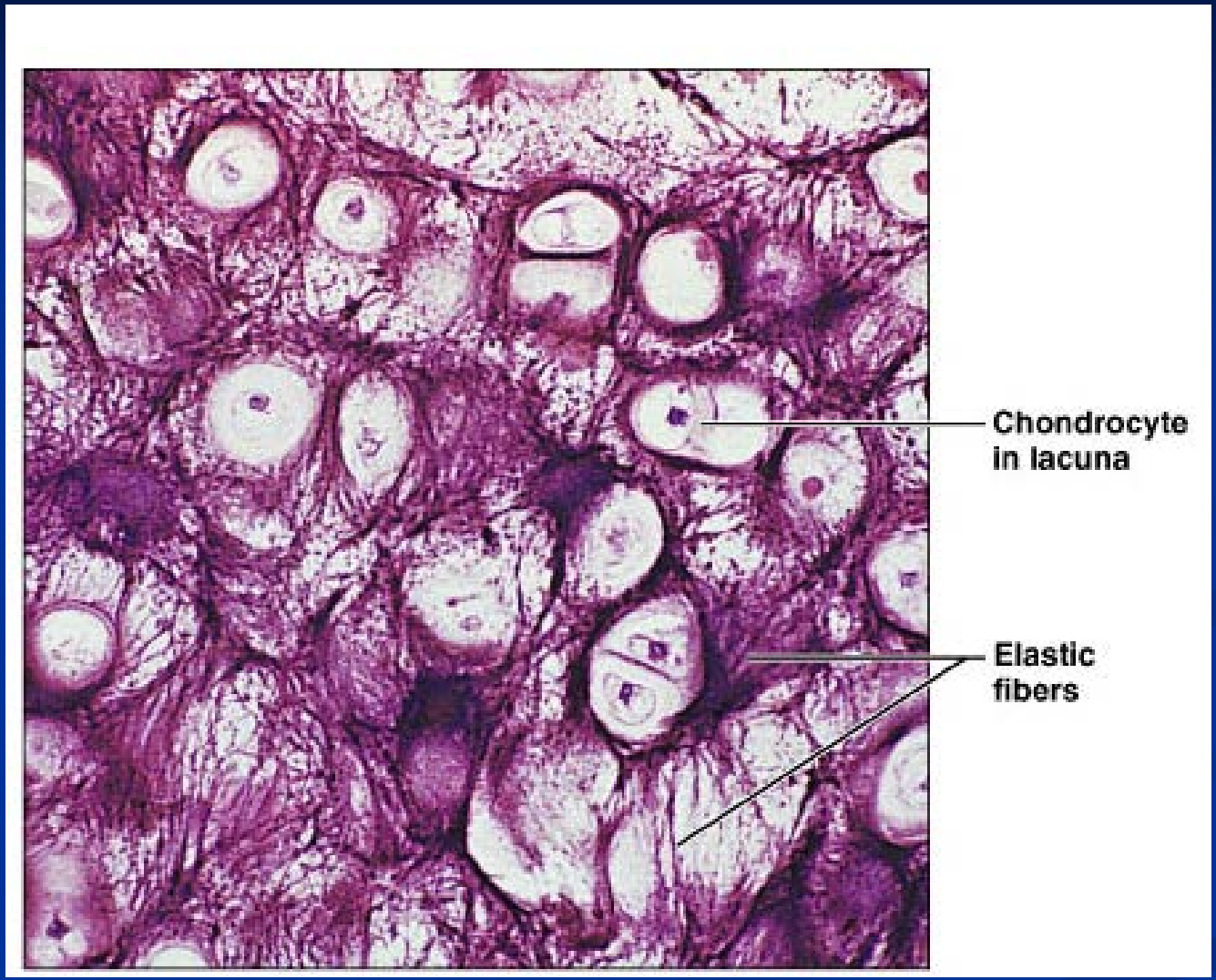



Healthy knee joint
Osteoarthritis
Eroded cartilage


Osteoarthriti
of the knee

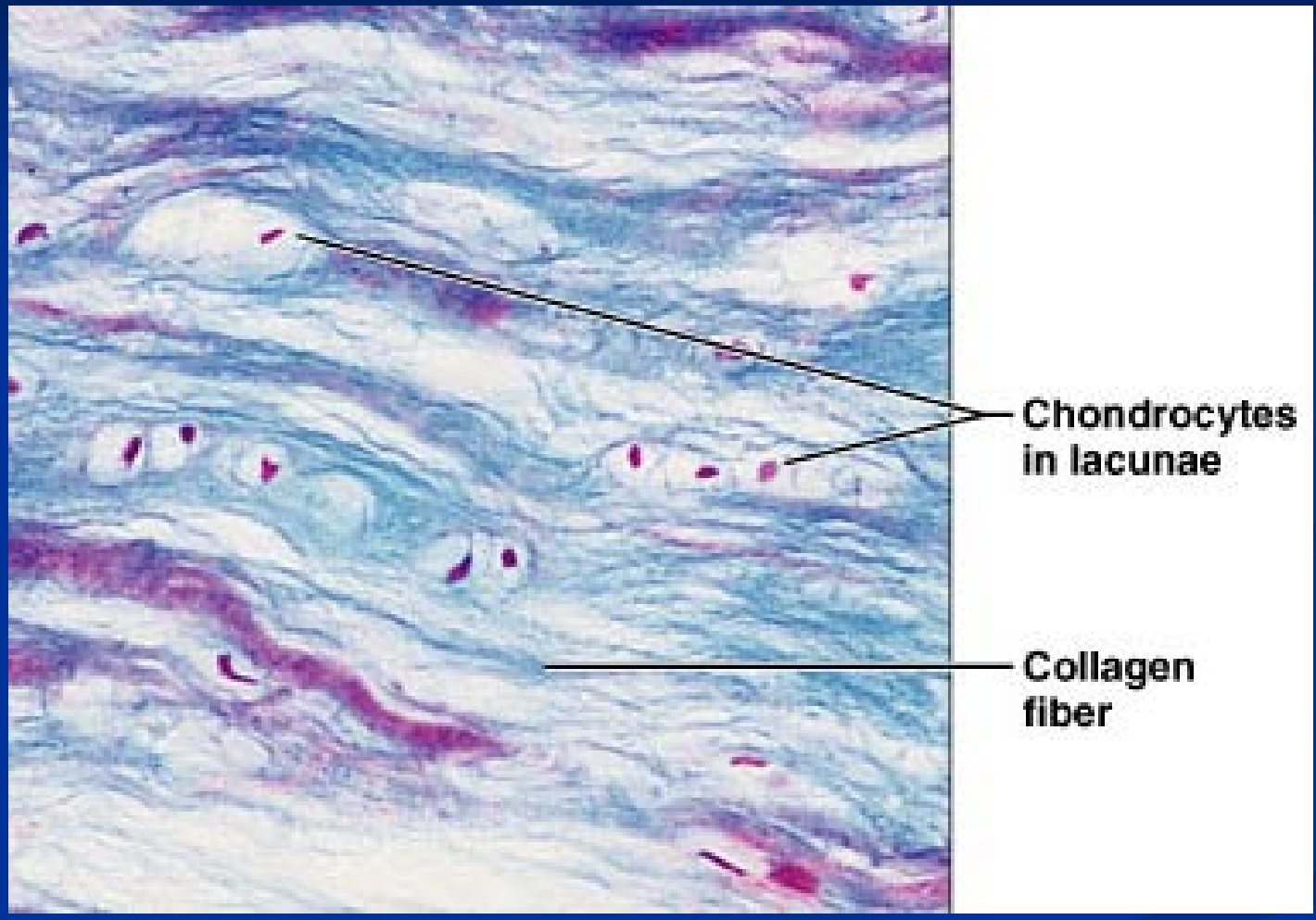
elastic cartilage:

- Elastic cartilage is located in the pinna of the ear, the external and internal auditory tubes, the epiglottis. Because of the presence of elastic fibers, elastic cartilage is somewhat yellow and is more opaque than hyaline cartilage in the fresh state. The perichondrium is rich in elastic fibers. The matrix consist of branching elastic fibers interposed with type II collagen fiber bundles, giving it much more flexibility than hyaline cartilage.


