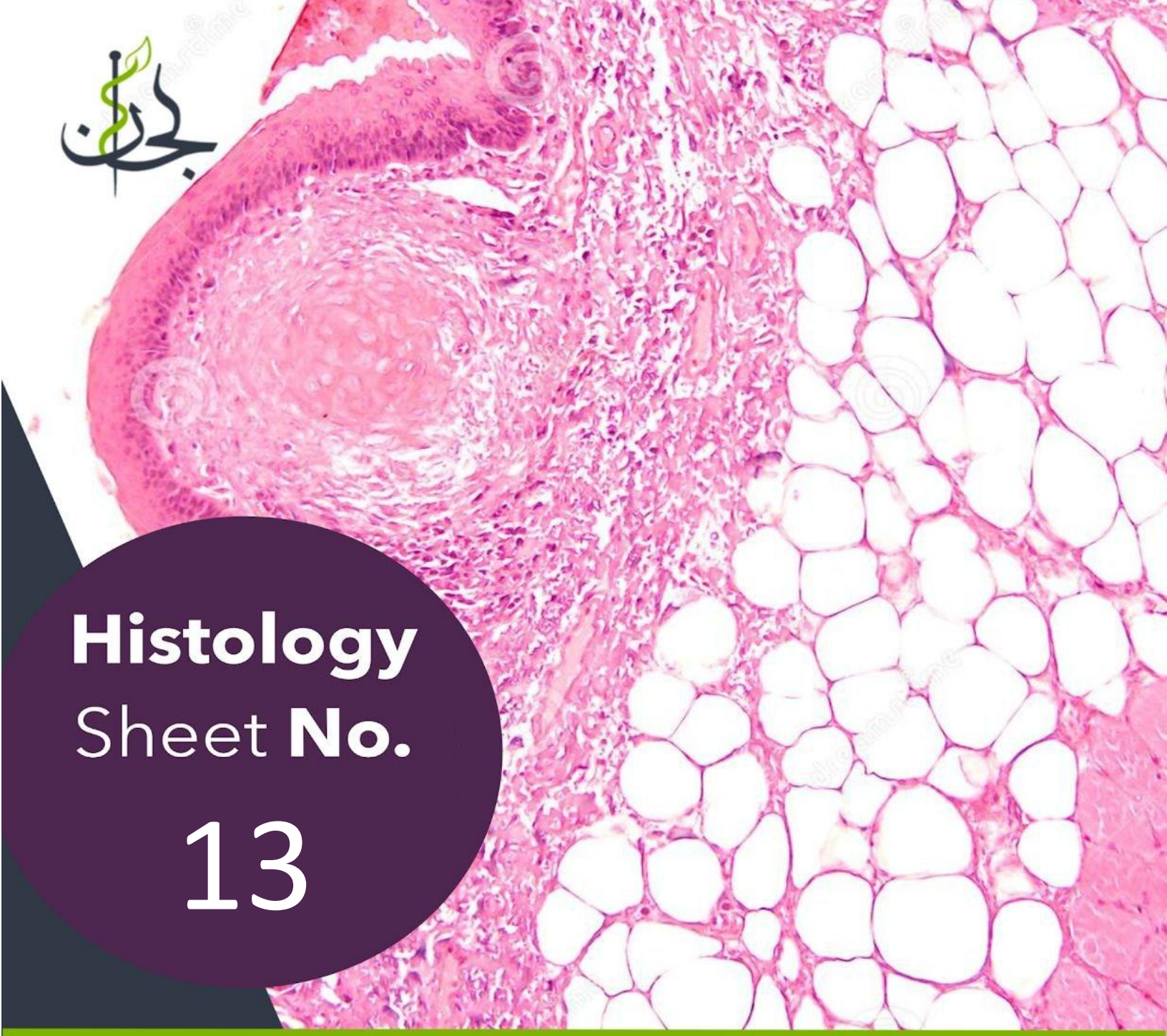


Histology Sheet No. 13

Writer Abdullah Isma’eal

Scientific correction Basil Makhamreh

Grammatical correction Basil Makhamreh

Doctor Dr. Ghadah Abu Elghanam

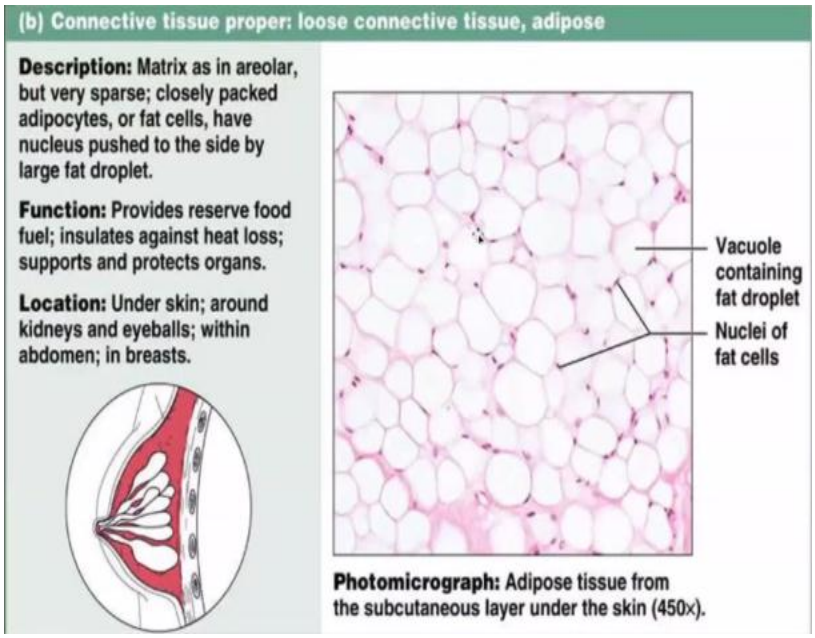
Notes:

Dr. Ghada's speech is in black color.

Additional information is in light blue

Dr. Hanan's speech is in green

General information:

- Specialized C.T: have specific functions to perform
- Types of specialized C.T (adipose, cartilage, blood, bone& lymph)
- Examples of functions of specialized C.T (Bones support and provide the architecture of the whole body)
- 

Women, compared to men, have higher percent body fat and deposit it in a different pattern, with relatively more adipose tissue in the hips and thighs, but men have more in the abdomen region. This 'female' fat distribution, independent of total body fat, confers protection against metabolic diseases, such as type 2 diabetes and atherosclerosis

General information about adipose tissue:

1. Adipose tissue: is connective tissue in which fat-storing cells or adipocytes predominate These large cells are typically found isolated or in small groups within loose or dense irregular connective tissue.

