Doctor 022

Histology

Sheet no. 2

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Black: things mentioned during the lecture by the doctor

Light Gray: slides

Cartilage

It is a special type of connective tissue characterized by being tough and durable with an ECM rich in GAGs and proteoglycans, interacting with collagen and elastin.

الفكرة من ال Elastic

Elastic Cartilage

Something that is strong, can hold its shape , and at the same time is bendable without breaking.

Fairly similar to hyaline cartilage except the part where it's rich with elastic fibers (hints the name), much more flexible than hyaline cartilage. Thus, it is bendable to a certain limit.

- 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

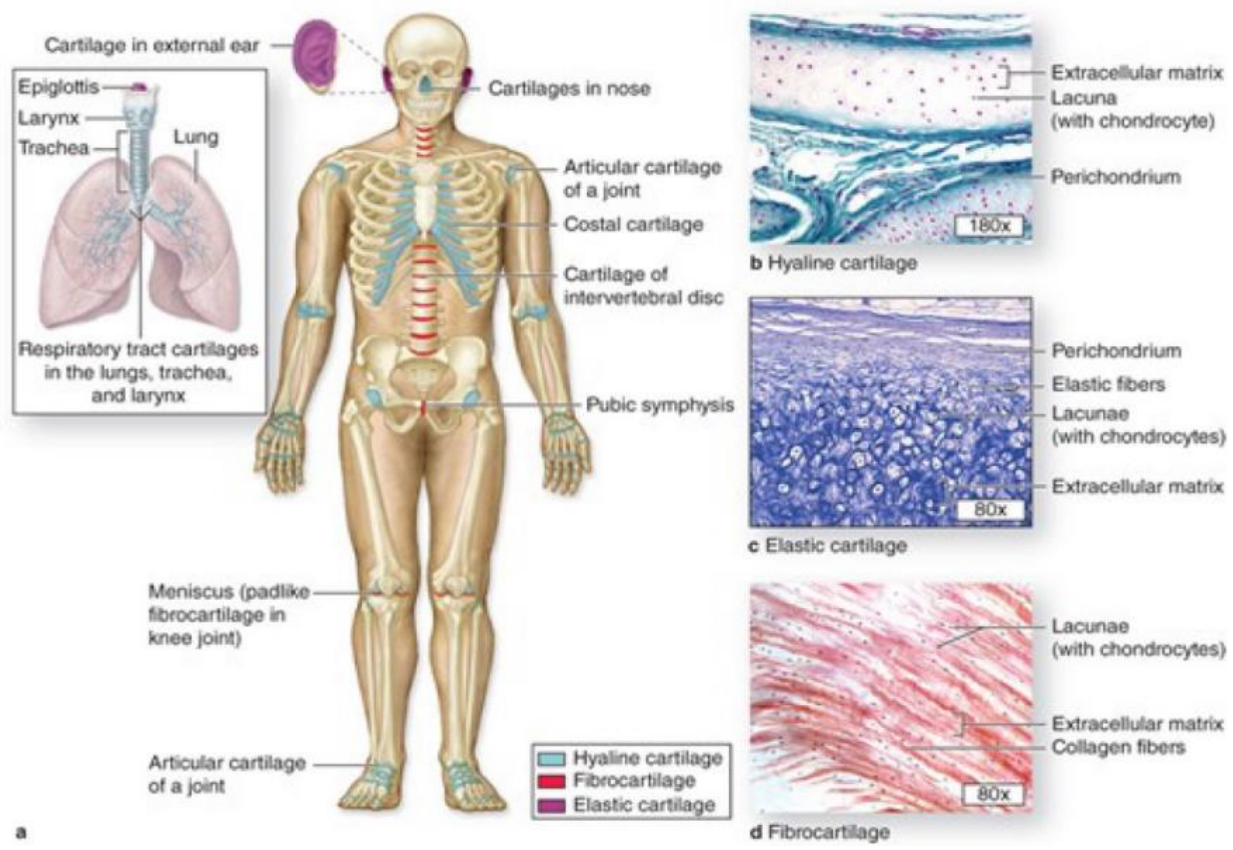
Having mentioned a second type of cartilage you might be wondering why there are diverse types?

This can be justified by the various functions cartilage is responsible for, and each structure (type) corresponds to a

specific function, which can be noticed easily by looking at the location of each type of cartilage.

