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HISTOLOGY

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CARTILAGINOUS TISSUE

Introduction

■ **Embryonic origin:** Mesenchymal cells of the mesoblast.

■ **Role:** support (constitutes the supporting elements of bones), structural support, movement and ossification.

■ **Composition:** Cells (10% chondrocytes) + ground substance (solid and elastic) + fibers (which confer physical properties).

■ **Development:** Cartilaginous and osseous tissues develop in a coordinated and concomitant manner until puberty.

Localization

→ **Fetus/embryo:** major part of the skeleton

→ **Child/adolescent:** in the metaphysis between the diaphysis and epiphyses of long bones = the growth plate (conjugation cartilage)

→ **In the adult:** less common (menisci, epiglottis...)

Cartilaginous Cells

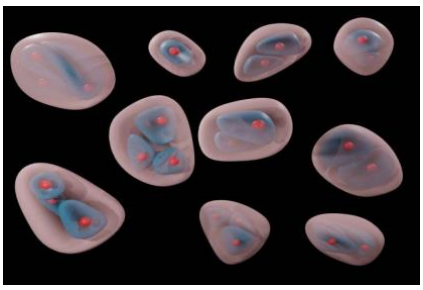
Chondrocytes

■ **Shape:** ovoid or spherical.

■ **Cytoplasm:** basophilic, rich in rough endoplasmic reticulum, Golgi apparatus...

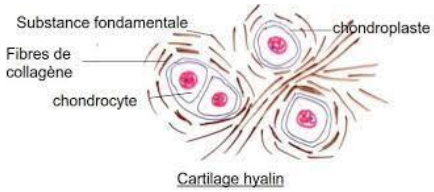
■ **Nucleus:** large and rounded, one or more nucleoli — housed in a cavity = chondroplast.

■ Irregular membrane projections that can cross the chondroplast toward the cartilaginous matrix.



Chondron

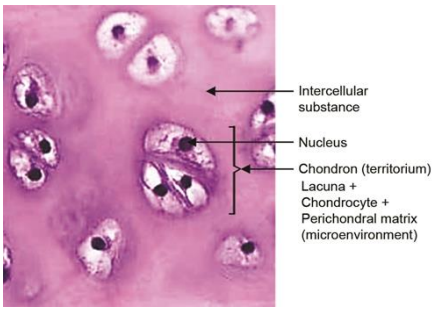
Chondron = chondrocyte + chondroplast + collagen fiber capsule (basket) = functional, structural and metabolic unit of hyaline cartilage.



Cartilage hyalin

■ **ROLE:** synthesis of protein precursors of fibers and ground substance, as well as growth factors and cytokines.

■ **Origin:** division of pre-existing chondrocytes or differentiation from chondroblasts.

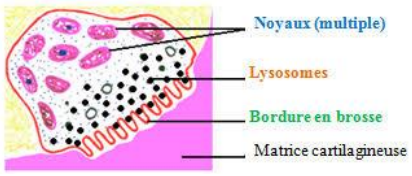


The Chondroclast

■ A giant multinucleated cell located on the surface of the cartilaginous matrix; with a brush-border plasma membrane.

■ An acidophilic cytoplasm, rich in lysosomes, possessing metalloproteinases (matrix metalloproteinases: MMP).

■ **Role:** chondroclasia = resorption of cartilaginous tissue.



Cartilaginous Fibers

They form a fine network composed essentially of collagen and elastic fibers.

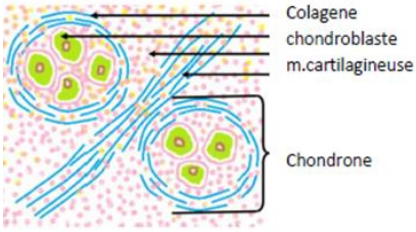
Collagen fibers type I, II or IX are not visible except under the polarizing microscope or after digestion of the ground substance with trypsin.

■ Their arrangement varies according to the location of the cartilage.