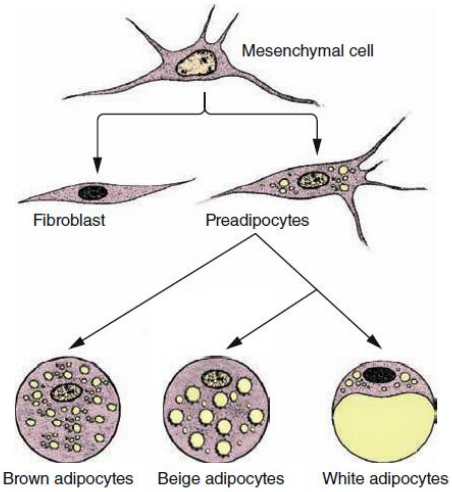
2. adipocytes function as key regulators of the body's overall energy metabolism.

3. triglyceride are stored in it, it has 2 properties: **Insoluble in water** (so it can be concentrated with no adverse osmotic effects), **the caloric density of triglycerides** (is twice that of proteins or carbohydrate).

4. Subcutaneous layers of adipose tissue help shape the body surface, and cushion regions subject to repeated mechanical stress such as the palms, heels, and toe pads.

5. There are two major types of adipose tissue : a)white adipose tissue b)brown adipose tissue

6. it comes from mesenchymal stem cells (Brown adipocytes emerge earlier than white fat during fetal development)



7. Lipids are mobilized from adipocytes by hormone-sensitive lipase activated by norepinephrine released from the adrenal gland and various peptide hormones.

White Adipose Tissue (unilocular):

1. common type specialized for fat storage consists of cells each containing one large cytoplasmic droplet of whitish-yellow fat.

2. adipocytes are spherical when isolated but are polyhedral when closely packed in situ.

3. contains a single huge droplet of lipid filling almost the entire cell, because lipid is removed from cells by xylene or other solvents used in routine histological techniques, unilocular adipocytes are often empty in standard light microscopy.

4. has a signet-ring appearance, with the lipid droplet displacing and flattening the nucleus against the cell membrane. (Also, the majority of organelles are near the peripheral nucleus)

5. Fibroblasts, macrophages and other cells typically comprise about half the total cell number in white adipose tissue. Reticular fibers form a fine interwoven network that supports individual fat cells and binds them together.

6. plays important rule in regulation of metabolic activities (especially that related to hormones like: lipoprotein lipase, Insulin)

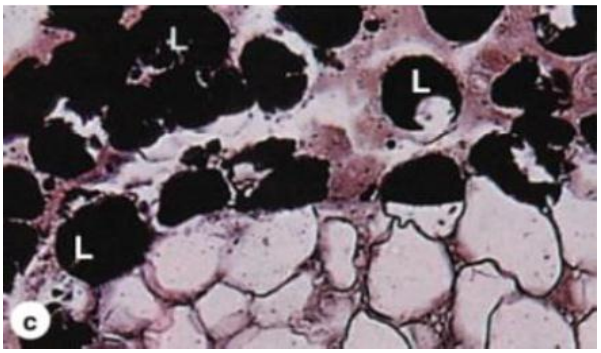
7. adipocytes can store triglycerides derived from three sources:

a) Dietary fats brought to the cells via the circulation as **chylomicrons.**

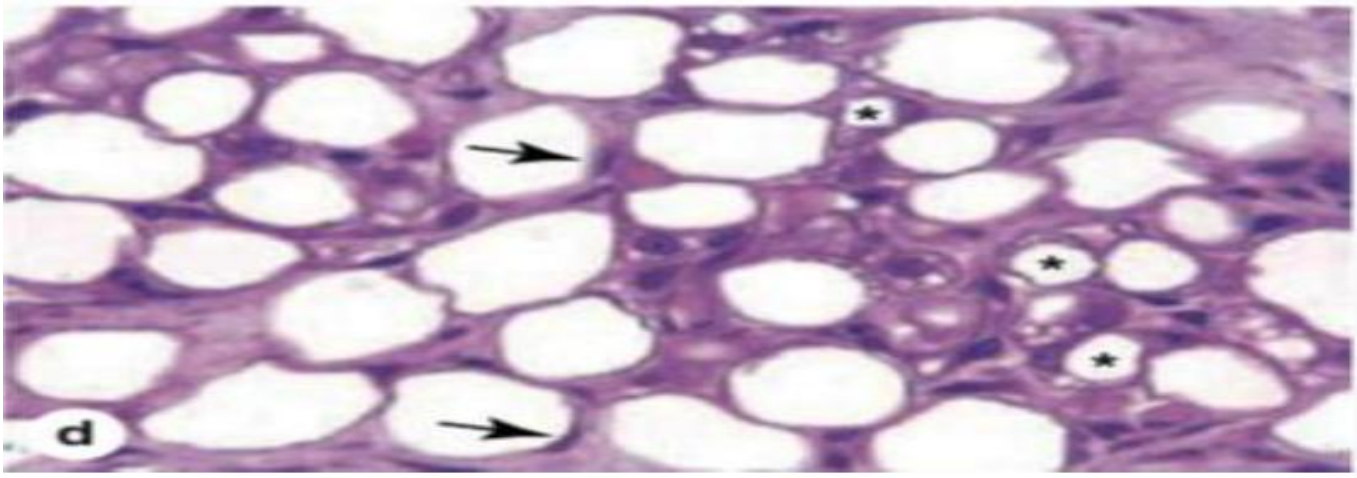
b) Lipids synthesized in the liver and transported in blood in the form of very-low-density lipoproteins **(VLDLs)**

c)Free fatty acids and glycerol synthesized by the adipocytes

8. Tissue was fixed here with **osmium tetroxide**, which preserves lipid (in order to see them)



9.adipocytes have an endocrine function (like synthesizing leptin hormone: Leptin is a protein that's made in the fat cells, circulates in the bloodstream, and goes to the brain. Leptin is the way your fat cells tell your brain that your energy thermostat is set right by inhibiting hunger when its levels are above threshold.)



