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Sources : DR Ghada's recorded lecture and her slides

CARTILAGE

بسم الله

Some abbreviations you might face in this sheet:

CT : connective tissue

ECM : Extra Cellular Matrix

First of all , let's remember the classification of the " **connective tissue** " as mentioned previously :



### ? (غضروف) What is cartilage

**GENERAL FEATURES** 

#### 1.It is a special type of connective tissue

#### 2. It is tough and durable CT

The two TOUGH structures are : **1.Bone 2.cartilage**, however, there is a huge **difference** between them , **WHY?** Because we need a structure that is **tough and compressible** at the same time (the cartilage), and we need something that is **extremely tough and incompressible** ( the Bone)

# 3.cartilage has rich extracellular matrix (ECM) with high concentrations of GAGS and proteoglycans



 $\ensuremath{\mathsf{NOTE}}$  : we can refer to the fibers and the ground substance all together as the  $\ensuremath{\mathsf{ECM}}$  .

### 3. cartilage is AVASCULAR

which means, there is no blood vessels that actually can be seen **WITHIN** the structure of cartilage ( they stop just right outside the cartilage , we call these blood vessels that wrap the cartilage **perichondrium**, to be discussed in the next pages ) However, nutrients will reach the cells by diffusion .

when we say AVASCULAR this also means that these cells have low metabolic activity

Here are some examples of cells with low or high metabolic activities

HIGH metabolic act : 1. Bone cells (osteoblasts) 2. Liver cells (hepatocytes)

LOW metabolic act : chondrocytes

### 4. Cartilage lacks nerves

# PERICHONDRIUM

1.Perichondrium is a sheath of **dense connective** tissue that surrounds(wraps) the cartilage , ( DR Ghada mentioned that we can see a lot of collagen type one fibers here )

2. It forms an interface (عازل او رابط) between the cartilage(inside) and the tissue that is supported by the cartilage(outside) like the bone , for example .

3. It contains Blood supply and a small neural component

And this really makes sense, because we have mentioned previously that nerves and blood vessels don't penetrate nor reach the cartilage , and they remain outside within the perichondrium

Peri : around

Chondrium : cartilage

### We have 3 TYPES OF CARTILAGE ;

### 1. ELASTIC CARTILAGE

#### 2.FIBROCARTILAGE

3. HYALINE CARTILAGE ( the most common one )

One special type of Hyaline cartilage is : Articular cartilage

Articular cartilage covers the ends of the bones in movable join

And it lacks perichondrium (diffusion of oxygen and nutrients f synovial fluid)

We should know that **not** all types of cartilage are surrounded by a perichondrium .

What are the 2 types of cartilage that don't have a perichondriu (devoid from perichondrium) ?

**1. Fibrocartilage 2. Articular cartilage** (which is a type of Hyaline cartilage as we mentioned right above )

SO , DO all kinds of Hyaline cartilage contain perichondrium ? NO , ARTICLAR DOESN'T .

# Other features regarding to CRTILAGE :

# 1.We refer to cartilage as Semi-rigid structure , which means it still have some compressibility.

(Note : we say compressibility but not elasticity , because we cannot actually stretch it but we can compress it , however, it is compressible but up to a limit , which means : after reaching a certain point (compressibility stops ) and it will be broken into smaller fragments , rather than being kept as a one solid structure .

#### Now the question is why it is considered as semi-rigid?

As we remember , we have proteoglycans in the ground substance , which are composed of GAGs (NEGATIVLY charged ) attached to a core protein .

Proteoglycan = GAGS + core protein

Femu

Articular Cartilage

Injury

Lateral ~ Meniscus As a result , many water molecules will bind to the negatively charged hyaluronan and GAGs that are extending from proteoglycan core protein, which in turn are enclosed within a dense meshwork of thin type 2 collagen fibrils ; that's why cartilage is compressible , and it acts as SHOCK ABSORBED ( متص صدمات )

 The physical properties of cartilage depends on electrostatic bonds between type II collagen fibrils , hyaluronan, and sulfated GAGS on densely packed proteoglycans . IMPORTANT!!



\*this is an extra image , just to understand the idea in a much better way, you can skip it as well ..

That's why we need Hyaline cartilage (specially articular) to cover the articular surfaces, we want something that is compressible to allow the movement and protect the inner structure that they cover (bones) ... we don't want something that is as hard as bones to cover the articular surfaces.



## Let's analyze this pic :

Keep in your mind that cartilage is usually associated with bones (they are side by side)

Notice that we have 3 different colors here , each color refers to a different type of cartilage

What is the most widely spread type of cartilage , as you can see in this image ?

It is the Hyaline for sure .

Mention the locations of Hyaline :

- 1. At the ends (tips) of the ribs
- 2. At the joints (articular cartilage)
- 3. the soft part of our nose which is movable

Mention the locations where we can find fibrocartilage :

- 1. in between the vertebrae
- 2. in between hip bones
- 3. at the knee

### Why can't we use Hyaline instead of Fibrocartilage in vertebrae?

Because fibrocartilage is Way stronger than the Hyaline cartilage.

\*An Important Note : Fibrocartilage is the toughest type of cartilage .

Fibrocartilage is a composet type of tissue it has 2 elements : 1.a dense\_irregular connective tissue with collagen type one 2.a cartilage with collagen type two ; this will resist the compression between vertebrae.

The main function of the vertebrae is to carry the weight (a weight transmission part), we can notice that the size of vertebrae changes from top to bottom(becoming bigger) **why?** Simply, Because it will be carrying more weight.



# Elastic cartilage :

#More flexible and remains flexible throughout the life .

