



# CARTILAGE

# Cartilage

- ▶ Cartilage is a tough and durable CT
- ▶ Rich extracellular matrix (ECM) with high concentrations of gags and proteoglycans
- ▶ Contains collagen and elastic fibers.
- ▶ **Avascular** (low metabolic activity).
- ▶ **Lacks nerves.**



# PERICHONDRIUM

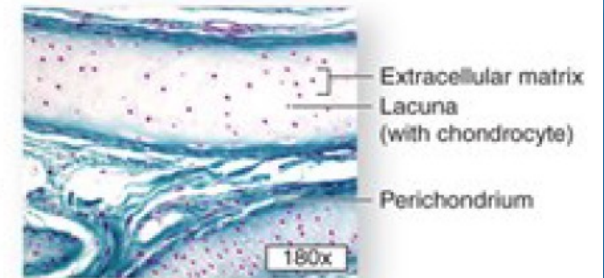
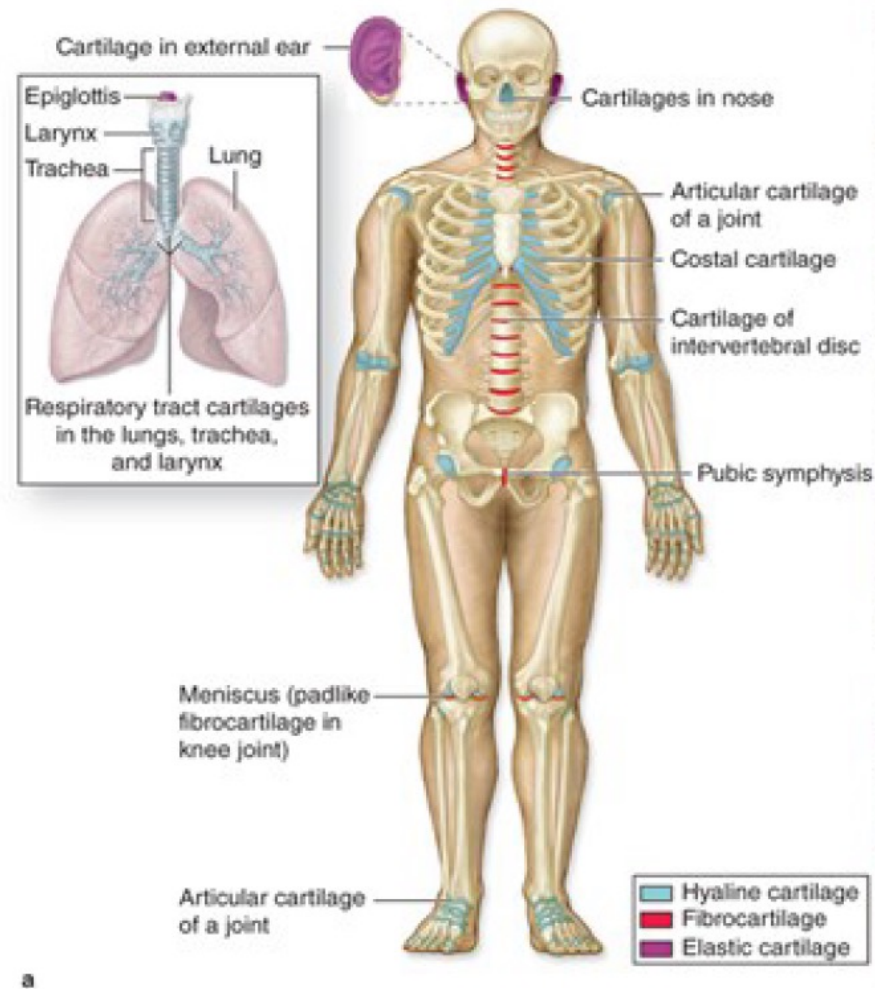
- ▶ Is a sheath of dense connective tissue that surrounds cartilage
- ▶ Forms an interface between the cartilage and the tissues supported by the cartilage.
- ▶ Contains blood supply and a small neural component.
- ▶ **Articular cartilage** (covers the ends of bones in movable joints) lacks perichondrium (diffusion of oxygen and nutrients from the synovial fluid)

# FEATURES

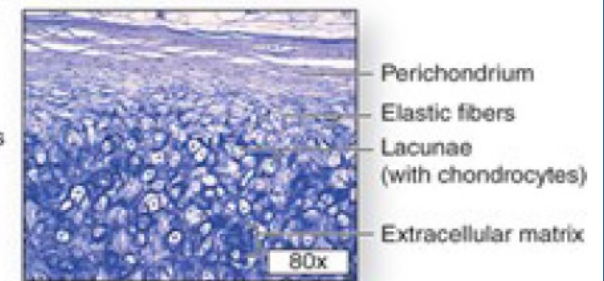
- ▶ *Its semi-rigid consistency is attributable to water bound to the negatively charged hyaluronan and GAG chains extending from proteoglycan core proteins, which in turn are enclosed within a dense meshwork of thin type II collagen fibrils---**shock absorber**.*
- ▶ *The physical properties of cartilage depend on electrostatic bonds between type II collagen fibrils, hyaluronan, and the sulfated GAGs on densely packed proteoglycans*

