Faculty of Medicine

Histology Department

Cartilage

Lecture 43 (5th Week)
In
Block 102PMS

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Learning objectives (5th *week/Lecture 43*)

After the lecture, students should be able to:

- **Enumerate cartilage types.**
- **Identify hyaline cartilage structure .**
- **Discriminate chondrocyte ultrastructure.**
- **Recognize elastic and fibrocartilage charactristics.**
- **Know cartilage development**

General characteristics of cartilage:

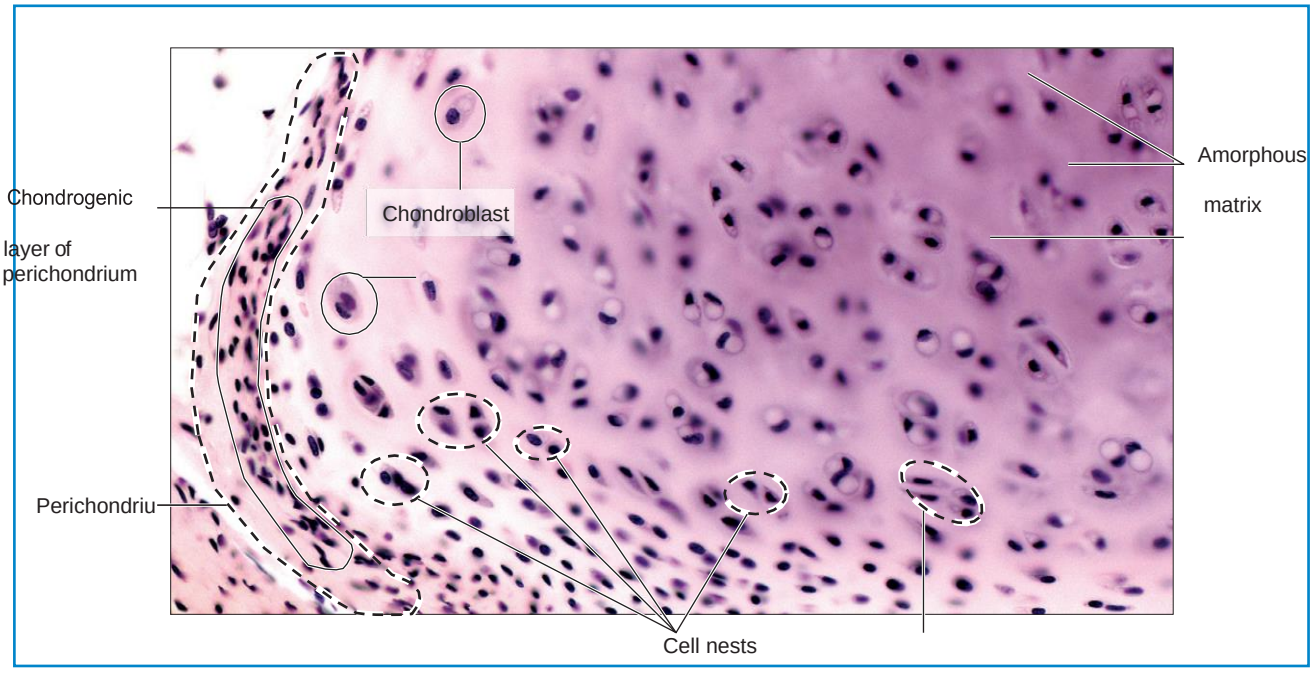
- **Cartilage is a connective tissue specialized to function as a supporting or weight-bearing tissue. It has the properties of a firm, rubbery, resilient gel.**

