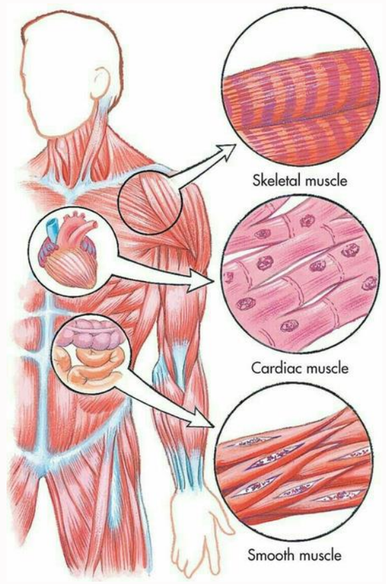
بسم الله الرحمن الرحيم

Histology - Lecture 10

Connective tissue pt.2



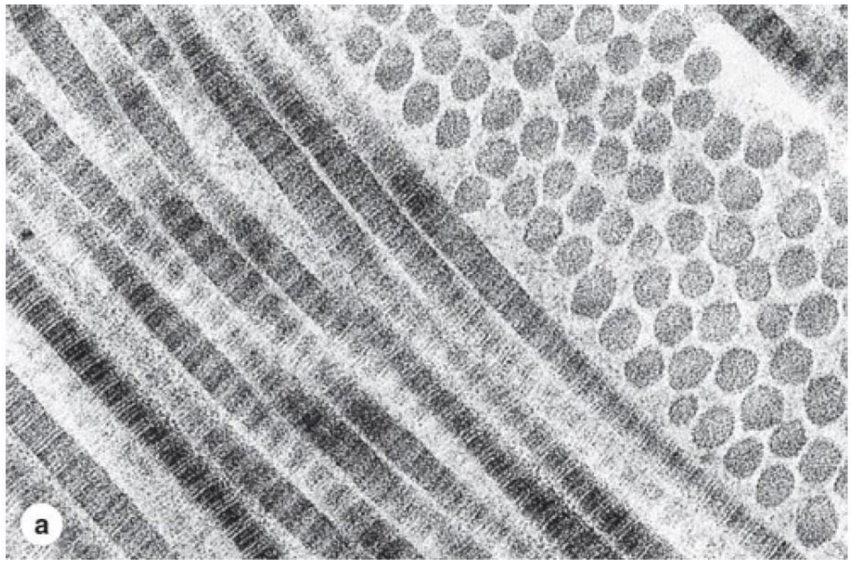
Written by : Nadeen Al-rawajfeh

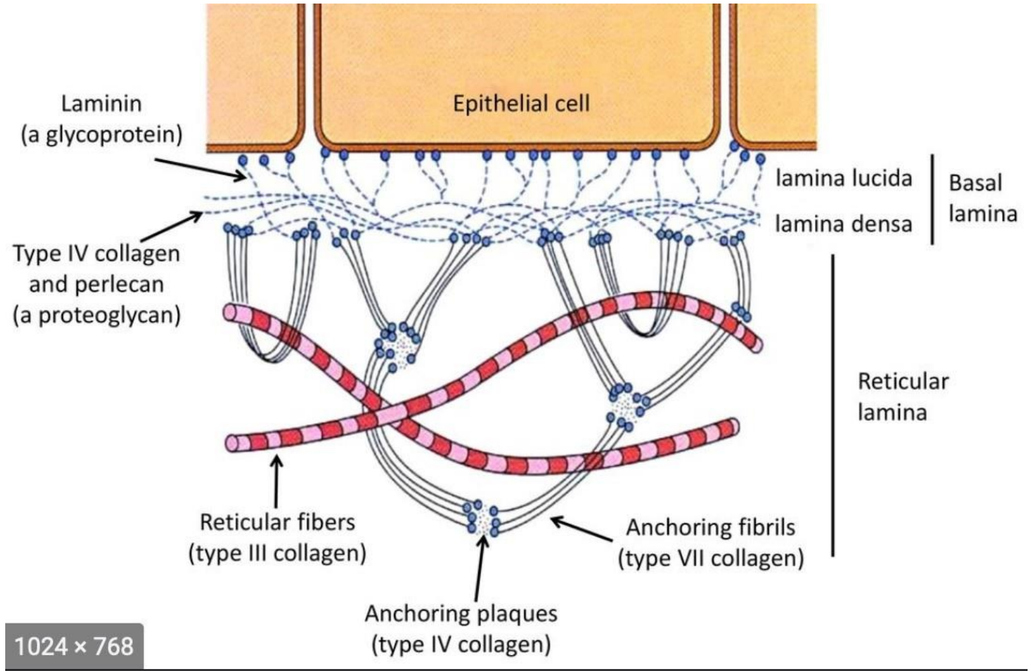
Connective Tissue Fibers/Collagen

- Form various extracellular fibers, sheets, and networks.
- Extremely strong and resistant to normal shearing and tearing forces.
- Collagen is a key element of all connective tissues, as well as epithelial basement membranes and the external laminae of muscle and nerve cells.
- Most abundant protein in the human body, representing 30% of its dry weight.
- A family of 28 collagens exists in vertebrates.

Collagen types

- **Fibrillar collagens**, notably collagen types I, II, and III. Form structures such as tendons, organ capsules, and dermis.
- **Network or sheet-forming collagens** such as type IV collagen have subunits produced by epithelial cells and are major structural of external laminae and all epithelial basal laminae.
- **Linking/anchoring** collagens are short.





- **Collagen represents about 30% of the body's dry weight and is considered very strong.**
- **There are 28 types of collagen, divided into three families, each with different characteristics.**
- **Collagen provides strength and elasticity, making it suitable for the ligaments that connect bones.**

Collagen Assembly

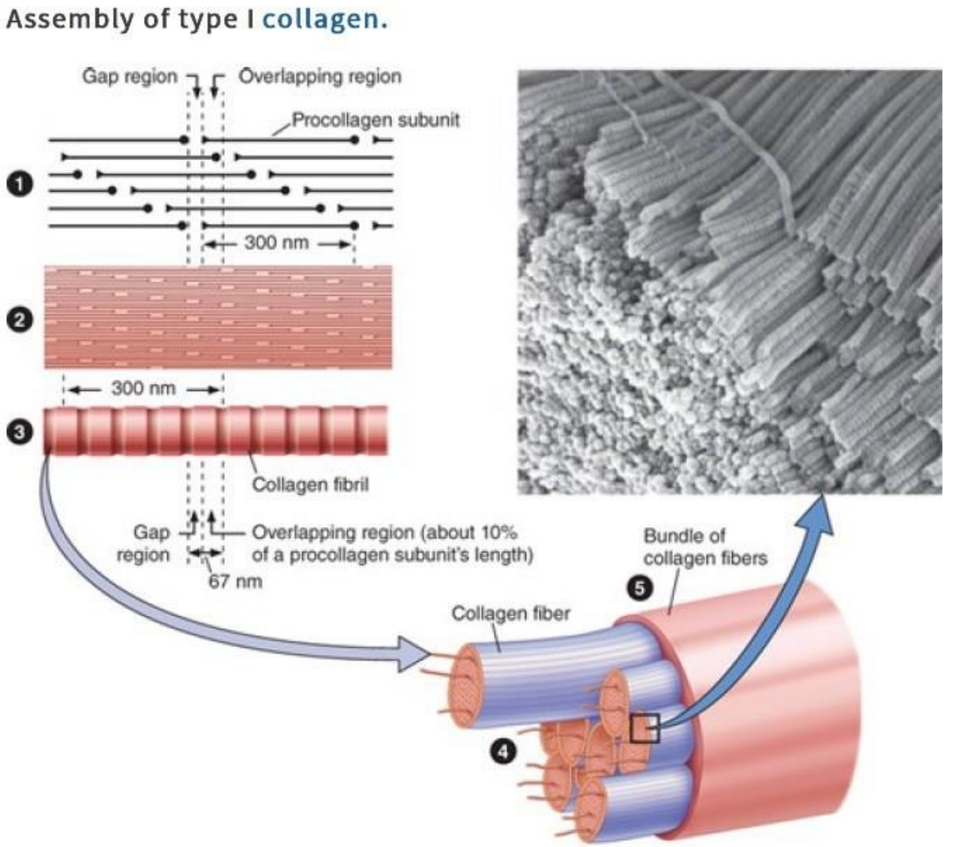
1. Rodlike triple-helix collagen molecules, each 300-nm long, self-assemble in a highly organized, lengthwise arrangement of overlapping regions.

2. The regular, overlapping arrangement of subunits continues as large collagen fibrils are assembled.

3. This structure causes fibrils to have characteristic cross striations with alternating dark and light bands when observed in the EM.