- (d) In this specimen from a young mammal the smaller adipocytes marked with asterisks are not unilocular, having many lipid droplets of various sizes.
- Such cells in white fat represent those in which differentiation is incomplete as well as a small subpopulation of beige cells with brown fat-forming potential. The eccentric nuclei of the unilocular cells are indicated by arrowheads.

Time is 12:30

Brown Adipose Tissue (multilocular):

1. constitutes 2%-5% of the newborn body weight, located mainly in the back, neck, and shoulders.

2. it reduced with growing up, so in adults it is found only in scattered areas, especially around the kidneys, adrenal glands, aorta, and mediastinum.

3. The color of brown fat is due to : a)the very abundant mitochondria containing **cytochrome pigment** b)the large number of blood capillaries in this tissue

4. this tissue can function as heat producer due to: The small lipid droplets, abundant mitochondria and rich vasculature.

5. Cells of brown fat are polygonal and smaller than white adipocytes, have more centrally located nuclei & are often closely packed around large capillaries, also receive direct sympathetic innervation to regulate their activities. (like stimulating thermogenic activity, promoting brown adipocyte differentiation and prevent apoptosis in mature brown fat cells)

Additional notes:

1. heat production= thermogenesis, to give heat & protect the baby from hypothermia

2. in adults you can find brown fat cells, in low numbers scattered in white adipose tissue, in the lower neck & the area above the collarbone also on the inter scapular region, they increase in number & activity in cold weathers

3. there is more brown fat cells in hibernating animals like bears

Adipose Tissue SUMMARY OF KEY POINTS

- The defining cells of adipose tissue (fat), **adipocytes**, are very large cells derived from mesenchyme and specialized for energy storage in lipid droplet(s) with **triglycerides**.
- Adipocytes store lipids from three sources: from dietary fats packaged as **chylomicrons** in the intestine; from triglycerides produced in the liver and circulating as **very-low-density lipoproteins** (VLDLs); and from fatty acids synthesized locally.
- Lipids are mobilized from adipocytes by **hormone-sensitive lipase** activated by **norepinephrine** released from the adrenal gland and various peptide hormones.
- Cells of adipose tissue are supported by reticular fibers, with connective tissue septa dividing the tissue into lobules of various sizes.
- There are two types of adipose tissue: **white fat** and **brown fat**.

White Adipose Tissue

- **White adipose tissue** is found in many organs throughout the body, typically forming about 20% of the body weight in adults.
- Adipocytes of white fat are typically very **large cells**, ranging in diameter from 50 to 150 µm.
- These cells each contain primarily **one large lipid droplet** (they are **unilocular**), causing the nucleus and remaining cytoplasm to be pushed against the plasmalemma.
- Fatty acids are released from white adipocytes by **lipase** activity when nutrients are needed and carried throughout the body on plasma proteins such as albumin.
- **Leptin** is a polypeptide hormone with target cells in the hypothalamus that is released from white adipocytes and helps regulate eating behavior.

Brown Adipose Tissue

- **Brown fat** comprises up to 5% of the newborn body weight but smaller amounts in adults.
- Adipocytes of this tissue are typically smaller than those of white fat and contain primarily **many small lipid droplets** (they are **multilocular**) in cytoplasm containing many mitochondria and a central nucleus.
- Fatty acids released in adipocytes of brown fat are metabolized in mitochondria of these cells for **thermogenesis** rather than ATP synthesis, using **uncoupling protein-1**.