Locations : you can go back to the image on page 6

- 1- The external part of the ear.
- 2- The epiglottis لسان المزمار





### Some notes about the cells :

1. consist of only chondrocytes embedded in the ECM

- 2. <u>Chondroblasts</u> synthesize ECM
- 3. Chondrocytes maintain ECM

4. Chondrocytes are located in matrix cavity called lacuna

They seem to be Two types BUT you will not see two types, they are actually one type , One type is a mature form of other type ( one type is young and the other type is a mature type)

# Now , we are going deeper into each type

# 1.Hyaline cartilage :

- Most common of the three types.
- Homogeneous and semitransparent in the fresh state : its color almost transparent.
  - Located in :

1. Articular surfaces of movable joint : generally synovial joints

2. in the walls of larger respiratory passages (nose, larynx, trachea قصبة هوائية , bronchi)

3. in ventral ends of ribs ,where they articulate with the sternum

4. epiphyseal plate of cartilage

# How do we get longer ?

#### Honestly, this is not that important I think we can read it and pass

In embryo we have :

- Flat bones : Which was a mesenchyme then it differentiated to osteoblast
- Long bones : Which was first a hyaline cartilage and by age it will be replaced with bone tissue EXCEPT some places where we have small disc ( epiphyseal plates ), so we are getting taller as the hyaline in the epiphyseal plate elongated and this is associated with growth hormone. We stop growing when no epiphyseal plates are present.

### Hyaline cartilage structure:

- Collagen is embedded in a firm, hydrated gel of proteoglycans and structural glycoproteins (the ground substance).
- Proteoglycans (mainly Keratan and Chondroitin) --matrix basophilic (because they are negatively charged) and the collagen fibrils are barely discernible.
  An example of proteoglycans found in Hyaline cartilage is

An example of proteoglycans found in Hyaline cartilage is Aggrecan.

- Aggrecan (A core protein linked to 150 GAGs—the GAGs include chondroitin sulfate and keratan sulfate) is the most abundant proteoglycan of hyaline c.
- Most of the collagen is type II (small amounts of minor collagens are present).

You will see almost 10 different types (out of 28 types found in human beings) in cartilage.

**BUT GENERALLY** when you are asked: What type of collagen shall we see in Hyaline cartilage? The answer is **collagen type 2.** 

You only need to know that there are other types of collagen (minors) but you don't have to know their names or any other details.

- Water bound to GAGs in the constitutes to **60%-80%** of the weight (the negative charge in proteoglycans attracts the positive charge in water molecules).
- Chondronectin: structural multiadhesive glycoprotein, binds specifically to GAGs, collagen, and integrins, mediating the adherence of chondrocytes to the ECM (it allows the cells "Chondrocytes" to bind to the collagen fibrils of type 2 that exist inside the ECM).



The letter **P** in this picture refers to the **Perichondrium** (the wrap or covering of the cartilage).

The Perichondrium actually has 2 parts/layers/surfaces:

- The external one is **fibrous** and rich with **collagen type1**. When we have collagen, then we should also have fibroblasts (remember: they synthesize the collagen fibers).
- The internal surface is more cellular.

We see more cells in this layer similar to the fibroblasts **BUT THEY ARE NOT FIBROBLASTS**, they are **progenitor cells** which will later differntiate into **Chondroblasts** (the young active cells) and once they mature, they will eventually become **Chondrocytes** (the mature ones).

Progenitor cells  $\rightarrow$  Chondroblasts  $\rightarrow$  Chondrocytes

After the cells have released everything around them (the ECM) and become Chondrocytes (mature and retired cells), they are more or less immovable and imprisoned inside their home(within an envelope called the lacunae) with the semi-rigid ECM surrounds them from outside and holds them in their places.

BUT they are not dead cells, they are JUST retired.

-The Chondrocytes are not present as single cells in their lacunae, instead they are in doublets or quadrilents..etc (groups of 2 or 4,8,16.. cells) due to their proliferation inside the lacunae.

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### MATRIX:



The letter **M** in this picture refers to **MATRIX** 

-**Territorial matrix**: immediately surrounding each chondrocyte, the ECM is relatively <u>richer in gags than collagen</u>, causing these areas of to stain more basophilic. Contains mostly proteoglycans and sparse collagen.

-Interterritorial matrix: more distant from lacunae, <u>richer in</u> <u>collagen with less GAGs</u> and may be less basophilic.

The GAGs are negatively charged so they will stain much more basophilic in hemotoxylin than structures that have more collagen and less GAGs (which tends to stain more ezenophilic).

### Clinical applications for Hyaline cartilage:

### **Osteoarthritis**

-A chronic condition that commonly occurs during aging. (fibrocartilage) Meniscus

Aging is the main reason (we are not talking about people of ages between 40-50, but much older, normally with ages 60-70..80), but there are other reasons including



**immune diseases, genes** or the **lifestyle** (how much active you are and how much you use your joints)  $\rightarrow$  and the more active the person is, the faster he/she goes through Osteoarthritis. Frequent cycling for example is a great contributor.

So it's not just exclusive for the elderly, but we refer here to the aging factor.

-Involves the gradual loss or changed physical properties of the articular cartilages (we lose the slippery/soup like cartilage that protects the inner structures: BONES, so we get **bone to bone contact** which causes **pain and limited movability** of the joint).

-Weight-bearing Joints (knees, hips) or heavily used (wrist, fingers) are most prone to cartilage degeneration.





P: the most outer layer; the perichondrium

M: the matrix

C: Chondrocytes

**NOTE**: The collagen found **in perichondrium is type 1** BUT collagen found **in the matrix is type 2** 

### The end

ثم إننا والله لنعجب ممن يرى أضعاف ما قد نرى ، ثم لا يملك إلا أن يقول : إنّ هذا لمحض صدفة! ويحه ، ألم يعلم أن... " و فوق كلِّ ذي علمٍ عليم " .