4. Fibrils assemble further and are linked together in larger collagen fibers visible by light microscopy.

5. Type I fibers often form into still larger aggregates bundled and linked together by other collagens.

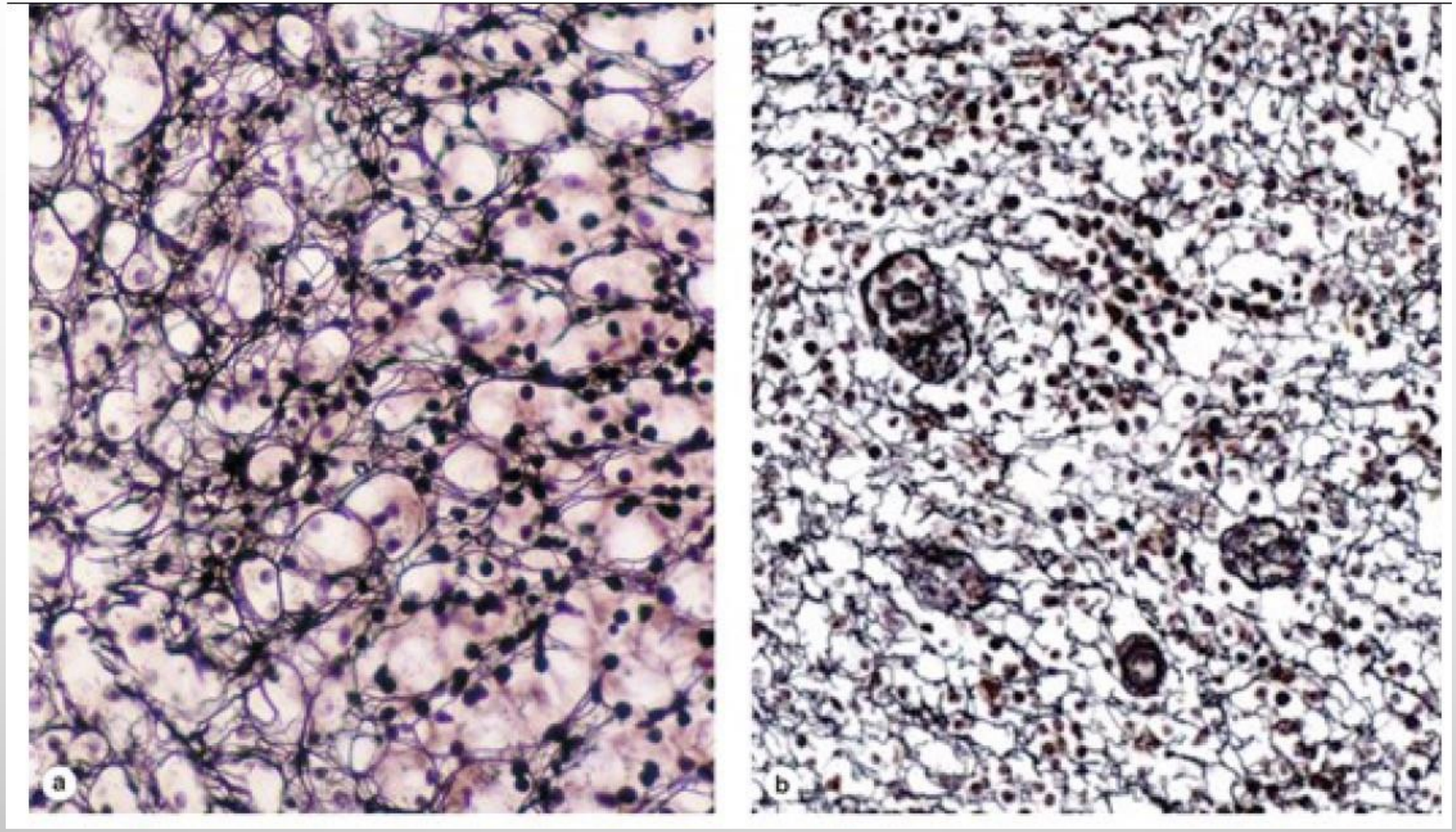


Connective Tissue Fibers/Reticular

- Found in delicate connective tissue of many organs, notably in the immune system.
- Consist mainly of collagen type III, which forms an extensive network.
- Seldom visible in hematoxylin and eosin (H&E) but are stained black after impregnation with **silver** salts.
- Periodic Acid-Schiff (PAS) positive-----due to the high content of sugar chains.
- Reticular fibers contain up to 10% carbohydrate as opposed to 1% in most other collagen fibers.
- Produced by fibroblasts.
- Surround adipocytes, smooth muscle and nerve fibers, and small blood vessels.
- Serve as the supportive stroma for the parenchymal secretory cells, liver and endocrine glands.
- Stroma of hemopoietic tissue (bone marrow), the spleen, and lymph nodes

RETICULAR FIBERS

Lymph nodes- silver stain

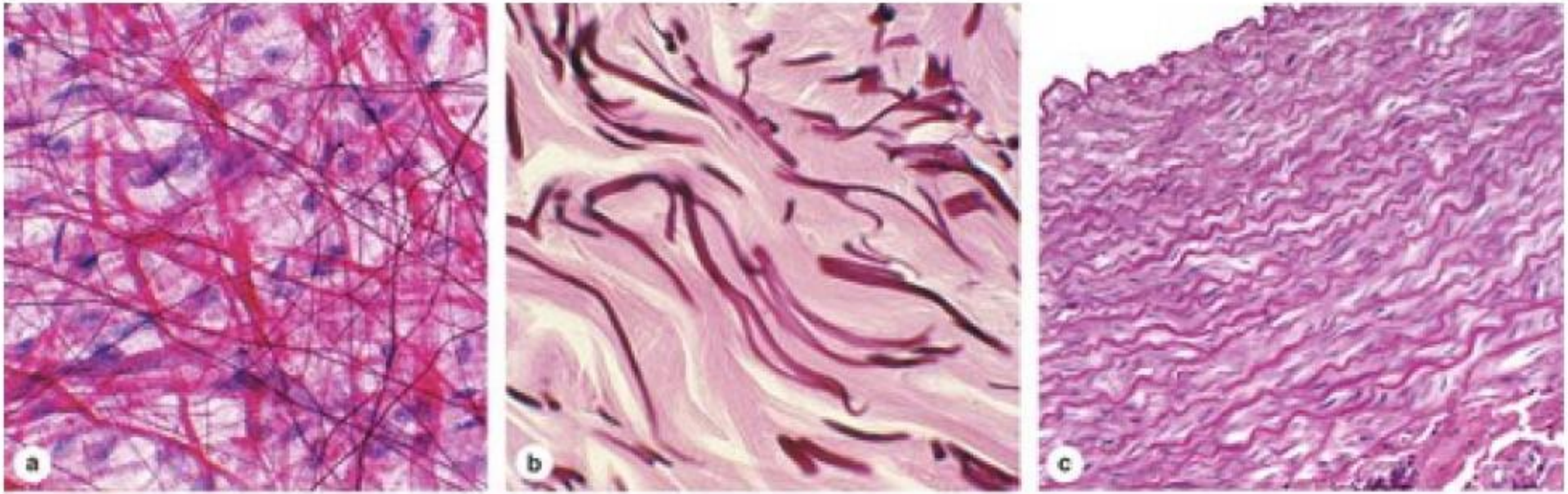


Reticular fibers are a type of connective tissue fiber that are thin and provide a supportive framework for various organs, particularly in lymphoid tissues like the spleen and lymph nodes. Silver staining makes these reticular fibers appear black or dark brown against a light background

Connective Tissue Fibers/Elastic

- Thinner than the type I collagen fibers and form sparse networks interspersed with collagen bundles in many organs (subject to regular stretching or bending).
- Have rubberlike properties that allow tissue containing to be stretched or distended (lungs).
- In the wall of large blood vessels, especially arteries, elastin also occurs as fenestrated sheets called **elastic lamellae**.
- Elastic fibers and lamellae are not strongly acidophilic and stain poorly with H&E.
- Stained more darkly than collagen with other stains such as orcein and aldehyde fuchsin.

Connective Tissue Fibers/Elastic



A- Hematoxylin and orcein)
B-Aldehyde fuchsin)
C- H&E

The image shows three types of elastic connective tissue, each stained with a different dye:

A - Hematoxylin and orcein: This stain shows elastic fibers in dark brown or black, while other tissue components appear in various colors depending on the hematoxylin stain.

B - Aldehyde fuchsin: This stain shows elastic fibers in dark purple or black.

C - Hematoxylin and eosin (H&E): This common stain shows elastic fibers in dark pink or relatively indistinct compared to the other stains, while the nucleus appears blue or purple and other tissue components in various colors.

Additional Notes:

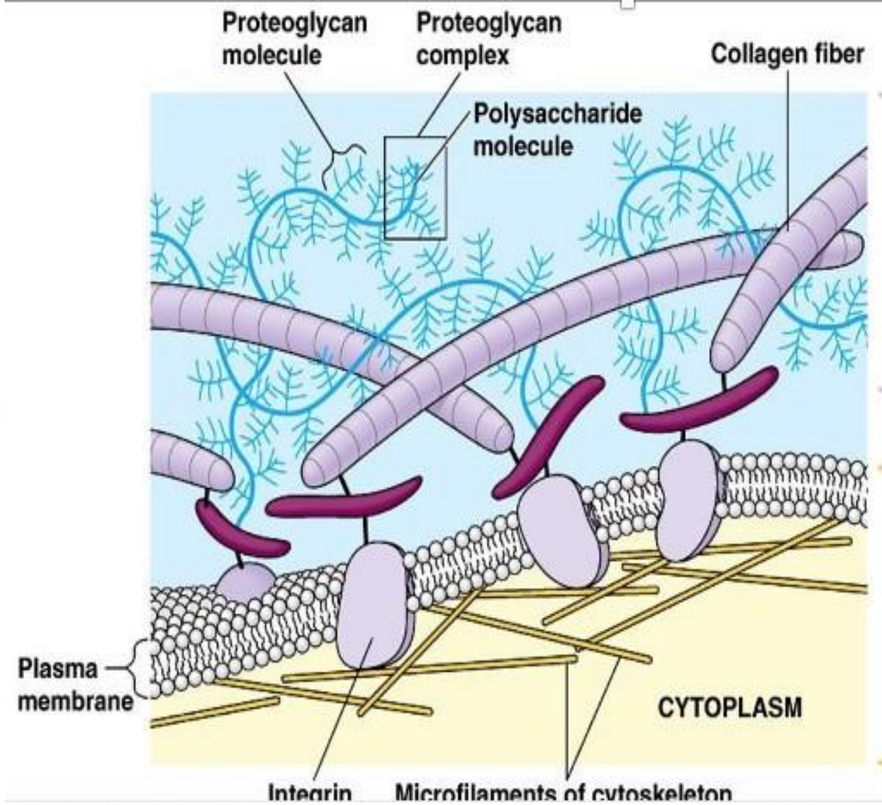
Elastic fibers are a type of connective tissue fiber that provides tissues with elasticity and the ability to stretch and return to their original shape.