Chondrocyte in lacuna
Elastic fibers

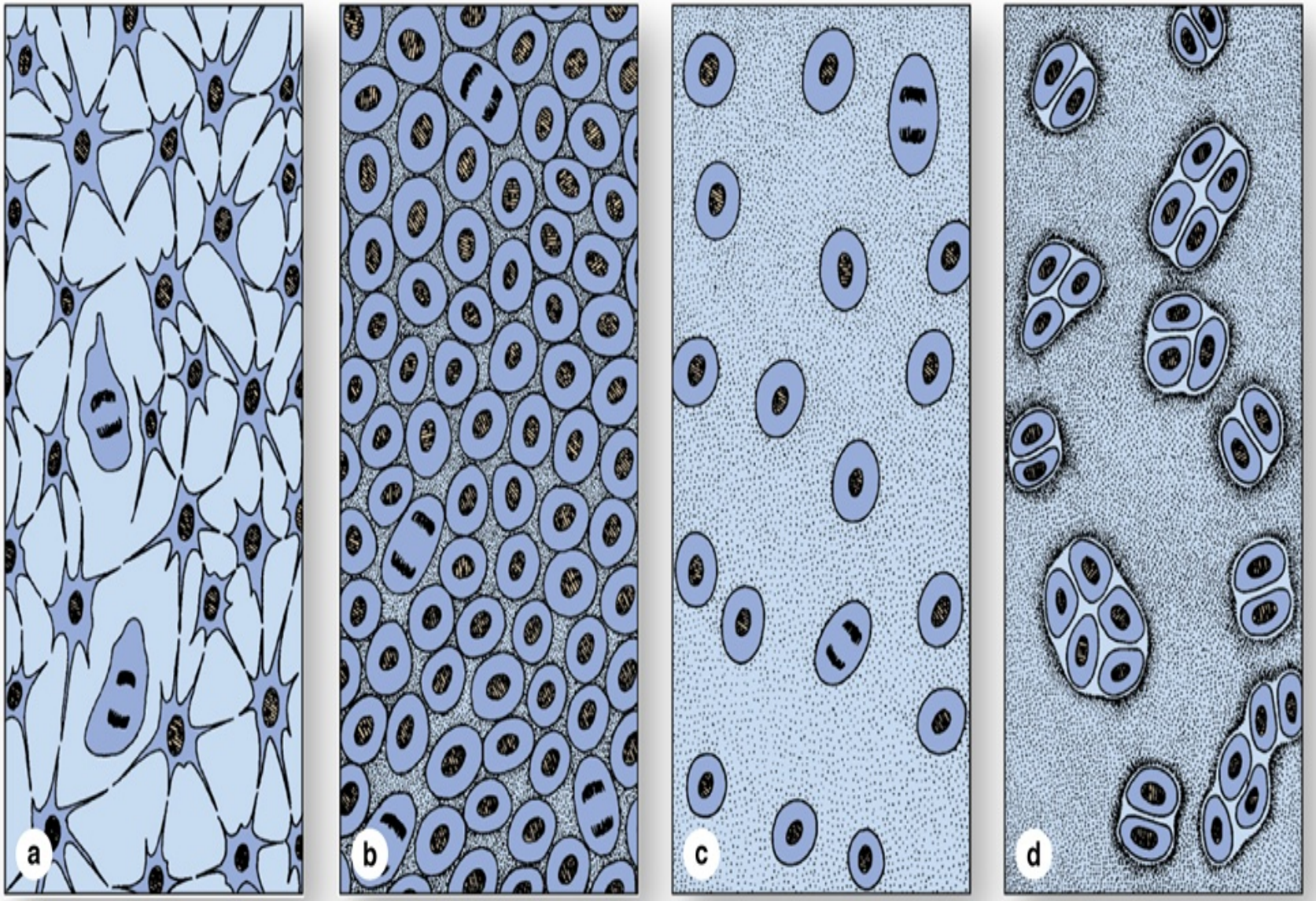
fibro cartilage:

- Is a type of connective tissue which form a transitional area between dense connective tissue (tendon and ligament) and hyaline cartilage, so the perichondrium is absent in fibro cartilage. Chondrocytes may lie singly or in pairs, but most often they form short rows alternating with rows of thick collagen fiber bundles. In contrast to other cartilage types, collagen type I is dominant in fibro cartilage. Fibro cartilage is typically found in relation to joints (forming intra articular lips), in the meniscus of the knee joint and is the main component of the intervertebral discs.


