

Cartilage

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Cartilage

- A **strong firm** and **pliable** CT composed of cells that called **chondrocytes** and highly specialized **extracellular matrix** (ECM)
- An **Avascular** tissue → Cartilage is a tissue of very **low metabolic activity** and **cell turnover**
- Cartilage receives its nutrients from blood vessels from a surrounding dense connective tissue, the **perichondrium**
- Nerves are **not** present in cartilage, but nerves and nerve ending are present in the perichondrium
- Contain large amount of glycosaminoglycans and water to permit **diffusion** of substances
- About 70% wt water for diffusion, binding and resilience

- There are 3 types:
 - **Hyaline cartilage**
 - **Elastic cartilage**
 - **Fibrocartilage**

The difference between the different cartilage types depend on the different properties of the **extracellular matrix**, and in particular on the amount and type of the **fibres** embedded in the matrix



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Hyaline cartilage

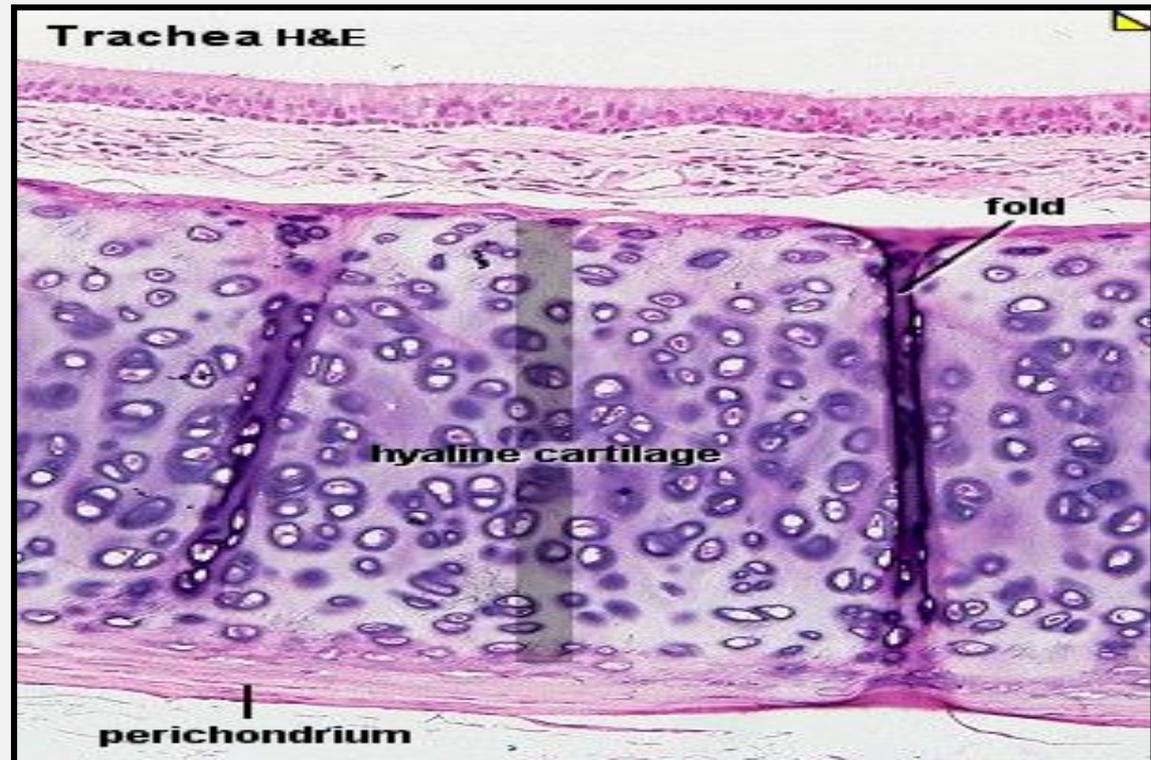
- From Greek *hyalos* means glassy, semi-transparent (**translucent**), that is both **flexible** and **resilient** to mechanical forces
- Homogeneous amorphous matrix
- Bluish-white and translucent

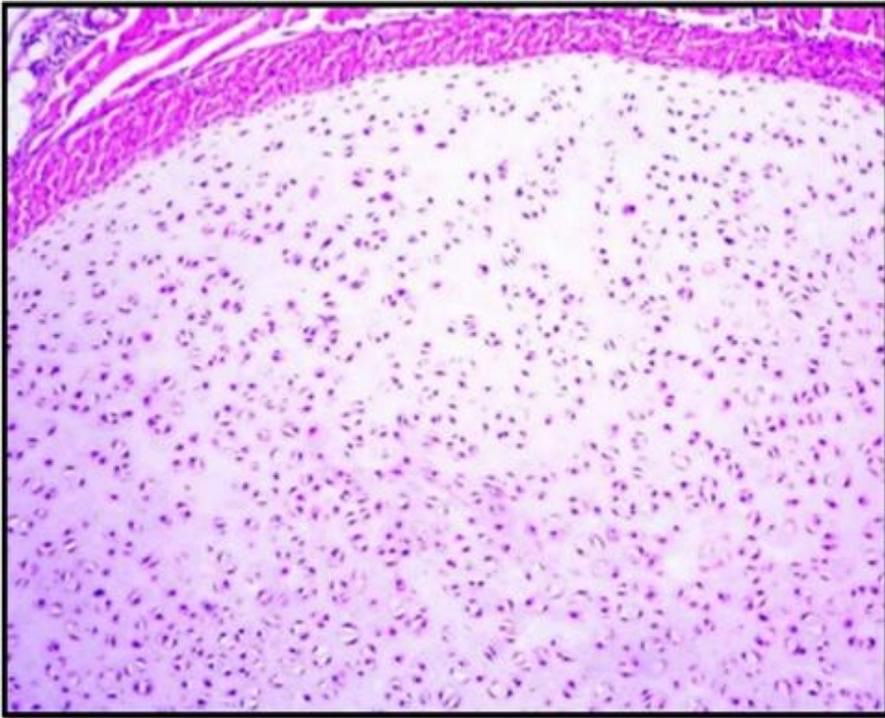
Found:

- Rib cartilage
- articulating surfaces
- nose
- larynx
- Trachea, bronchi
- embryonic skeleton

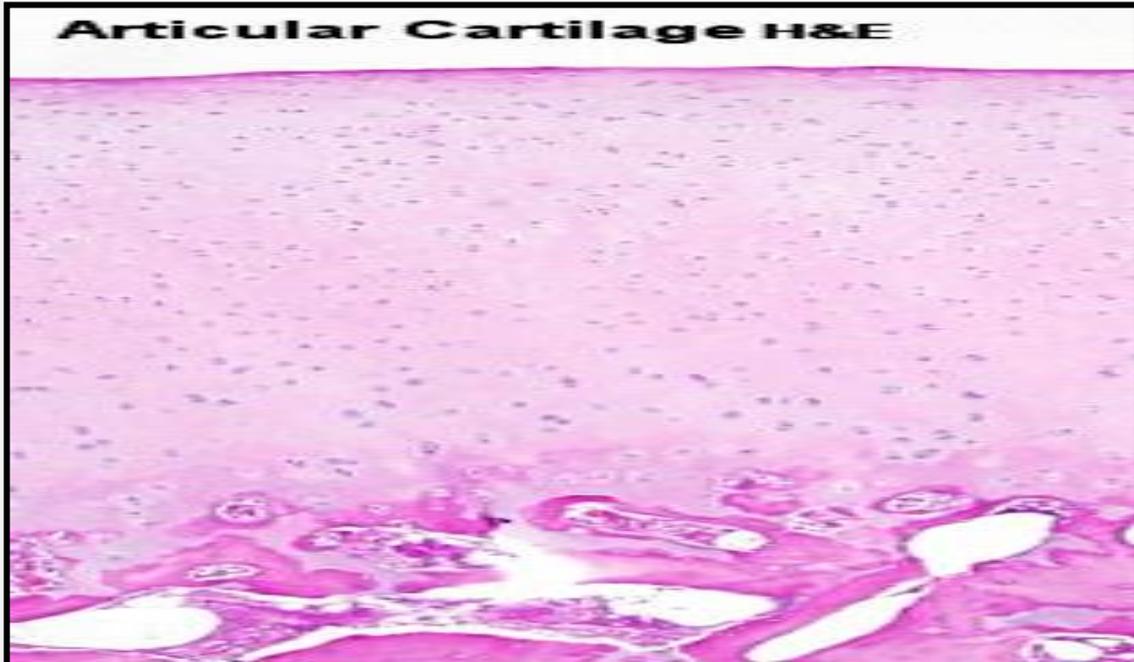
The cartilage consists of

1. **Cells**
2. **ECM**
 - a. fibres
 - b. ground substance





Articular Cartilage H&E



1. Cells

Chondroblasts

- # differentiated from the **perichondrium**
- # Oval or **spindle** in shape with **basophilic** cytoplasm
- # High rER, Golgi apparatus and mitochondria
- # **provide** collagen and proteins
- # change to **chondrocytes**