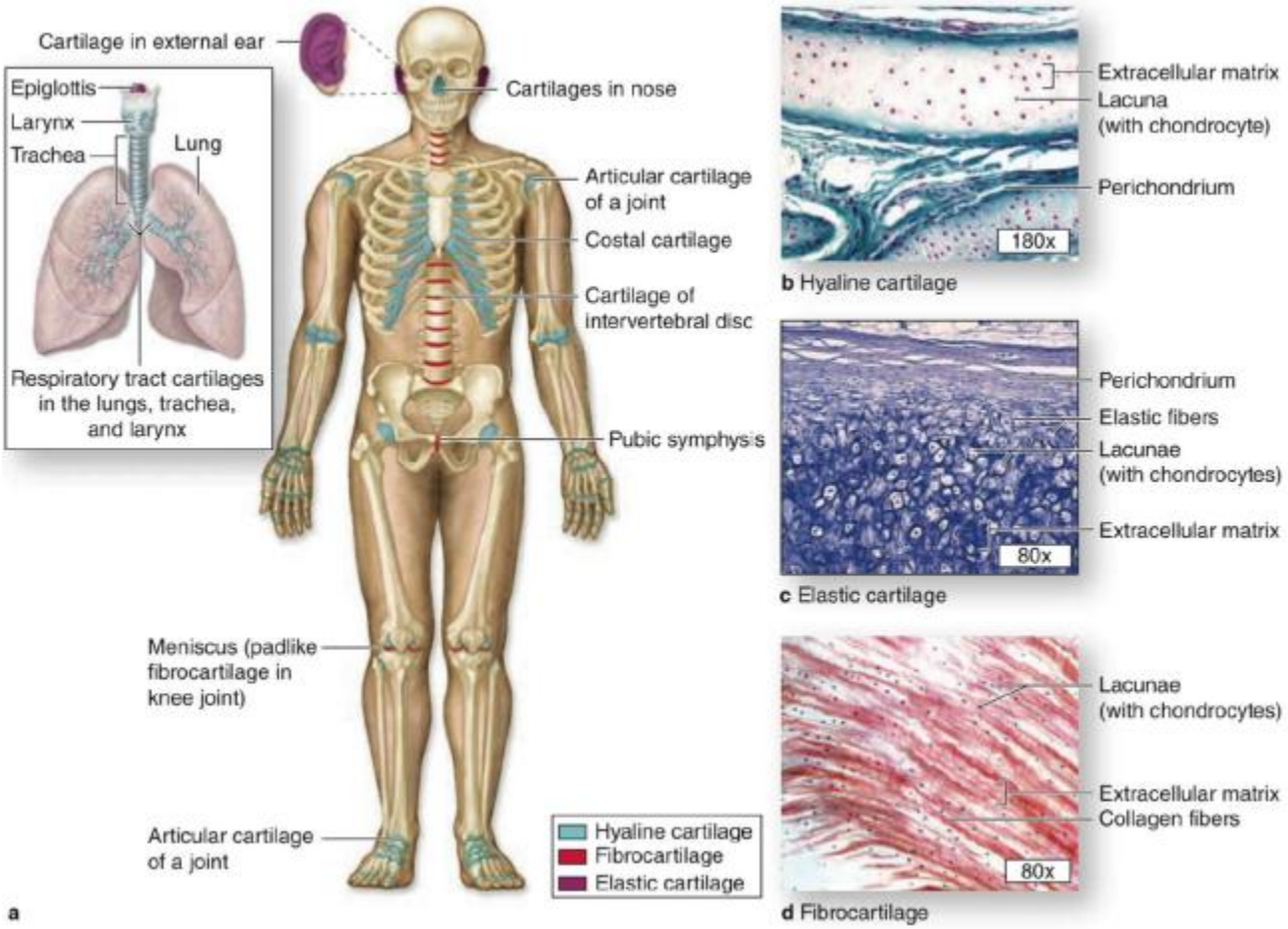
Time is 16:37

CARTILAGE:

General information:

1.Avascular and lack of nerves (nutrient and waste transport happens through perichondrium or neighboring structures)

2. specialized C.T. (tough **matrix= ground substance + fibers**)



3. cartilage types: a) Hyaline (most common) in joints

b) Elastic c) Fibrous

4. it origins from mesenchymal cells which originates from mesoderm.

5. The physical properties of cartilage depend on electrostatic bonds between type II collagen fibrils, hyaluronan and the sulfated GAGs on densely packed proteoglycans.

6. water bound to the negatively charged hyaluronan and GAG chains extending from proteoglycan core proteins (allows cartilage to serve as a shock absorber)

Hyaline cartilage:

1. the most common of the three types, is homogeneous and semitransparent in the fresh state

2. In adults hyaline cartilage is located in the: **a)** articular surfaces of movable joints

b) in the walls of larger respiratory passages (nose, larynx, trachea, bronchi), in order to keep permanent passage way for air.

c) in the ventral ends of ribs, where they articulate with the sternum

d) in the epiphyseal plates of long bones, where it makes possible longitudinal bone growth

3. In the embryo, hyaline cartilage forms the temporary skeleton that is gradually replaced by bone, except the articular surfaces like joints they're still cartilage.

Elastic cartilage:

1. similar to hyaline cartilage except that it contains an abundant network of elastic fibers in addition to a meshwork of collagen type II fibrils, which give fresh elastic cartilage a yellowish color (hyaline cartilage is susceptible to partial or isolated regions of calcification during aging, but elastic cartilage doesn't & **this is the most important difference**)

2. More flexible than hyaline cartilage, elastic cartilage is 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.

3. cartilage in these locations includes a perichondrium.

Fibrous cartilage:

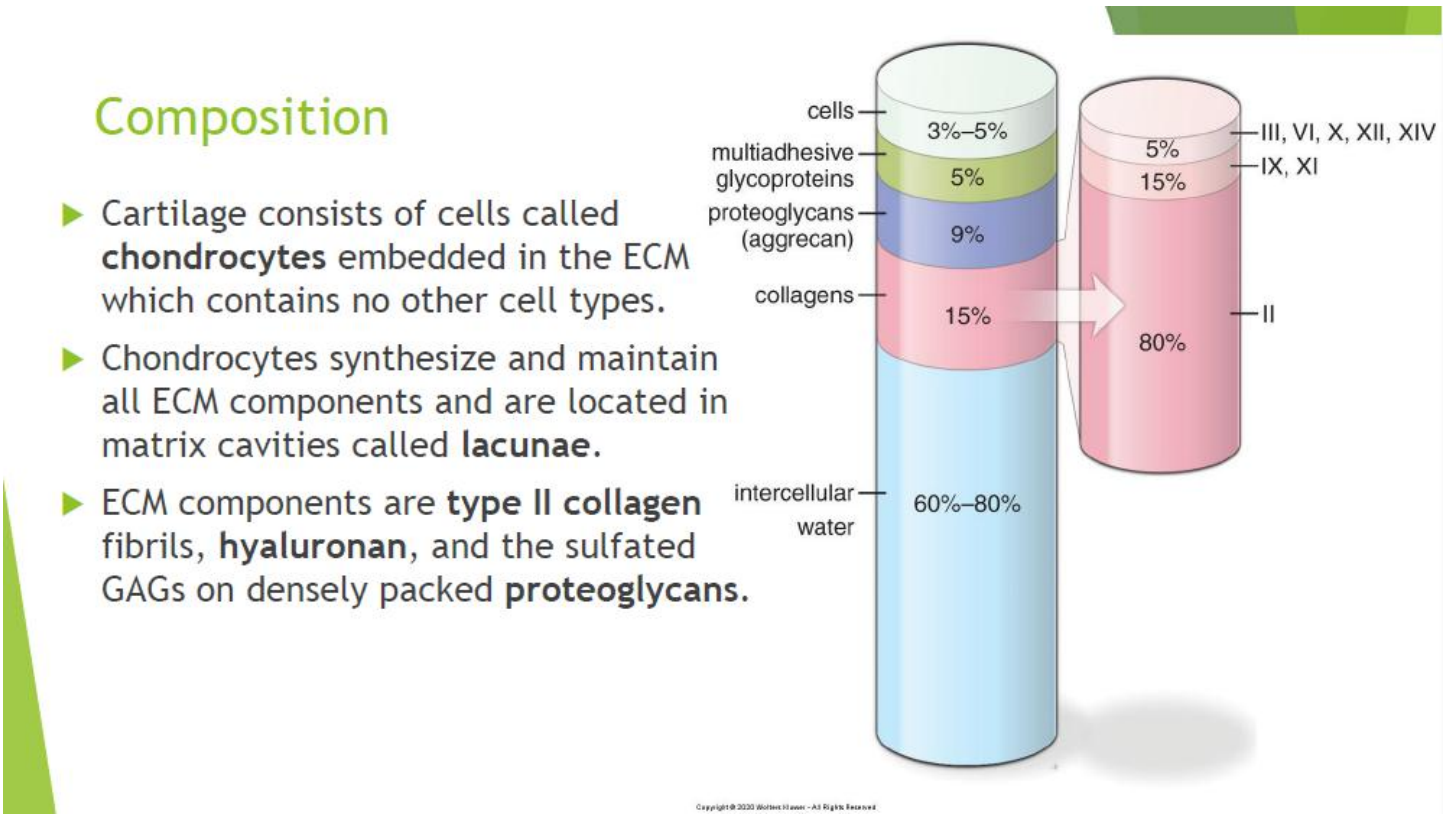
1. essentially a mixture of hyaline cartilage and dense connective tissue

2. Areas with chondrocytes and hyaline matrix are separated by other regions with fibroblasts and dense bundles of type I collagen which confer extra tensile strength to this tissue.

