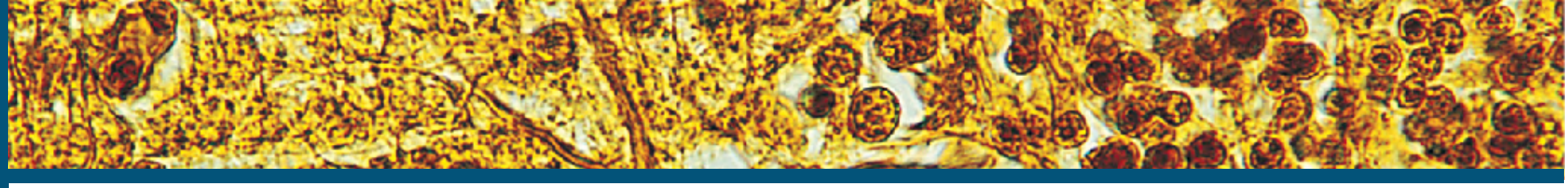


Cartilage

Textbook of Histology, 4th ed.

Gartner

Cartilage

Cartilage possesses cells:

chondrocytes, which occupy small cavities called **lacunae,** within the **extracellular matrix** they secreted.

The cartilage is neither vascularized nor supplied with nerves or lymphatic vessels!

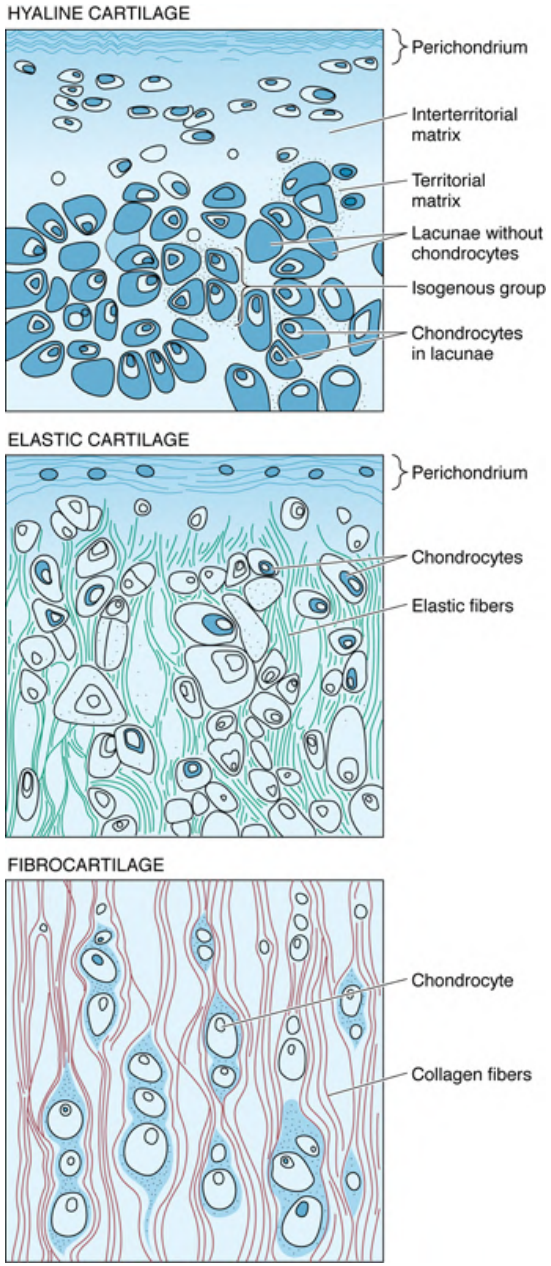
however, the cells receive their nourishment from blood vessels of surrounding connective tissues by diffusion through the matrix.

The extracellular matrix is composed of **glycosaminoglycans** and **proteoglycans**, which are intimately associated with the collagen and elastic fibers embedded in the matrix.

The flexibility and resistance of cartilage to compression permit it to function as a shock absorber, and its smooth surface permits almost friction-free movement of the **joints of the body** as it covers the articulating surfaces of the bones.

Types of cartilage.

Cartilage



Types of cartilage.

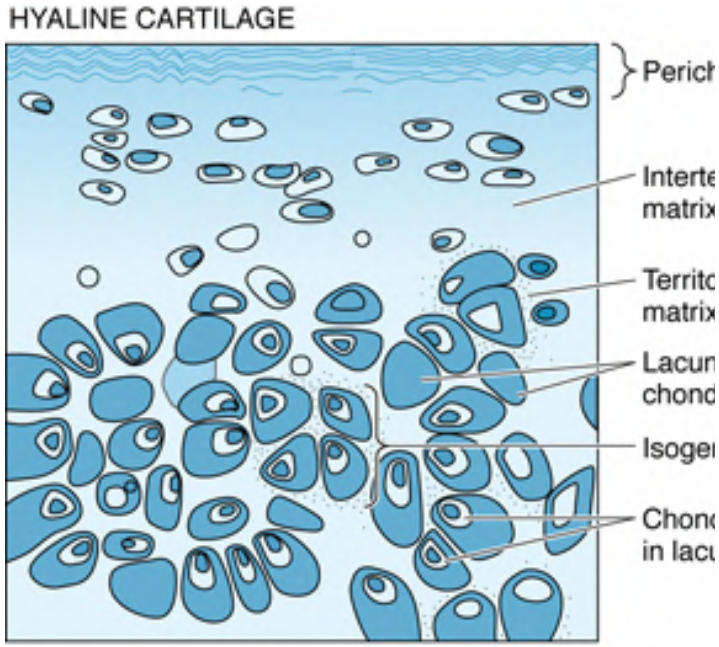
Hyaline cartilage contains **type II** collagen in its matrix; it is the most abundant cartilage in the body

Elastic cartilage contains **type II** collagen and abundant elastic fibers scattered throughout its matrix, giving it more pliability.

Fibrocartilage possesses dense, coarse **type I** collagen fibers in its matrix, allowing it to withstand strong tensile forces.

Cartilage

The most abundant



Perichondrium lacks in the joints of the body

Hyaline cartilage contains **type II** collagen in its matrix; it is the most abundant cartilage in the body and serves many functions, such as the template for endochondral bone formation

Glassy appearance
Blu/grey transparent/translucent Appearance.
It is the most abundant, located in the nose, larynx, tracheal rings, ventral-end of the Rrbs.
Form cartilage template for the long bones formation during embryonic development

Types of cartilage.