Chondrocytes

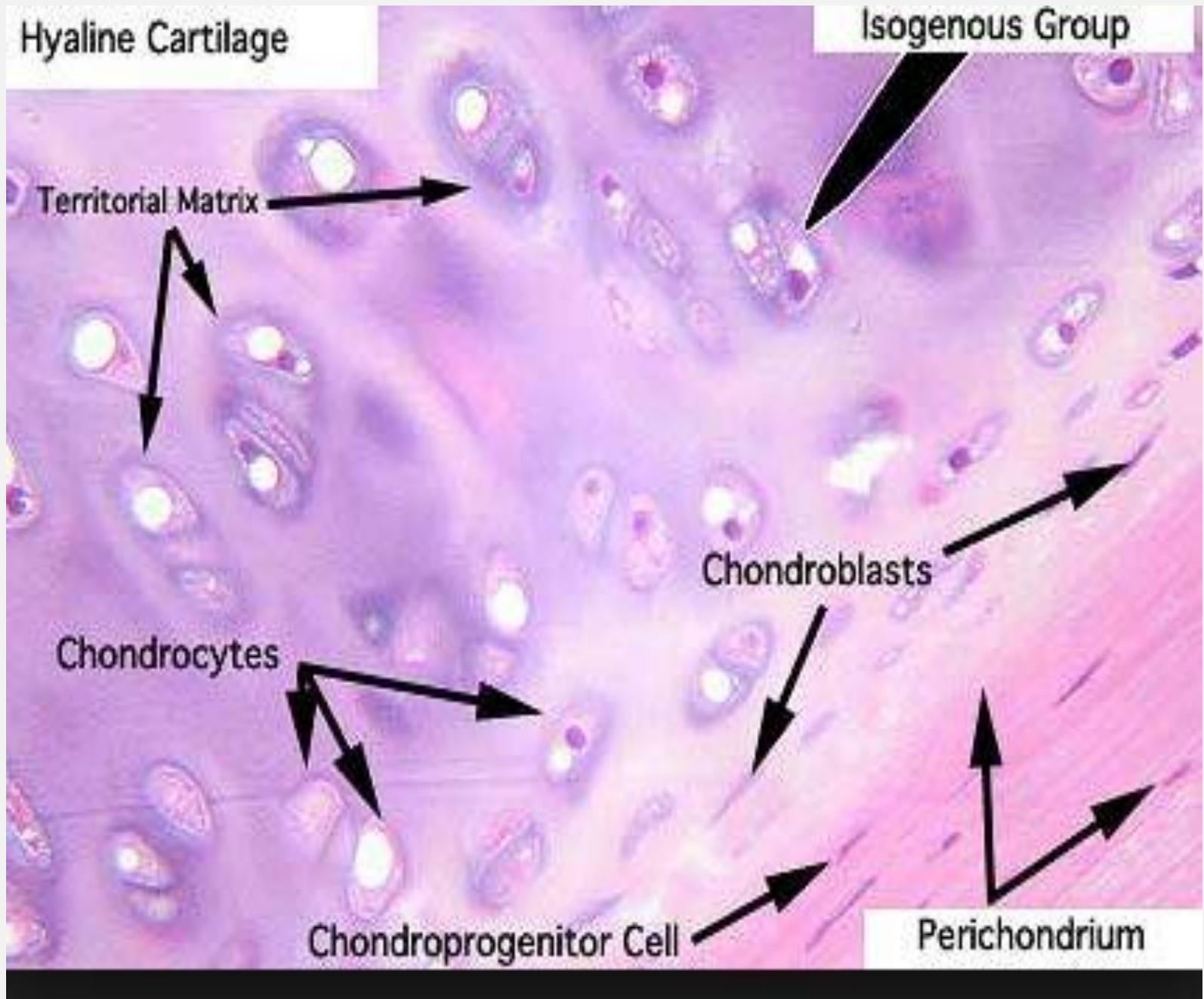
- # surrounded by **lacuna** within the matrix, usually 1-3 sometimes more (**nest cells or isogenous group**)
- # **round** in shape with **basophilic** cytoplasm
- # secrete collagen, glucosaminoglycan and proteoglycans
- # numerous rER, large Golgi and secretory granules

2. Fibres

- **Collagen** fibres mainly **type II**
- Elastic fibres

Hyaline Cartilage

Isogenous Group



3. Matrix

The main components of hyaline cartilage (wet weight) are approximately:

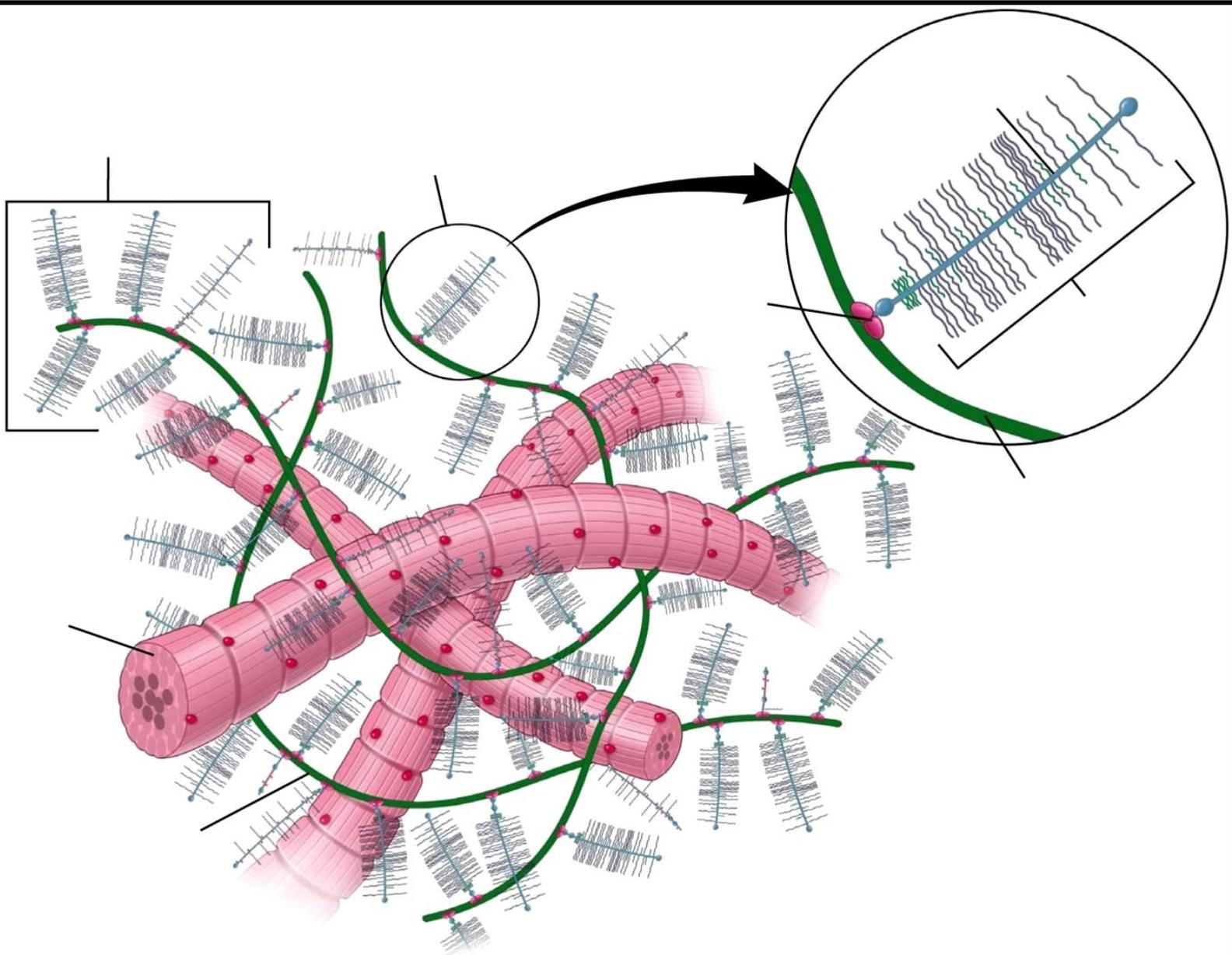
- Water 70-75%
- Proteoglycans 10%
- Collagen (type II) 16%
- Other glycoproteins 1.6%
- Minerals 0.5%

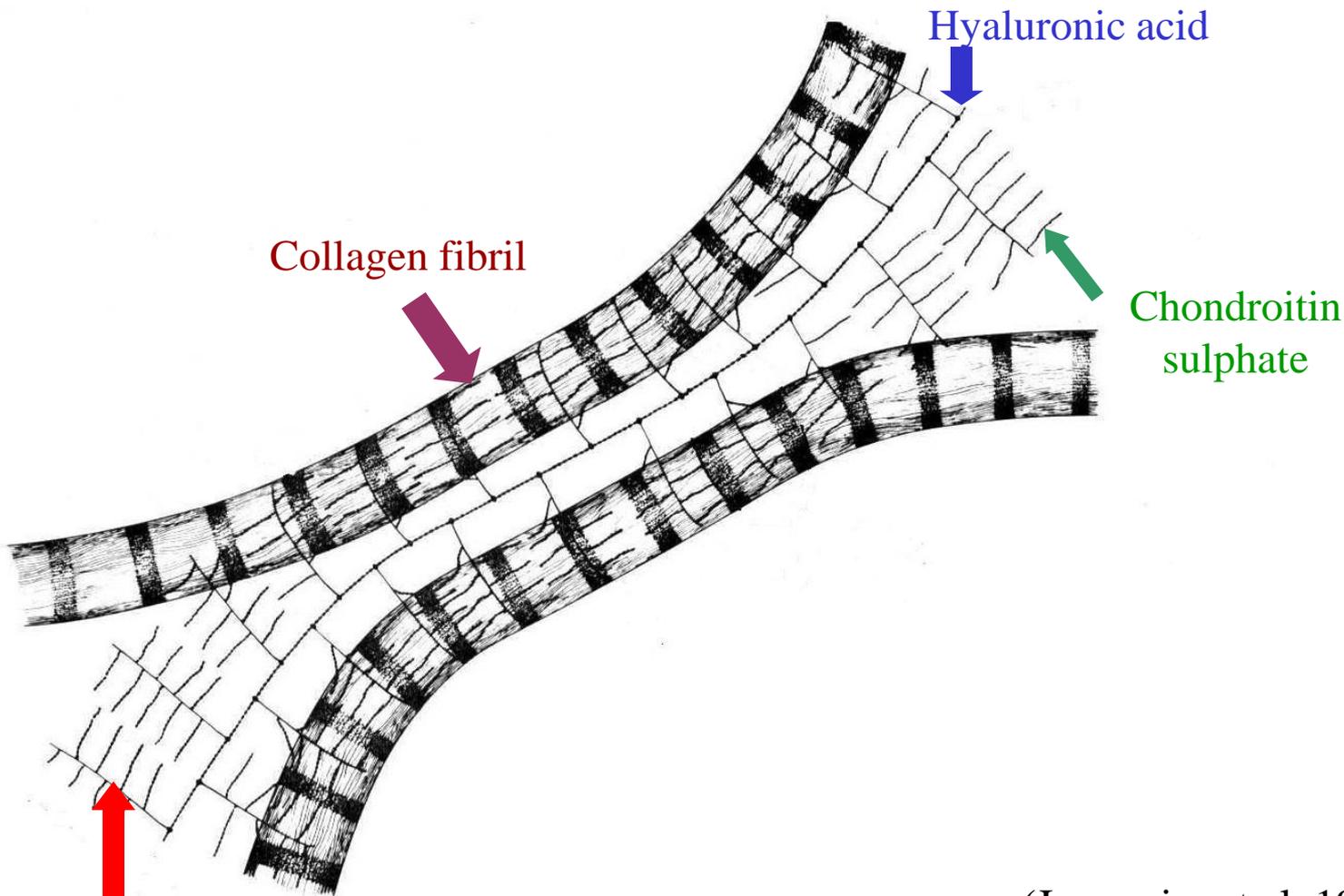
Proteoglycans

- * **Hyaluronic acid (non-sulfated glycosaminoglycans)**
- * **Sulfated glycosaminoglycans (composed of chondroitin sulphate and keratan sulphate)**

In cartilage the **protein core** of the proteoglycan molecule binds through a **linking** protein to **hyaluronic** acid to form a proteoglycan **aggregate** which binds to the fibres by **electrostatic** inter action

- The highest concentration of proteoglycan around the chondrocyte lacunae (intense stain) called **territorial matrix**
- Low concentration far from cells **interterritorial matrix**

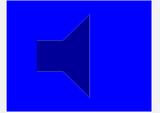




(Junqueira et al, 1986).