3. The relative scarcity of proteoglycans overall makes fibrocartilage matrix more acidophilic than that of hyaline or elastic cartilage. There is no distinct surrounding perichondrium in fibrocartilage.

4. It is found in intervertebral discs, in attachments of certain ligaments, and in the pubic symphysis—all places where it serves as very tough, yet cushioning support tissue for bone, in the knee joint (**fibrocartilage** (meniscus) gives stability & cushioning + **hyaline cartilage**).

5. this type is very special and is composed of (dense C.T. “fibroblasts & collagen I” + cartilage “collagen II”.

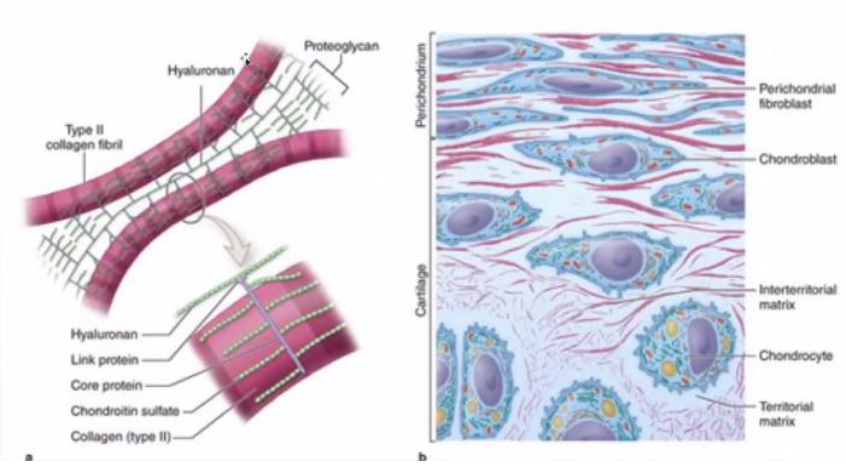


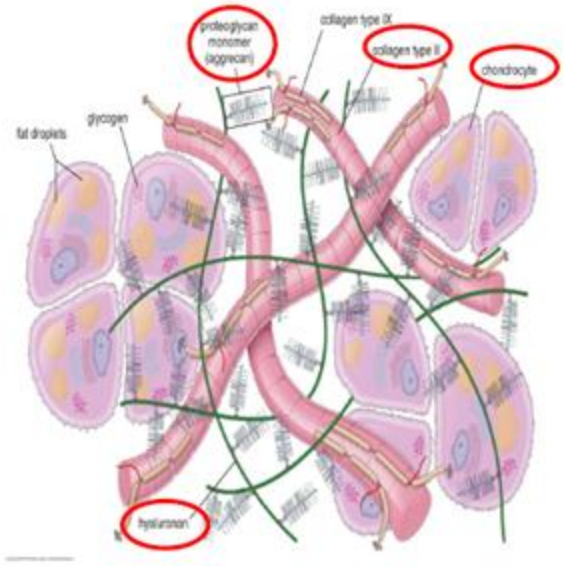
The chondroblasts are able to convert to chondrocytes when we need.

Perichondrium:

General information:

1. sheath of dense connective tissue that surrounds cartilage in most places (harbors the blood supply serving the cartilage and a small neural component)
2. Except in the articular cartilage of joints, all hyaline cartilage is covered by it.
3. The outer region of the perichondrium consists largely of collagen type I fibers and fibroblasts. The inner layer adjoining the cartilage matrix also contains mesenchymal stem cells which provide a source for new chondroblasts that divide and differentiate into chondrocytes.
4. chondroblasts are present between perichondrium & cartilage, they make matrix and grow to become chondrocytes.





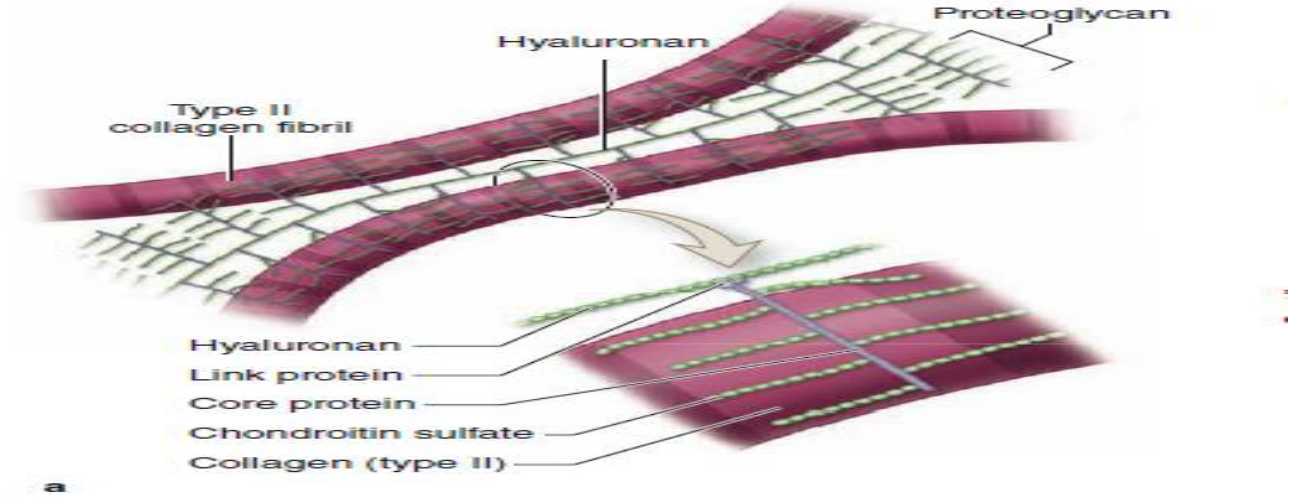
The ECM: (especially in hyaline cartilage)

1. The dry weight of hyaline cartilage is nearly 40% collagen embedded in a firm, hydrated gel of proteoglycans and structural glycoproteins. Most of the collagen in hyaline cartilage is type II.
2. **Aggrecan** (cartilage-specific proteoglycan core protein) with approximately 150 GAG side chains of chondroitin sulfate and keratan sulfate, is the most abundant proteoglycan of hyaline cartilage.
3. **Chondronectin**: important component of cartilage matrix is the structural multi-adhesive glycoprotein. (Like fibronectin in other connective tissues)

2.The matrix divide into:

a) The territorial matrix: (closer to the lacunae) relatively richer in proteoglycans& GAGs than collagen, which make it more basophilic.

b) The interterritorial matrix: (far from lacunae) richer in collagen & proteins which make it less basophilic.



