بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

HISTOLOGY

Final | Lecture# 4

Cartilage Pt.2

وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

Written by : NST

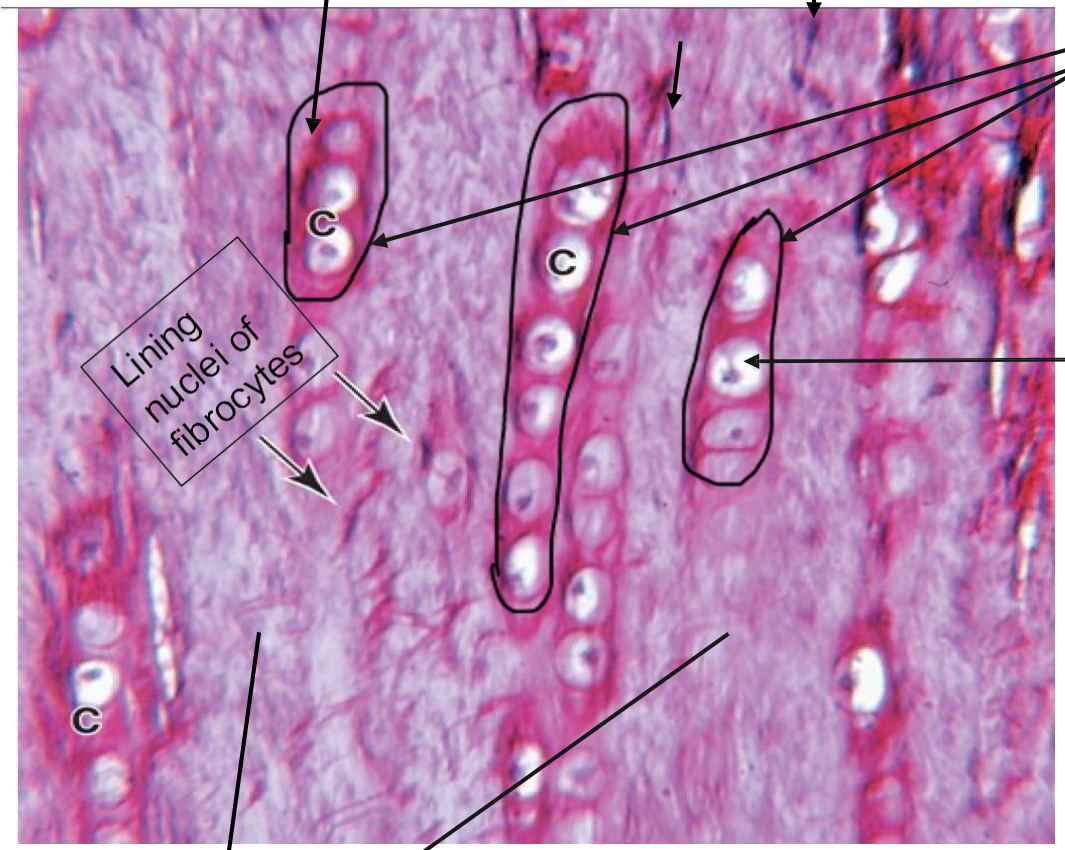
Reviewed by : Amal Al-khatib

Color coding used in the modified:

- *Black: the original slides*
- *Maroon: the doctor’s explanation/words*
- *Gray: additional information and explanation*
- *Red: important information*

Fibrocartilage

Matrix of cartilage surrounds the chondrocytes.



Isogenous groups

chondrocyte resides in its lacuna

Dense connective tissue

	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

The basophilic elongated nuclei belong to fibroblasts or fibrocytes within the dense connective tissue.

Fibrocartilage

- 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 (the joint between two pubic bones anteriorly)— serves as very tough, yet cushioning support tissue for bone. It is also found in the menisci of some joints such as knee joint

These are regions where high stress is actually applied, and they are weight-bearing.