■ Fiber groups are arranged:

→ circularly in baskets (chondrons) around one or more chondrocytes.

→ in parallel, tightly packed, between the baskets (interterritorial collagen fibers).



The Ground Substance:

■ Homogeneous, translucent and basophilic.

■ It is metachromatic with toluidine blue and PAS (Periodic Acid–Schiff) positive.

■ **Composition:** water, mineral salts (K^+, Na^+, Mg^+), sulfated proteoglycans and Glycosaminoglycans (GAG) [chondroitin sulfate (cartilagein), sulfated keratan].

■ Hyaluronic acid in much smaller quantities compared to connective tissue.

Varieties of Cartilaginous Tissue

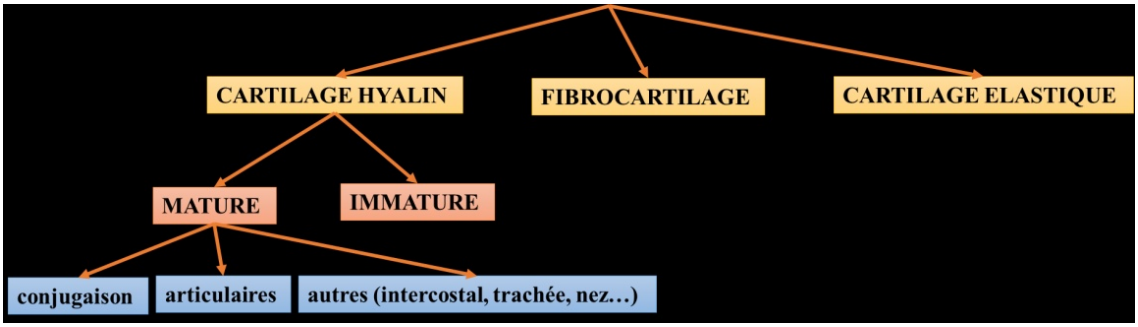
There are several varieties defined by:

→ The quantity of ground substance,

→ The quantity and arrangement of collagen fibers,

→ The absence or presence of elastic fibers.

We distinguish:



Structure of Cartilaginous Tissue

1. Hyaline Cartilage

- Composed of cells, fibers and ground substance in equivalent proportions.

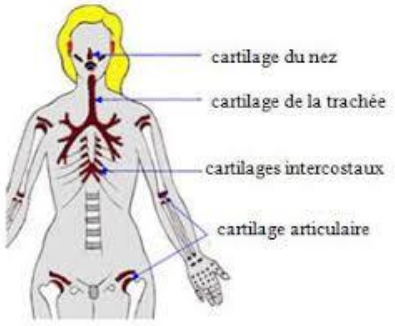
- Revealed by H.E.S. (Hematoxylin-Eosin-Safranin) staining.

- Hyaline cartilage is the most widespread cartilaginous tissue.

- Hyaline (from Greek hyalos = glass); white, pearly, slightly translucent appearance; due to its intercellular substance.

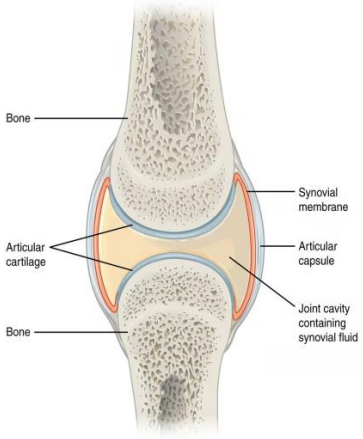
a) Immature Hyaline Cartilage

- Observed at the level of growth cartilages.
- In the embryo and fetus, at the level of the cartilaginous templates of bony elements.
- Its matrix ≠ matrix of mature hyaline cartilage (it contains type IV collagen).