(a) A schematic representation of the most abundant molecules in cartilage matrix shows the interaction between type II collagen fibrils and proteoglycans linked to hyaluronan. Link proteins noncovalently bind the protein core of proteoglycans to the linear hyaluronan molecules. The chondroitin sulfate side chains of the proteoglycan electrostatically bind to the collagen fibrils, forming a cross-linked matrix. The circled area is shown larger in the lower part of the figure. Physical properties of these matrix components produce a highly hydrated, pliable material with great strength. Approximately 75% of the wet weight of hyaline cartilage is water.

Required

TABLE 7–1 Important features of the major cartilage types.

	Hyaline Cartilage	Elastic Cartilage	Fibrocartilage
Main features of the extracellular matrix	Homogeneous, with type II collagen and aggrecan	Type II collagen, aggrecan, and darker elastic fibers	Type II collagen and large areas of dense connective tissue with type I collagen
Major cells	Chondrocytes, chondroblasts	Chondrocytes, chondroblasts	Chondrocytes, fibroblasts
Typical arrangement of chondrocytes	Isolated or in small isogenous groups	Usually in small isogenous groups	Isolated or in isogenous groups arranged axially
Presence of perichondrium	Yes (except at epiphyses and articular cartilage)	Yes	No
Main locations or examples	Many components of upper respiratory tract; articular ends and epiphyseal plates of long bones; fetal skeleton	External ear, external acoustic meatus, auditory tube; epiglottis and certain other laryngeal cartilages	Intervertebral discs, pubic symphysis, meniscus, and certain other joints; insertions of tendons
Main functions	Provides smooth, low-friction surfaces in joints; structural support for respiratory tract	Provides flexible shape and support of soft tissues	Provides cushioning, tensile strength, and resistance to tearing and compression

Some notes:

1. fibrocartilage has fibroblasts in order to secrete collagen I

2. Deeper in the cartilage, chondrocytes may appear in groups of up to eight cells that originate from mitotic divisions of a single chondroblast and are called isogenous aggregates.

3. hyaline has much more nests (in the form of group 2,4,8), elastic has some (groups of 1,2 or 4), fibrous has some in groups of 2 or 4, but not as fashion as cartilage.

4. if we have perichondrium then it differentiates &becomes chondroblast

Time is 40:00

Some notes on chondrocytes:

1. Cells occupy relatively little of the hyaline cartilage mass.

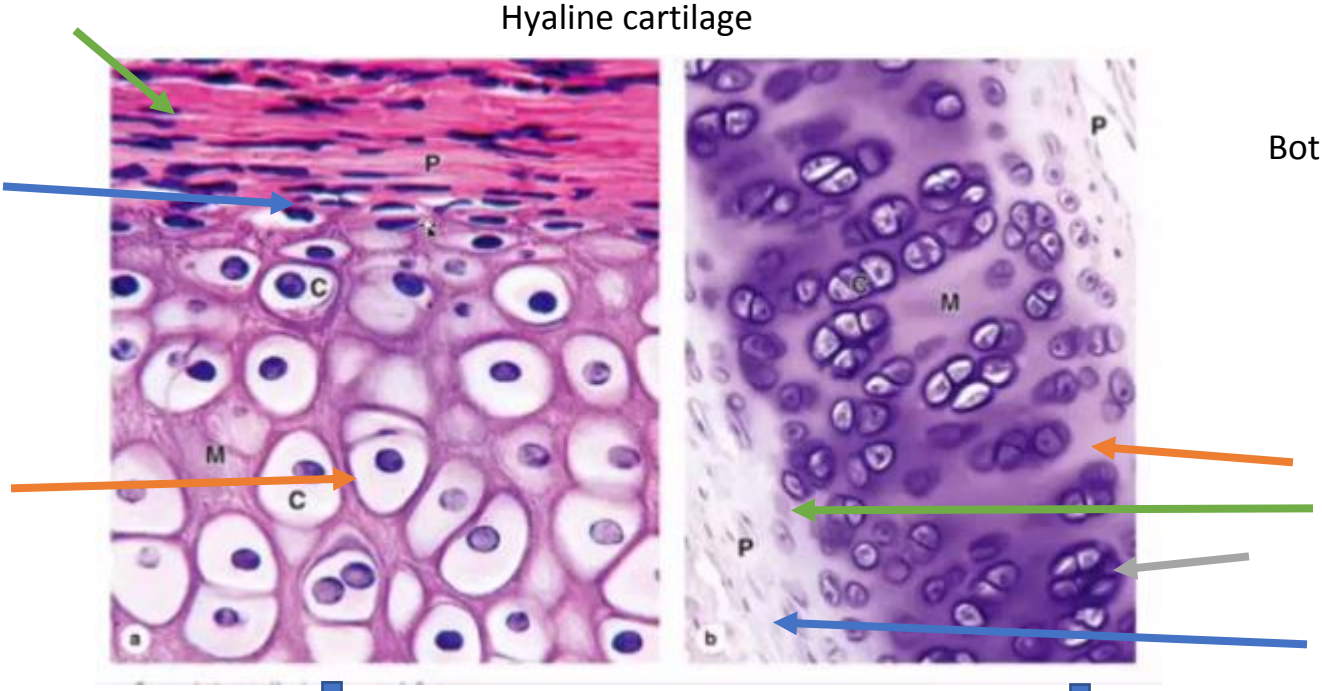
2. **Chondroblasts**: At the periphery of the cartilage have an elliptic shape, with the long axes parallel to the surface. (Deeper in the cartilage, they are round and may appear in groups of up to eight cells that originate from mitotic divisions of a single chondroblast called **isogenous aggregates**)

3. chondrocytes: more active in secreting collagens and other ECM components, respire under low-oxygen tension, so they metabolize glucose mainly by anaerobic glycolysis.