# Types of cartilage

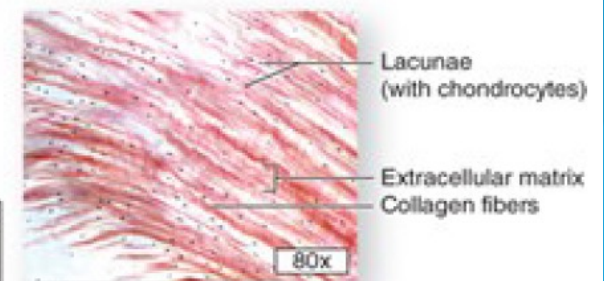
1. Hyaline
2. Elastic
3. Fibrocartilage



**b** Hyaline cartilage



**c** Elastic cartilage



**d** Fibrocartilage

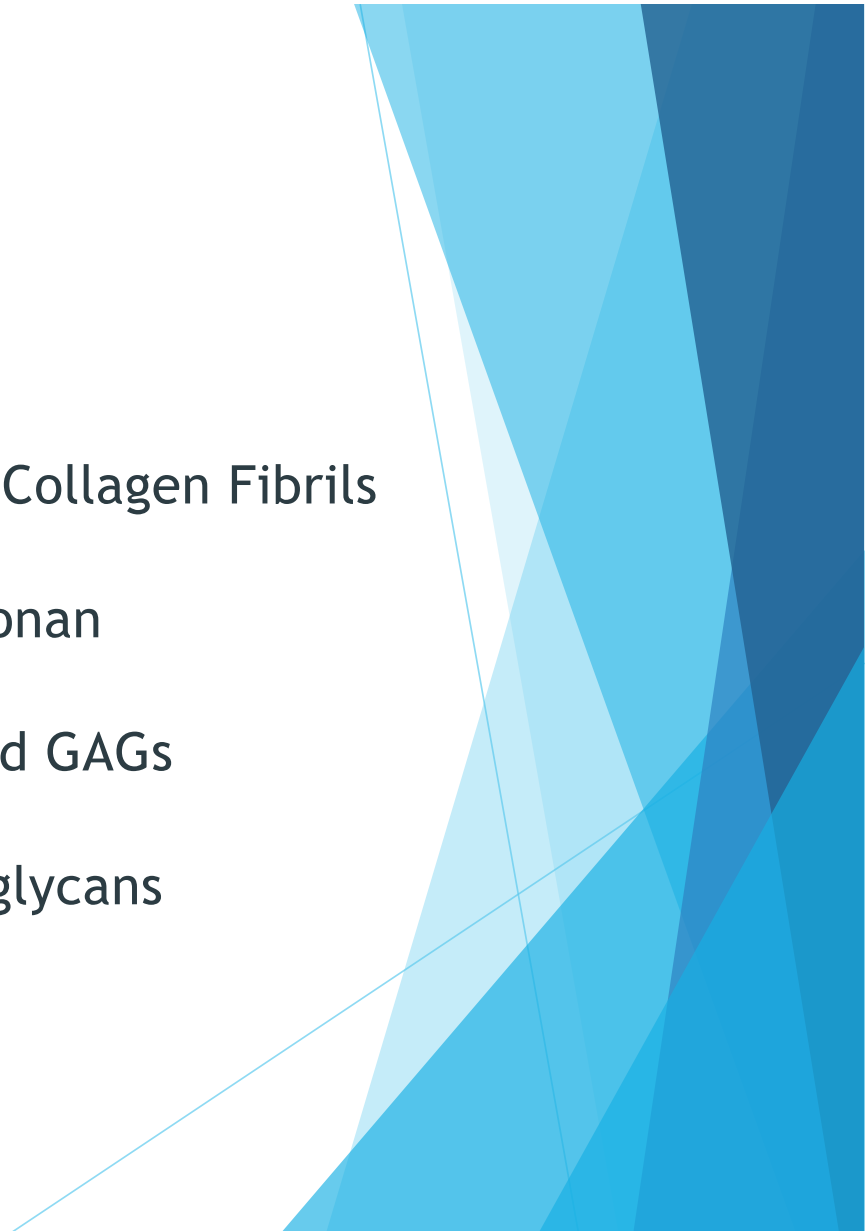
# STRUCTURE

## Cells

- ▶ Consists of only chondrocytes embedded in the ECM
- ▶ Chondrocytes synthesize and maintain all ECM
- ▶ Located in matrix cavities called lacunae.