Hyaline Cartilage

- **Hyaline cartilage** is the most widespread cartilage in humans. Its name derives from the clear appearance of the matrix (Greek *hyalos*, glass).
- **In the fetus**, hyaline cartilage forms most of the skeleton before it is reabsorbed and replaced by bone by a process known as **endochondral ossification**.
- **In adults**, hyaline cartilage persists as the nasal, laryngeal, tracheobronchial and costal cartilage. **The articular surface of synovial joints** (knees, shoulders) **is hyaline cartilage and does not participate in endochondral ossification**. *Articular surfaces are not lined by an epithelium/perichondrium*

Hyaline Cartilage histogenesis

- Differentiate from mesenchymal cells, that retract their processes and round up and form the chondrification centers.
- Differentiate into chondroblasts and secreted collagen 2 and aggrecan (matrix) → lacunae →chondrocytes which upon few divisions give rise to ISOGENOUS groups
- Interstitial growth
- Mesenchymal cells at the periphery differentiate into fibroblasts, producing dense irregular connective tissue (perichondrium)

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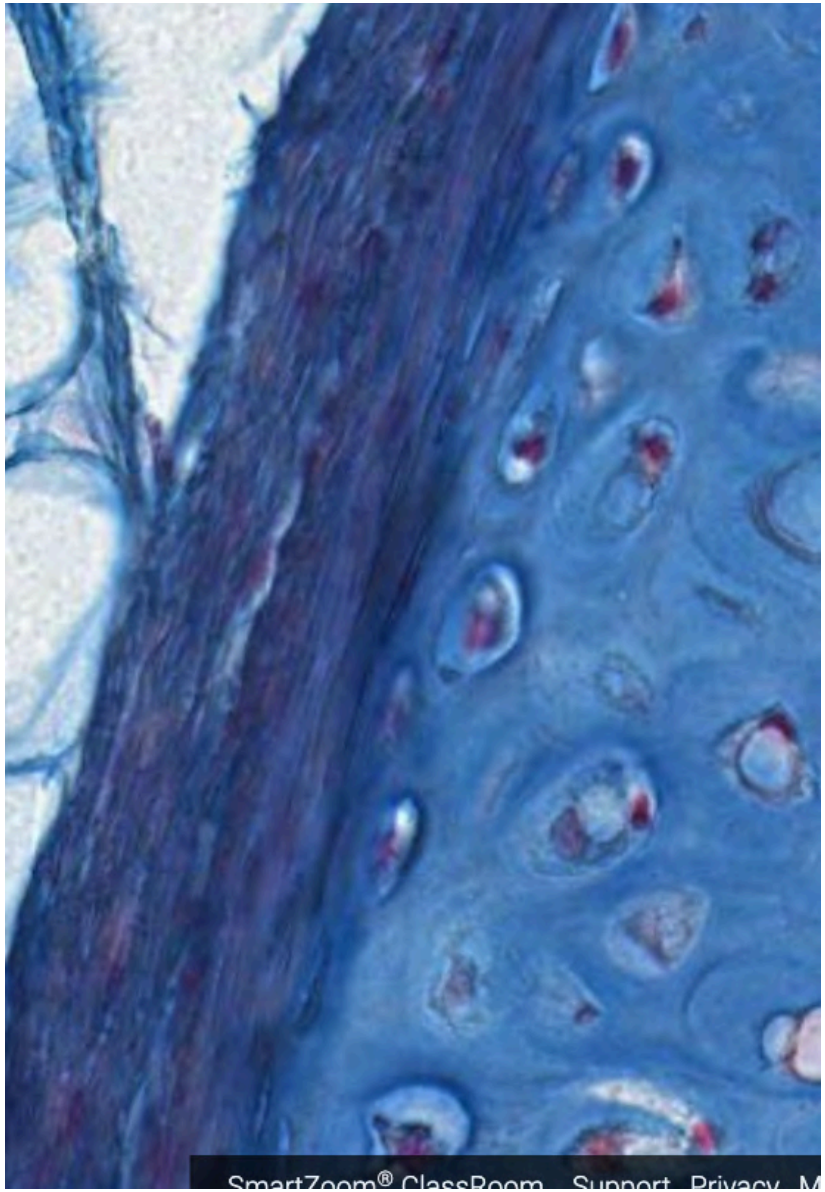
Perichondrium

Responsible for the growth and maintenance of the cartilage

- Outer fibrous layer with fibroblasts, Collagen I and **blood vessels**
- Inner layer of chondrogenic cells that undergo division and differentiation to chondroblasts which deposit matrix to the periphery (**appositional growth**).



Cartilage cells- 3 types

Chondrogenic cells precursors: spindle-shaped cells derived from mesenchymal cells (can differentiate in Chondroblasts/Chondrocytes)

Chondroblasts derived directly from mesenchymal cells or from chondrogenic cells of the inner layer of perichondrium (as in appositional growth) - basophil cells. Note: interstitial growth happens only in the early phase of development.

Chondrocytes are chondroblasts surrounded by matrix, and are ovoid in the periphery and rounded deeper in the cartilage (10-30um)

Matrix of Hyaline Cartilage

- Type II collagen, about 40%
- Proteoglycans aggregates
- Glycoproteins
- Extra cellular fluid

Territorial Matrix → around each lacuna, poor of collagen and rich proteoglycans

Inter-Territorial Matrix → richer in collagen and poor in proteoglycans

Surrounding each lacuna is the pericellular capsule

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Histopatology

In **cartilage**, chondroblasts and chondrocytes are sustained by diffusion of nutrients and metabolites through **the aqueous phase of the extracellular matrix**.

At all ages, chondrocytes have significant nutritional requirements, but their metabolic rate is low.

Cartilage repair after injury

Cartilage has a modest capacity of **chondrogenesis** (cartilage growth).

Cartilage injuries result in the formation of **repair cartilage** from the perichondrium.