- 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. **The presence of hyaline cartilage provides cushioning to fibrocartilage, but the strength of this cartilage comes from the dense connective tissue, which consists of type I collagen fibers.**

*Please note that the professor mentioned it as regular, but after referring to many sources, it is actually classified as irregular

- Relative scarcity of proteoglycans---- matrix more acidophilic.
- There is no distinct surrounding perichondrium.
- Intervertebral discs of the spinal column are composed primarily of fibrocartilage.

the lack of a perichondrium is a critical feature of this type of collagen, as it plays an essential role in regeneration and repair. When we discussed the perichondrium, we mentioned that it has two layers: the outer layer is fibrous and composed of dense irregular* connective tissue, while the inner layer is more cellular and contains chondrogenic cells, which give rise to chondroblasts. As a result, if these components are absent, it will affect the regeneration and repair of fibrocartilage. Therefore, damage to fibrocartilage won't be repaired by the formation of new fibrocartilage but by the formation of scar tissue derived from fibroblasts found within fibrocartilage.

Fibrocartilage, its name indicates “fibro”, which means there’s an additional element added to the cartilage.

Fibrocartilage is simply a composite tissue made of two parts:
cartilage—mostly hyaline cartilage—and dense connective tissue.

Under the light microscope,in the dense connective tissue, you’re going to see both fibroblasts and chondrocytes present in the tissue.

This kind of tissue (dense connective tissue) contains collagen type I, which is the strongest type of collagen fibers. These fibers add extra protection and resistance, especially against pulling forces and compression.
This explains why fibrocartilage is located in areas exposed to mechanical stress, like intervertebral discs and other pressure-bearing joints.

Hyaline cartilage usually has cells called chondrocytes, and they typically occur in isogenous groups. So, it's rare to see single cells; we usually see them in groups.

In fibrocartilage, you might see chondrocytes as single cells or in isogenous groups. However, these chondrocytes tend to be lined up, so you will see the cells next to each other rather than forming a group of cells clustered in a 3D arrangement.

Fibrocartilage is a very strong type of cartilage. This strength comes at the expense of proteoglycans, as more space is needed for the collagen fibers. Therefore, the amount of proteoglycans is significantly lower compared to other types of cartilage.

Hyaline cartilage and elastic cartilage are rich in negatively charged GAGs, which makes their matrix basophilic. In contrast, fibrocartilage has fewer GAGs, so the matrix is less basophilic and tends to be more eosinophilic, due to the presence of collagen types I and II.

Cartilage Formation, Growth, & Repair

The mesenchymal stem cells differentiate along specific pathways, and this process is upregulated, leading to their transformation into chondroblasts.

- 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

If you compare before and after, you'll notice that the mesenchymal stem cells are spaced by ground substance and collagen fibers. As time passes during their differentiation, the cells become more rounded, and we see many more of them compared to when the process of cartilage formation first started.

These chondroblasts will form the extracellular matrix around them. Once they do, they embed themselves into this new environment, which is called a lacuna. Over time, they lay down more of the matrix, and these chondroblasts, now called chondrocytes, become more spaced apart from their neighboring chondroblasts.

How does it grow, and where does it start? In the mesenchyme of the embryo, it starts at the center, the primary site of cartilage formation or chondrogenesis. From there, it spreads outward.
However, this is not the only way. The more peripheral mesenchymal stem cells also differentiate to form the perichondrium, which participates in cartilage formation by giving rise to more chondroblasts. These chondroblasts also produce matrix, and the complete cartilage structure forms.

At first, the cartilage is smaller since it is still part of the embryo. As the embryo grows older, the cartilage continues to grow larger, and it keeps growing even after birth.

- **Once formed, the cartilage tissue enlarges both by:**
  - **Interstitial growth** (chondrocytes) **from center of the cartilage**
  - **Appositional growth:** chondroblast differentiation from progenitor cells **(chondrogenic)** in the perichondrium.
  - In both cases, the synthesis of matrix contributes greatly to the growth of the cartilage.

Chondrogenic cells differentiate into chondroblasts. These chondroblasts then begin the process of synthesizing and releasing the matrix. By doing so, we are simply adding more volume to the existing cartilage.