Location

say hi to our skeletal friend



As you can see elastic cartilage is found in 1. Epiglottis

2. External ear (you can freely bend your ear and sleep on it whit no problems)

First let's look at our throat which contains the larynx, the air passageway which is covered by the epiglottis made of elastic

cartilage. The main function of the epiglottis is preventing whatever we swallow (food, saliva, etc..) from going into our air passageway (larynx) and thus suffocating us. And it does that by bending over the larynx whenever we swallow something to cover it and allow food for e.g., to slide over it and go in the right direction. this requires constant movement and a considerable elasticity provided by the elastic cartilage tissue.

Now you may ask why not just use hyaline cartilage?

Well, this is explained by the process of calcification which only hyaline cartilage is subject to unlike elastic cartilage, why is that?

In order to answer this question, we have to zoom in on what's called osteogenesis (formation of bones in the embryo). Bones are formed in two pathways;

1. Mesenchyme → bone cells → osteoblasts → bone tissue (intramembranous)
2. Mesenchyme → chondroblasts → hyaline catilage ↓ calcification → Bone

(Endochondral ossification) this is how long bones are formed e.g. ulna, radius, humerus. The skeleton of the embryo starts as hyaline cartilage and calcifies later on. The calcification of long bones' epiphysial cartilage after birth stops roughly around the age of 18. (all of your bones are then made of entirely bone tissue)

- 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.
  Dense irregular connective tissue surrounding some cartilage types and it what's so special about it is that it contains progenitor cells which are undifferentiated and can yield chondrocytes.

Perichondrium traps and covers the cartilage from outside and it consists of outer fibrous layer and inner cellular .

Outer fibrous means: mainly fibers made by fibroblasts

Inner cellular : هذا بكون على الinterface

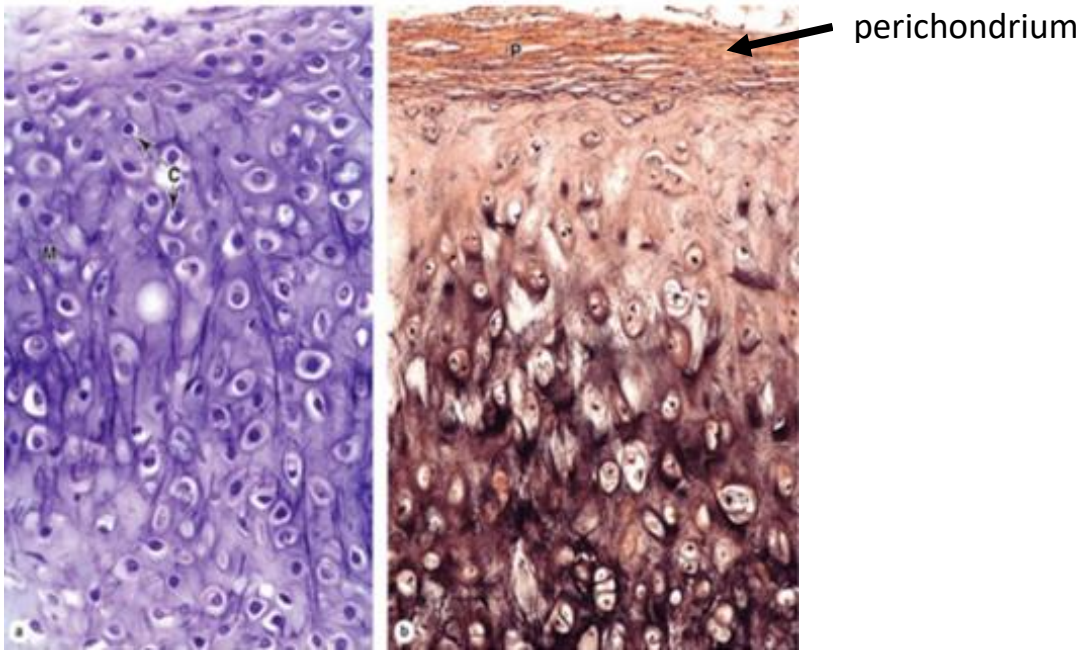
- Is a sheath of dense connective tissue that surrounds cartilage.
- Forms an interface between the cartilage and the tissues supported by the cartilage.
- Contains blood supply and a small neural component.
- Articular cartilage (covers the ends of bones in movable joints) lacks perichondrium (diffusion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

Calcification

Is the process of depositing calcium ions inside a tissue which eventually hardens it. Note that calcification of hyaline cartilage in the joints occurs in older people and not young individuals.

- 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 aspects resembles endochondral ossification by which bone is formed.