## ECM

- ▶ Type II Collagen Fibrils
- ▶ Hyaluronan
- ▶ Sulfated GAGs
- ▶ Proteoglycans



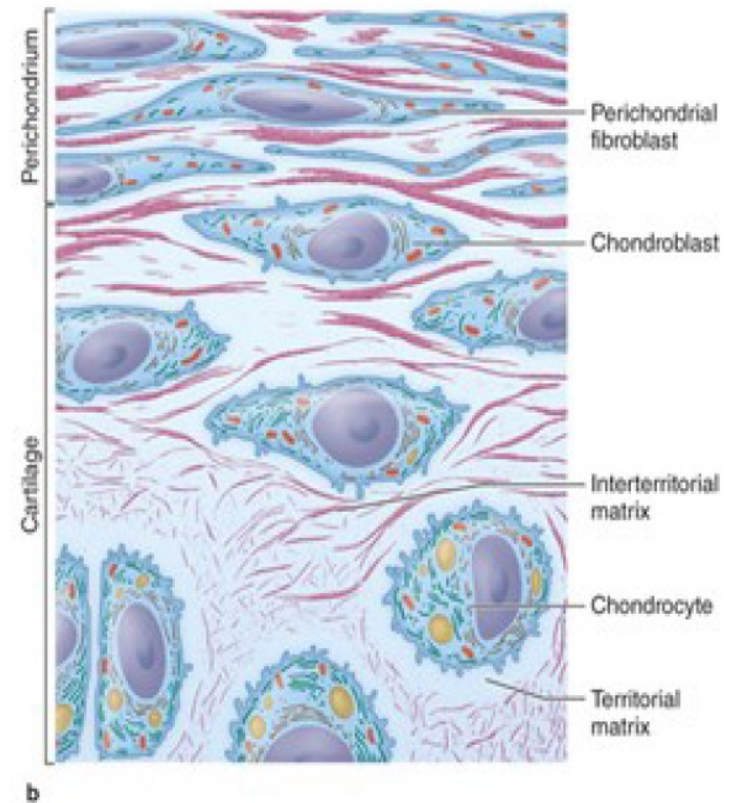
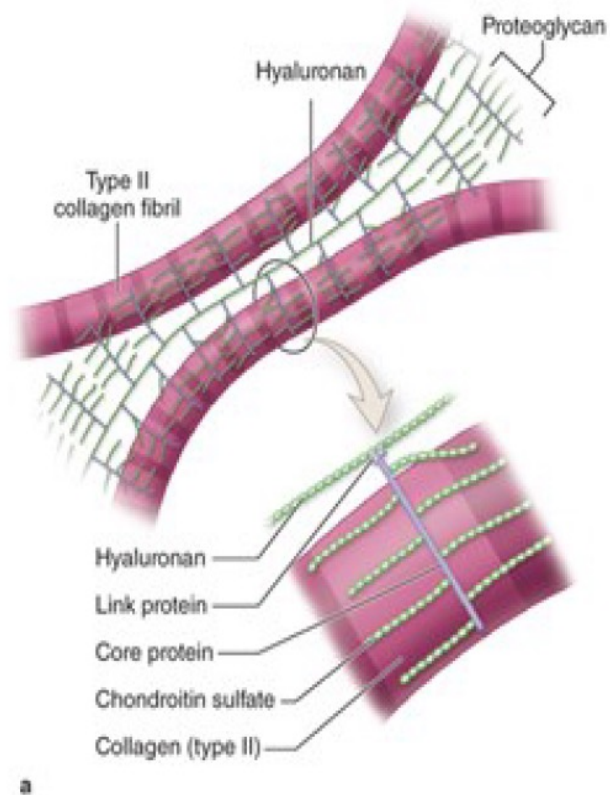
# ECM

Type II Collagen

Hyaluronan

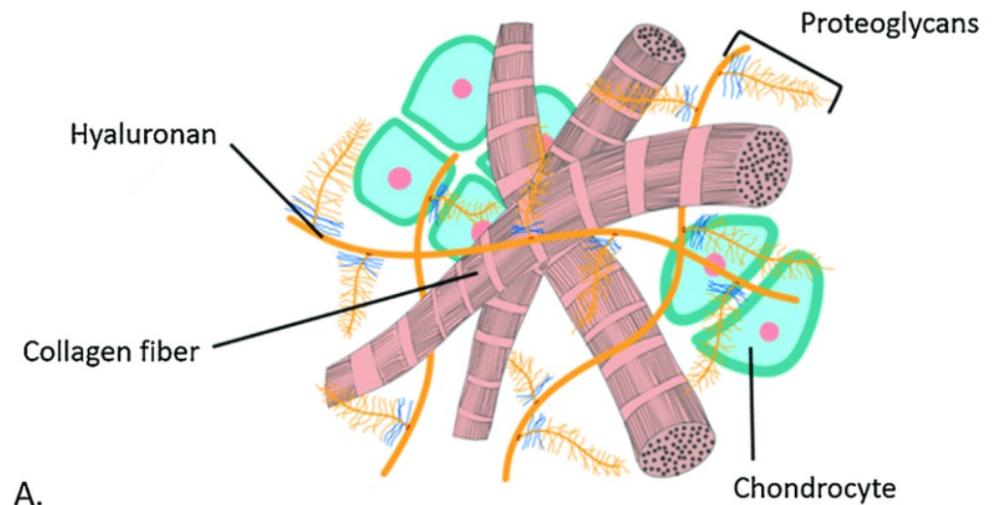
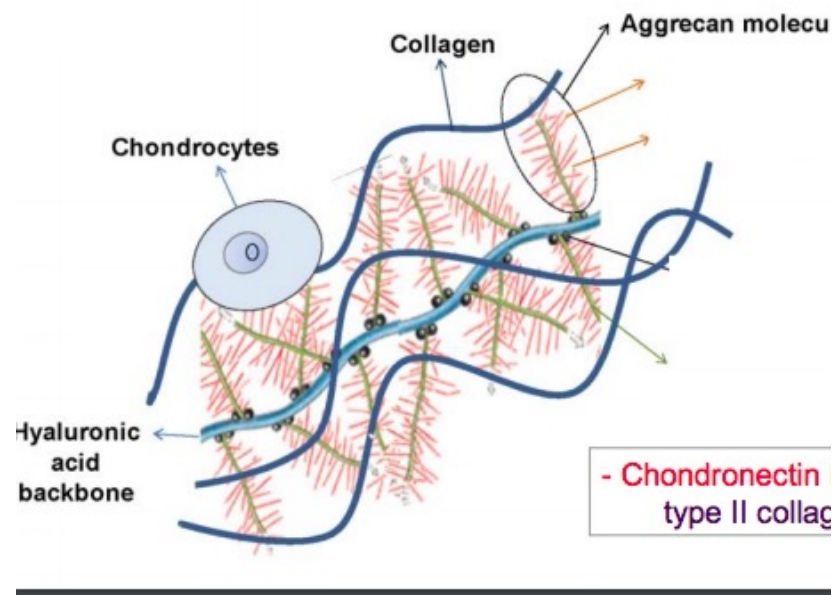
Sulfated GAGs