➢ There are three types of cartilage:

a- Hyaline cartilage **b-Elastic cartilage** **c- Fibrocartilage**

- Cartilage has the properties of a firm, rubbery, resilient gel.
- Hyaline cartilage is the most abundant type.
- Hyaline cartilage has important roles during fetal development, postnatal growth and development, and in the adult. So, most of our understanding of cartilage structure and function is based on hyaline cartilage. All three types of cartilage have many similarities but are differentiated by their matrix appearance and composition.
- Cartilage is completely **avascular**; this means that all nutrients have to diffuse through the matrix to the cartilage cells (chondrocytes), and waste materials have to diffuse out from capillaries originating from the perichondrium.in order to sustain the vital functions of the chondrocytes.
- The cartilage matrix, with its high water content and high anionic charge, facilitate this diffusion. Cartilage matrix undergoes metabolic turnover; the half-life of hyaline cartilage is on the order of 1 to 2 months.
- **Perichondrium;** Most cartilage is surrounded or enclosed by a vascular fibrous connective tissue sheath—the perichondrium—**with two notable exceptions, articular cartilage of movable joints and fibrocartilage, neither of which have a perichondrium**. Perichondrium It is essential for the growth and maintenance of cartilage, as it harbors its vascular supply, as well as its nerves and lymphatic vessels. Perichondrium consists of two layers.
- The outer layers of the perichondrium consist of fibrous layers of type I collagen with a small number of fibroblasts embedded among them.
- The innermost layers of the perichondrium contain relatively undifferentiated mesenchymal cells, which can differentiate into new fibroblasts of the outer perichondrium or into chon- dro progenitor cells that differentiate further into chondroblasts, the cells that actively synthesize and secrete cartilage matrix.
- Although the articular cartilage of movable joints is not covered by perichondrium, they are sustained by diffusion of oxygen and nutrients from synovial fluid.

Hyaline cartilage

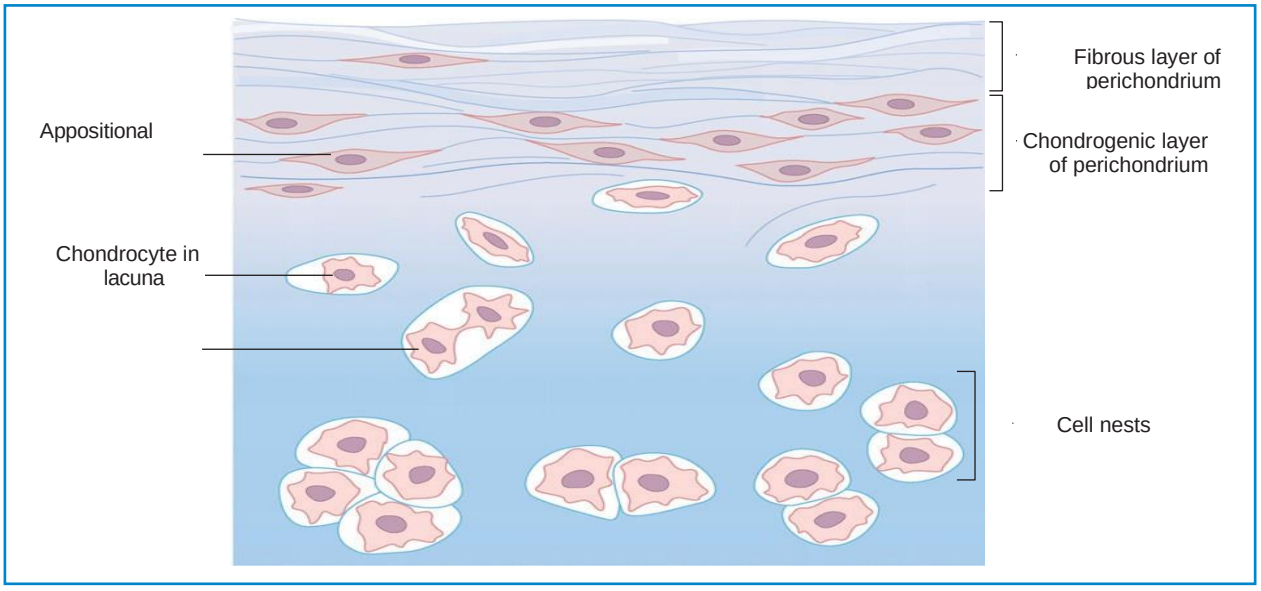


Hyaline cartilage stains by H&E

Site: It is found in the fetus as the "models" from which most of the long bones of the body develop. In the adult, the articular surfaces of bone are covered with hyaline cartilage, the larger airway passages in the respiratory system are supported by rings and plates of hyaline cartilage, and the main supporting material of the nose is hyaline cartilage.