- **Appositional growth of cartilage is more important during postnatal development. because those chondrogenic cells continue to differentiate into chondroblasts, and these chondroblasts continue to produce matrix, contributing to the increase in cartilage size as the body grows larger**
- .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.**

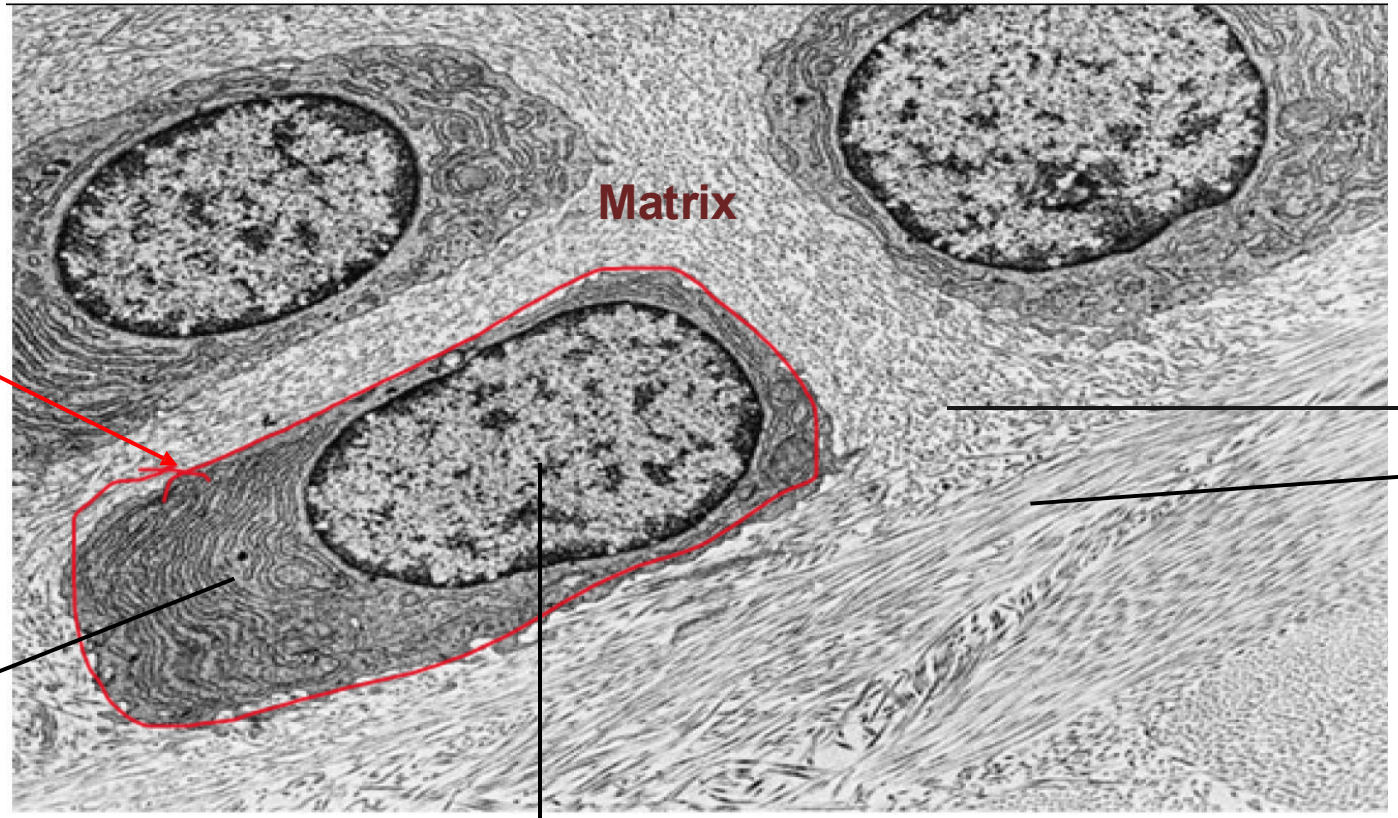
The significant volume of the cartilage comes from the matrix, not the cells. While the cells do participate in part of it, the matrix constitutes the majority of the cartilage's volume.

The perichondrium plays a vital role in cartilage growth, regeneration, and repair. It contains chondrogenic cells that differentiate into chondroblasts, which produce and secrete cartilage matrix. Cartilage types without perichondrium, like fibrocartilage and articular cartilage ,which covers the articular surface of the bone, lack this regenerative capacity and tend to wear down over time.

Although some matrix synthesis occurs from within to compensate for loss, this is limited and not enough to fully restore damaged cartilage. Since cartilage receives nutrients and oxygen via diffusion, it has a low metabolic rate and limited repair ability. When repair does occur, it is slow and often results in fibrous scar tissue (rich in collagen type I), produced by fibroblasts and different from normal cartilage.