Chondrocytes
in lacunae
Collagen
fiber

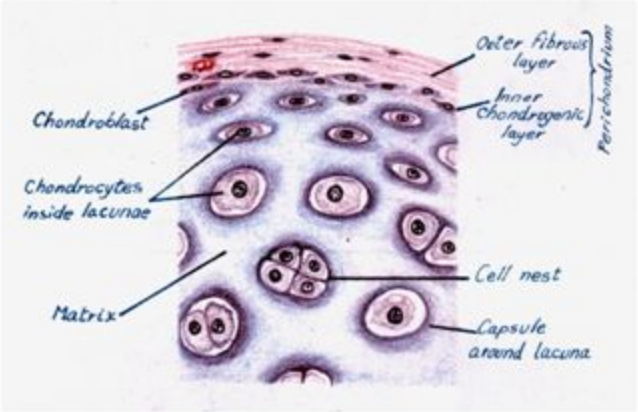
Cartilage histogenesis

- Cartilage derives from the embryonic mesenchyme in the process of **chondrogenesis**. The first modification observed is the rounding up of the mesenchymal cells, which retract their extensions, multiply rapidly, and form mesenchymal condensations of chondroblasts. The cell formed by this direct differentiation of mesnechymal cells, now called chondroblasts. Synthesis and deposition of the matrix then begin to separate the chondroblasts from one another. During development, the differentiation of cartilage takes place from the center outward; therefore, the more central cells have the characteristics of chondrocytes, whereas the peripheral cells are typical chondroblasts. The superficial mesenchyme develops into the perichondrium.


a
b
c
d

1. Appositional growth:

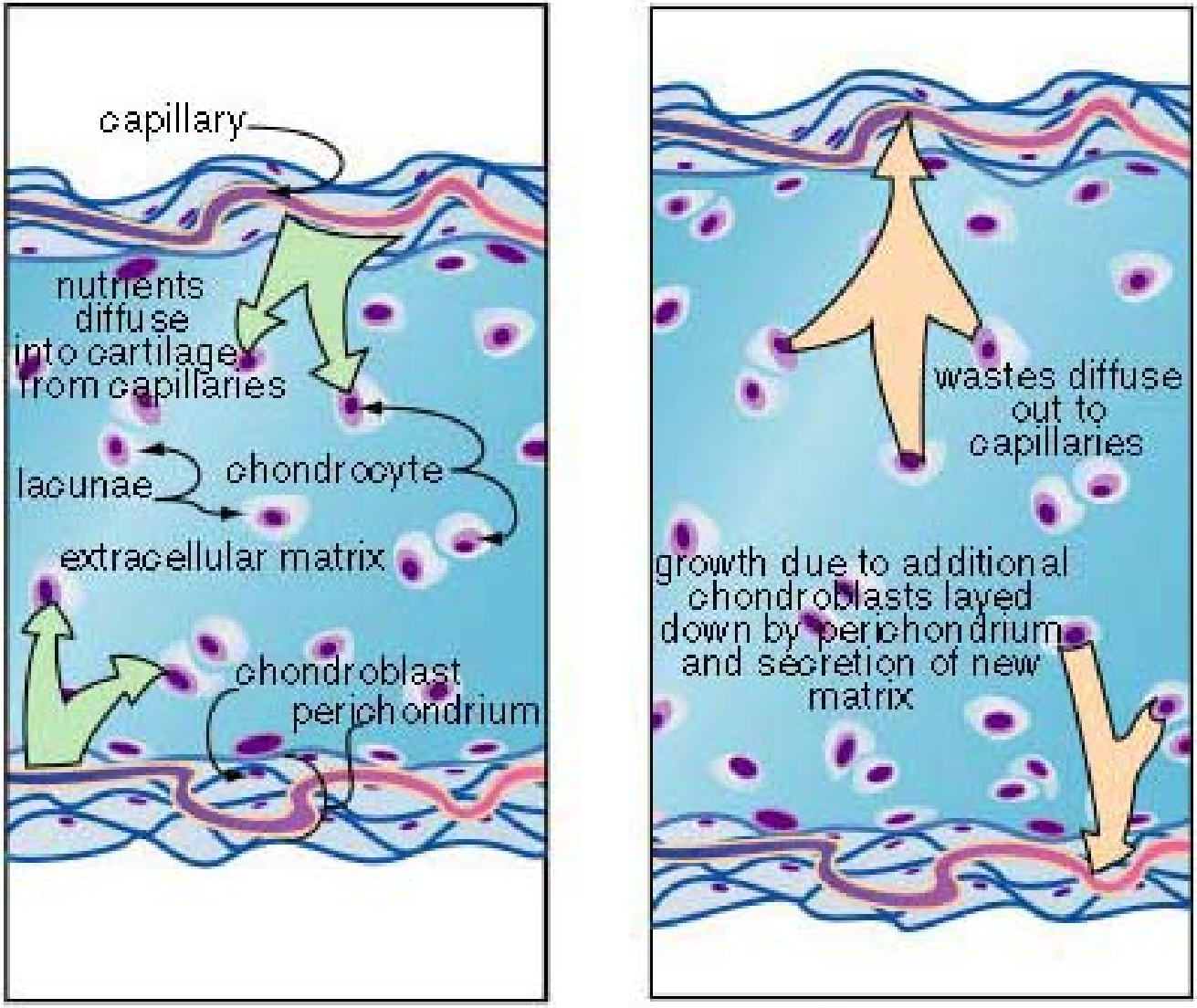
- Is produced by the activity of Chondroblasts in the inner chondrogenic layer.
- It leads to increase in width.