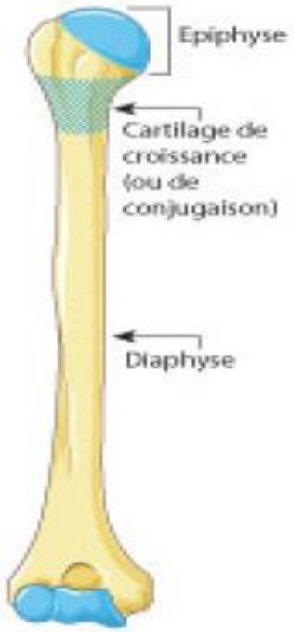
b) Mature Hyaline Cartilage

Type II collagen fibers (elastic fibers are absent).



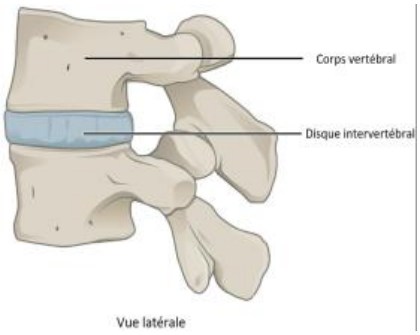
❖ Hyaline Growth Plate Cartilage (Conjugation Cartilage)

- Located at the metaphyses of long bones.
- Role: determines the final stature of the future adult during childhood and adolescence.



❖ Hyaline Articular Cartilage

- Located at mobile joints.
- The articular surface ensures joint mobility.
- The abarticular surface (facing away from the joint) is embedded in bone, with calcification of the adjacent cartilaginous ECM.
- Laterally, the joint is bounded by synovial tissue.
- Nutrition: from synovial fluid, as it lacks a perichondrium.
- Role: together with synovial fluid, it prevents friction between bone surfaces.



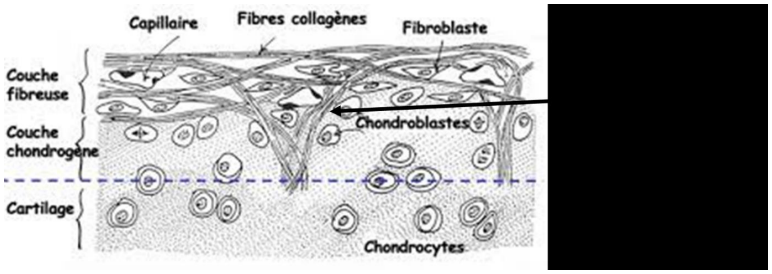
Vue latérale

2. Fibrocartilage

■ Found in locations requiring rigidity and high resistance, such as intervertebral discs, pubic symphysis, knee meniscus, Achilles tendon insertion, etc.

■ Capable of withstanding very high pressures while maintaining a certain flexibility.

■ Thick, oriented bundles of type I collagen, visible by Masson's trichrome staining.



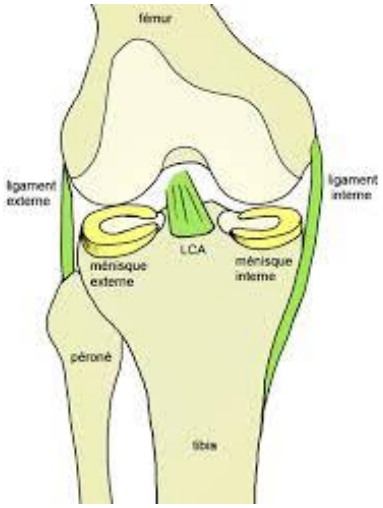
Intervertebral discs | Pubic symphysis | Knee meniscus | Achilles tendon

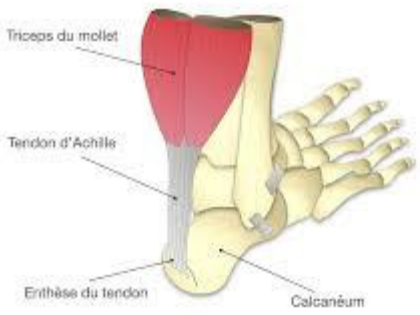
3. Elastic Cartilage

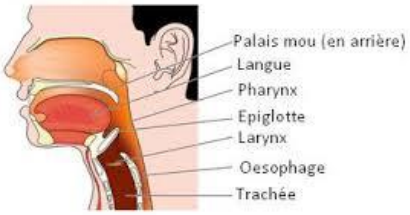
■ A higher cellular density than other types.

