Medical Biology

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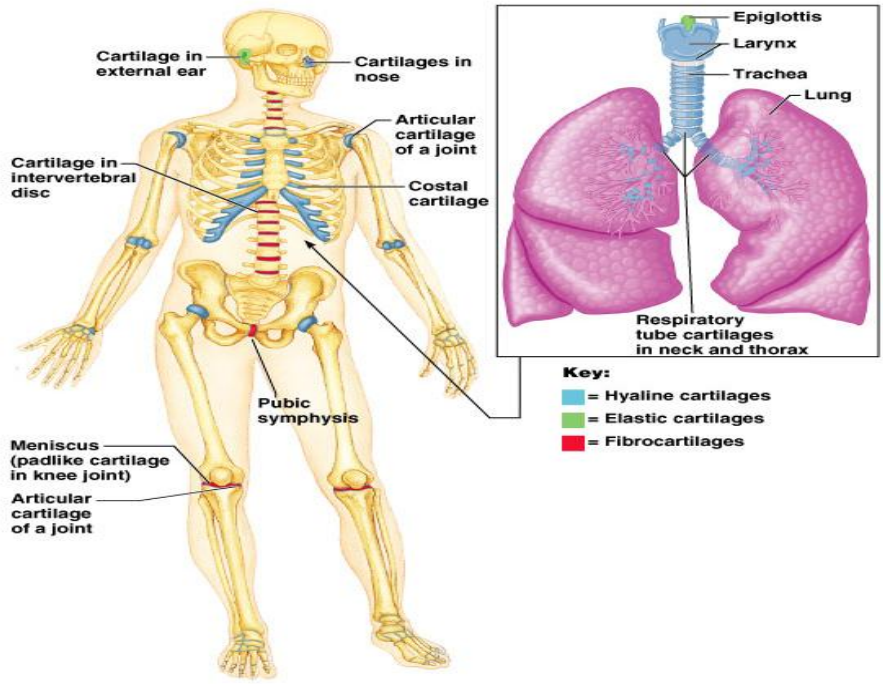
The cartilage

General characteristics:

1. Cartilage is a type of supporting connective tissue.
2. Consists, like other connective tissues, of cells and extracellular matrix composed of connective tissue fibers and ground substance.
3. Does, unlike other connective tissue, not contain vessels or nerves.
4. Cartilage consists mainly of cells called chondrocytes and chondroblasts that synthesize the extracellular matrix.
5. It is surrounded by a layer of dense connective tissue, the perichondrium.
6. Unlike connective tissue proper, contains no other cell types than chondrocytes.
7. Cartilage is rather rare in 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 temporary cartilage.



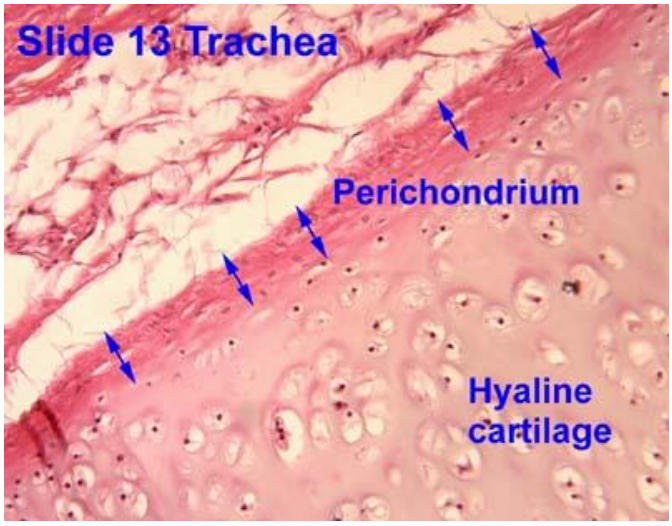
Perichondrium

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:

1. The outer one which is fibrous containing type I collagen fibers and fibroblasts.
2. 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 secretes the cartilage matrix and differentiate into chondrocytes.