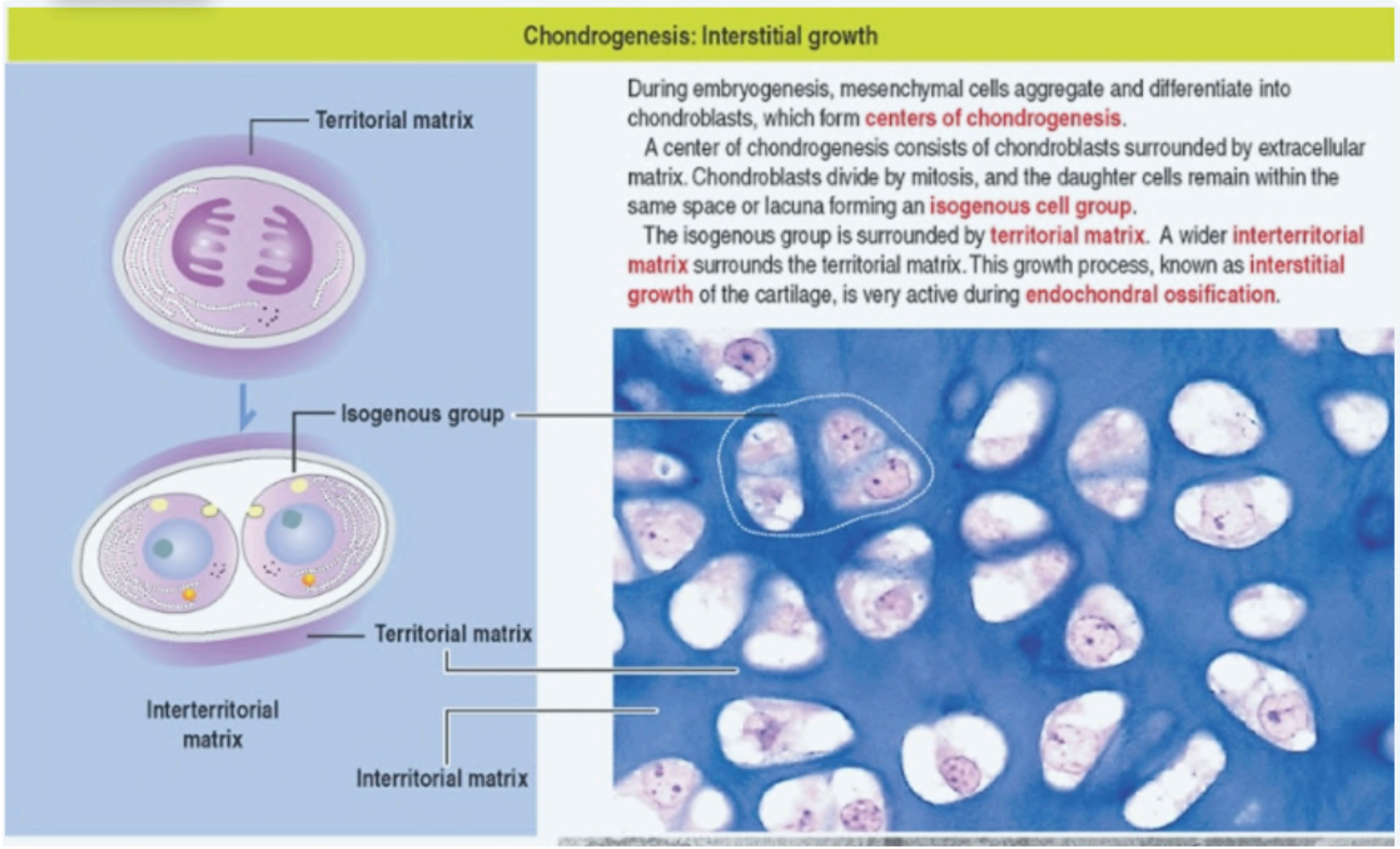
This repair cartilage contains undifferentiated cells with a potential to differentiate into chondrocytes that synthesize components of the cartilage matrix. This important property facilitates the healing of a **bone fracture** .

The repair cartilage has a matrix composition intermediate between hyaline and fibrous cartilage (for example, it contains both types I and II collagen).