Elastic fibers are found in many tissues, such as the walls of blood vessels, lungs, and skin.

Different stains are used to better visualize elastic fibers, with each stain highlighting the fibers in a different color and emphasizing them differently.

Ground Substance

- A semi- fluid gel (highly hydrated) and transparent material
- The ground substance of the ECM is a highly hydrated (with much bound water), transparent, complex mixture of three major kinds of macromolecules: glycosaminoglycans (GAGs), proteoglycans, and multiadhesive glycoproteins. Laminin and fibronectin
- Filling the space between cells and fibers in connective tissue.
- Allows diffusion of small molecules.
- Because it is viscous---lubricant and a barrier to the penetration of invaders.



Electron microscope images show how network fibers are assembled from smaller subunits.

- Collagen fibers are composed of procollagen units and gather in larger collagen structures.
- Network fibers are a type of collagen found in thin organs, such as the endocrine and pancreatic glands.
- They are difficult to visualize with ordinary stains and require special silver salts to be seen under a microscope.

GAGs

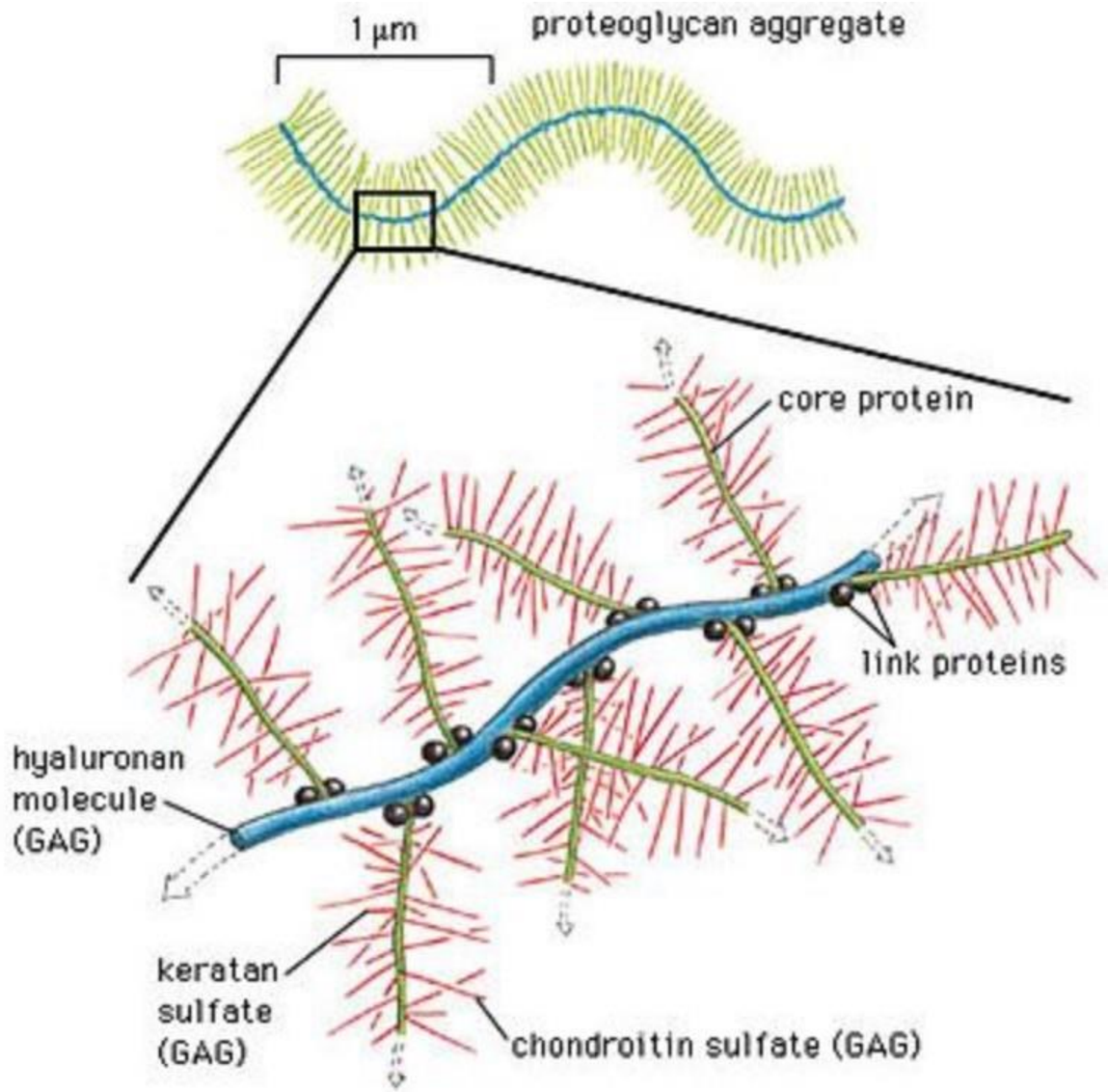
- GAGs (mucopolysaccharides) are long polymers of repeating disaccharide units, usually a hexosamine and uronic acid.
- The largest and most ubiquitous is hyaluronan (hyaluronate or hyaluronic acid).
- Hyaluronan forms a viscous, pericellular network that binds a considerable amount of water (diffusion through connective tissue and in lubricating various organs and joints).

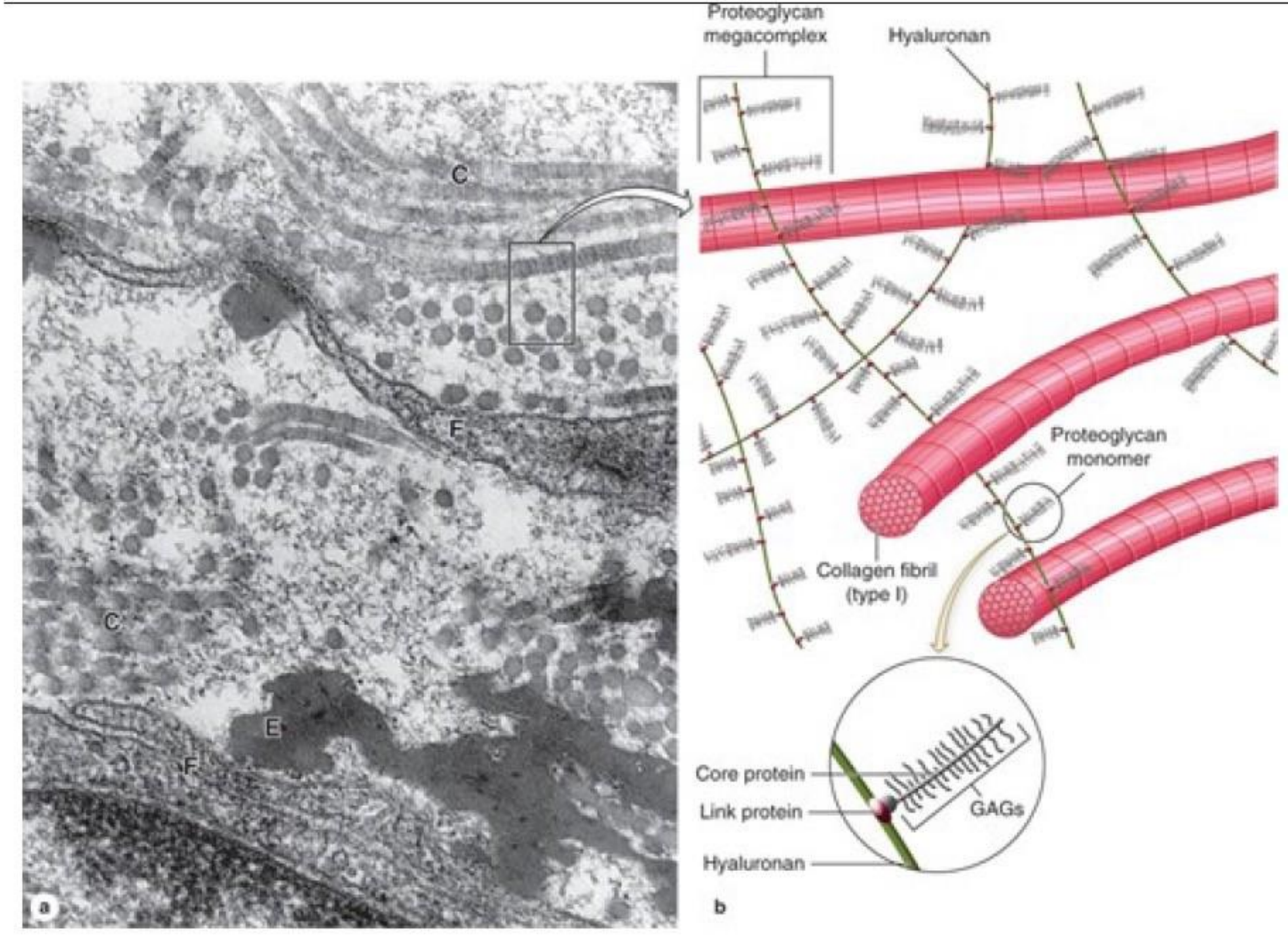
GAGs

- All other GAGs are much smaller, sulfated, bound to proteins (as parts of proteoglycans).
- Major GAGs found in proteoglycans are dermatan sulfate, chondroitin sulfates, keratan sulfate, and heparan sulfate (different disaccharide units)
- Their high negative charge forces GAGs to an extended conformation and causes them to sequester cations as well as water.
- These features provide GAGs with space-filling, cushioning, and lubricant functions.