Protein core (**Proteoglycans**)

In this drawing one can see 2 collagen fibrils (↓) that are linked by thread like structures in the matrix of the cartilage. In the center between the 2 collagen fibrils runs a hyaluronic acid (↓) chain. Perpendicular from this chain, proteoglycans (↑) stretch towards the fibrils. Chondroitin sulphate (↑) side chains stretch out perpendicular from the proteoglycans and bind to the collagen fibrils.

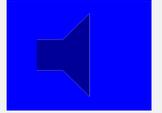
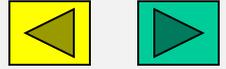


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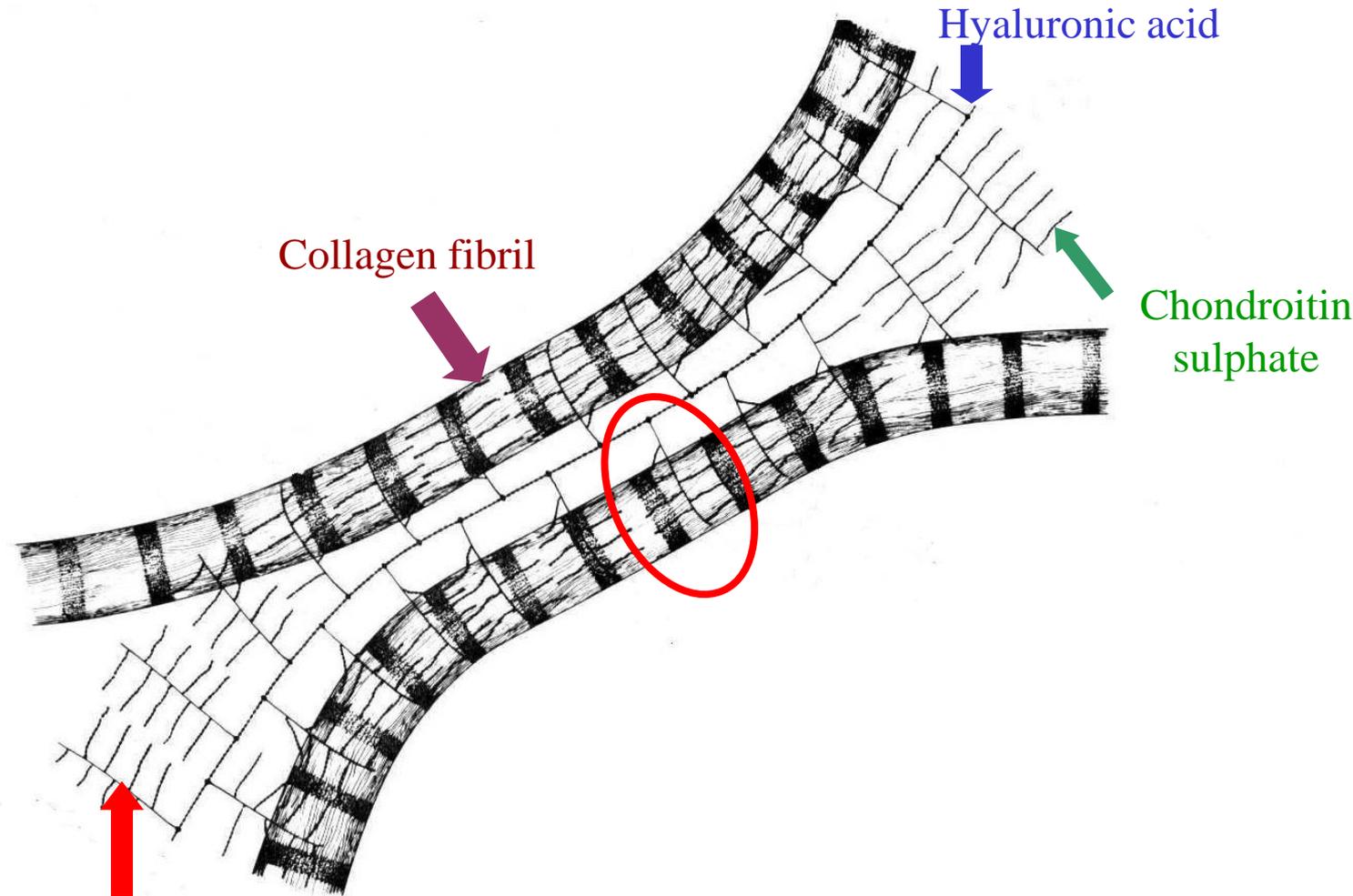


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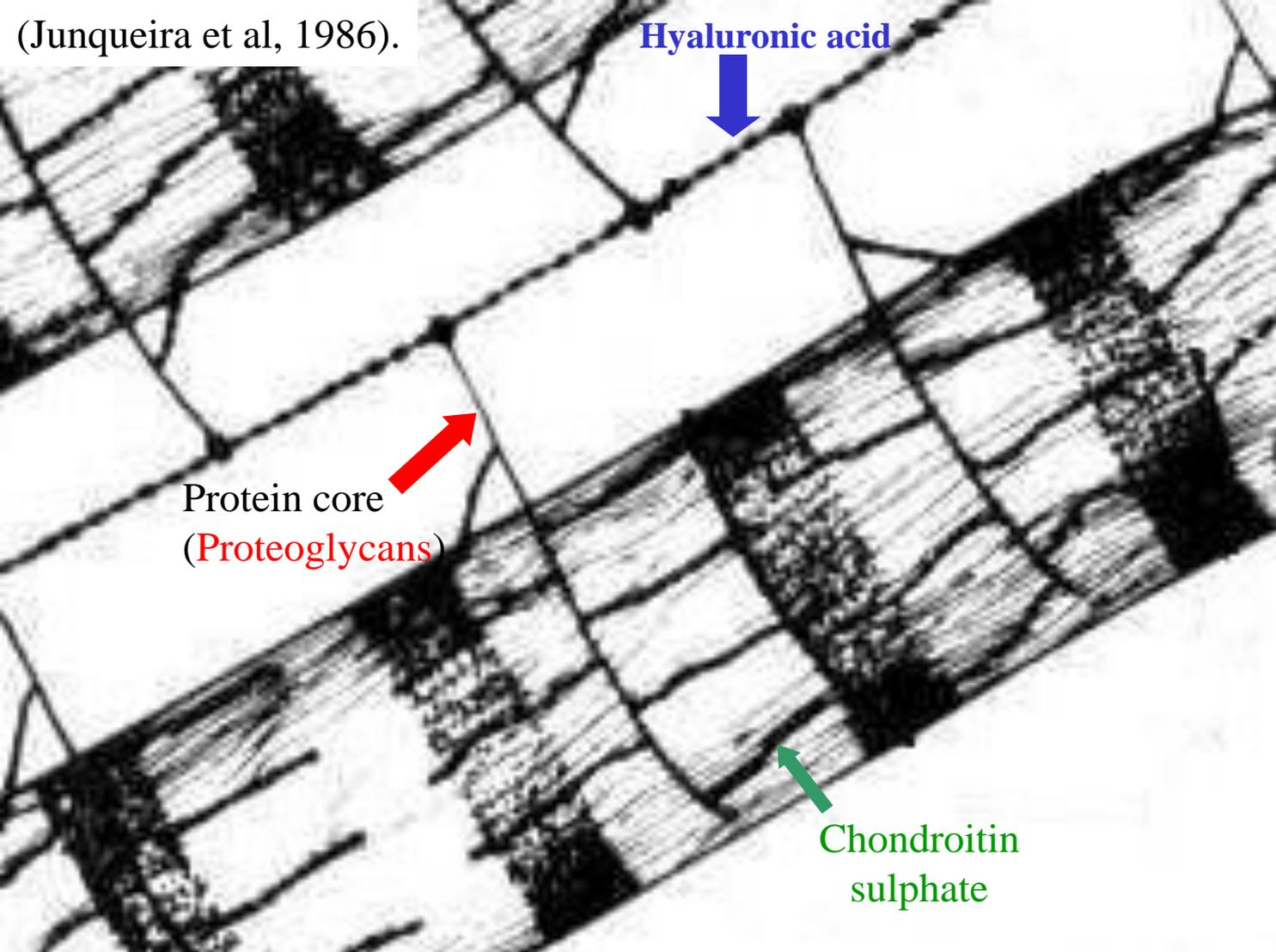
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(Junqueira et al, 1986).

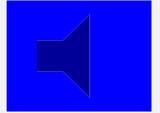
Let us take a closer look at how the collagen fibrils are bound together in the area marked by the red circle.

(Junqueira et al, 1986).



The hyaluronic acid chain lies between two collagen fibrils. From this chain proteoglycans stretch towards the collagen fibrils. On the collagen fibrils chondroitin sulfates link perpendicular to the proteoglycans. Lets take another look at how the linking system between the collagen fibrils is build up.