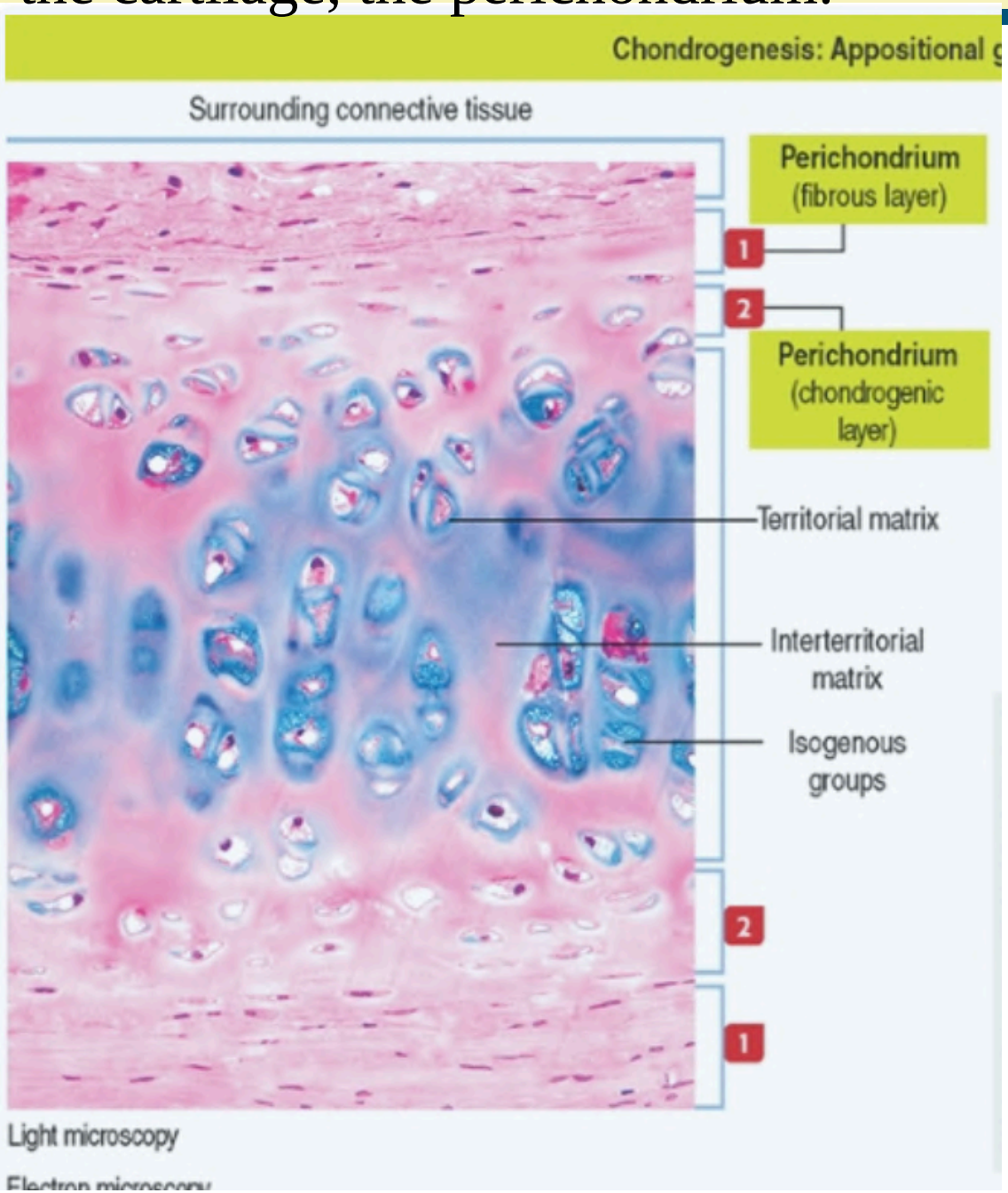
Chondrogenesis

Cartilage grows by two mechanisms:

1. By **interstitial growth**, from chondrocytes within the cartilage (inside lacunae) (early in development)



By **appositional growth**, from undifferentiated cells at the surface of the cartilage, the perichondrium.

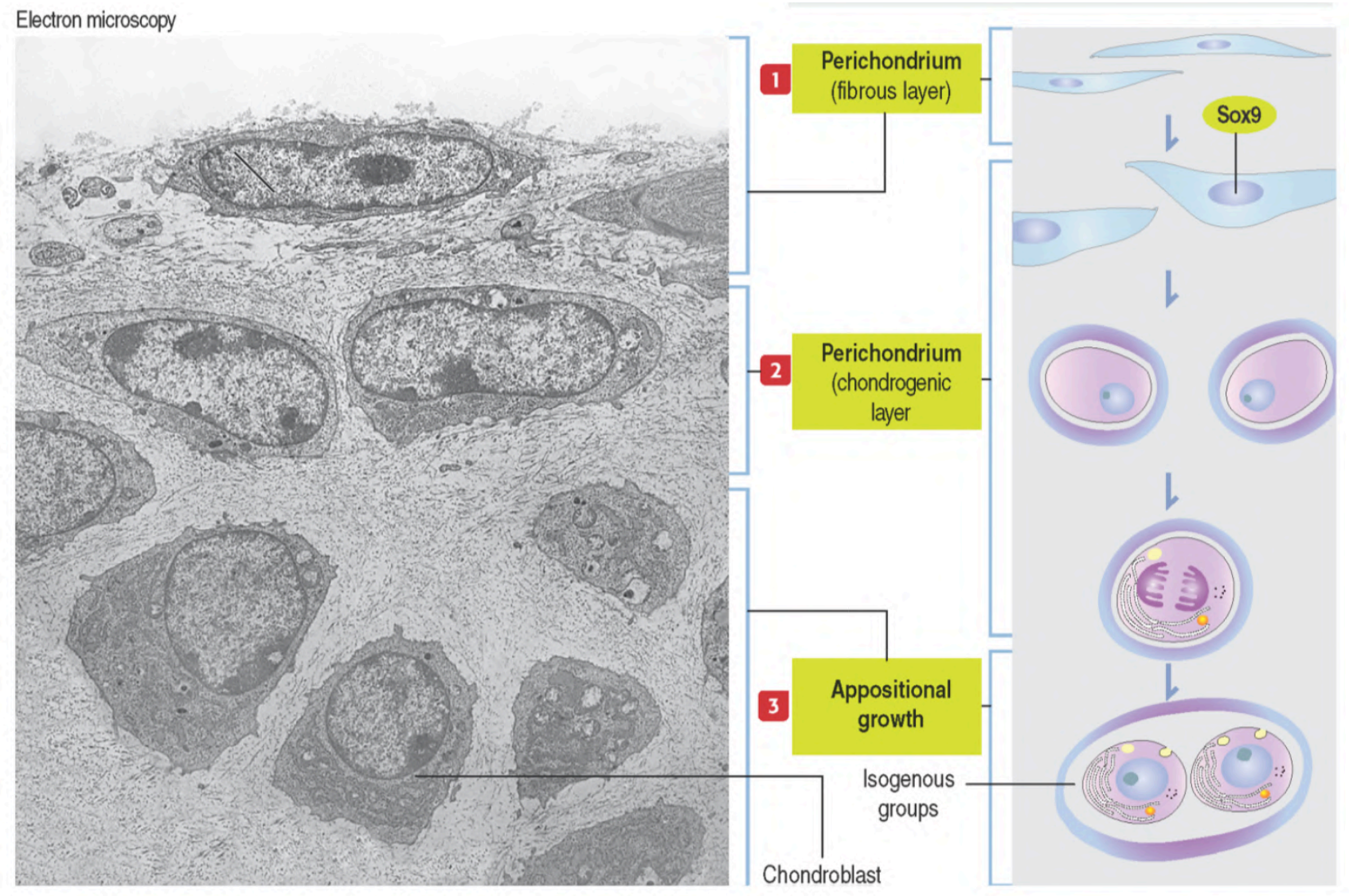


1 The outermost cells of the developing cartilage are spindle-shaped and clustered in a regular fibrous layer called perichondrium, a transitional zone between cartilage and the surrounding general connective tissue.

2 The inner cells of the perichondrium, the chondrogenic layer, differentiate into chondroblasts, which synthesize and secrete type II collagen precursors and other extracellular matrix components.