GAGs that form proteoglycans

- Hyaluronic acid
- Chondroitin 4-sulfate
- Chondroitin 6-sulfate
- Dermantan sulfate
- Heparan sulfate
- Heparin
- Keratan sulfate



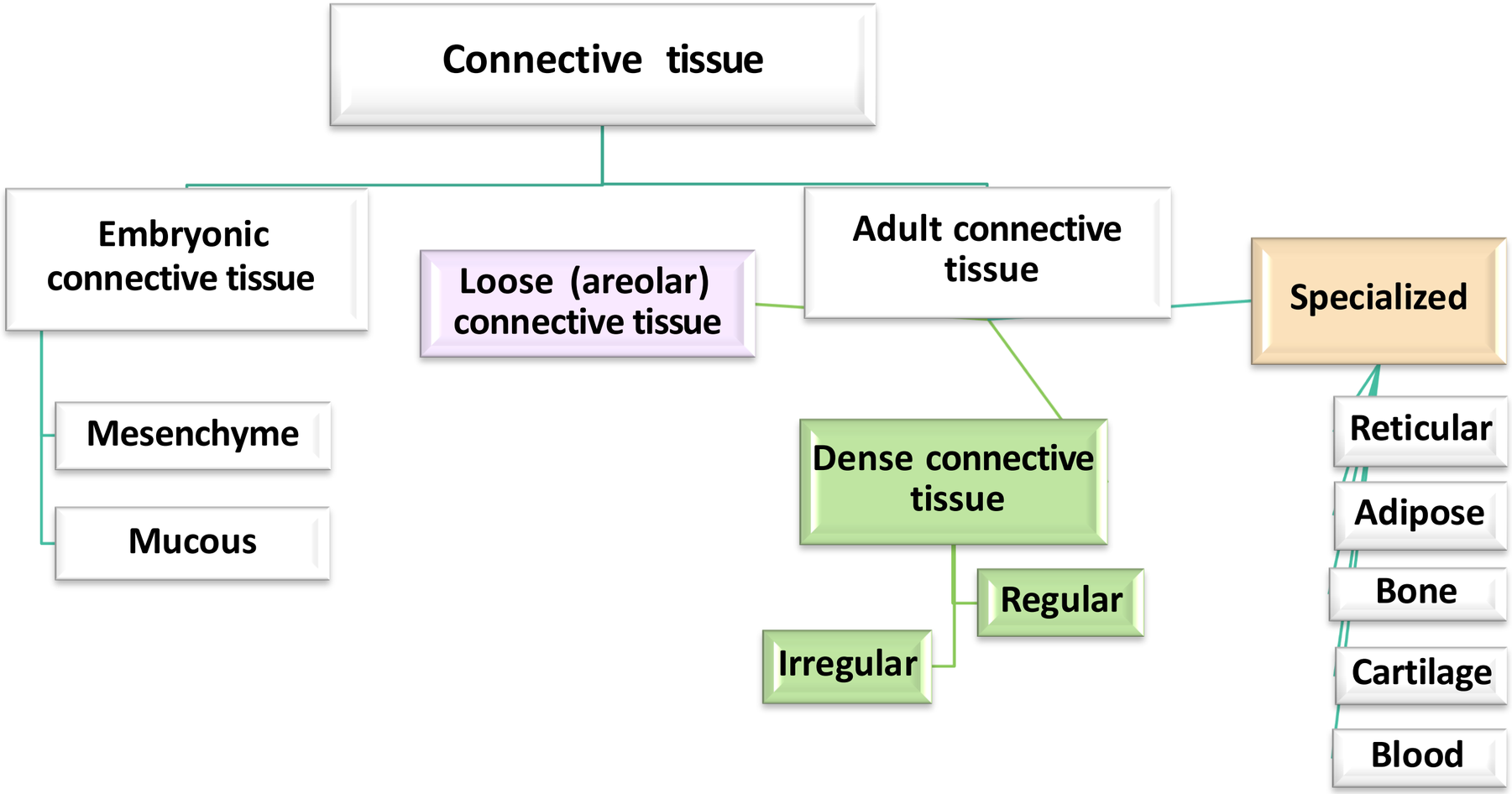

C
F
C
E
F
a
Proteoglycan megacomplex
Hyaluronan
Proteoglycan monomer
Collagen fibril (type I)
Core protein
Link protein
Hyaluronan
GAGs
b

- Large molecules interact with collagen in connective tissues.
- Basic materials interact between fibers and cells , and interact with collagen very importantly.
- It is necessary to know the type of large molecules and their distribution in tissues
- Hyaluronic acid works as a basic structure linked to smaller structures, and the type of large molecules depends on the type of tissues.

GAGs

Glycosaminoglycan	Repeating Disaccharides		Distribution	Electrostatic Interaction with Collagen
	Hexuronic Acid	Hexosamine		
Hyaluronic acid	D-glucuronic acid	D-glucosamine	Umbilical cord, synovial fluid, vitreous humor, cartilage	
Chondroitin 4-sulfate	D-glucuronic acid	D-galactosamine	Cartilage, bone, cornea, skin, notochord, aorta	High levels of interaction, mainly with collagen type II
Chondroitin 6-sulfate	D-glucuronic acid	D-galactosamine	Cartilage, umbilical cord, skin, aorta (media)	High levels of interaction, mainly with collagen type II
Dermatan sulfate	L-iduronic acid or D-glucuronic acid	D-galactosamine	Skin, tendon, aorta (adventitia)	Low levels of interaction, mainly with collagen type I
Heparan sulfate	D-glucuronic acid or L-iduronic acid	D-galactosamine	Aorta, lung, liver, basal laminae	Intermediate levels of interaction, mainly with collagen types III and IV
Keratan sulfate	D-galactose	D-glucosamine	Cartilage, nucleus pulposus, annulus fibrosus	None

Classification Of Connective Tissue



- Connective tissue consists of cells, fibers, and ground substance, which determine its type
- In adults, connective tissue is divided into :

1. Connective tissue proper (loose and dense)

2. Specialized types (cartilage, bone, blood) Characteristics of Different Connective Tissues: -

Loose connective tissue: - Has more ground substance and cells - Provides cushioning and support - Facilitates nutrient diffusion -

Dense connective tissue: - Primarily composed of fibers - Can be classified as regular (tendons and ligaments) and irregular - Fibers can be aligned in different orientations

Specific Types and Their Properties: -

Dense Irregular Connective Tissue:

- Found in the dermis

- Collagen fibers oriented in multiple directions for multidirectional strength

Ligaments:

- Have parallel collagen fibers

- Provide unidirectional tensile strength

Reticular Connective Tissue:

- Contains reticular fibers (collagen type III)

- Supports delicate structures

- Found in lymphoid organs

Classification-Embryonic C T

Embryonic Connective Tissues	General Organization	Major Functions	Examples
Mesenchyme	Sparse, undifferentiated cells, uniformly distributed in matrix with sparse collagen fibers	Contains stem/progenitor cells for all adult connective tissue cells	Mesodermal layer of early embryo
Mucoid (mucous) connective tissue	Random fibroblasts and collagen fibers in viscous matrix	Supports and cushions large blood vessels	Matrix of the fetal umbilical cord

Embryonic Development:

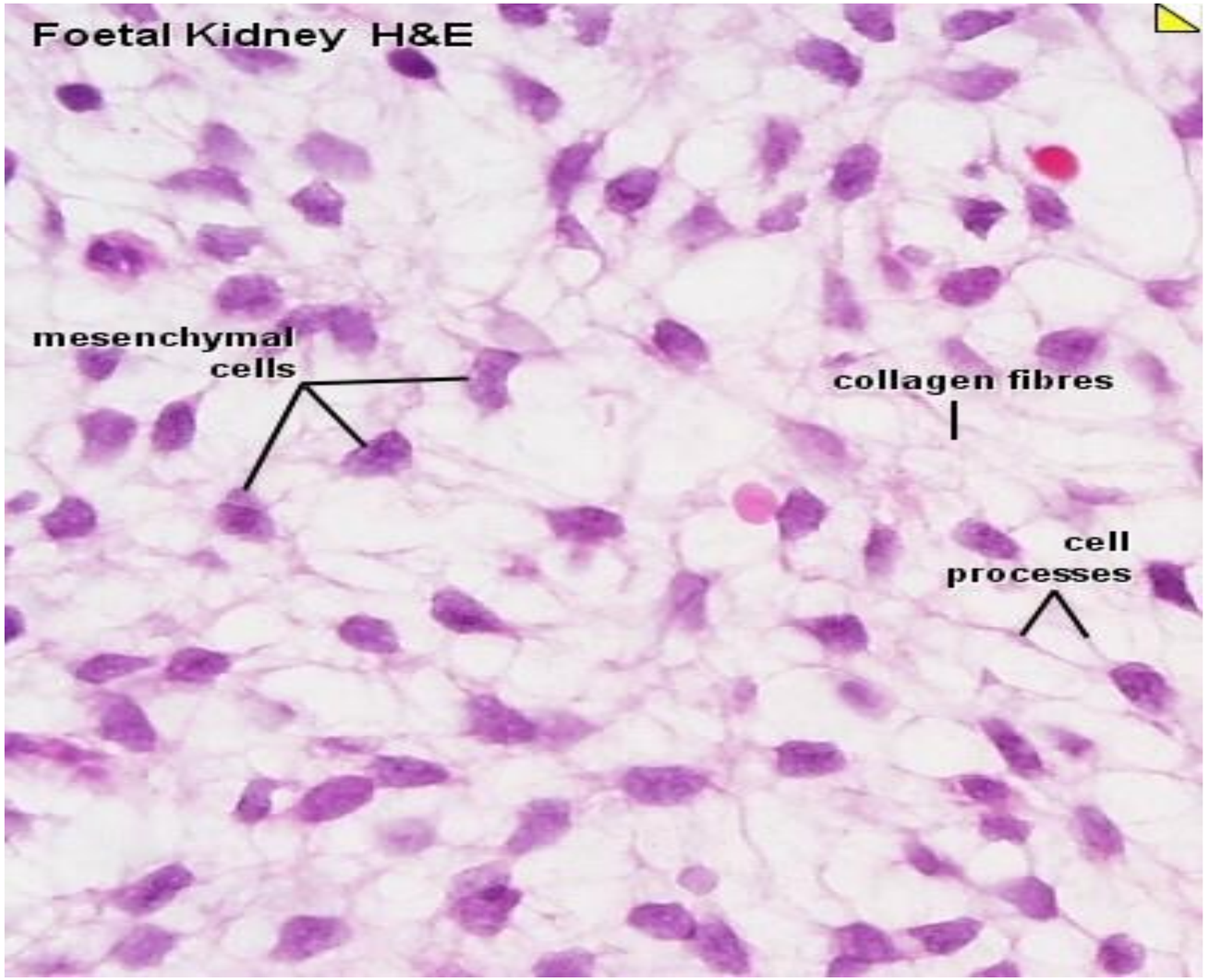
- Embryonic connective tissues include mesenchyme and mucous tissue

- Undifferentiated cells differentiate into various adult connective tissues like fibroblasts and osteoblasts

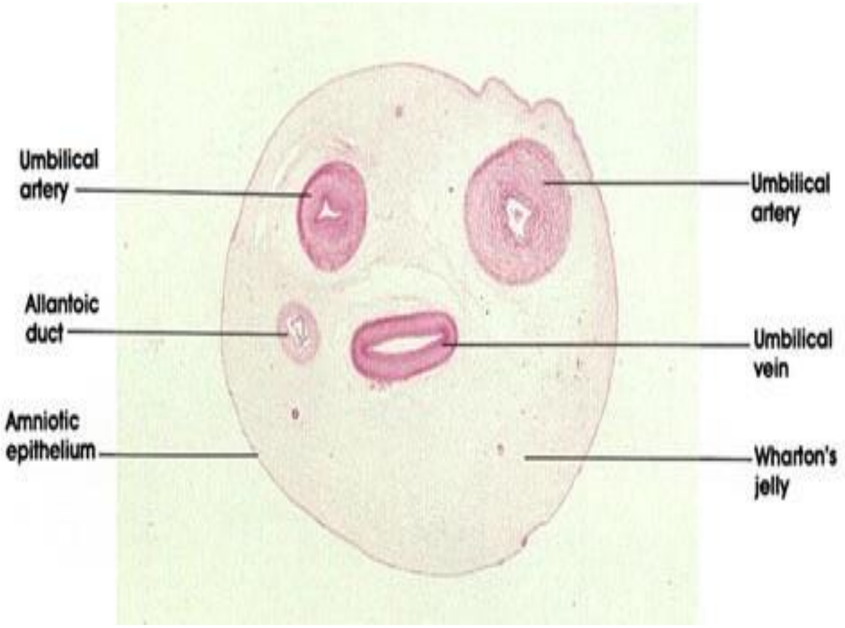
- Mucous connective tissue is present in the umbilical cord

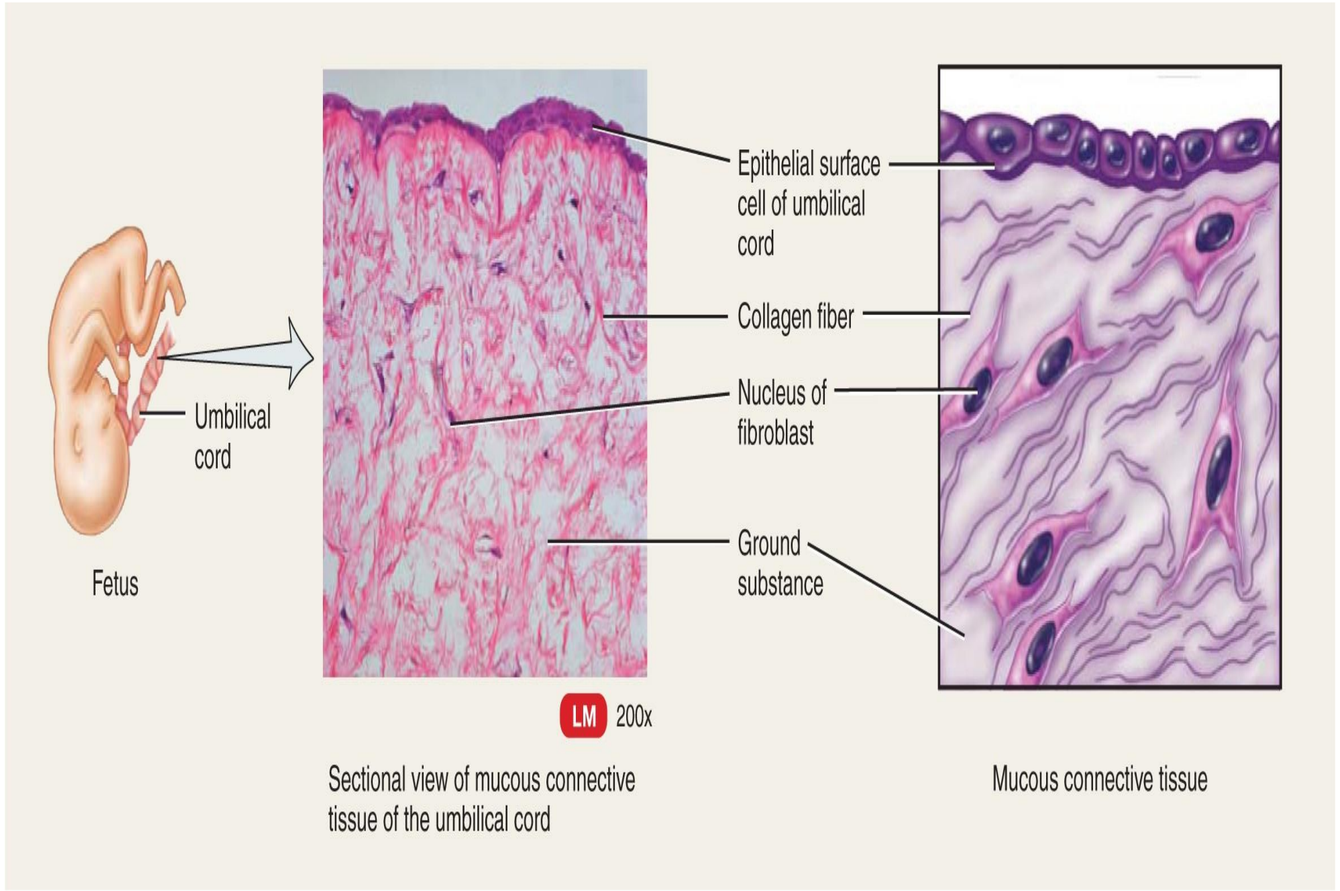
- The umbilical cord connects the embryo to the placenta, facilitating nutrient and waste exchange