Elastic cartilage

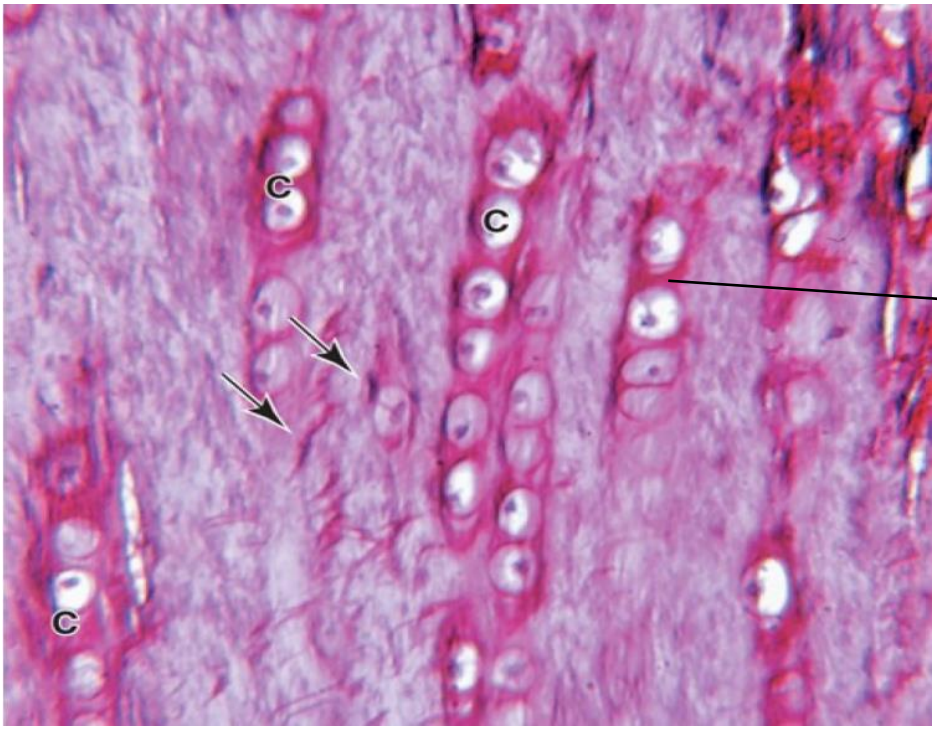


	Elastic Cartilage
Main features of the extracellular matrix	Type II collagen, aggrecan, and darker elastic fibers
Major cells	Chondrocytes, chondroblasts
Typical arrangement of chondrocytes	Usually in small isogenous groups
Presence of perichondrium	Yes
Main locations or examples	External ear, external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

Fibrocartilage

The most special type out of the three. In either elastic or hyaline cartilage, the formation process is something like; mesenchyme, chondroblasts, ECM, lacunae. While the fibrocartilage consists of two types to tissues (cartilage, dense irregular connective tissue) embedded in one.

*Cartilage mostly contains type 2 collagen. While dense irregular connective tissue contains type 1 collagen. Which gives it superior physical strength. Thus, providing greater support.



Identify the collagen type? Type TWO collagen

- Arrows represent fibroblasts.
- Notice how isogenous groups occur in an elongated linear fashion.
- In between the cartilage we have dense irregular CT, mostly collagen type 1.
- The more eosinophilic substance surrounding the chondroblasts\cytes is rich with collagen type 2.

Fibrocartilage provides superior compressive strength. It's very hard to compress.

It is void of Perichondrium (similarity with articular hyaline cartilage) and it receives its blood supply from the surrounding environment.

What is so important about having a layer of perichondrium?

It contains progenitor cells which aid in the repair of the cartilage type it surrounds. Meanwhile fibrocartilage and articular hyaline cartilage rely on fibroblasts for regeneration and repair which leads to a slower, less sufficient

regeneration (healing) along with a scar tissue. That in turn affects the physical properties of the original tissue.

- 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.