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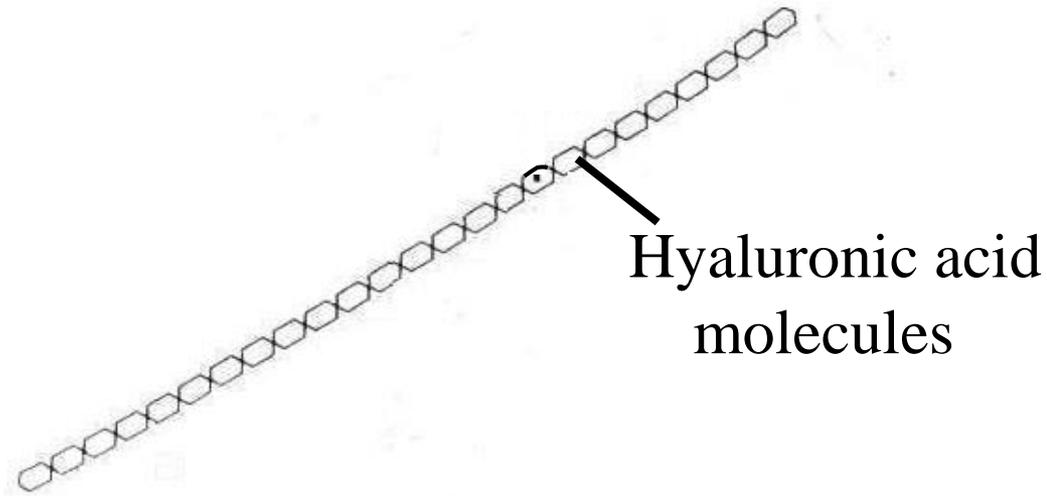


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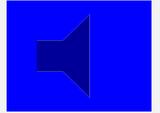
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Hyaluronic acid
molecules

(Junqueira et al, 1986).

Hyaluronic acid molecules form a chain.

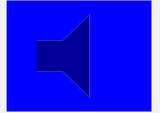
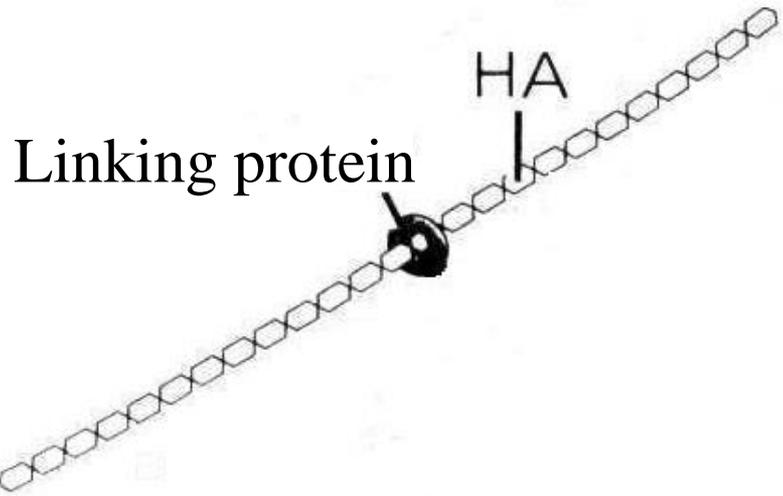


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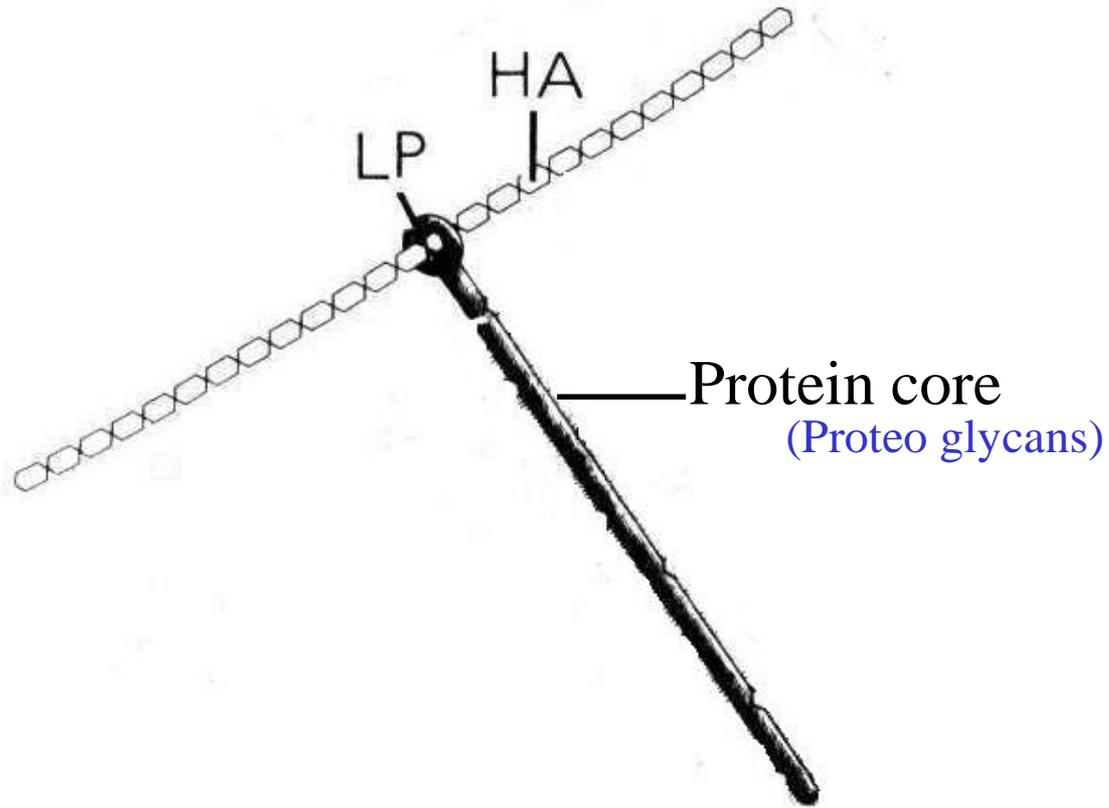
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(Junqueira et al, 1986).

A linking protein then attaches to this chain.

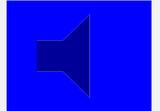
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(Junqueira et al, 1986).

A protein core made up by proteoglycans then attaches to the protein link.

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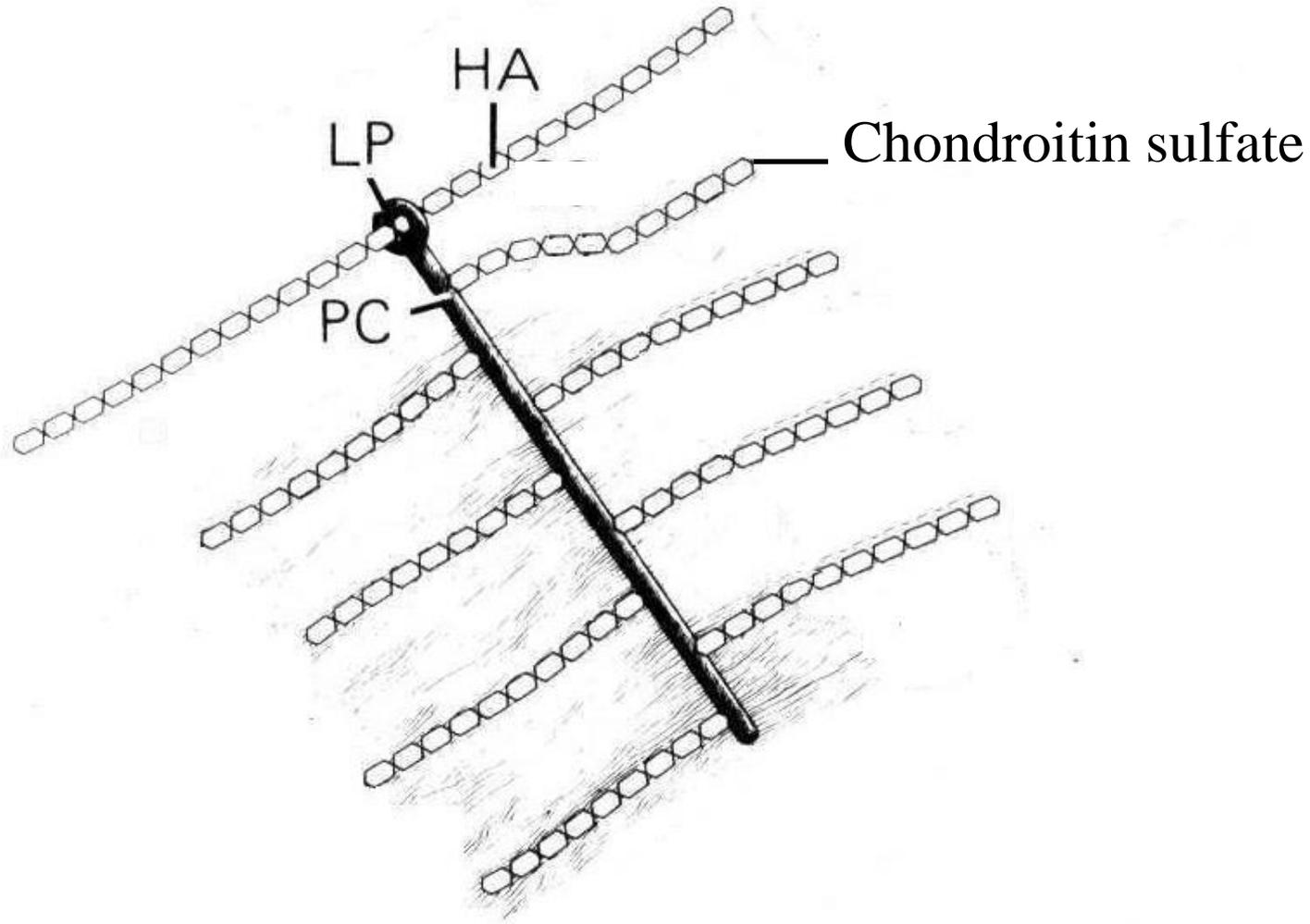


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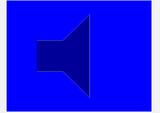


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(Junqueira et al, 1986).

From the protein core (PC) – chondroitin sulphate side chains stretch perpendicular.