4. Cartilage cells and matrix may shrink slightly during routine histologic preparation, resulting in both the irregular shape of the chondrocytes and their retraction from the matrix.

5. Chondrocyte synthesis of sulfated GAGs and secretion of proteoglycans are accelerated by many hormones and growth factors (like: **somatotropin** which acts indirectly, promoting the endocrine release from the liver of insulin-like growth factors, or somatomedins which directly stimulate the cells of hyaline cartilage), from the book

Hyaline cartilage



Both stained with H&E

Highly magnified picture

(we have applied eosin stain for long time in this section)

Orange arrow→ chondrocytes

Blue arrow→ chondroblasts

Green arrow→ fibroblast, collagen I & mesenchymal cells.

Orange arrow→ structure of the hyaline (more basophilic)

Blue arrow→ perichondrium

(less basophilic)

The cells with flattened nucleus are fibroblasts

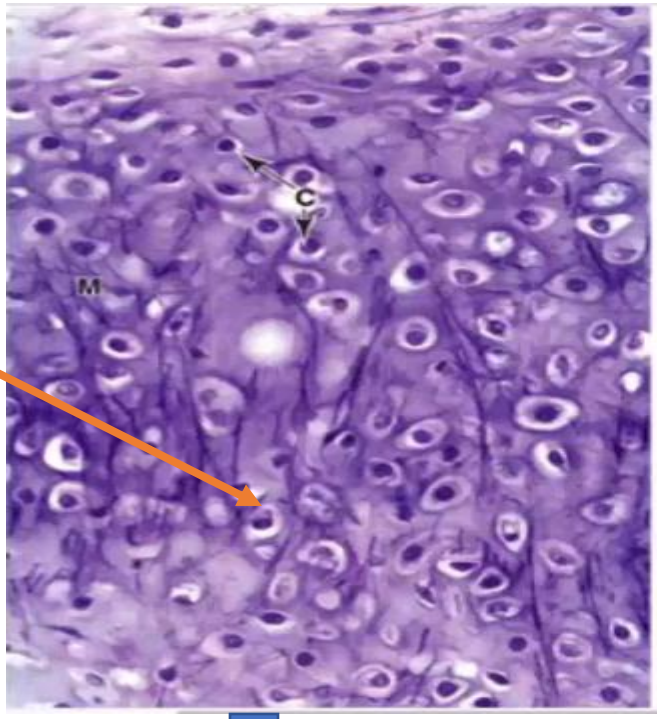
Grey arrow→ nest (isogenous)

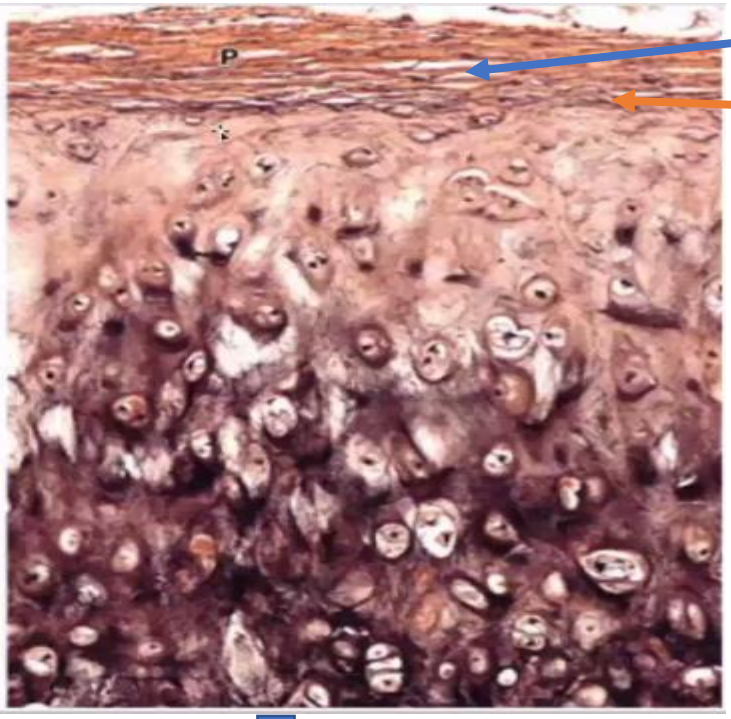
Around it The territorial matrix (a lot sulfated GAGs which make it more basophilic)

Far from it The interterritorial matrix which is less basophilic.

Green arrow→ chondroblast (bigger than fibroblast)

Elastic cartilage





Hematoxylin and Orcein stain

The high intensity of basophilic stuff covers the brownish color, but we can still able to distinguish elastic fibers

Orange arrow⟶ chondrocytes

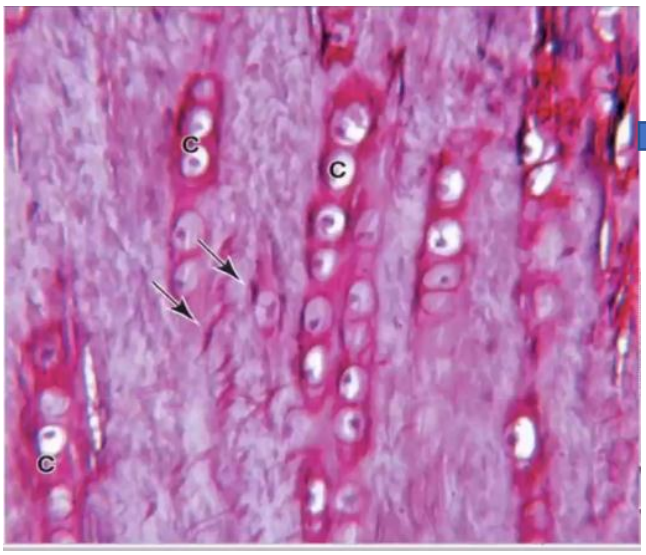
There are not many isogenous groups

Resorcin and Verhoeff (van Gieson)

Elastic fibers are well scattered

Blue arrow⟶ perichondrium & collagen I

Orange arrow⟶ chondroblasts



Fibrocartilage

hematoxylin and picrosirius (usually for collagen)

the chondrocytes are in groups of 2,4

Orange arrow⟶ dense C.T & collagen I

Black arrows⟶ fibroblasts

Chondrogenesis:

1. 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.