Perichondrial cells can reach the damaged area and form new chondroblasts, aiding repair—especially in small injuries. However, larger damage usually leads to scar tissue formation rather than true cartilage regeneration.

Fibrocartilage



Chondrocyte

Those are collagen type II and I

Rich with RER

Nucleus

TEM image

Chondrogenesis

Good amount of ground substance which has a small amount of fibres collagen

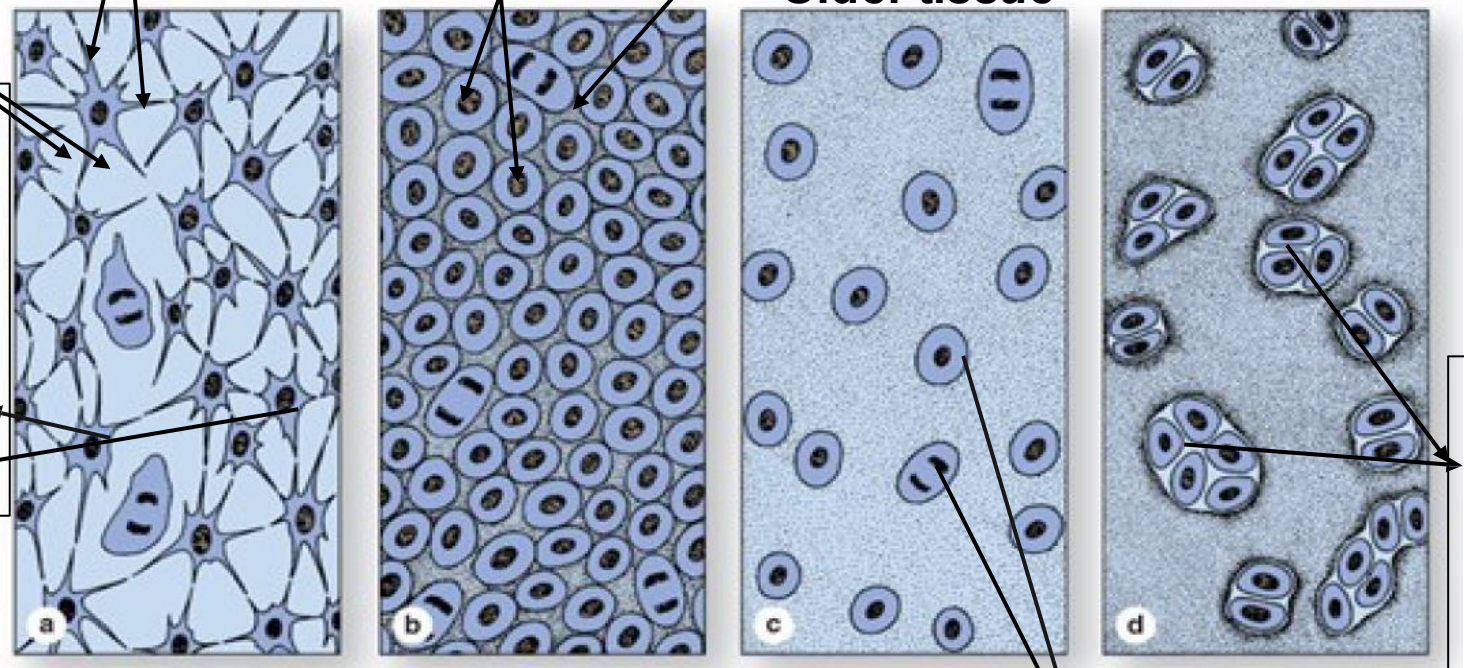
Processes

Those are more toward the chondroblast (rounding up and releasing matrix)

The colour between the cells just tells you that these cells have started synthesising and releasing matrix

Older tissue

Those precursors are cells of the cartilage, and they are being activated to go toward chondrogenesis. So they start to retract their processes, take on a more rounded shape, and begin to multiply. In (b) we have more cells (double or more)



Those cells within their lacunae do multiply and that why we have isogenous groups that's why we see more than one cell in a single lacuna

Those cells have synthesised and released the matrix, so this cartilage becomes bigger due to the formation and release of the matrix

- 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

Chondrogenesis

- (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.

Test Yourself

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			

Additional Resources:

رسالة من الفريق العلمي:

- **"To cure sometimes, to relieve often, to comfort always."**

Attributed to Hippocrates