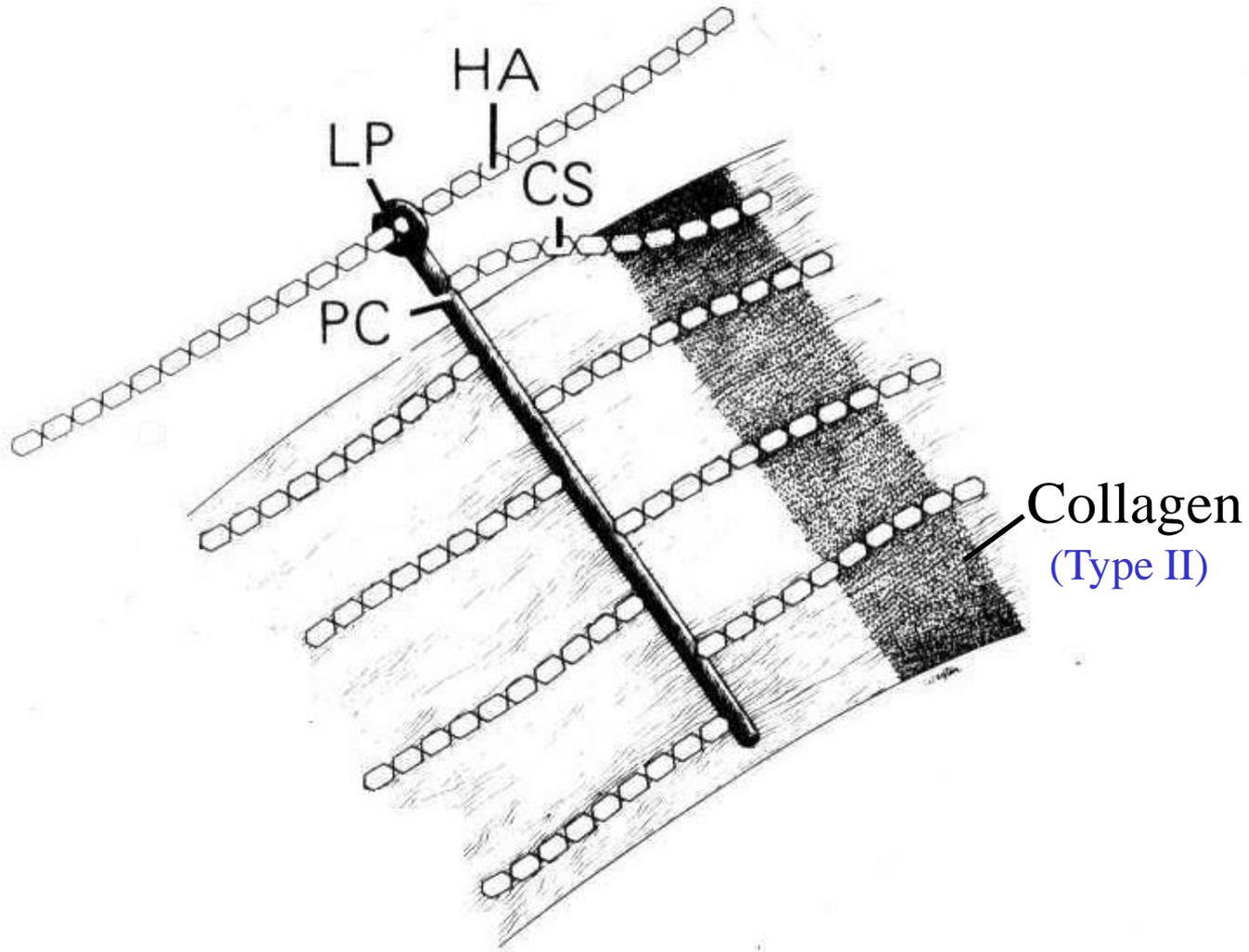


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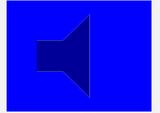


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(Junqueira et al, 1986).

The chondroitin side chains (CS) bind electrostatically to the collagen fibrils.

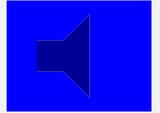


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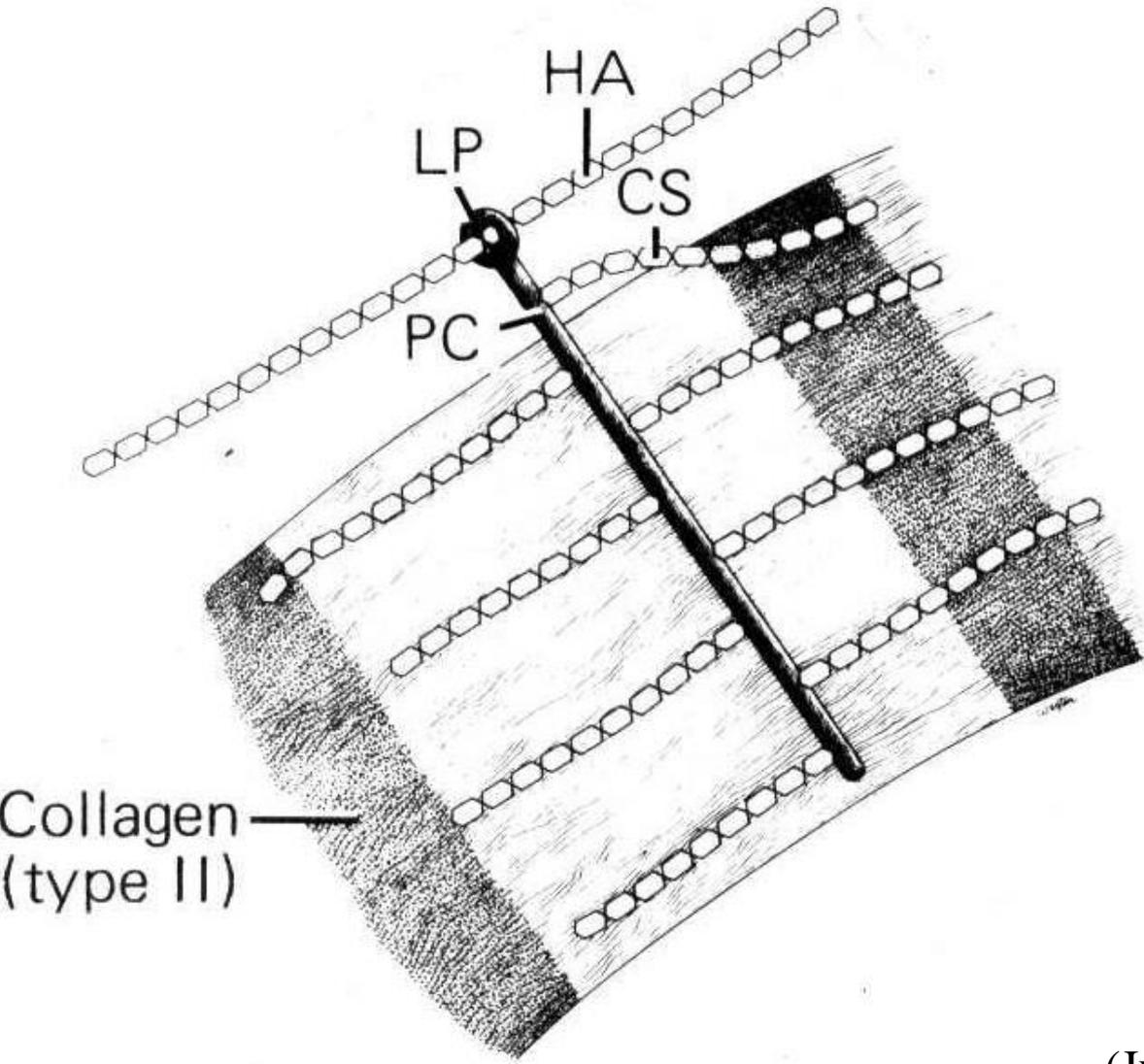


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(Junqueira et al, 1986).

Let us now take a closer look at the chondroitin side chains (CS).

Perichondrium

- Dense CT firmly surround the hyaline cartilage resembling capsules that surround glands and many organs
- Two layers (actively growing perichondrium)
 - outer fibrous** rich in blood vessels and nerves
 - inner cellular** (chondrogenic cells) rich in chondroblasts

Chondrogenesis

- Like all connective tissue, cartilage is derived in the embryo from **mesenchyme**. Mesenchyme cells grow and differentiate into young cartilage cells or **chondroblasts** that are very active in secreting the surrounding matrix. The chondroblasts grow and develop in lacunae. These chondroblasts further differentiate into mature cartilage cells or **chondrocytes**.

*** The ability of cartilage to repair itself is **limited** particularly in adults.
Mainly due to the activity of the perichondrium during the period of growth in young individuals
Cardiothoracic surgery // costal cartilage cut



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Two different types of chondrogenesis

• ***Appositional growth*** takes place in **the perichondrium** the fibroblasts (**chondrogenic cells**) of the perichondrium change to **chondroblasts** which later change to round **chondrocytes** (addition from **outside**)

• ***Interstitial growth*** (addition from **inside**) takes place around the **lacunae** providing new cells for growth in areas where **perichondrium** is **absent** like

- articular surfaces in joints

- or in areas with **direct** contact with **bone** e.g. nasal and costal cartilages

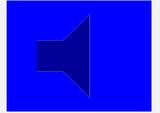
- in forming bones

As a consequence of this mitotic activity, lacunae may possess two, four, eight daughter chondrocytes. These are known as **isogenous** or **nest cells**

Functions of hyaline cartilage

- bone formation in fetal skeleton
- epiphyseal bone growth
- provide smooth articulation for joints