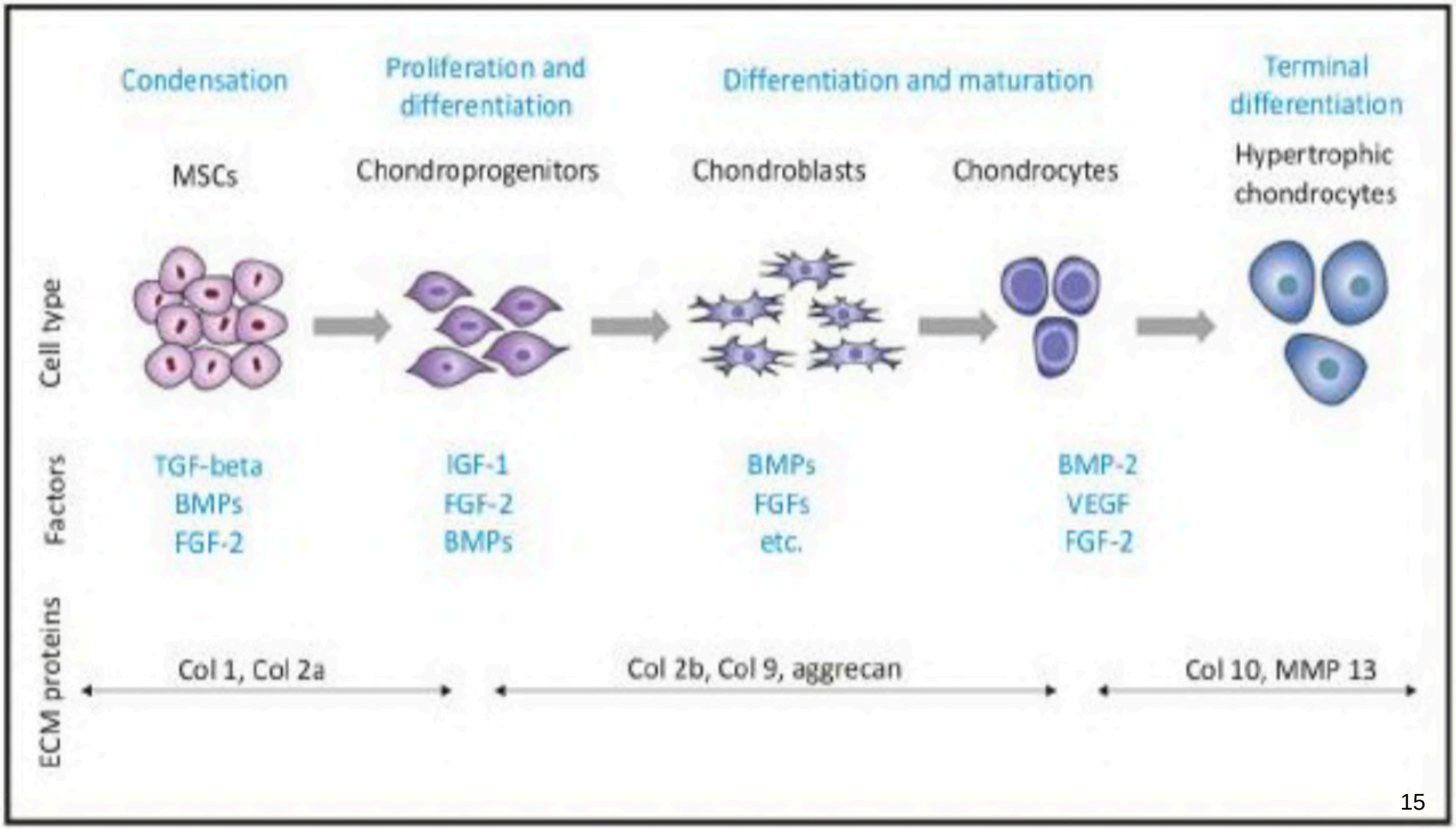
By this mechanism, new layers of cells and extracellular matrix are added to the surface of the cartilage by the process of appositional growth, and the overall size of the cartilage increases. This process

By **appositional growth**, from undifferentiated cells at the surface of the cartilage, the perichondrium.



Chondrogenesis: Formation of Chondrocytes

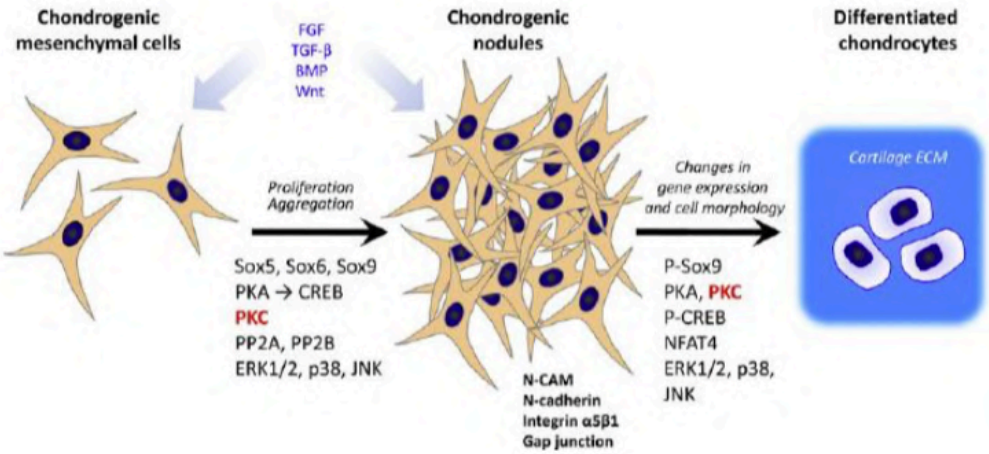
Chondrogenesis is the earliest phase of skeletal development, involving mesenchymal cell condensation and chondroprogenitor cell differentiation and maturation, resulting in the formation of cartilage.