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

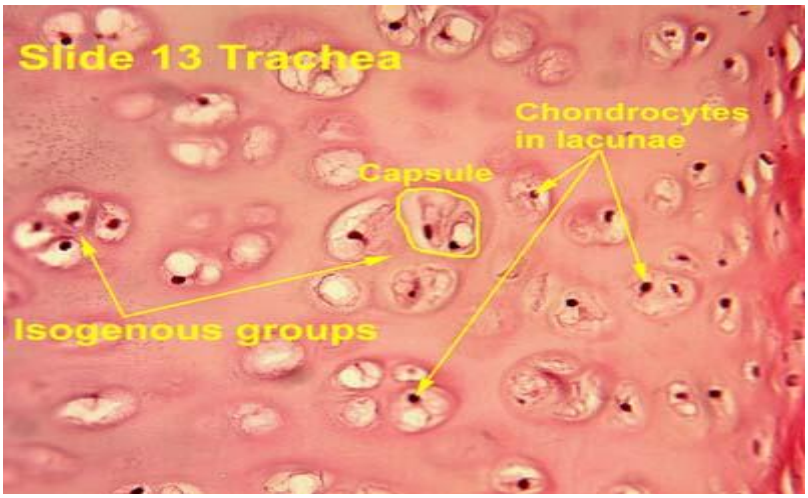


Functions of the perichondrium:

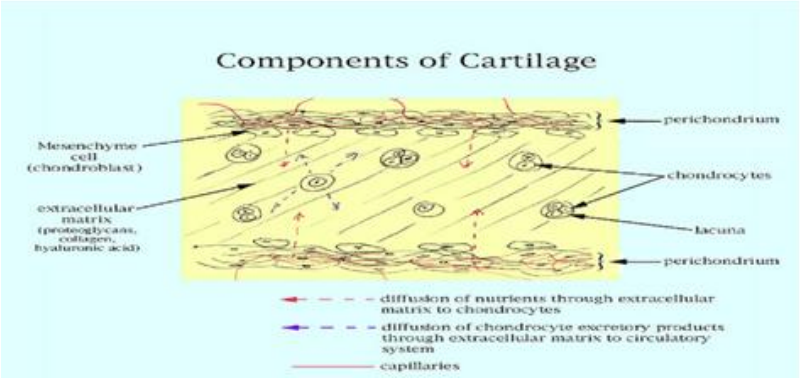
1. **growth of cartilage.**

2. **Nutrition**: because the cartilage is devoid of blood vessels, so the perichondrium passes the blood from connective tissue through the matrix to the chondrocytes. Articular cartilage sustained by the diffusion of oxygen and nutrient from synovial fluid.

Cartilage cell



❋ Cartilage develops from primitive mesenchyme cells that differentiate into chondroblasts (elliptic shape cells). These cells divide mitotically and synthesize the cartilage matrix and extracellular material. As the cartilage grows, the individual chondroblasts are surrounded by extracellular matrixes and become trapped in compartments called lacunae (cavity in matrix holding chondrocyte). In the lacunae are mature cartilage cells called chondrocytes (spherical cells). The main function of chondrocytes is to maintain the cartilage matrix. some lacunae may contain more than one chondrocyte; these groups of chondrocytes are called isogenous groups or aggregates.



❋ The inner cellular layer of perichondrium contains chondrogenic cells (spindle-shaped narrow cells), which can differentiate into chondroblasts, secrete cartilage matrix, and become trapped in lacunae as chondrocytes.

Because cartilage is devoid of blood capillaries, chondrocytes respire under low oxygen tension. They metabolize glucose mainly by anaerobic glycolysis to produce lactic acid as the end product. Nutrients from the blood cross the perichondrium to reach more deeply placed cartilage cells. Because of this, the maximum width of the cartilage is limited.

Chondrocyte function is hormone dependent. Synthesis of sulfated GAGs is accelerated by growth hormone.

Cartilage matrix

It is produced and maintained by chondrocytes and chondroblasts. It consists of:

1. Fibers: The collagen or elastic fibers give cartilage matrixes its firmness and resilience. The presence of collagen and elastic fibers characterizes cartilage as hyaline, elastic or fibrocartilage.

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 called aggrecan which composed of chondroitin sulfate and keratan sulfate. In addition to type II collagen fibers, cartilage matrix contains adhesive glycoprotein called chondronectin, this provides adherence of chondroblasts and chondrocytes to collagen fibers of surrounding matrix.