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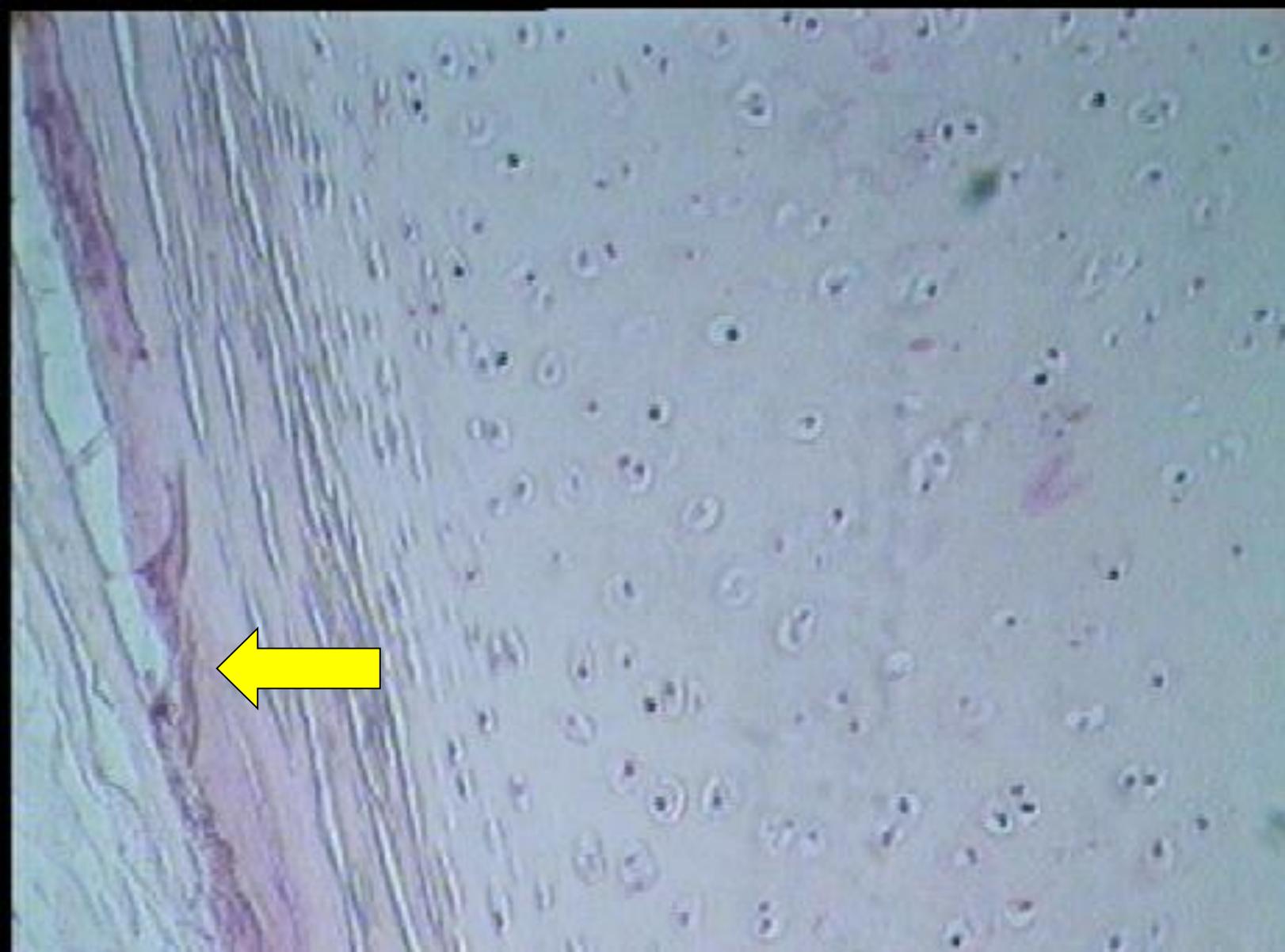


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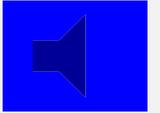
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This is hyaline cartilage. The ← indicates the perichondrium. In the perichondrium there are oval chondroblasts that will change to round chondrocytes because of appositional growth that takes place.



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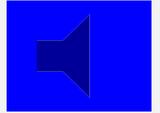
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This is hyaline cartilage the ← indicates a lacuna with 2 chondrocytes in it. The ↓ indicates the perichondrium.



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This is a high magnification of hyaline cartilage. The **blue** area around the lacuna is the **territorial matrix**. The indicates two chondrocytes that lie together in one lacuna.

Elastic cartilage

Similar to hyaline except that it contains many **elastic fibres** to provide **elasticity** and **resiliency**

Yellow in colour

Unlike hyaline cartilage its matrix usually **does not calcify**

Found:

- external ear (pinna of ear)
- external auditory canal
- epiglottis
- Eustachian tube
- Larynx (corniculate and cuneiform cartilage)

All location are surrounded by perichondrium

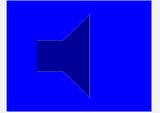


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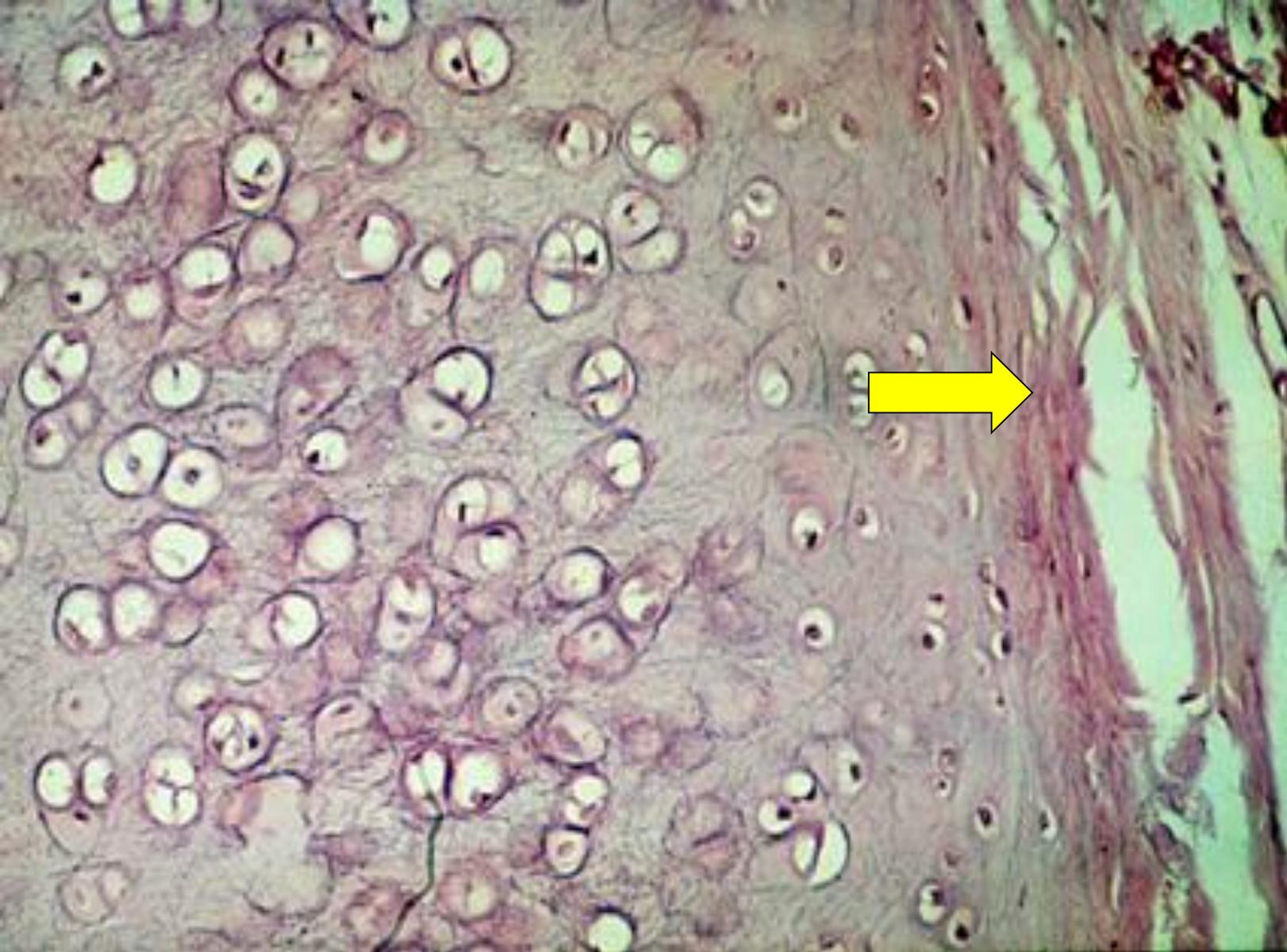


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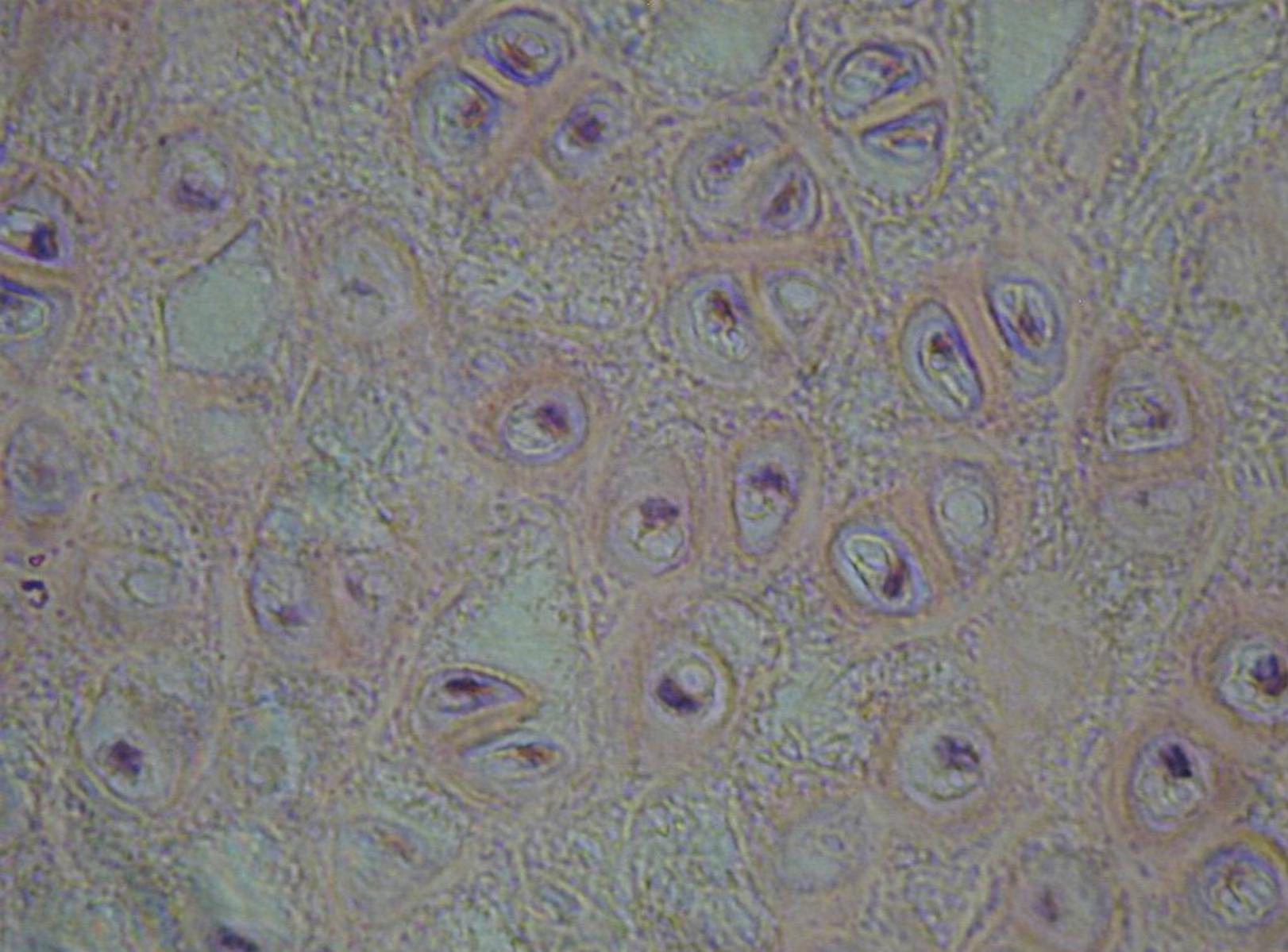
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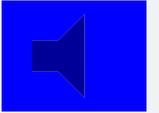
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This is elastic cartilage. Like hyaline it has a → perichondrium on the outside. The matrix of elastic cartilage contains a lot of visible elastic fibers. This cartilage also has lacunae with chondrocytes and territorial matrix.



