

## CARTILAGE

The cartilage is a semi-rigid, flexible, avascular form of connective tissue designed to perform a supportive function. It is composed of cells and matrix (fibers and amorphous ground substance). Cartilage is composed of cells called **chondrocytes** and a highly specialized extra-cellular matrix. Cartilage is **avascular, alymphatic and aneural**. More than 95% of cartilage volume consists of extra-cellular matrix, which is functional element. Chondrocytes are sparse but are essential participants in producing and maintaining matrix. Chondrocytes rely on diffusion to obtain nutrients as, unlike bone, cartilage is avascular, meaning there are no vessels to carry blood to cartilage tissue. This lack of blood supply causes cartilage to heal very slowly compared with bone. Types of cartilage:

1. **Hyaline cartilage**
2. **Elastic cartilage**
3. **Fibro-cartilage**

Characteristics	Hyaline cartilage	Elastic cartilage	Fibro-cartilage
<b>Location</b>	<ul style="list-style-type: none"> <li>• Nasal septum</li> <li>• Trachea &amp; Bronchi</li> <li>• Larynx</li> <li>• Fetal skeleton</li> <li>• Articular surface of synovial joints</li> </ul>	<ul style="list-style-type: none"> <li>• Ear pinna</li> <li>• External acoustic meatus</li> <li>• Eustachian tube</li> <li>• Epiglottis</li> <li>• Cuneiform process of Larynx</li> </ul>	<ul style="list-style-type: none"> <li>• Inter-vertebral disc</li> <li>• Menisci of stifle joint</li> <li>• Pubic symphysis</li> </ul>
<b>Perichondrium</b>	Present	Present	Absent
<b>Collagen type</b>	Type II collage	Type II	Type I & II
<b>Function</b>	Reduce friction	Elasticity	Shock absorber

### Cells of cartilage:

1. **Chondroblasts**
  - Found in growing cartilage
  - Oval shaped with prominent Golgi apparatus
  - Cytoplasm is basophilic because of large amount of RER
  - Forms matrix
2. **Chondrocytes:** After cartilage matrix formation is complete, chondroblasts become less active cell called chondrocytes located within lacunae. They have spherical nucleus.

### Matrix of cartilage:

- **Mainly type II collagen is present. In fibrocartilage, both type I & II collagen.**
- Ground substance:
  - GAGs: Hyaluronic acid and Chondroitin sulfate. *The distinctive appearance of cartilage is due to polysaccharides called **chondroitin sulfates**, which bind with ground substance proteins to form proteoglycans.*

- Proteoglycans: Aggrecans (Versican in fibrocartilage). *Aggrecans is cartilage-specific proteoglycans core protein*
- Multiadhesive glycoproteins: Fibronectin, Chondronectin

### HYALINE CARTILAGE

It is distinguished by homogenous amorphous matrix (*Greek 'hyalos' – means glassy*). Throughout the matrix are spaces called lacunae containing chondrocytes.

**Perichondrium:** It is a vascular connective tissue capsule that invests the external surface of cartilage except *articular surface of joints*. It is composed of two layers:

a) Outer fibrous layer composed of dense irregular connective tissue containing blood vessels and nerves.

b) Inner cellular or *chondrogenic layer* made up of chondroblasts that are actively involved in production of matrix during cartilage growth and regeneration.

#### **Cartilage Cells:**

##### **a. Chondroblasts (cartilage forming cells)**

- They are found mainly in the inner chondrogenic layer of the perichondrium.
- They are oval or spindle-shaped cells with oval euchromatic nuclei.
- The cytoplasm is basophilic rich in ribosomes, rER and Golgi saccules.
- They secrete matrix around themselves and become deeply buried in the cartilage matrix where they are called chondrocytes.

##### **b. Chondrocytes (mature cartilage cells)**

- They are located in tiny spaces within the cartilage matrix known as *lacunae*.
- Beneath the perichondrium, chondrocytes are small and their lacunae are elliptical with their long axes parallel to the surface.
- Deep within the cartilage, the cells are larger and polyhedral with short processes.
- They have a spherical nucleus with one or more nucleoli. The cells accumulate glycogen and lipid in their cytoplasm those appear vacuolated.
- Some lacunae contain only one cell; others contain two, four, or sometimes six cells. These multicellular lacunae are called cell nests or *isogenous groups/cell nest* because each cluster is the progeny of one cell.

Because the proteoglycans of hyaline cartilage contains high concentration of bounded sulfate group, ground substance stains with basic dyes and with Hematoxylin. Different zones are seen:

1. **Peri-cellular matrix (capsular matrix):** It is located immediately around chondrocyte. It has highest concentration of sulfated proteoglycans.
2. **Territorial matrix:** It surrounds cell nests. Mainly contain proteoglycans and type II collagen. It has lowest concentration of sulfated proteoglycans and stain less intensely than capsular matrix.

3. **Inter-territorial matrix:** Surrounds territorial matrix.