Proteoglycans

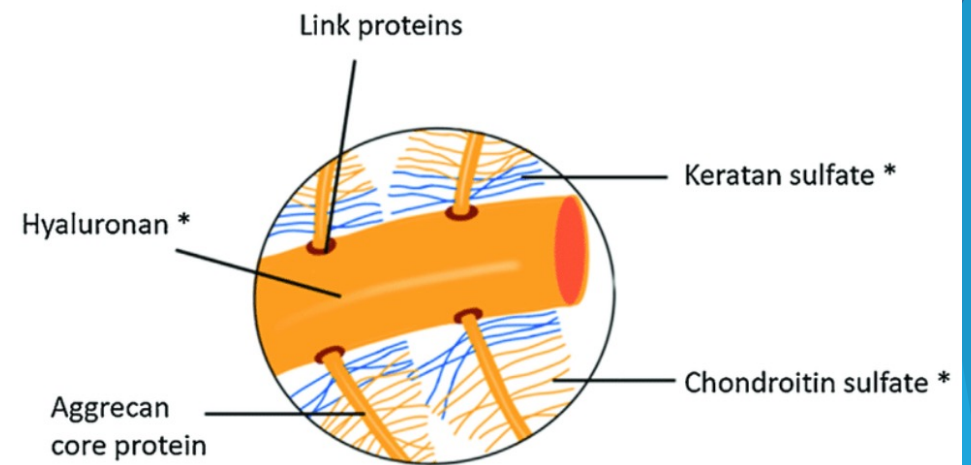




# HYALINE CARTILAGE



A.



B.



# HYALINE CARTILAGE

- ▶ Most common of the three types,
- ▶ Is homogeneous and semitransparent in the fresh state.
- ▶ 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.
- ▶ In the embryo, hyaline cartilage forms the temporary skeleton that is gradually replaced by bone.

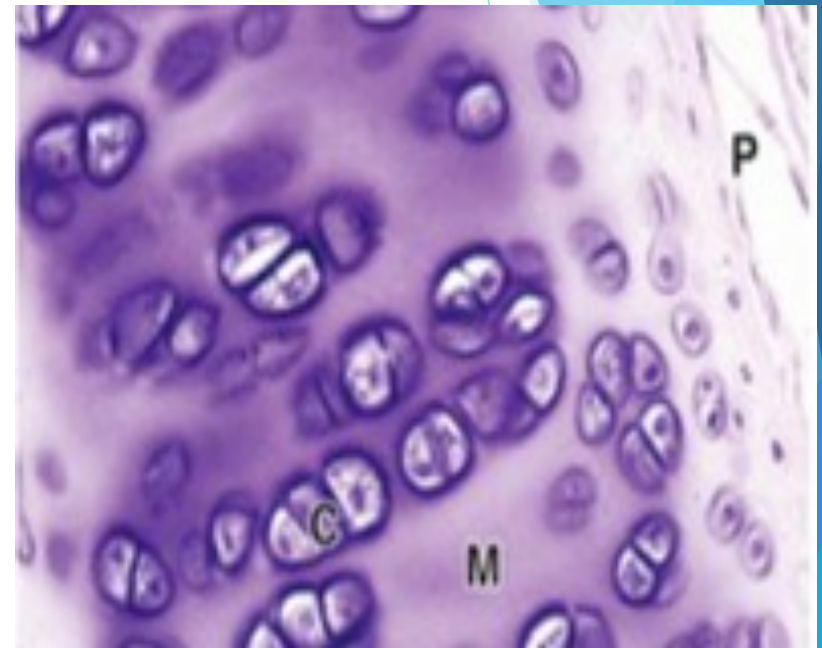


# HYALINE CARTILAGE-structure

- ▶ Collagen is embedded in a firm, hydrated gel of proteoglycans and structural glycoproteins.
- ▶ Proteoglycans --matrix basophilic and the collagen fibrils are barely discernible.
- ▶ Most of the collagen is type II (small amounts of minor collagens are present).
- ▶ **Aggrecan** (150 GAGs--chondroitin sulfate and keratan sulfate) is the most abundant proteoglycan of hyaline c.
- ▶ Water bound to GAGs in the constitutes to 60%-80% of the weight.
- ▶ **Chondronectin**: structural multiadhesive glycoprotein, binds specifically to GAGs, collagen, and integrins, mediating the adherence of chondrocytes to the ECM.