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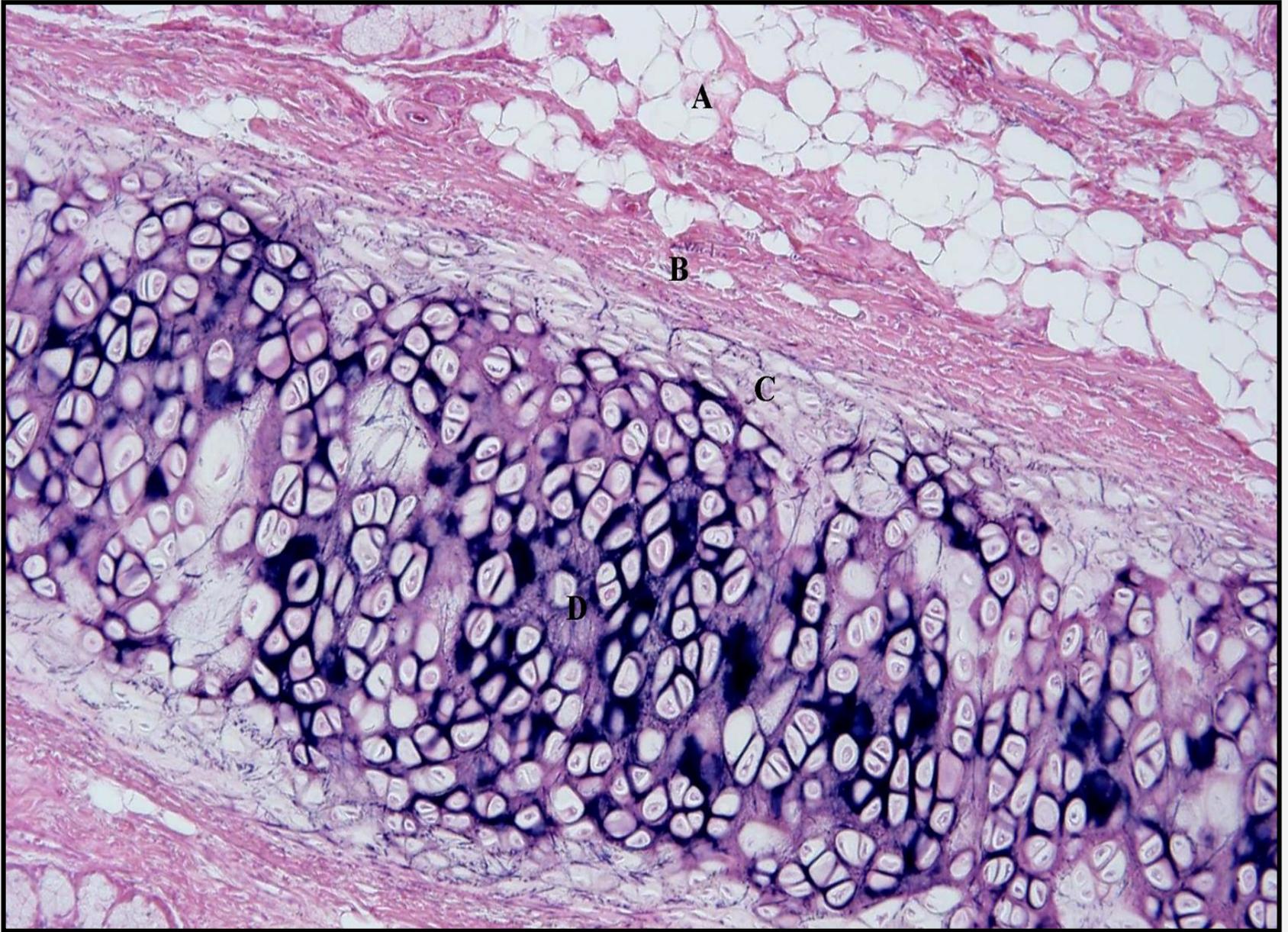
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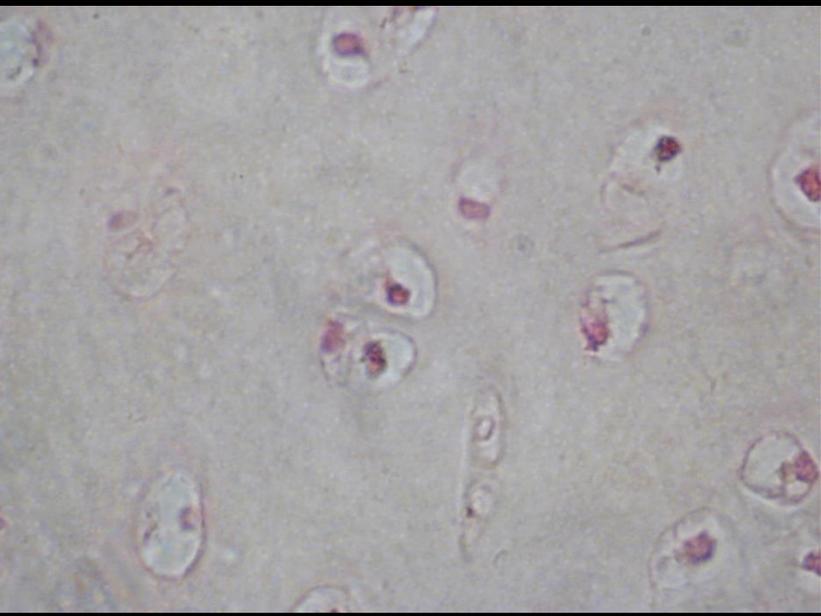


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This is a high magnification of elastic cartilage. Notice the matrix containing fibers.

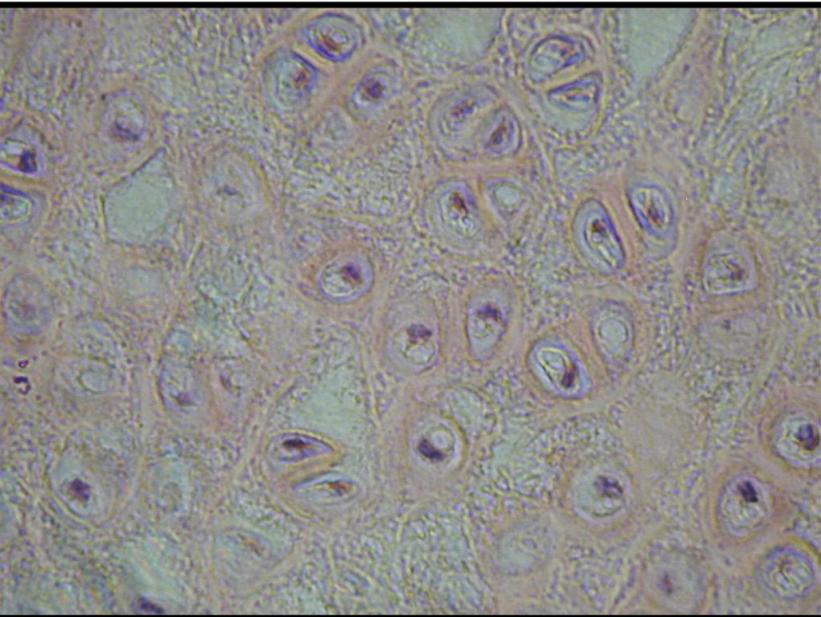


Two slides taken at the same magnification



Hyaline cartilage

± 14 chondrocytes are visible in this slide.

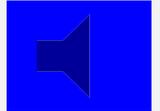


Elastic cartilage

± 38 chondrocytes are visible in this slide.

In elastic cartilage the concentration of lacunae with chondrocytes is much higher than in hyaline cartilage.

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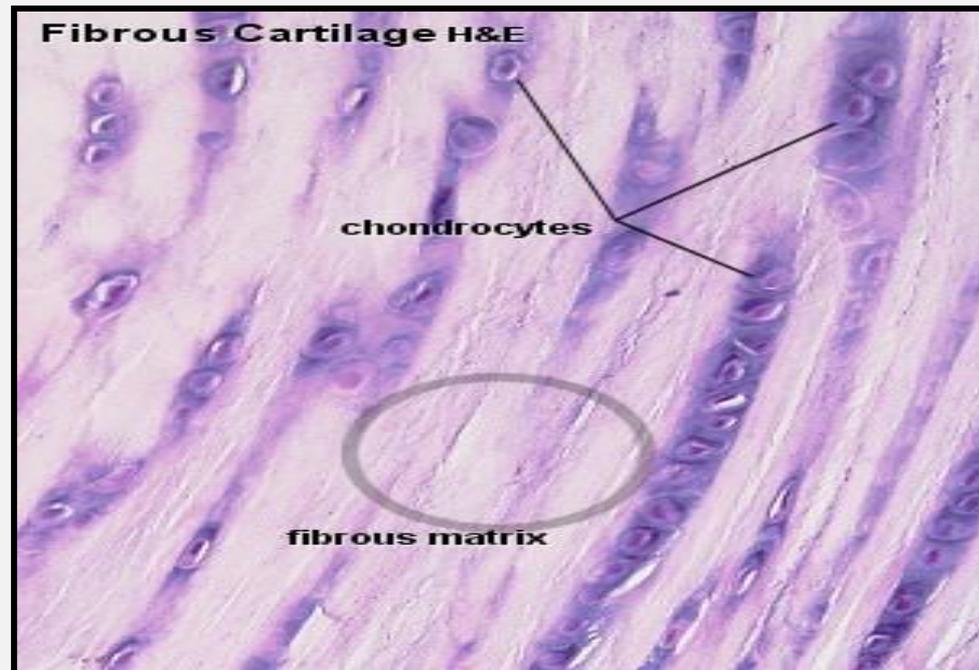
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Fibrocartilage