Type I collagen fibers are the dominant fiber in fibrocartilage.

While plenty of elastic fibers with few collagen fibers are present in elastic cartilage.

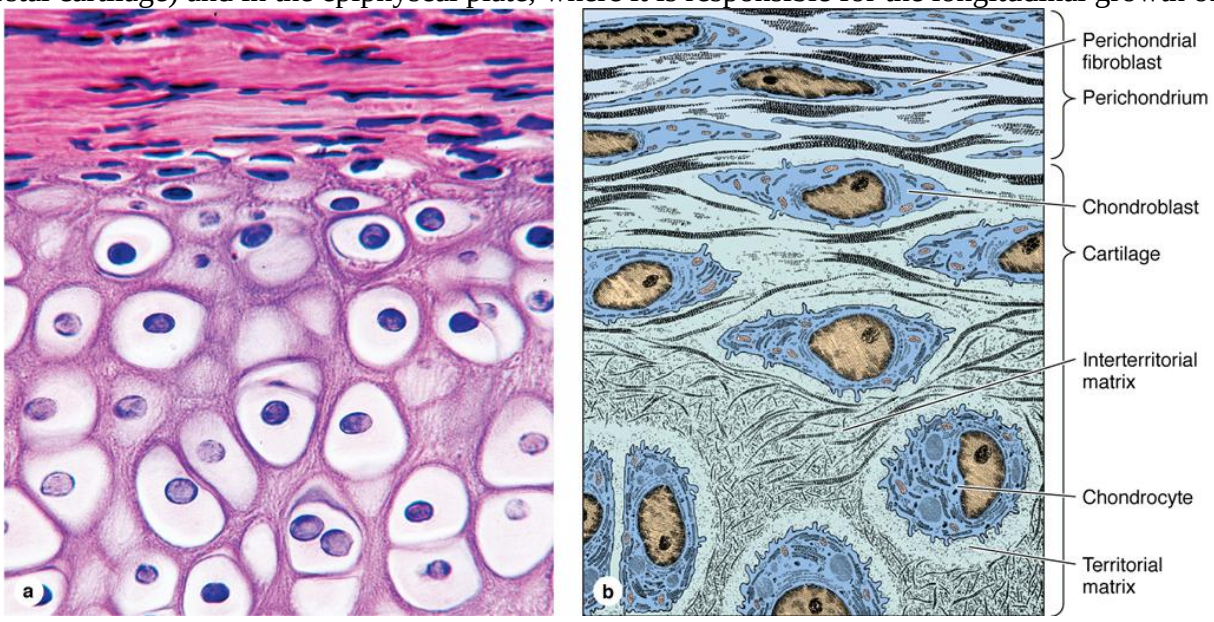
Types of cartilage

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

1. **Hyaline cartilage: flexible and resilient.**
2. **Elastic cartilage: highly bendable.**
3. **Fibrocartilage: resists compression and tension.**

1. **hyaline cartilage:**

Hyaline cartilage is the most common and best studied of the three types. Fresh hyaline cartilage is a bluish gray, semi translucent, in the embryo, it serves as a temporary skeleton of embryo until gradually replaced by bone. 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.



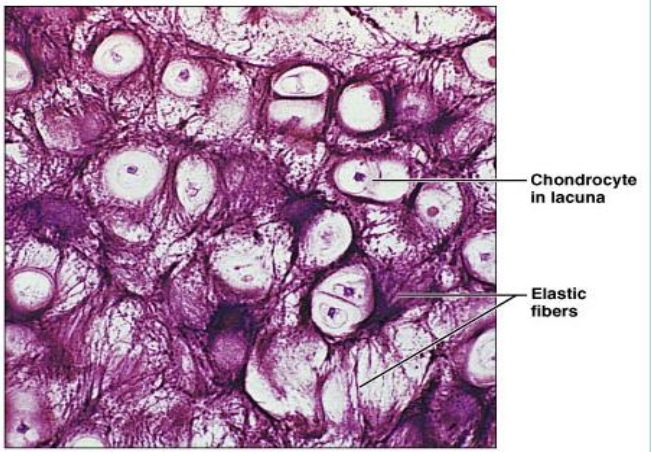
The matrix of hyaline cartilage appears homogeneous and basophilic and is subdivided into 2 regions: the lighter staining matrix between chondrocytes is called interterritorial matrix rich in collagen fibers. The darker matrix adjacent to the chondrocytes (around lacunae) is the territorial matrix or **capsular** matrix is rich in glycosaminoglycan and poor in collagen, therefore it stains darker than the rest of the matrix. Collagen fibers type II is the only fibers present in hyaline cartilage matrix.