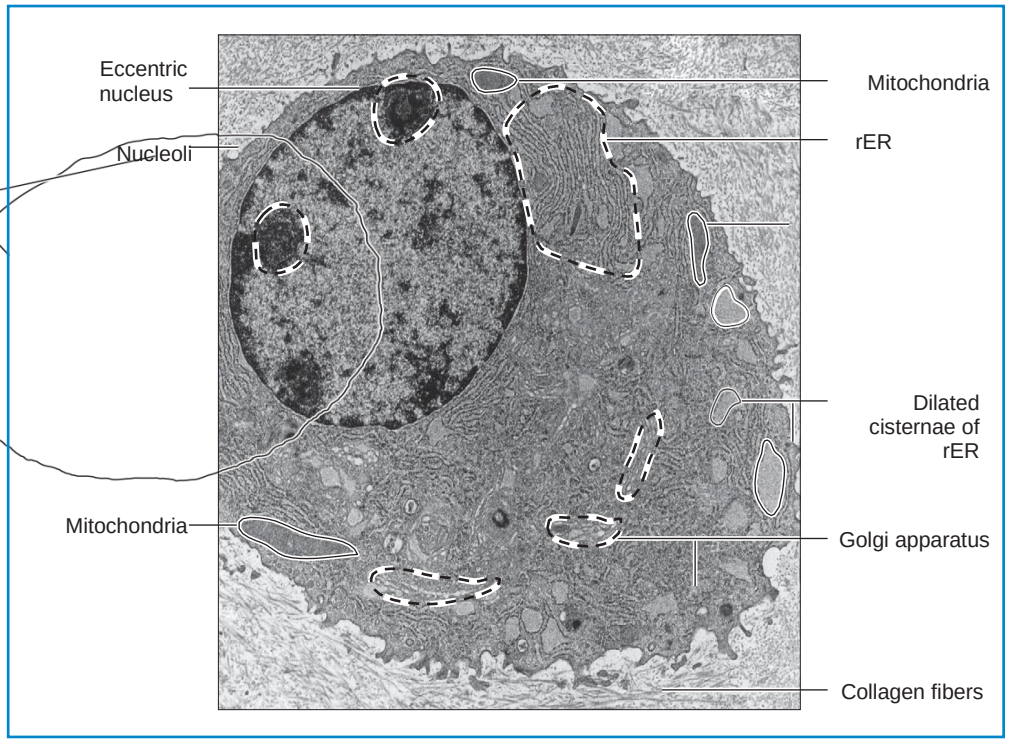
- In the living state, hyaline cartilage is bluish- white with a slight glassy translucence.
- In fixed and stained preparations, its matrix has an amorphous appearance.
- At the periphery of hyaline cartilage; chondroblasts have an elliptic shape, with their long axis parallel to the surface.
- At the core, hyaline cartilage has mature chondrocytes with round shape embedded in a large volume of cartilage matrix. The chondrocytes may occur as single cells or in groups of two, three, or four cells in close proximity. These groups often called cell nests are called isogenous groups arose from a single precursor cell even and have the same genome.
- The cartilage matrix is so firm that even if chondrocytes had the capacity to locomote, they would not be able to because of the rigidity of the matrix.
- In the living state, the chondrocytes completely fill the space in which they are seen (lacuna), but it is typical for the chondrocyte to shrink during fixation, which gives the impression that they reside in a small space or hole in the cartilage matrix.

➢ The edges of the lacuna that are in contact with the chondrocyte often stain darker than the adjacent matrix, giving another impression, namely, that the chondrocyte has a "capsule." This is a reflection of the presence of another minor collagen, type VI, and therefore is not a capsule in any usual sense of the term.