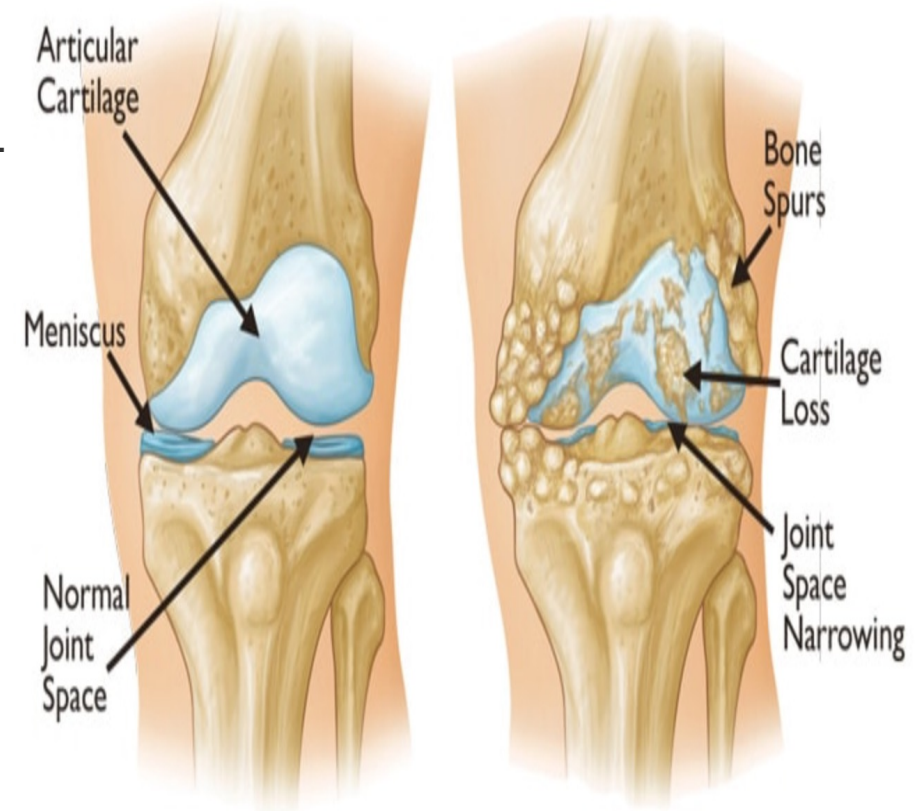
# MATRIX

- ▶ **Territorial matrix:** immediately surrounding each chondrocyte, the ECM is relatively richer in gags than collagen, causing these areas of to stain more basophilic. Contains mostly proteoglycans and sparse collagen
- ▶ **Interterritorial matrix:** more distant from lacunae, richer in collagen and may be less basophilic.



# Osteoarthritis

- ▶ A chronic condition that commonly occurs during aging.
- ▶ Involves the gradual loss or changed physical properties of the articular cartilages.
- ▶ Weight-bearing Joints (knees, hips) or heavily used (wrist, fingers) are most prone to cartilage degeneration.

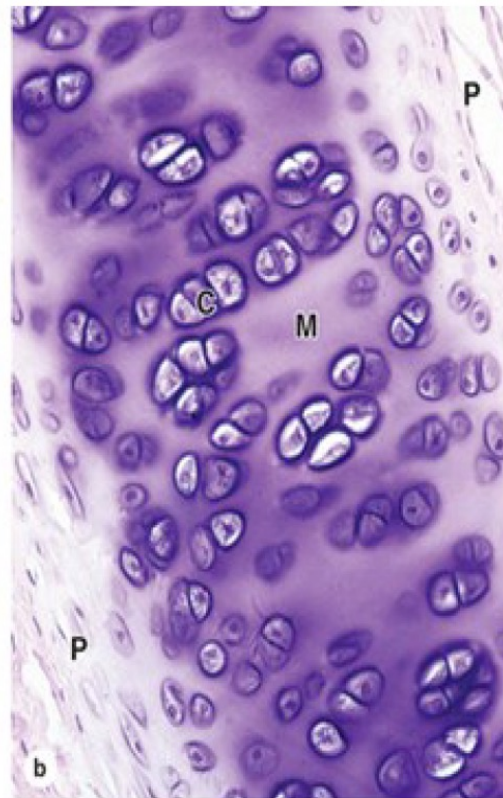
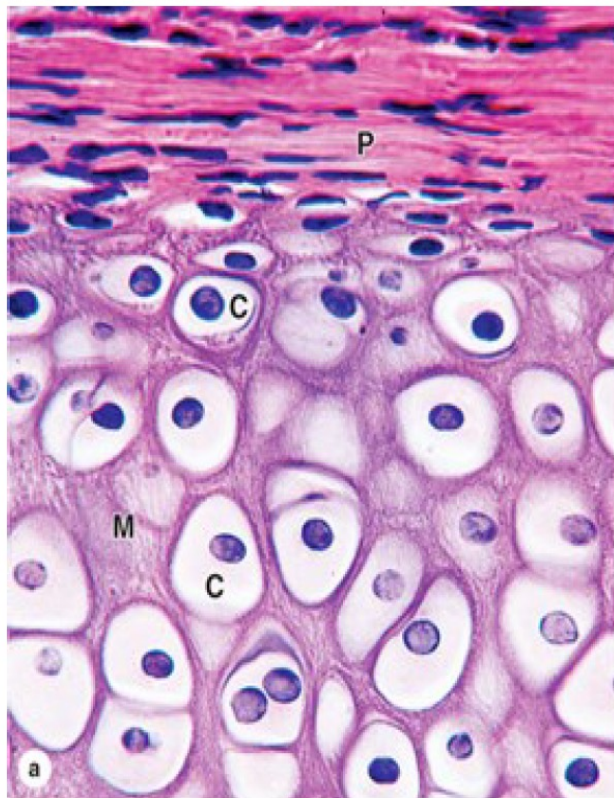