- Always associated with **dense CT**
- Many **collagen** fibres in the matrix with relatively **little** amorphous matrix (In contrast to other cartilage types, **collagen type I is dominant in fibrous cartilage.**)
- **No perichondrium**
- Chondrocytes tend to lie in **rows**
- Can withstand **strong forces**, resist compression and shear forces

Found:

- Intervertebral disk
- symphysis pubis
- articular disc of sternoclavicular and tempromandibular joints

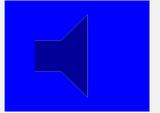


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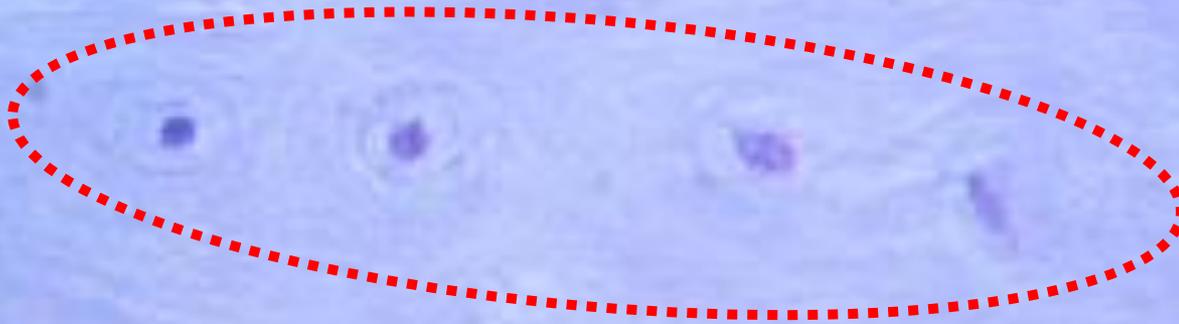


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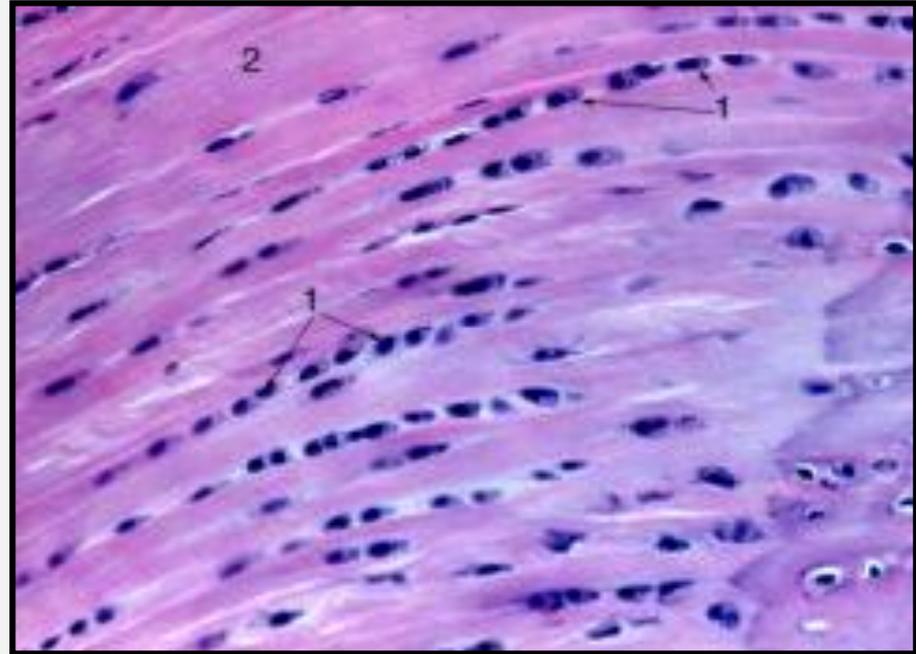
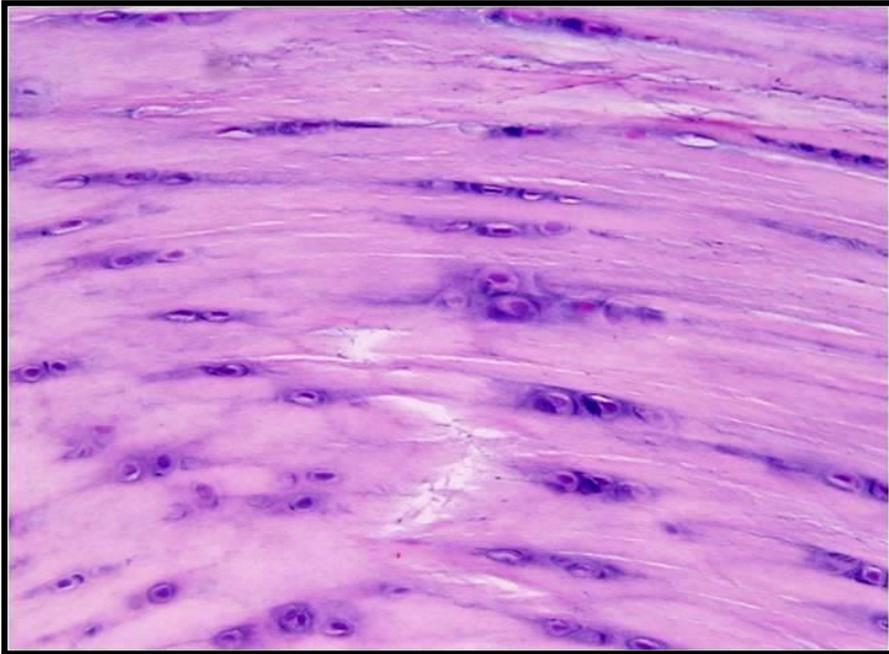
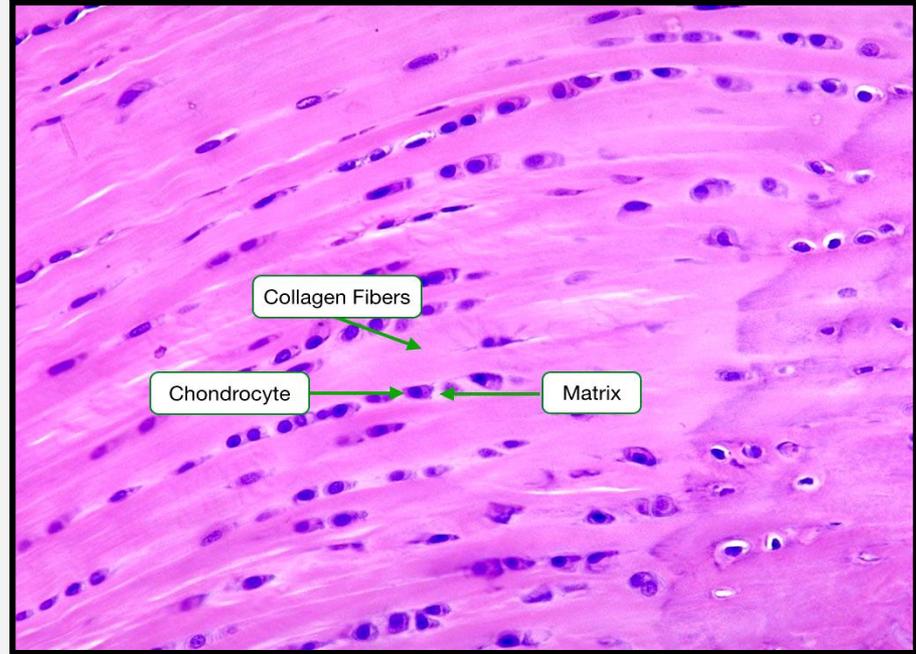
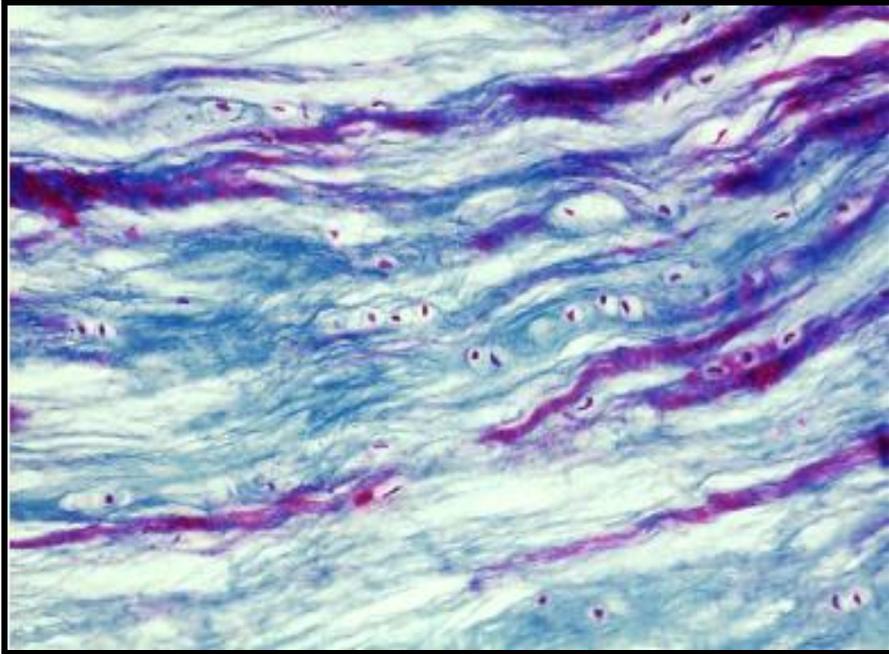
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This is fibrocartilage. The matrix contains a lot of collagen fibers. The lacunae with chondrocytes are few and tend to lie in rows. The indicates a row of chondrocytes.



Intervertebral disks

consist of **fibrocartilage** plates between the vertebrae and act as mechanical shock absorbers. In sections they are seen to be formed of two components:

annulus fibrosus, which is the outer region consisting of orderly concentric arrangements of cells and matrix dominated by **type I collagen + chondrocytes**

nucleus pulposus (large vacuolated cells, that are vestiges of the embryonic notochord).