2. “chondroblasts” and “chondrocytes” respectively refer to the cartilage cells during and after the period of rapid proliferation.

3. 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)

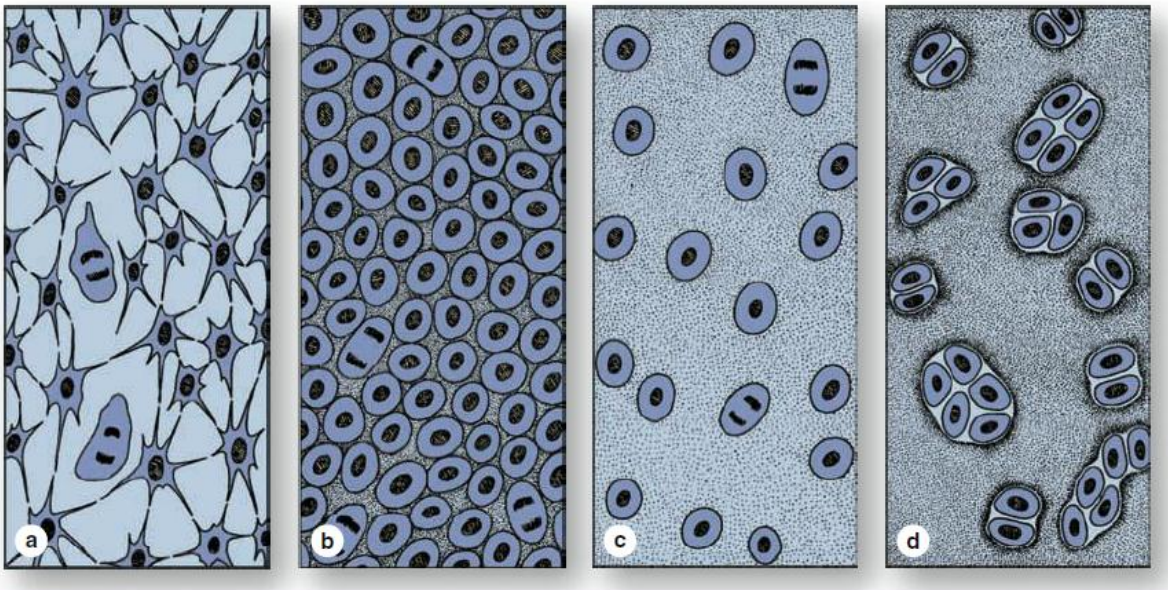
4. **interstitial growth**: involving mitotic division of preexisting chondrocytes

appositional growth: which involves chondroblast differentiation from progenitor cells in the perichondrium (more important during postnatal development)

Note: In both cases, the synthesis of matrix contributes greatly to the growth of the cartilage.

5. in young children, damaged cartilage undergoes slow and often incomplete repair

(generally, the poor capacity of cartilage for repair or regeneration is due in part to its avascularity and low metabolic rate)



The major stages of embryonic cartilage formation, or chondrogenesis, are shown here.

(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.

المصادر التي تم اعتمادها في كتابة هذا الشيت هي المحاضرة والكتاب وسلايدات الدكتورة غادة.

Cartilage SUMMARY OF KEY POINTS

- Cartilage is a **tough, resilient** type of connective tissue that structurally supports certain soft tissues, notably in the respiratory tract, and provides cushioned, low-friction surfaces in joints.
- Cells of cartilage, **chondrocytes**, make up a small percentage of the tissue's mass, which is mainly a flexible mass of **extracellular matrix** (ECM).
- Chondrocytes are embedded within **lacunae** surrounded by the ECM.
- Cartilage ECM typically includes **collagen** as well as abundant **proteoglycans**, notably **aggrecan**, which bind a large amount of **water**.
- Cartilage always **lacks blood vessels**, lymphatics, and nerves, but it is usually surrounded by a dense connective tissue **perichondrium** that is vascularized.
- There are three major forms of cartilage: (1) **hyaline cartilage**, (2) **elastic cartilage**, and (3) **fibrocartilage**.

Hyaline Cartilage

- The ECM of hyaline cartilage is **homogenous and glassy**, rich in fibrils of type II collagen and aggrecan complexes with bound water.
- The ECM has less collagen and more proteoglycan immediately around the lacunae, producing slight staining differences in this **territorial matrix**.
- Chondrocytes occur **singly** or in small, mitotically derived **isogenous groups**.
- **Perichondrium** is usually present, but not at the hyaline cartilage of articular surfaces or the epiphyses of growing long bones.

Elastic Cartilage

- Elastic cartilage generally resembles hyaline cartilage in its chondrocytes and major ECM components, but its matrix includes **abundant elastic fibers**, visible with special stains, which increase the tissue's **flexibility**.
- Elastic cartilage provides flexible support for the external ear as well as certain structures of the middle ear and larynx; it is always surrounded by **perichondrium**.

Fibrocartilage

- Fibrocartilage contains varying **combinations of hyaline cartilage** in small amounts of **dense connective tissue**.
- Histologically it consists of small **chondrocytes** in a hyaline matrix, usually layered with larger areas of bundled **type I collagen** with scattered **fibroblasts**.
- Fibrocartilage provides very **tough, strong support** at tendon insertions and in **intervertebral discs** and certain other joints.

Cartilage Formation, Growth, & Repair

- All forms of cartilage form from embryonic **mesenchyme**.
- Cartilaginous structures grow by mitosis of existing chondroblasts in lacunae (**interstitial growth**) or formation of new chondroblasts peripherally from progenitor cells in the perichondrium (**appositional growth**).
- Repair or replacement of injured cartilage is very slow and ineffective, due in part to the tissue's **avascularity** and **low metabolic rate**.

تم بحمد الله

دعواتكم لنا بظهر الغيب

وشكر خاص لفريق السلايدات المعدلة رقم ١٣ لإتقانهم في العمل وشمولية الصنع.