# Calcification

- ▶ In contrast to other forms of cartilage and most other tissues, hyaline cartilage is susceptible to partial or isolated regions of **calcification** during aging, especially in the costal cartilage adjacent to the ribs.
- ▶ Calcification of the hyaline matrix, accompanied by degenerative changes in the chondrocytes, is a common part of the aging process and in many respects resembles endochondral ossification by which bone is formed



# Hyaline cartilage



	Hyaline Cartilage
<b>Main features of the extracellular matrix</b>	Homogeneous, with type II collagen and aggrecan
<b>Major cells</b>	Chondrocytes, chondroblasts
<b>Typical arrangement of chondrocytes</b>	Isolated or in small isogenous groups
<b>Presence of perichondrium</b>	Yes (except at epiphyses and articular cartilage)
<b>Main locations or examples</b>	Many components of upper respiratory tract; articular ends and epiphyseal plates of long bones; fetal skeleton
<b>Main functions</b>	Provides smooth, low-friction surfaces in joints; structural support for respiratory tract



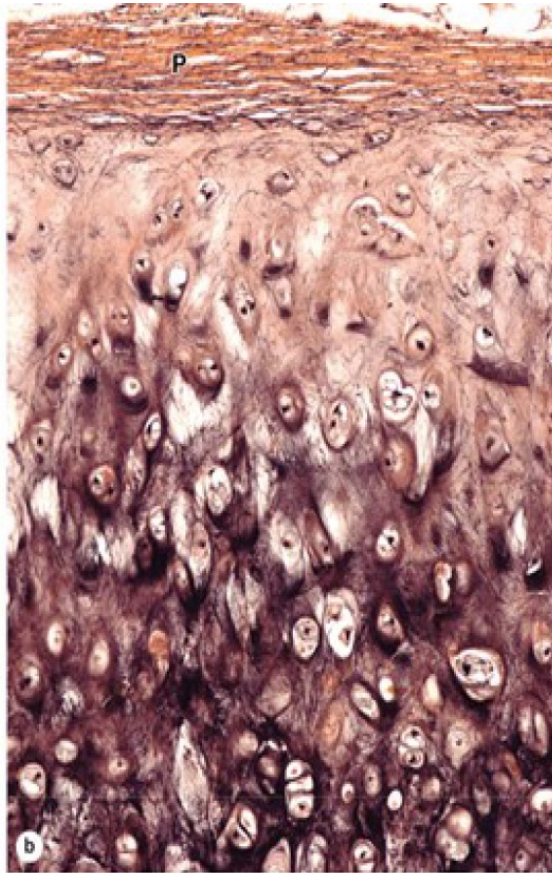
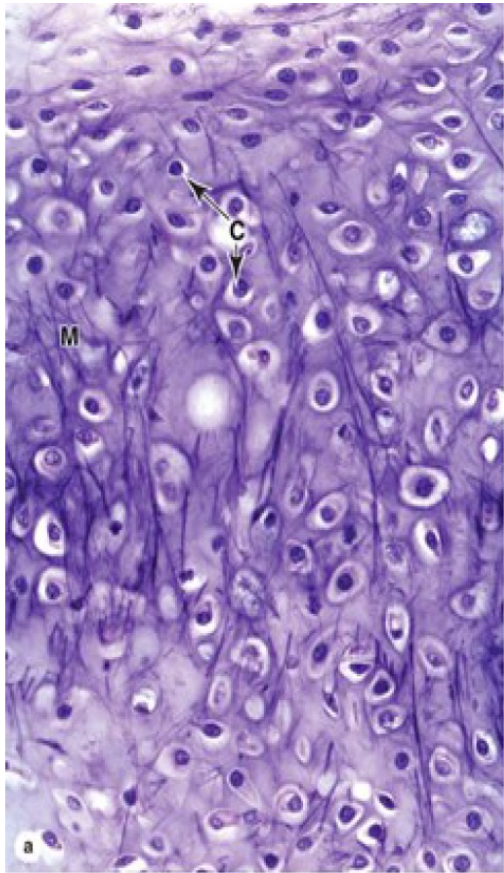
# Elastic cartilage

- ▶ Similar to hyaline cartilage except that it contains an abundant network of elastic fibers in addition to a meshwork of collagen type II fibrils.
- ▶ The abundant elastic fibers provide greater flexibility to this type of cartilage.
- ▶ More flexible than hyaline cartilage,
- ▶ Found in the auricle of the ear, the walls of the external auditory canals, the auditory (eustachian) tubes, the epiglottis, and the upper respiratory tract.
- ▶ Includes a perichondrium.