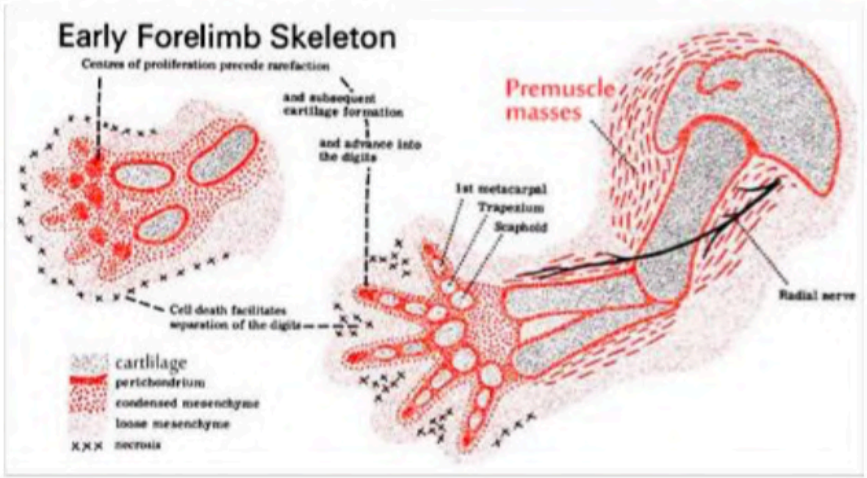


Chondrogenesis, two interdependent processes: Cell Differentiation AND Body Structure Patterning

Cell fate determination is the process by which the combinatorial interactions of genetic and environmental factors serve to direct the developmental progression of a cell lineage. Cell fate is progressively restricted, and tissue specificity is gradually committed.

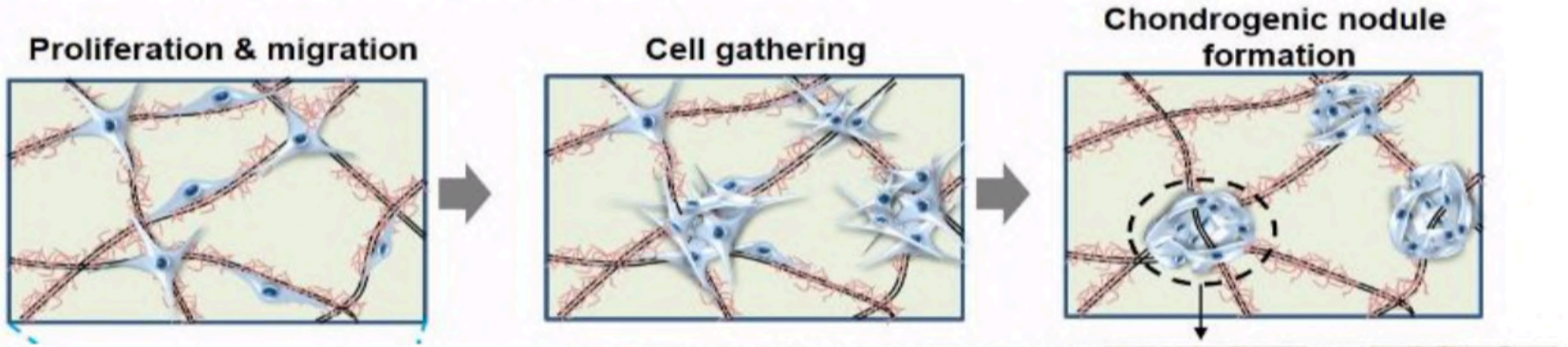
Pattern formation is the process during which number, size, and shape of the cartilaginous template is delineated and established.



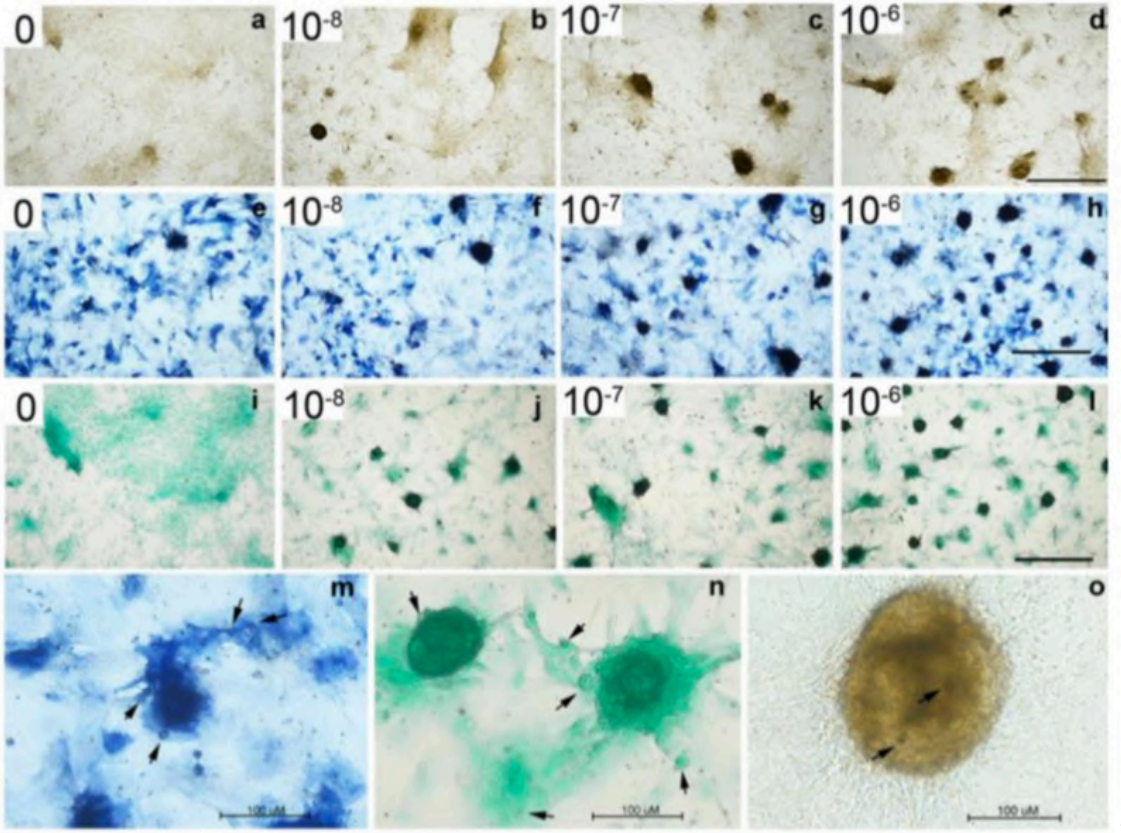


Chondrogenesis: First step of MSC Condensation

1. **Chondroprogenitor mesenchymal cells aggregate** into a mass of cells called, **CHONDROGENIC NODULE**, following FGF and Bone Morphogenic protein (BMP) signaling.