2. Interstitial growth:

- Is produced by division and activity of mature chondrocytes.
- It leads to increase in length.

Appositional growth of cartilage



Cartilage Growth (1 of 2)

- Interstitial growth

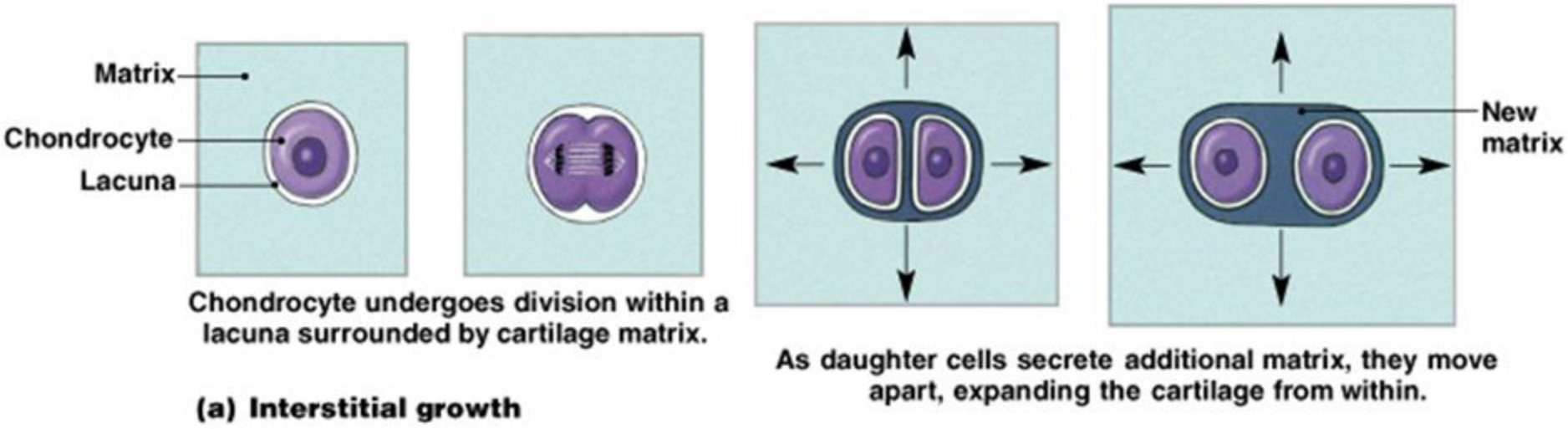


Figure 4-13a

Degenerative changes in cartilage

- Due to the poor access of nutrients to the chondrocytes they may atrophied in deep parts of thick cartilage. Water content decreases and small cavities arise in the matrix, which often leads to the calcification of the cartilage. The chondrocytes may eventually die, and the cartilage is gradually transformed to bone.
- In contrast to hyaline cartilage, which can calcify with aging, the matrix of elastic cartilage does not calcify.

Regeneration of cartilage tissue

- Except in young children, damaged cartilage undergoes slow and often incomplete **regeneration**, by activity of cells in the perichondrium which invade the injured area and generate new cartilage. In extensively damaged areas—and occasionally in small areas—the perichondrium produces a scar of dense
- connective tissue instead of forming new cartilage. The poor regenerative capacity of cartilage is due in part to the avascularity of this tissue.

	Hyaline	Elastic	Fibrocartilage
Appearance	Hundreds of eyes staring back at you.	Similar to hyaline, but differs in staining	Layers of collagen fibers visible; Chondrocytes aligned between collagen fibers
Function	Support of tissues & organs; bone development	Support with flexibility	Support with great tensile strength (must sustain pressure & shear)
Locations	Nasal septum, larynx, tracheal rings, articular surfaces of joints, sternal margins of ribs	External ear, external auditory canal, epiglottis, part of laryngeal cartilage, Eustachian tubes	Intervertebral discs, pubic symphisis, in the meniscus of the knee joint articular disks of sternoclavicular joint
Matrix **Collagen** **Ground Substance**	**Type II** (thin fibrils) 3 types of GAGSs 1. chondroitin sulfate 2. keratin sulfate 3. hyaluronic acid 4. proteoglycan 5. contains a lot of water	**Type II** / elastic fibers (same as hyaline)	Lots of **Type I** collagen layers (oriented parallel to stress plane)

THANK YOU