Chondrocyte Ultrastructure

- Mature chondrocytes are rounded polygonal to oval cells with an eccentrically placed spherical nucleus.
- They have an extensive amount of rough endoplasmic reticulum (rER) that is often dilated if the cell is in an active phase of matrix synthesis and secretion,
- A prominent Golgi apparatus,
- Many stubby filopodia.
- Numerous large lipid droplets or glycogen granules in the chondrocyte cytoplasm; these two cytoplasmic inclusions reflect storage forms of the precursors of proteoglycan and collagen synthesis.



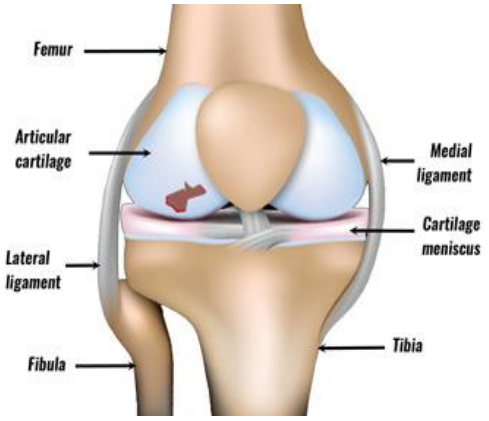
Electron micrograph of chondrocytes. Note the eccentric placement of the nucleus, abundant rER with electron- dense cisternal contents, and filopodia on the plasma membrane.

Hyaline cartilage matrix

- Hyaline cartilage has a matrix rich The extracellular matrix (ECM) of hyaline cartilage is homogeneous and glassy, rich in proteoglycan (aggrecan) aggregates molecules, type II collagen and structural glycoproteins such as chondronectin.
- One hundred or more aggrecan molecules are bound to very long molecules of hyaluronic acid to form enormous **macromolecular complexes of the matrix.**
- **Type II collagen is often called cartilage-specific collagen.** large amount of proteoglycan aggregates to collagen fibers II. The proteoglycan aggregates and collagen fibers form a large, space- filling complex that binds large amounts of water and anions.
- Chondronectin binds specifically to glycosaminoglycans, collagen type II fibers, as well as integrins, and mediates the adherence of chondrocytes to the ECM.
- Minor collagens, specifically types IX, X, and XI; are dispersed in the cartilage matrix. Some of the staining characteristics of hyaline cartilage matrix reflect differential distribution of these minor cartilage collagens (see note below).

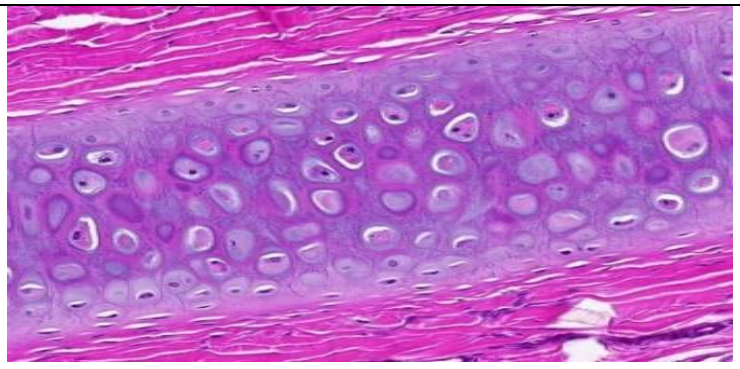
- Collagen molecules do not stretch and the matrix forms a rigid gel, a mass of cartilage resists compression very effectively.
- The matrix may be relatively unstained, may be eosinophilic or basophilic , or may show a shift in color (metachromasia) with certain stains such as alcian blue.

Articular cartilage is hyaline cartilage which is a very smooth, hard material that lines the ends of bones. Its purpose is to protect the ends of the bone and allow smooth movement between the surfaces of bones. It has no direct blood supply. Therefore, once injured it is extremely slow to heal. Attempts to stimulate the recovery of the articular cartilage itself such as recruitment of marrow stem cells into the affected area.