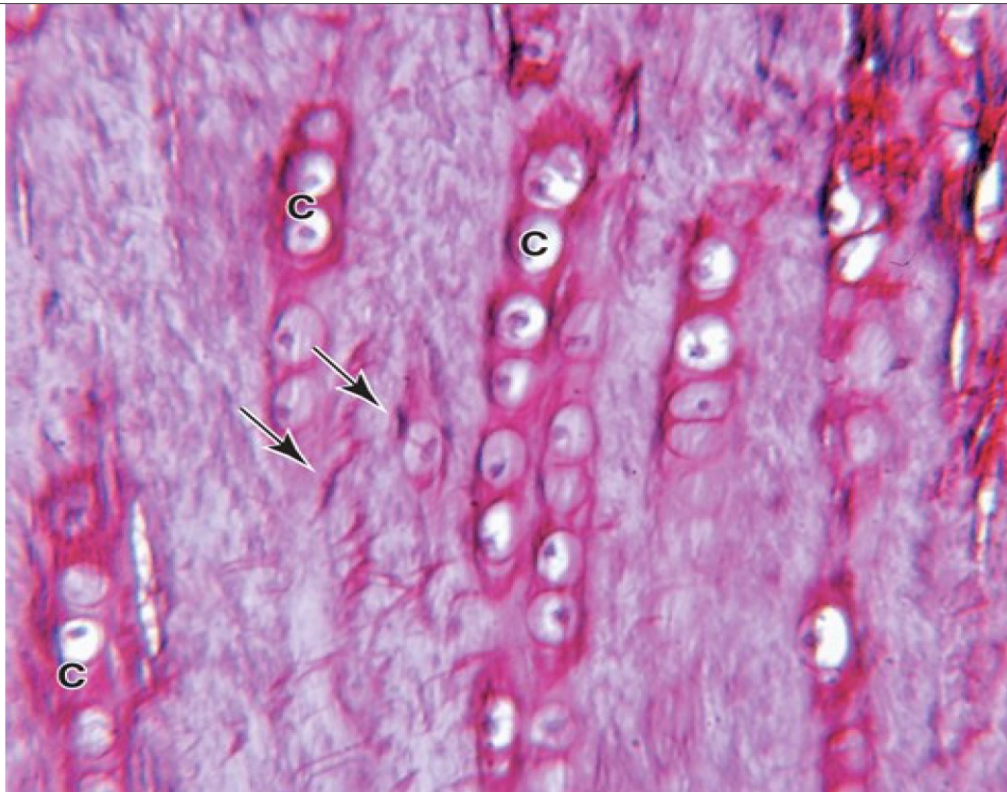


# Elastic cartilage



	Elastic Cartilage
<b>Main features of the extracellular matrix</b>	Type II collagen, aggrecan, and darker elastic fibers
<b>Major cells</b>	Chondrocytes, chondroblasts
<b>Typical arrangement of chondrocytes</b>	Usually in small isogenous groups
<b>Presence of perichondrium</b>	Yes
<b>Main locations or examples</b>	External ear, external acoustic meatus, auditory tube; epiglottis and certain other laryngeal cartilages
<b>Main functions</b>	Provides flexible shape and support of soft tissues

# Fibrocartilage



## Fibrocartilage

<b>Main features of the extracellular matrix</b>	Type II collagen and large areas of dense connective tissue with type I collagen
<b>Major cells</b>	Chondrocytes, fibroblasts
<b>Typical arrangement of chondrocytes</b>	Isolated or in isogenous groups arranged axially
<b>Presence of perichondrium</b>	No
<b>Main locations or examples</b>	Intervertebral discs, pubic symphysis, meniscus, and certain other joints; insertions of tendons
<b>Main functions</b>	Provides cushioning, tensile strength, and resistance to tearing and compression


# FIBROCARILAGE

- ▶ A composite of hyaline cartilage and dense connective tissue
- ▶ It is found in intervertebral discs, in attachments of certain ligaments, and in the pubic symphysis—serves as very tough, yet cushioning support tissue for bone.
- ▶ Chondrocytes occur singly and often in aligned isogenous aggregates.
- ▶ Areas with chondrocytes and hyaline matrix are separated by other regions with fibroblasts and dense bundles of type I collagen----- extra tensile strength.
- ▶ Relative scarcity of proteoglycans---- matrix more acidophilic.
- ▶ There is no distinct surrounding perichondrium.
- ▶ Intervertebral discs of the spinal column are composed primarily of fibrocartilage.