Clinical notes:

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 (knee, hips) or heavily used (wrist, fingers) are most prone to cartilage degeneration. The disease is characterized by chronic joint pain with various degrees of joint deformity and destruction of the articular cartilage. Osteoarthritis has no cure, and treatment focuses on relieving pain and stiffness to allow a greater range of joint movement. Osteoarthritis may stabilize with age, but more often it slowly progresses with eventual long-term disability.

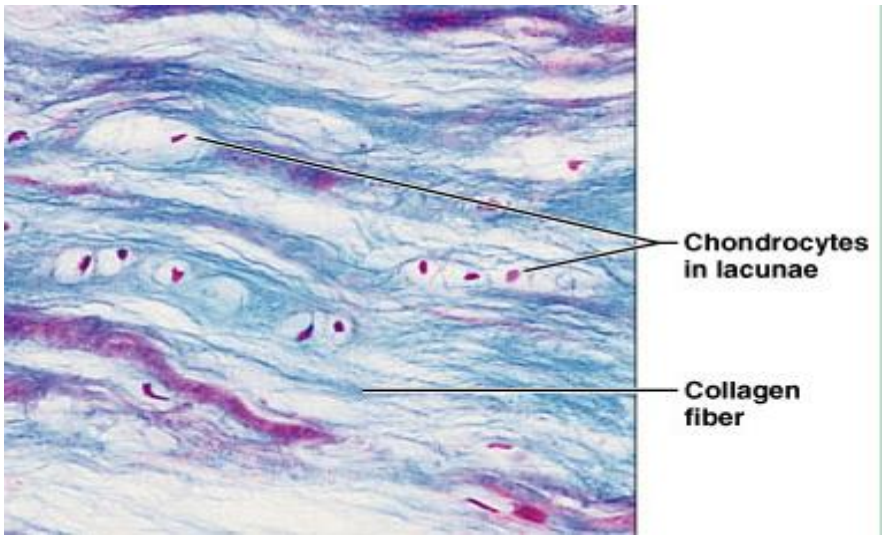
2. **elastic cartilage:**

Elastic cartilage is located in the pinna of the ear, the external and internal auditory tubes, and 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 consists of branching elastic fibers interposed with type II collagen fiber bundles, giving it much more flexibility than hyaline cartilage. The cells are similar to those in hyaline cartilage.



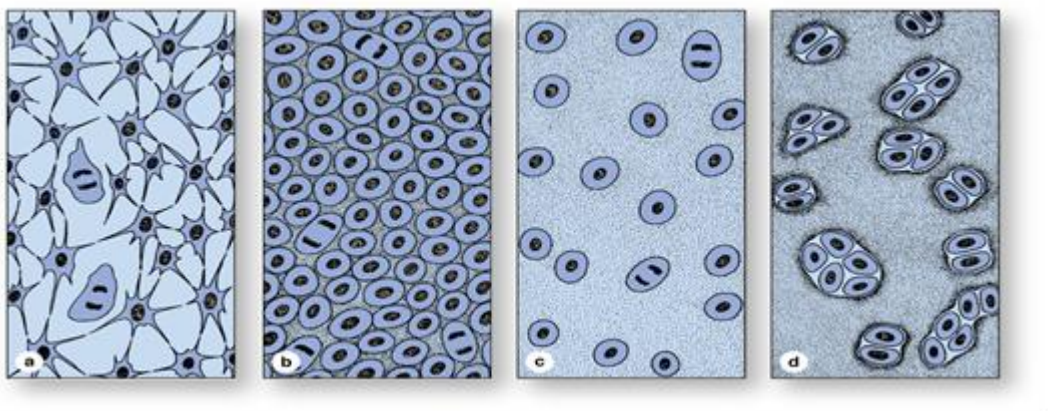
3. fibro cartilage:

It is a type of connective tissue which forms a transitional tissue 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. The matrix is acidophilic due to its low proteoglycan content. Fibro cartilage is typically found in relation to joints (forming intra articular lips), in the meniscus of the knee joint, pubic symphysis and is the main component of the intervertebral discs.