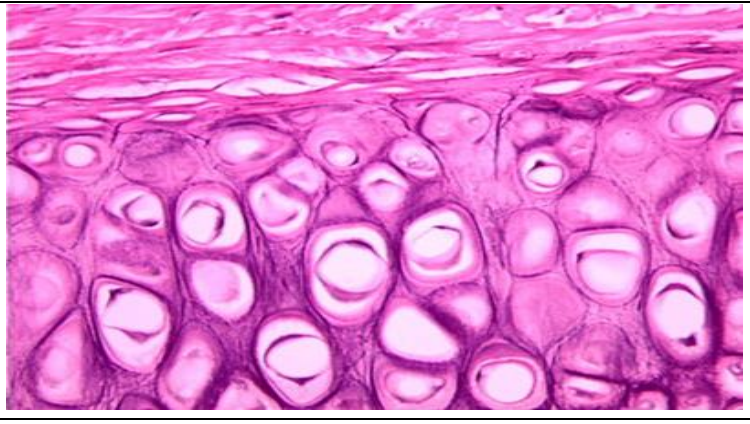


Elastic Cartilage

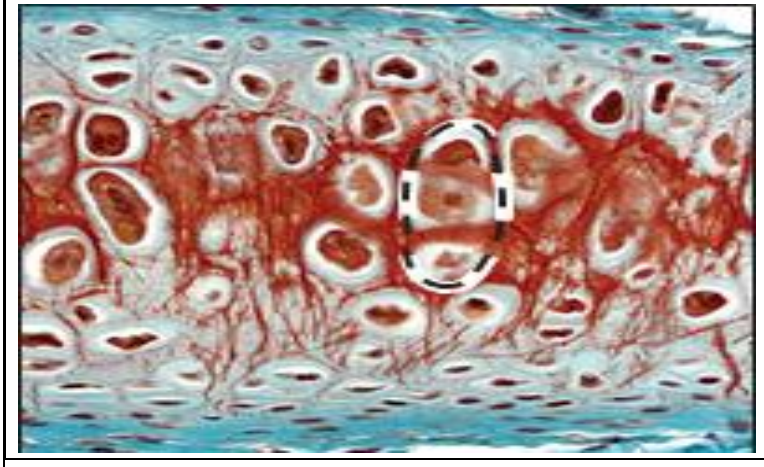
- Elastic cartilage bears many similarities to hyaline cartilage.
- It is surrounded by a perichondrium, the cells in its matrix are chondrocytes.
- Elastic cartilage matrix also has proteoglycan aggregates and type II collagen plus significant quantities of elastin fibers.
- The elastin fibers are synthesized and secreted by the chondrocytes.
- **It is found in the epiglottis, parts of the auditory system (the external acoustic meatus and parts of the eustachian tubes), and in the pinnae of the ears.**
- Verhoeff van Gieson (stains elastic fibers black), and Orcein (stain elastic fibers brown)