■ Presence of elastic fibers (demonstrated by orcein staining) in 3D networks.

■ Located in areas requiring great flexibility: external auditory canal, epiglottis, Eustachian tube and certain cartilages of the larynx.







L'intérieur du nez et de la gorge en vue de profil

Interior of nose and throat (lateral view)

Eustachian Tube

Cartilage Nutrition

■ It is avascular.

■ Nutrition occurs either from blood capillaries (outer layer of the perichondrium), or through synovial fluid for articular cartilages.

■ The large quantity of fluid in the matrix allows diffusion of gases, nutrients and waste products.

■ Matrix calcification leads to blockage of diffusion → death of chondrocytes.

Perichondrium

■ A thin layer of connective tissue covering the surface of cartilage (except articular and growth plate cartilage).

■ **Role:** nutrition, growth and degeneration of cartilage.

■ Composed of two layers:

- **Superficial fibrous layer:** richly vascularized, containing collagen and fibroblasts.
- **Deep chondrogenic layer:** containing Sharpey's fibers, mesenchymal cells and chondroclasts.

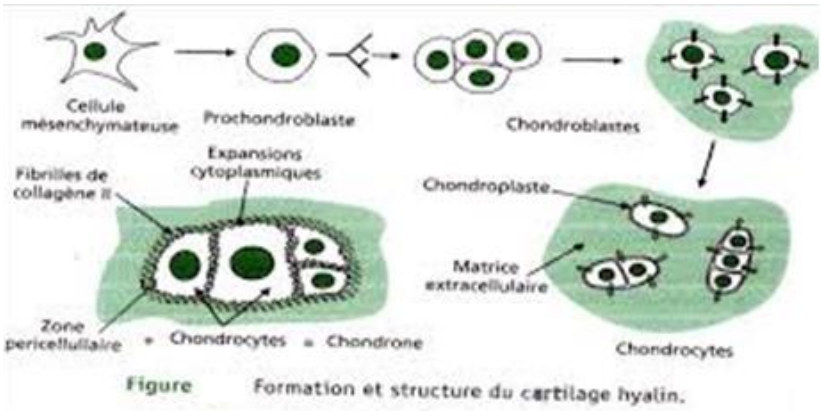


Figure Formation et structure du cartilage hyalin.

Sharpey's fibers = arciform collagen fibers; anchoring points that penetrate into the cartilaginous tissue.

Development of Cartilage (Chondrogenesis)

Chondrogenesis occurs from mesenchymal cells (C) which transform into chondroblasts; the latter synthesize the constituents of the ECM and eventually become enclosed, transforming into chondrocytes.

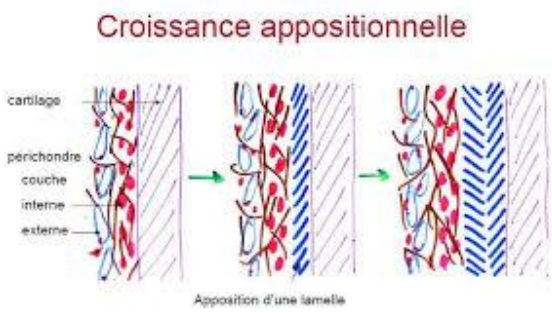


Figure — Formation and structure of hyaline cartilage.