Mesenchyme


Foetal Kidney H&E
mesenchymal cells
collagen fibres
cell processes

Mucous Connective Tissue





Classification-Adult C T

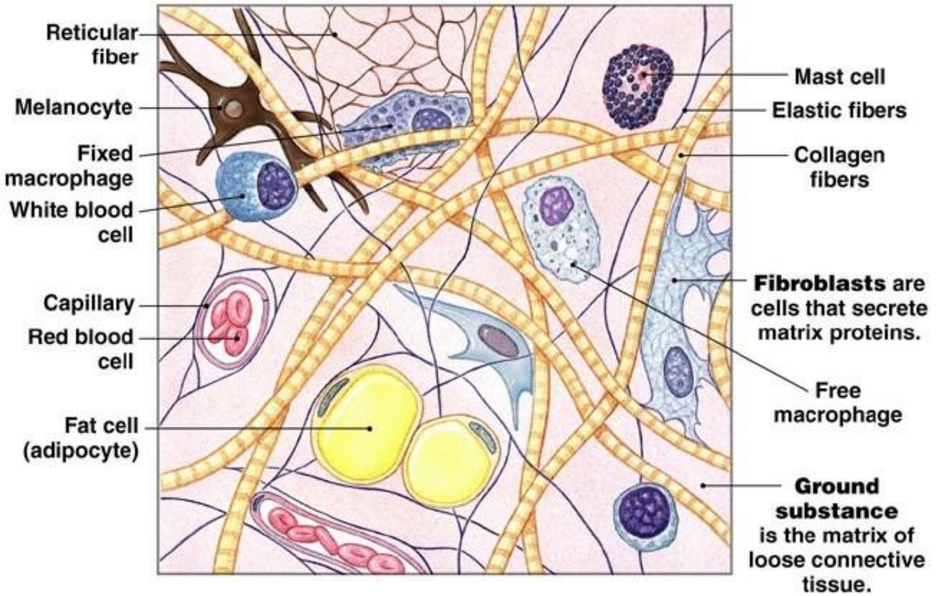
	General Organization	Major Functions	Examples
Connective Tissue Proper			
Loose (areolar) connective tissue	Much ground substance; many cells and little collagen, randomly distributed	Supports microvasculature, nerves, and immune defense cells	Lamina propria beneath epithelial lining of digestive tract
Dense irregular connective tissue	Little ground substance; few cells (mostly fibroblasts); much collagen in randomly arranged fibers	Protects and supports organs; resists tearing	Dermis of skin, organ capsules, submucosa layer of digestive tract
Dense regular connective tissue	Almost completely filled with parallel bundles of collagen; few fibroblasts, aligned with collagen	Provide strong connections within musculoskeletal system; strong resistance to force	Ligaments, tendons, aponeuroses, corneal stroma

Classification-Specialized CT

	General Organization	Major Functions	Examples
Reticular connective tissue (see Chapter 14)	Delicate network of reticulin/collagen III with attached fibroblasts (reticular cells)	Supports blood-forming cells, many secretory cells, and lymphocytes in most lymphoid organs	Bone marrow, liver, pancreas, adrenal glands, all lymphoid organs except the thymus

Loose (Areolar) Connective Tissue

- Consists of all 3 types of fibers, several types of cells, and semi-fluid ground substance.
- Found in subcutaneous layer and mucous membranes, and around blood vessels, nerves and organs
- Function = strength, support and elasticity



Loose connective tissue

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Fig. 3-29

Cellular and Molecular Composition:

- The matrix surrounding cells contains:
  - Collagen fibers
- Ground substance
  - Hyaluronic acid

Special Observations:

- Elastic fibers in the aorta a llow for stretching and recoil
- Visualization of elastic fibers requires special stains like orcein
- Stem cells from the umbilical cord can potentially treat diseases

Dense Connective Tissue

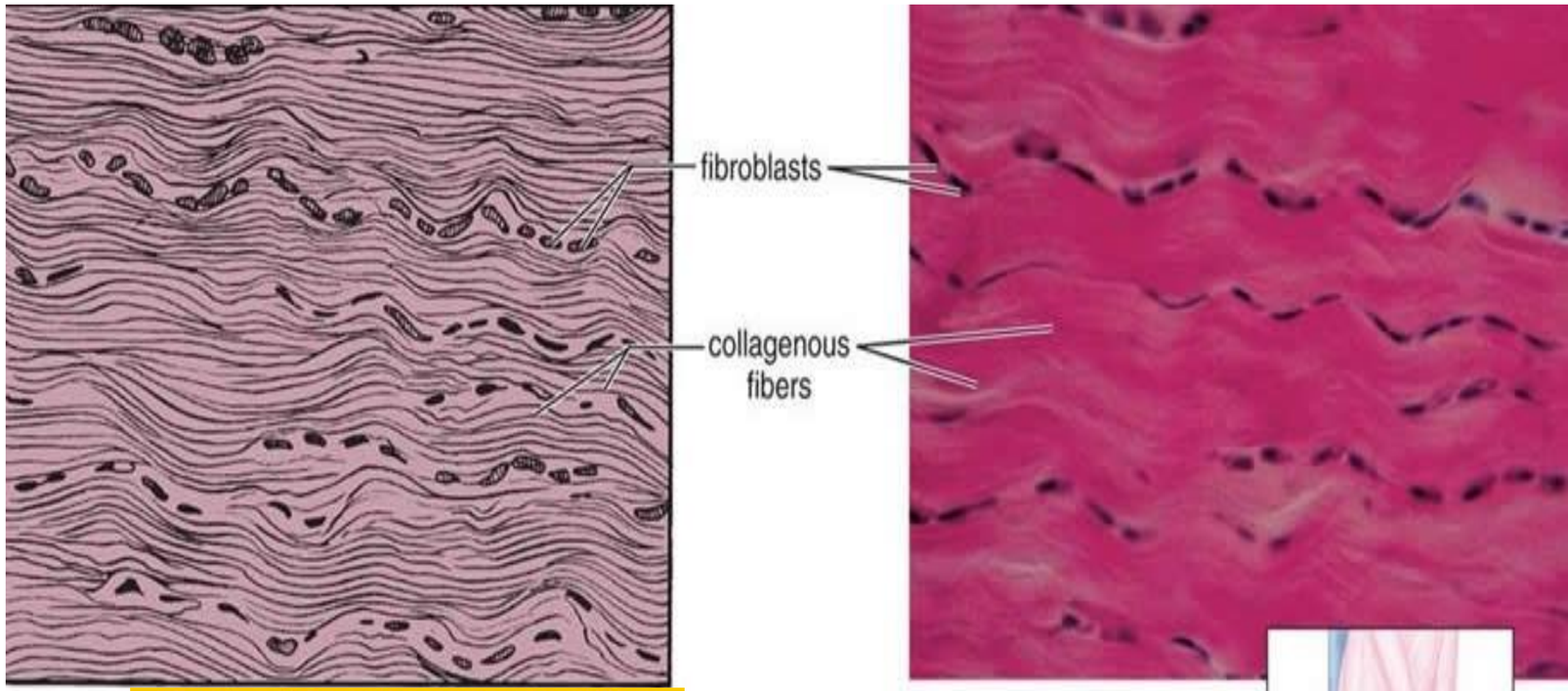
Contains more numerous and thicker fibers and far fewer cells than loose CT.

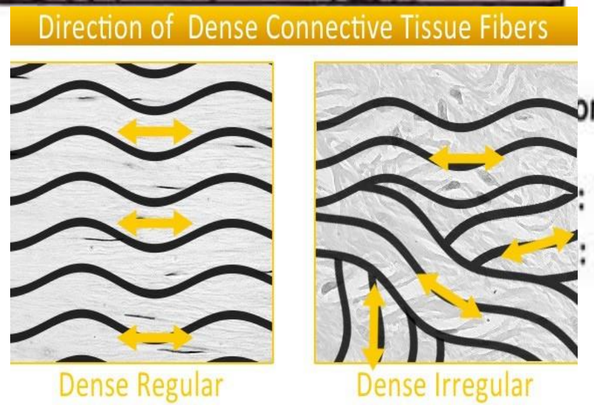
a. Dense regular connective tissue
   Tendons and ligaments

b. Dense irregular connective tissue
   Dermis of skin

Dense Regular Connective Tissue

- Consists of bundles of collagen fibers and fibroblasts.
- Forms tendons, ligaments.
- Function = provide strong attachment between various structures.