Elastic cartilage (H&E); low power



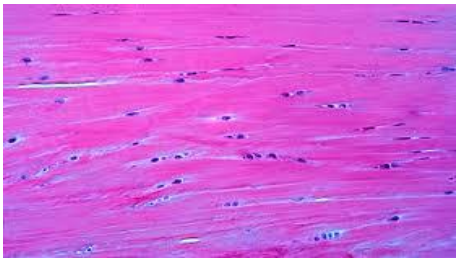
Elastic cartilage (H&E); high power



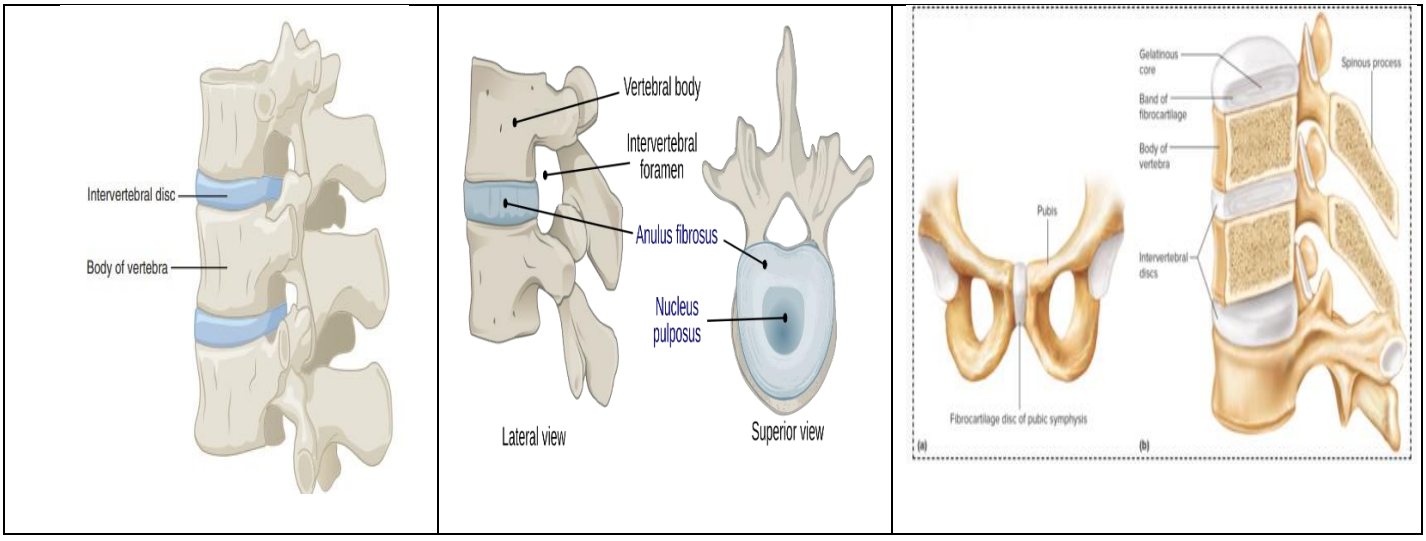
Brown elasic fibers by orcein specific stain

Fibrocartilage

- Fibrocartilage is a mixture or combination of small numbers of chondrocytes surrounded by scant amounts of hyaline cartilage matrix (contain collagen II); intermingled with thick collagen fibers (collagen I) that are characteristically found in tendons or ligaments (dense regular connective tissue).
- No perichondrium is present.
- It is found in intervertebral disks, symphysis pubis and a number of specialized joints.



Fibrocartilage HX&E



Cartilage Development

- Cartilage development begins when mesenchymal cells are stimulated to proliferate, differentiate, and secrete cartilage matrix molecules.
- The first cells that synthesize and secrete cartilage matrix are called chondroblasts.
- As the matrix accumulates, the chondroblasts surround themselves by more and more cartilage matrix and become separated from each other. When this happens, the cartilage cells are called chondrocytes.
- As cartilage grows and develops, the mass of cartilage can grow from within the cartilage matrix (interstitial growth/ chondrocytes) or by addition of new cartilage at its surface (appositional growth/ chondroblasts and progenitor cells).
- These two terms refer to cell division and to the addition of new cartilage matrix. Young or fetal cartilage is much more cellular than mature cartilage.
- Cartilage is somewhat pliable, but when it is subjected to too much stress or to trauma, it will fracture. This can cause serious problems, since cartilage does not have the capacity to regenerate or "heal." Cracks fill in with fibrous connective tissue, much like a scar, and the mass of cartilage will malfunction for the remainder of life.

References:

- Elsevier's Integrated Histology/ 2007
-Lippincott Illustrated Reviews: Integrated Systems 24th ed. 2015
-Junqueira's Basic Histology Text & Atlas 13th ed. 2013

1-Case

A- During a football game a player has fallen down on the ground and hurted. A fellow from the other team has kicked his right knee strongly. Few days later, he had swelling in the right knee joint and clicking noises when moving the knee. On Physical examination and X ray; it had found the articular cartilage of his knee joint was injured. Please, complete the following sentences.

1- ……. is the type which found in the knee joint
2- The mature cell of cartilage is called ……..
3- This cartilage is surrounded by ……

Self assessment

1- Hyaline cartilage has type ….. …….collagen
2- Cartilage development by ……
3- Chondrocytes have ……..nucleus
4- Cartilage matrix contain ……
5- ……. Has type I collagen