Cartilage Growth

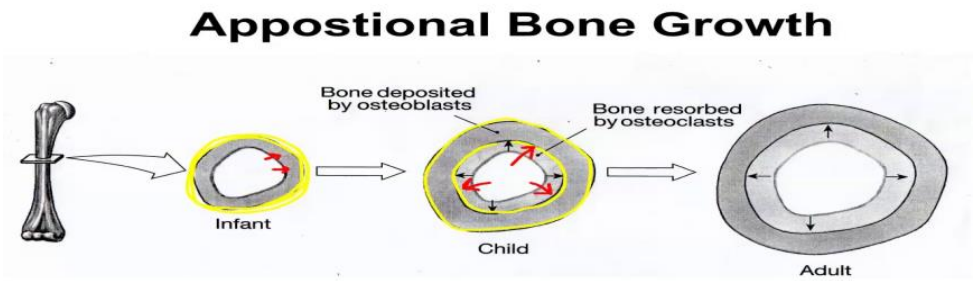
According to a dual modality:

a) Appositional Growth (perichondrium)

It depends on the activity of the inner layer of the perichondrium.

- Cells with stem-cell characteristics proliferate and differentiate into chondroblasts; the latter surround themselves with ground substance and transform into chondrocytes.
- By this mechanism, new layers of cartilage are deposited, increasing cartilage thickness.

Appositional Growth



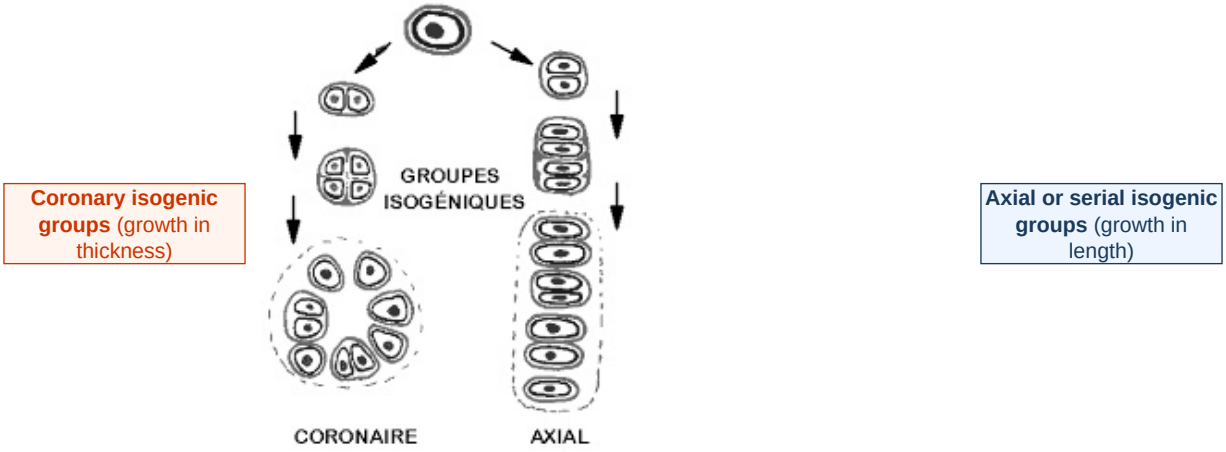
❖ Apposition of peripheral layers resulting from chondrification of the perichondrium starting from the innermost cells (growth in thickness).

b) Interstitial Growth:

It depends on the mitogenic capacity of young cartilage cells and the orientation of the mitotic plane:

- When the plane remains the same from one mitosis to the next, cells arrange in small columns forming: **axial isogenic groups**.
- When the mitotic plane varies, cells arrange in rings forming: **coronary isogenic groups**.

This mode of growth is responsible for elongation (axial isogenic groups) and thickening (coronary isogenic groups) of the cartilage.



❖ Interstitial growth by axial isogenic groups is observed in the fetus and during post-natal bone growth of long bones.

Cartilage Degeneration

Due to either:

➤ **Cellular:** (calcification, lysis).

➤ **Extracellular matrix:** lysis of the ground substance and thickening of collagen fibers, leading to various disorders such as osteoarthritis (degeneration of articular cartilage).