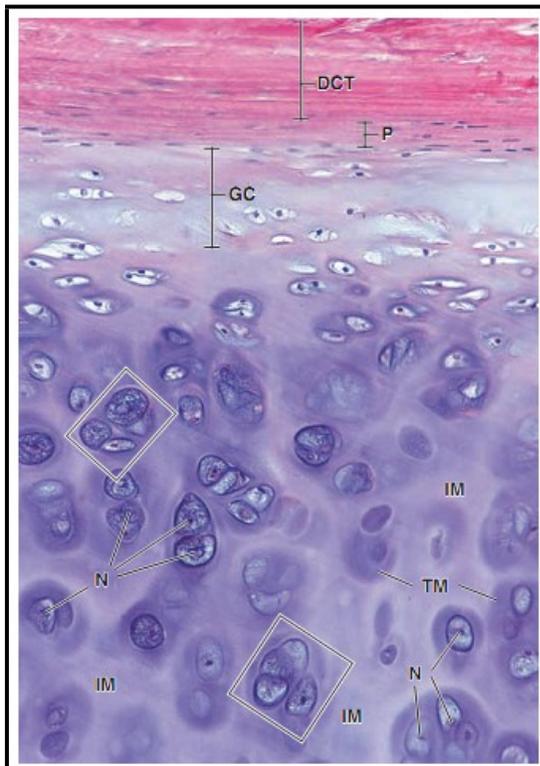
**Matrix of Hyaline cartilage:**

1. **Cartilages:** Type II, IX, X, XI. These are found in significant amounts only in cartilage matrix, hence called *cartilage specific collagen molecules*. The fibrous component represented by fine collagen fibrils made up of *type II collagen that has the same index of refraction as the amorphous ground substance*, therefore, they cannot be seen in common H&E sections.
2. **Proteoglycans:** Hyaluronic acid, Chondroitin sulfate and Keratan sulfate. *Aggrecan* (chondroitin sulfate and keratin sulfate) is most abundant proteoglycans of hyaline cartilage.
3. **Multiadhesive glycoproteins:** Chondronectin. It binds specifically to GAGs, type II collagen.

**Main function:** Reduces friction at joints. By virtue of smooth surface of cartilage, it provides sliding area which reduces friction.

**Location:** The hyaline cartilage occurs in many places such as

- Articular surfaces of long bones
- Rib tips
- Fetal skeleton
- Nasal septum, Larynx and Trachea and bronchi.



**Photomicrograph of a typical hyaline cartilage showing dense connective tissue (DCT) overlying perichondrium (P), growing cartilage (GC), nucleus of chondrocytes (N), territorial matrix (TM) and inter-territorial matrix (IM)**

## ELASTIC CARTILAGE

*It is distinguished by presence of elastic fibers.* It gives the cartilage elastic properties in addition to resilience. The histological structure of the elastic cartilage is similar to that of the hyaline cartilage except:

- Cell nests are few or absent
- The matrices contain a dense network of elastic fibers that are visible in H&E sections.

The elastic cartilage occurs in the *external ear* and *external auditory canal*, the *epiglottis*, *corniculate and cuneiform cartilage of the larynx*.



**Photomicrograph of elastic cartilage (epiglottis)**

## FIBRO CARTILAGE

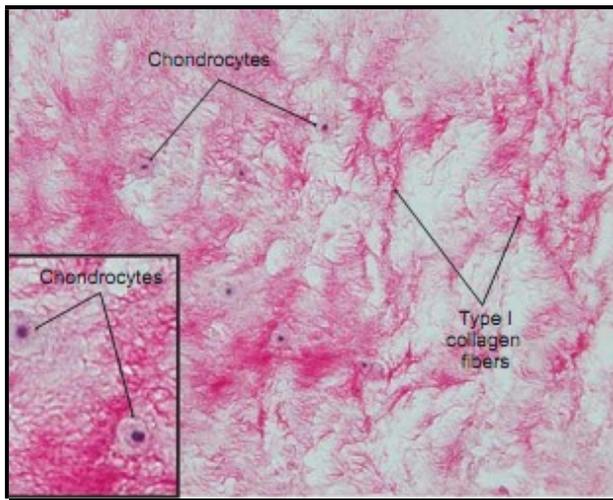
It is a transitional form between hyaline cartilage and dense regular connective tissue. It consists of regular parallel bundles of collagen fibers separated by encapsulated chondrocytes that occur singly, in pairs or sometimes form rows. The ground substances are little and only found around the chondrocytes. Chondrocytes are dispersed among collagen fibers singularly in rows. The fibrocartilage is found in the *intervertebral discs*, *menisci* of the stifle joint and at the *attachment of tendons and bones*.

- Perichondrium is absent
- **Contain both type I & II collagen**
- Presence of versican (secreted by fibroblast) than aggrecans (secreted by chondrocytes)

### Types of cartilages:

1. **Temporary cartilage:** Cartilage act as model and gradually replaced by bone as embryo grows.
2. **Permanent cartilage:** Does not ossify with age. E.g. nasal septum, trachea, larynx, epiglottis

**Nutrition to cartilage:** By diffusion



Fibrocartilage (IV disc)

### Growth of cartilage:

#### 1. Appositional growth

- a. New cartilage is formed at surface of an existing cartilage
- b. Cells in perichondrium (chondrogenic layer) becomes chondroblasts
- c. Produces new matrix under perichondrium. The cells begin to secrete matrix around them forming new cartilage layer that is added to the periphery of the cartilage. *These cause the cartilage to grow in width.*

#### 2. Interstitial growth

- a. New cartilage is formed within existing cartilage mass
- b. Cells in deeper part becomes active and produce new matrix all around themselves
- c. The chondrocytes located inside their lacunae start to divide forming cell nests (isogenous group). The matrix produced by each daughter cells cause the cartilage matrix as a whole to expand from within. *This causes the cartilage to grow in length.*