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.

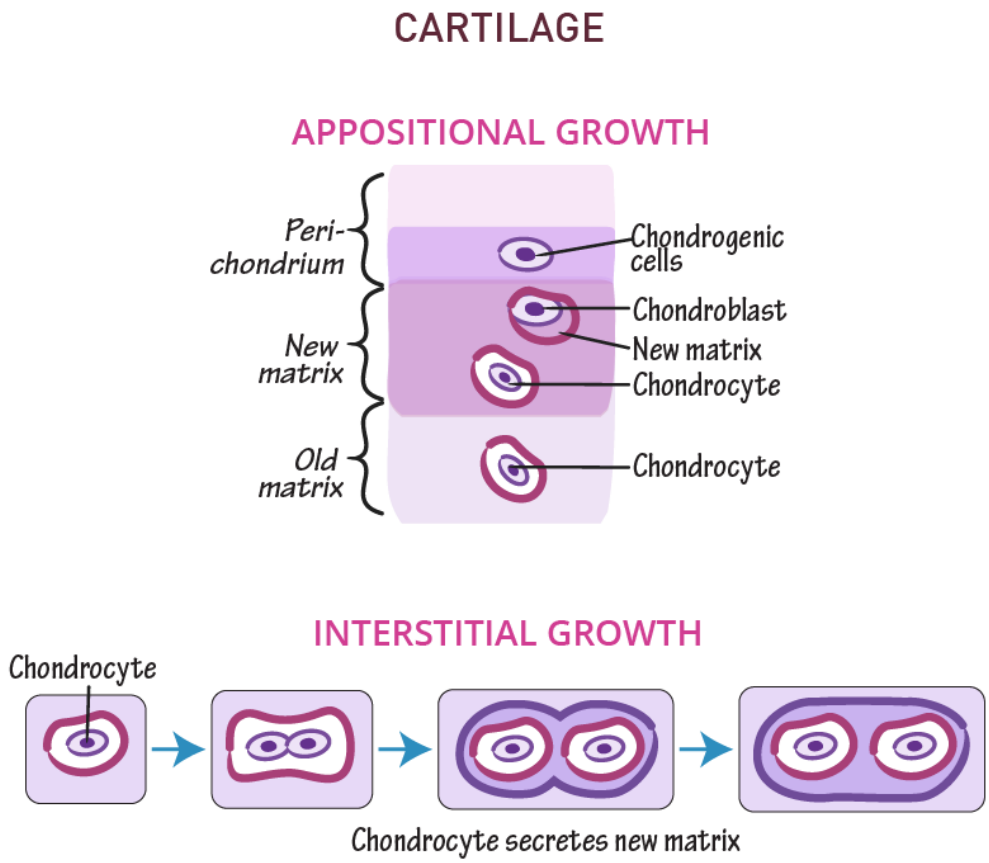


Growth of cartilage

Growth occurs by 2 mechanisms:

- **interstitial growth (endogenous growth):** it occurs only in young cartilage (mainly in immature cartilage), in which the chondrocytes lie in the central part of the cartilage divide and increase in no. and secrete intercellular substance and causing an increase of length from inside to outside. Interstitial growth also occurs in the epiphyseal plates of long bones and within articular cartilage. In the epiphyseal plates, interstitial growth is important in increasing the length of long bones.

- **Appositional growth (exogenous growth):** it occurs in mature cartilage, the chondroblasts within the inner layer of perichondrium multiply and some of them form intercellular substances and become chondrocytes whereas the other remain chondroblasts, this way causes increase of width from outside to inside.



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 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 for 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.

Medical Applications

Cells of cartilage can give rise to either benign **chondroma** or slow growing malignant **chondrosarcoma** tumors in which cells produce normal matrix components. Chondrosarcomas will metastasize and are generally removed surgically.