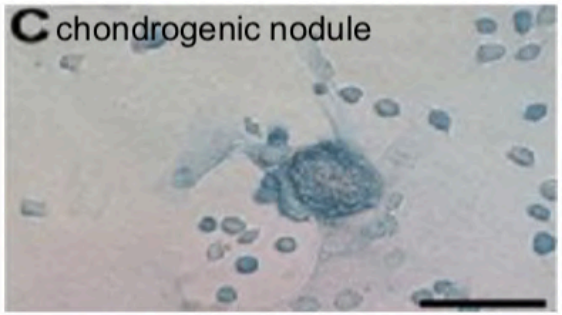


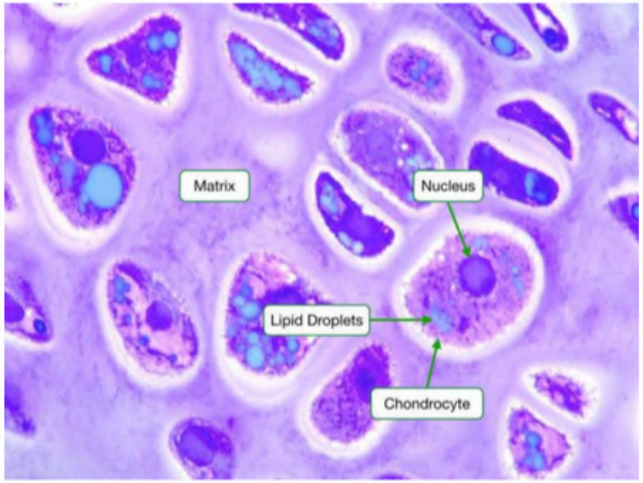
Condensation is signaled by changes in cell adhesion and cytoskeletal architecture as well as by the cell's response to growth and differentiation factors in the extracellular environment.



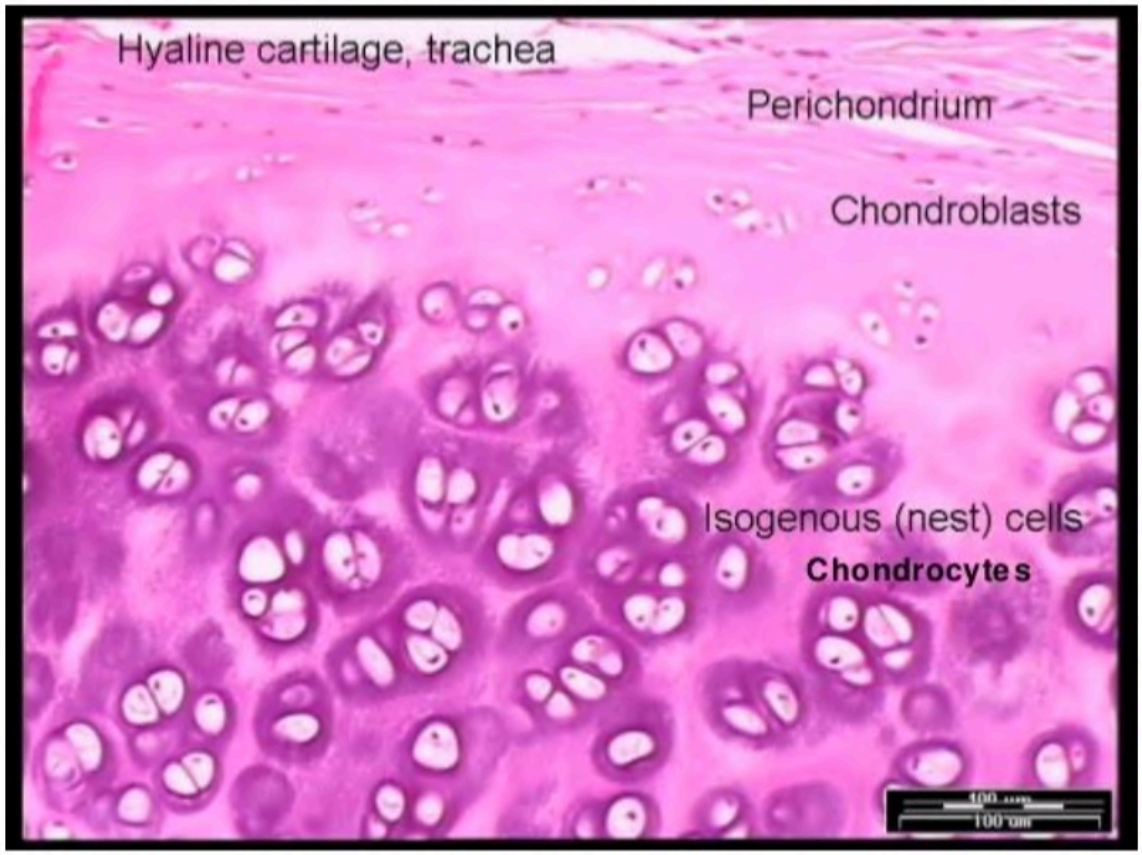
Photomicrographs were taken using bright files scannning power (40X magnification). Cultures were stained for mineral (a–d), stained for alkaline phosphatase (e–h) or stained for proteoglycan matrix (i–k).

Chondrogenesis: From Chondrogenic Nodule to Chondrocyte





C) Stained cartilaginous nodule. Week four of culture–mono filter. Bar=100 µm
Hyaline Cartilage - Toluidine Blue