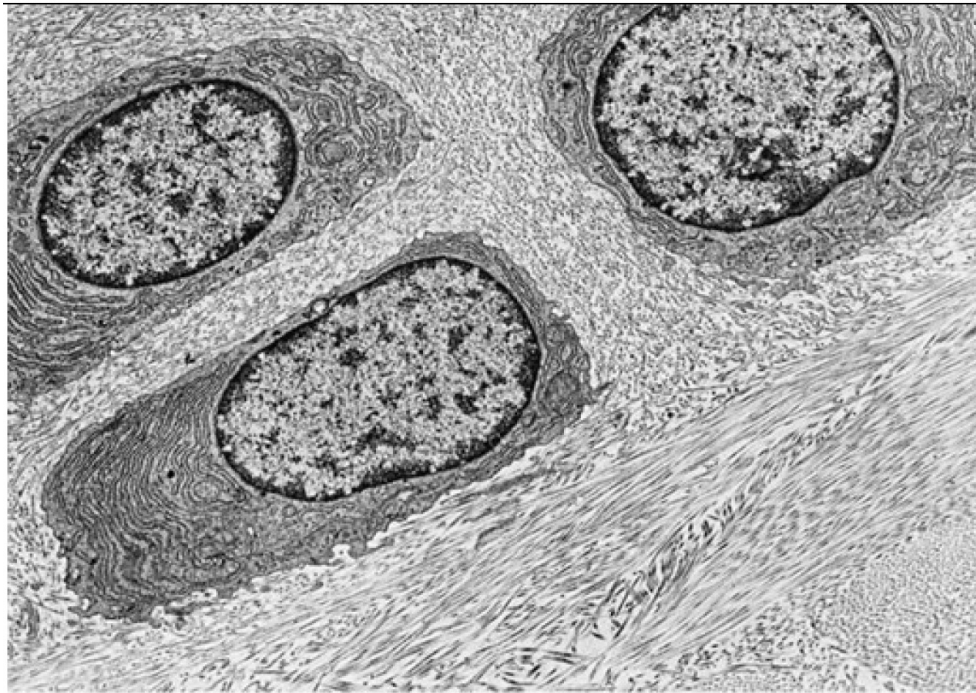
# CARTILAGE FORMATION, GROWTH, & REPAIR

- ▶ All cartilage forms from mesenchyme in the process of chondrogenesis.
- ▶ The first indication of cell differentiation is the rounding up of the mesenchymal cells, which retract their extensions, multiply rapidly, and become more densely packed together.
- ▶ Production of the ECM encloses the cells in their lacunae and then gradually separates chondroblasts from one another.
- ▶ During embryonic development, the cartilage differentiation takes place primarily 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 as the perichondrium

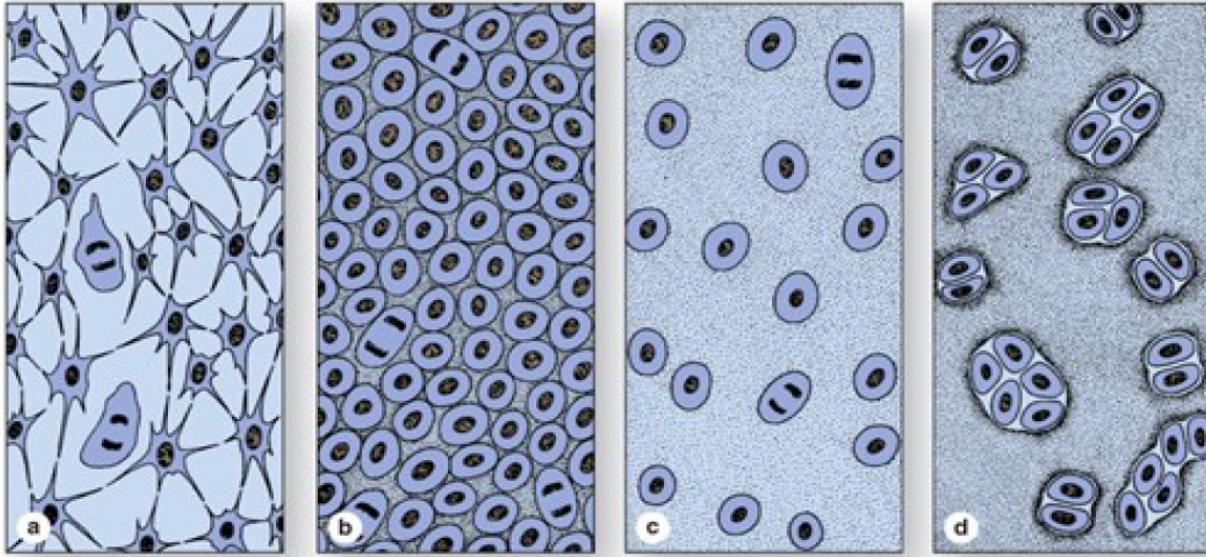


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- ❖ **Once formed, the cartilage tissue enlarges both by:**
    - ▶ Interstitial growth (chondrocytes)
    - ▶ Appositional growth: chondroblast differentiation from progenitor cells in the perichondrium.
    - ▶ In both cases, the synthesis of matrix contributes greatly to the growth of the cartilage.
  - ❖ **Appositional growth of cartilage is more important during postnatal development.**
  - ❖ Articular cartilage-- no perichondrium -- worn away tissue replaced from within.
    - ▶ Damaged cartilage undergoes slow and often incomplete repair.
    - ▶ Cells in the perichondrium invade the injured area and produce new cartilage.
    - ▶ In damaged areas the perichondrium produces a scar of dense connective tissue instead of forming new cartilage.
  - ▶ **The poor capacity of cartilage for repair or regeneration is due in part to its avascularity and low metabolic rate.**

# Fibrocartilage



# Chondrogenesis



- ▶ Mesenchyme is the precursor for all types of cartilage
- ▶ Mitosis and initial cell differentiation (chondroblasts)
- ▶ Chondroblasts produces various matrix components
- ▶ Multiplication of chondroblasts gives rise to isogenous cell



- ▶ (a) Mesenchyme is the precursor for all types of cartilage.
- ▶ ( b ) Mitosis and initial cell differentiation produces a tissue with condensations of rounded cells called chondroblasts.
- ▶ (c) Chondroblasts are then separated from one another again by their production of the 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.
- ▶ In mature cartilage, this interstitial mitotic activity ceases and all chondrocytes typically become more widely separated by their production of matrix.