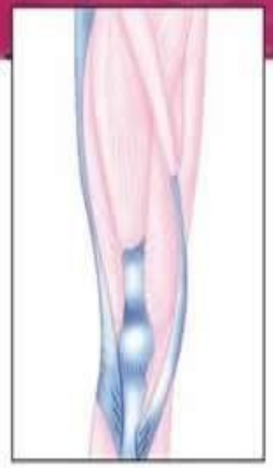


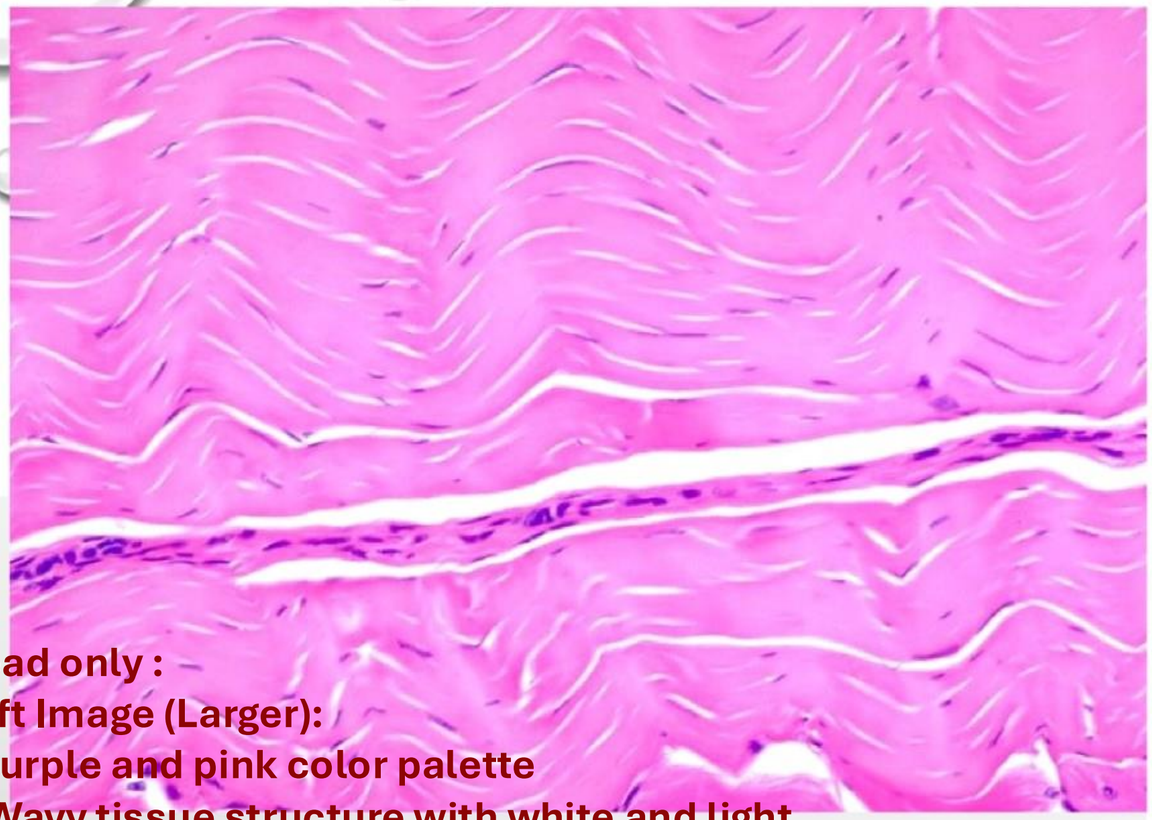


onnective Tissue

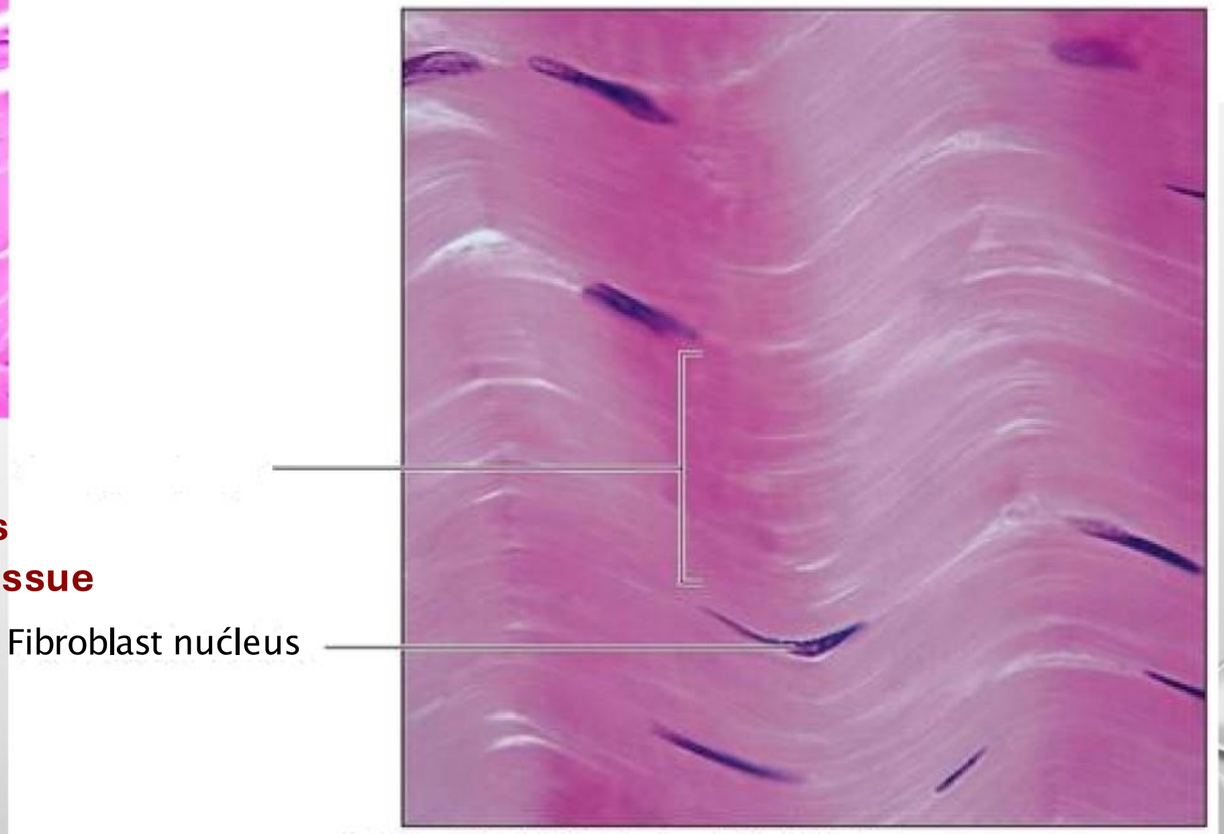
: Tendons; ligaments

: Binds organs together





Read only :
Left Image (Larger):
- Purple and pink color palette
- Wavy tissue structure with white and light colored undulating lines
- Shows tissue architecture with overlapping color gradations
- Appears like layered, wavy patterns typical of microscopic tissue slides
Right Image (Smaller):
- Darker purple tone
- Similar wavy pattern to the left image
- Labeled "Fibroblast nucleus"
- Displays more detailed cellular tissue structure



Dense Irregular CT

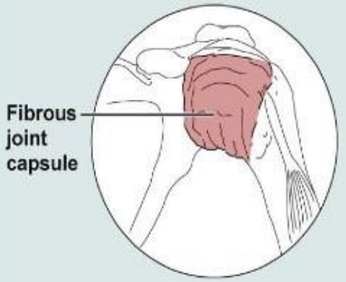
- Consists Of Randomly-arranged Collagen Fibers And A Few Fibroblasts.
- Found In Dermis Of Skin, capsules of joints and organs
- Function = Provide Strength and protection

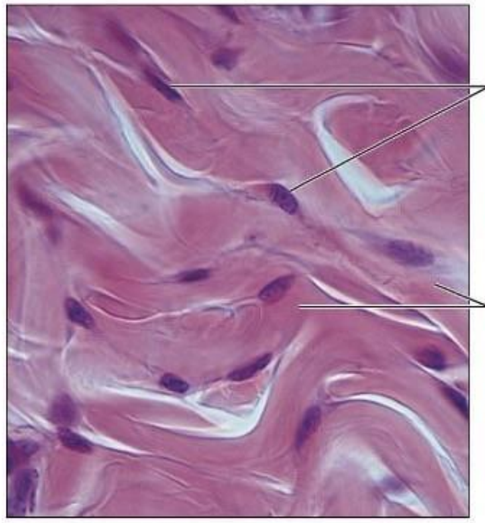
Microscope Images Show: - Purple and pink colored tissue - Intertwined, wavy fiber patterns - Different layers and textures

Description: Primarily irregularly arranged collagen fibers; some elastic fibers; major cell type is the fibroblast.

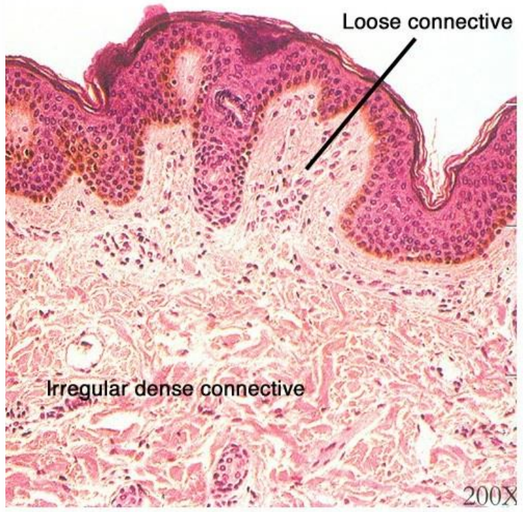
Function: Able to withstand tension exerted in many directions; provides structural strength.

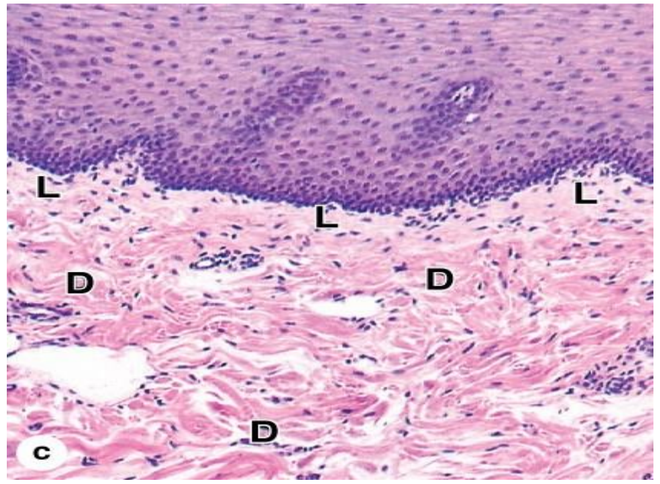
Location: Fibrous capsules of organs and of joints; dermis of the skin; submucosa of digestive tract.