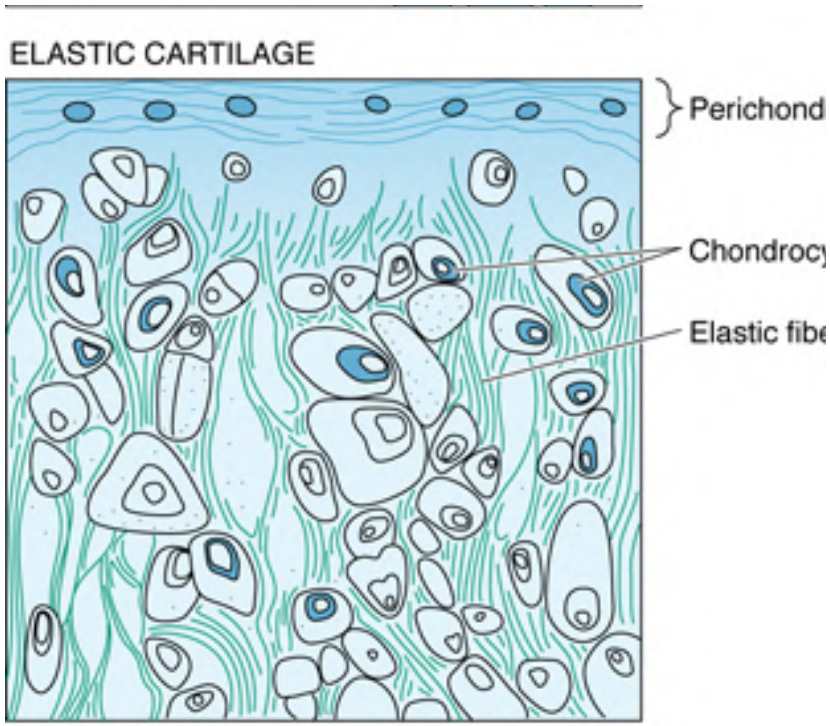


2. Expression of transcription factor Sox-9 triggers **differentiation of the nodule into chondroblasts** .

3. **Chondroblasts** with euchromatic nuclei, stained by basic dyes, **secrete cartilage ECM** components like Agreccan and Collagen II and progressively move apart as matrix is deposited.

4. When completely surrounded by matrix, the cells undergo terminal differentiation into **chondrocytes**, distributed either singularly or as **isogenous groups of 4 cells**, displaying extensive rER and Golgi due to maintenance and production of ground substance.

Elastic cartilage



Elastic cartilage contains **type II** collagen and abundant elastic fibers scattered throughout its matrix, giving it more pliability.

The structure of the **elastic cartilage** is similar to that of hyaline cartilage except that the ECM contains abundant **elastic fibers** synthesized by chondrocytes.
Elastic cartilage predominates in the auricle of the external ear, a major portion of the epiglottis and some of the laryngeal cartilages.

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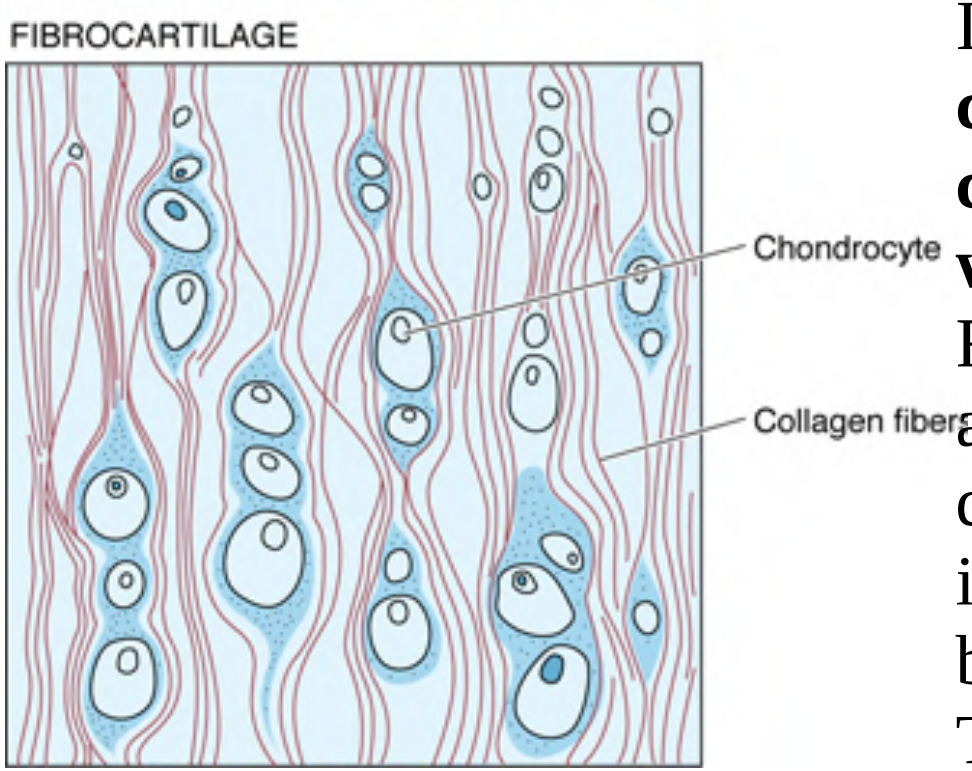
Fibrocartilage



Fibrocartilage possesses dense, **type I** collagen fibers in its matrix, allowing it to withstand strong tensile forces.

https://unibo.smartzoom.com/s1241/course1776/f1841/i1845/

Types of cartilage.

It is opaque, the matrix contains **type I collagen fibers**, the **ECM has a low concentration of proteoglycans and water** and **it lacks a perichondrium**.
Fibrocartilage has great tensile strength and forms part of the intervertebral disk, pubic symphysis and sites of insertion of tendon and ligament into bone.
The fibrocartilage is sometimes difficult to distinguish from dense regular connective tissue of some regions of tendons and ligaments.
Fibrocartilage is recognized by **characteristic chondrocytes within lacunae, forming short columns**

Summary of Cartilage Features

Features	Hyaline Cartilage	Elastic Cartilage	Fibrocartilage
Function	Resists compression Provides cushioning, smooth, and low-friction surface for joints Provides structural support in respiratory system (larynx, trachea, and bronchi) Forms foundation for development of fetal skeleton and further endochondral bone formation and bone growth	Provides flexible support for soft tissues	Resists deformation under stress
Presence of perichondrium	Yes (except articular cartilage and epiphyseal plates)	Yes	No
Undergoes calcification	Yes (i.e., during endochondral bone formation, during aging process)	No	Yes (i.e., calcification of fibrocartilaginous callus during bone repair)
Main cell types present	Chondroblasts and chondrocytes	Chondroblasts and chondrocytes	Chondrocytes and fibroblasts
Characteristic features of extracellular matrix	Type II collagen fibrils and aggrecan monomers (the most important proteoglycan)	Type II collagen fibrils, elastic fibers, and aggrecan monomers	Types I and II collagen fibers Proteoglycan monomers: aggrecan (secreted by chondrocytes) and versican (secreted by fibroblasts)
Growth	Interstitially and appositionally, very limited in adults		
Repair	Very limited capability, commonly forms scar, resulting in fibrocartilage formation		

Test

https://www.histologyguide.com/quizzes/05-cartilage-and-bone.html