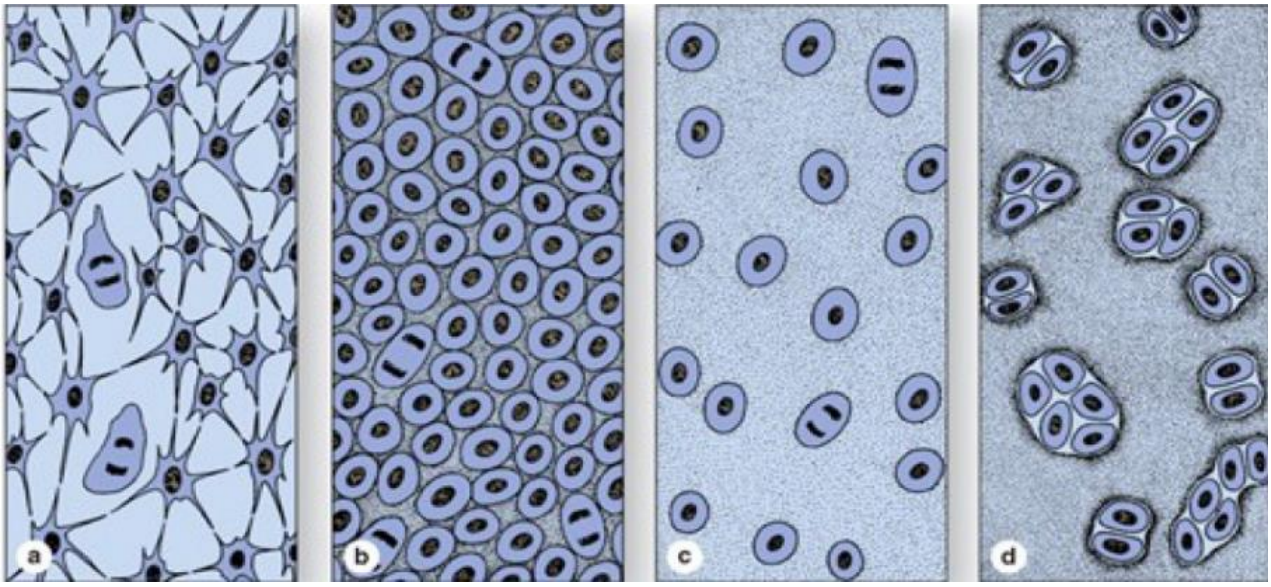
To understand its locations better refer to the skeleton image above.

and as you look at the skeleton, you will notice that the size of each vertebra grows as we go down the spinal cord, which makes sense because the lumbar and sacral vertebrae are bearing a weight (force) greater than that of the cervical vertebrae. So, now you understand and appreciate the existence of such a strong cartilage in the specific location.

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

Growth, Repair, Formation

chondrogenesis



Chondrogenesis occurs only in the embryo

Mesenchyme is the precursor for all types of cartilage

Mitosis and initial cell differentiation (chondroblasts)

Chondroblasts produce various matrix components

Multiplication of chondroblasts gives rise to isogenous cell

The first sign that cells are going in the direction of forming cartilage is a change in their shape. They become more rounded by retracting their processes and losing the star shape exhibited in mesenchymal cells. They also undergo proliferation through mitosis. Which can be seen clearly in picture B.

Following that, they start synthesising the Extra Cellular Matrix (ECM). Which is the factor responsible for the size and surface area of the cartilage (it increases the size). This type

of increase in size is called interstitial growth and only occurs in the embryo. Which can be seen clearly in picture C.

Another mode of growth is Oppositional growth, which occurs through the differentiation of progenitor cells in the perichondrium or fibroblasts. This type of growth continues after the baby is born (postnatal).

The mesenchymal cells on the outside surface (surrounding the cartilage) give rise to the perichondrium while some cells remain undifferentiated as progenitor cells for future growth mentioned above.

Cells are then imprisoned in the lacunae, due to the semi-tough or thick gelatinous nature of the ECM. However, they can proliferate and divide to form isogenous groups.

You might see even or odd numbers of chondrocytes within the same isogenous group .

(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.

Repair in tissues lacking a perichondrium.

Repair and regeneration is extremely limited in those lacking perichondrium .

articular cartilage undergoes a lot of pressure even though the synovial fluid absorbs a bit of it and makes the movement more passive and reduces friction. With that being said, it's still a subject to wear and tear forces.

So, how do we fix that?

Regeneration and repair occur in the form of a scar tissue, which fixes part of the problem but the whole tissue will not be as sufficient.

This is a greater issue in cartilage because the blood supply is insufficient for the cells to maintain a high metabolic rate.

And why is the blood supply insufficient? Because cartilage is avascular (void of blood vessels) and therefore cells obtain their blood supply by diffusion through the Extra Cellular Matrix which is semi-tough making it even harder for blood to reach the cells.

You might wonder, epithelial tissue is also avascular, why isn't that such a big problem? It's a result of ECM in epithelium

having a more fluid consistency so it's easier for substances to diffuse through it.

Points mentioned in slides regarding the same headlines.

- **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 centre 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.**

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.**

*some histological sections in the doctor's presentation are not included because she said she will elaborate them in the lab lectures.

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