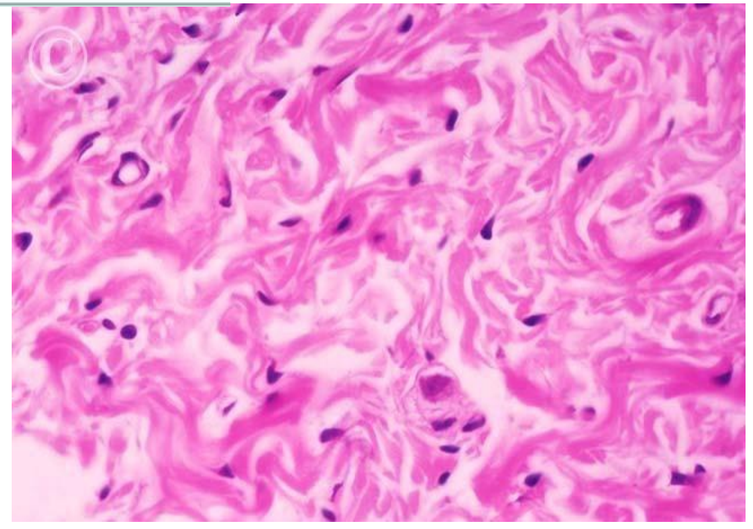




Photomicrograph: Dense irregular connective tissue from the dermis of the skin (600×).







- What Makes It Unique:
  - Fibers are scattered in different directions
- Looks complex under a microscope
- Helps maintain structural integrity of body parts
- Supports and protects different organs and tissues
- Think of it like a strong, randomly woven fabric that:
  - Can withstand pressure from multiple directions
- Acts as a protective shield
- Helps tissues maintain their shape and resist stretching

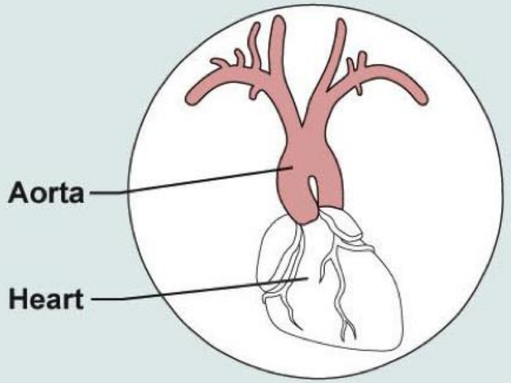
Elastic Connective Tissue

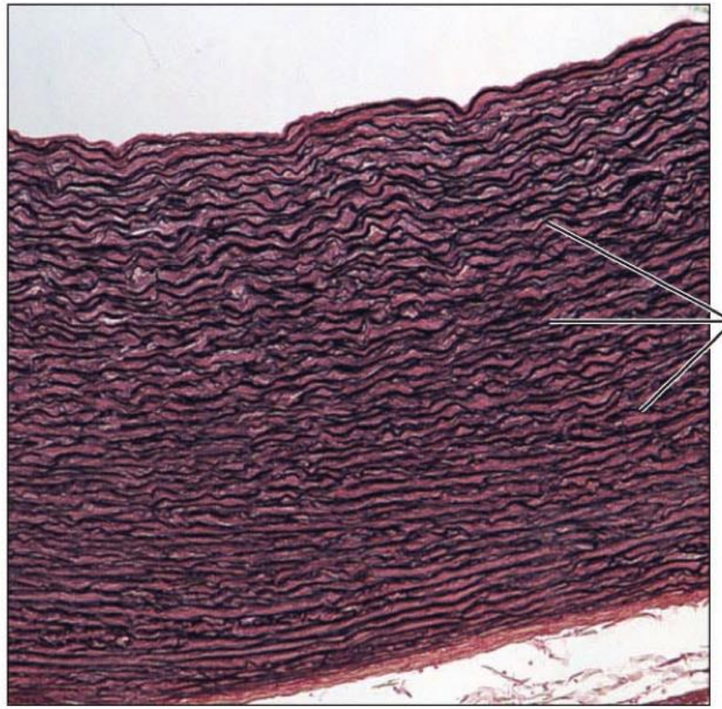
(g) Connective tissue proper: dense connective tissue, elastic

Description: Dense regular connective tissue containing a high proportion of elastic fibers.

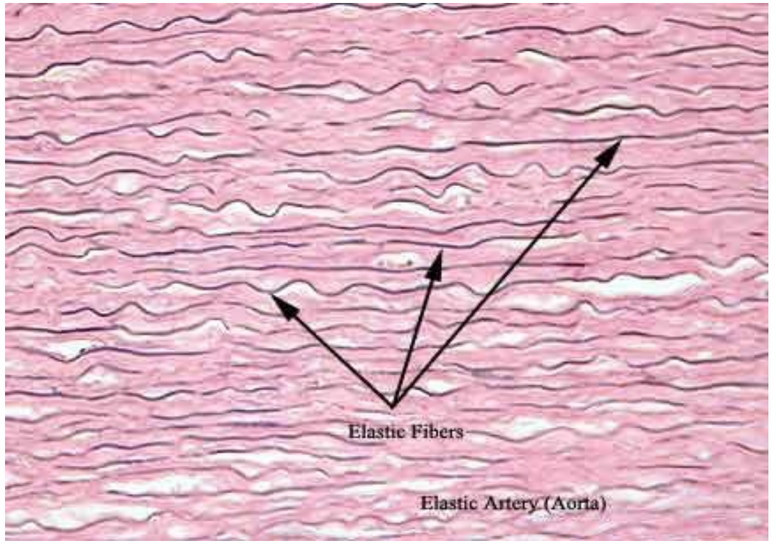
Function: Allows recoil of tissue following stretching; maintains pulsatile flow of blood through arteries; aids passive recoil of lungs following inspiration.

Location: Walls of large arteries; within certain ligaments associated with the vertebral column; within the walls of the bronchial tubes.



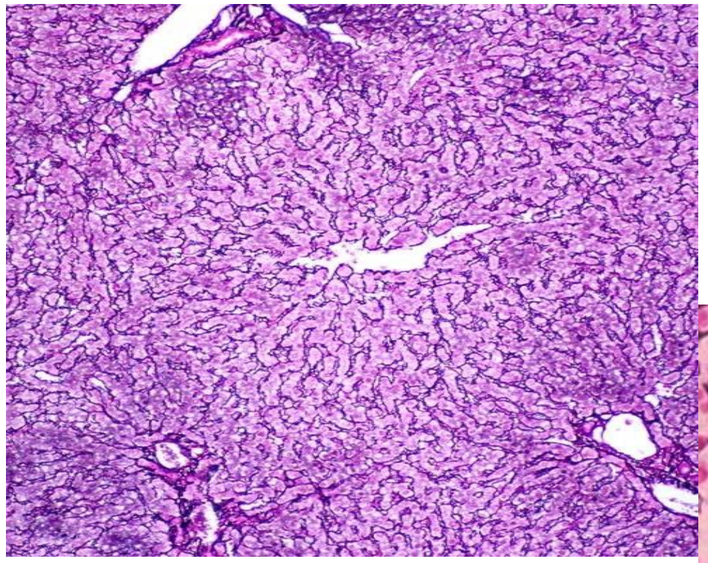


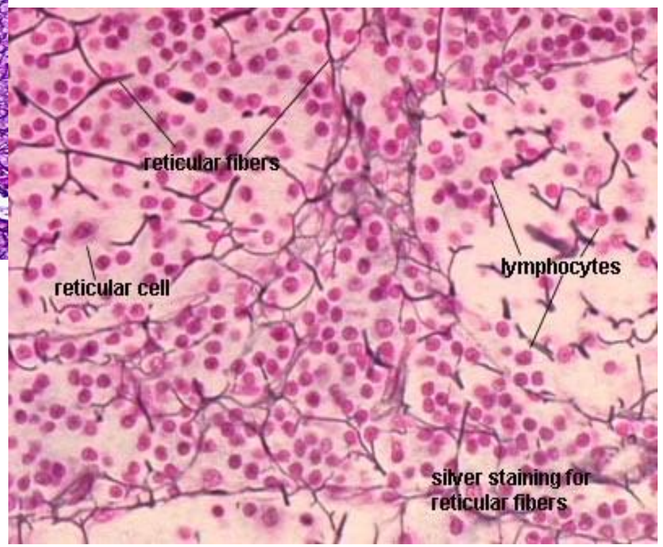
Photomicrograph: Elastic connective tissue in the wall of the aorta (85×).



RETICULAR CT

- Consists of fine interlacing reticular fibers and reticular cells.
- Found in liver, spleen and lymph nodes.
- Function = forms the framework (stroma) of organs and binds together smooth muscle tissue cells.





Medical Application
Collagen

Scurvy	Lack of vitamin C, a required cofactor for prolyl hydroxylase	Ulceration of gums, hemorrhages
Osteogenesis imperfecta	Change of 1 nucleotide in genes for collagen type I	Spontaneous fractures, cardiac insufficiency

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	12	Example	Laminin and fibronectin
V1 → V2	10	**light pink**	Dark purple

Additional Resources:

رسالة من الفريق العلمي: