

Tissues

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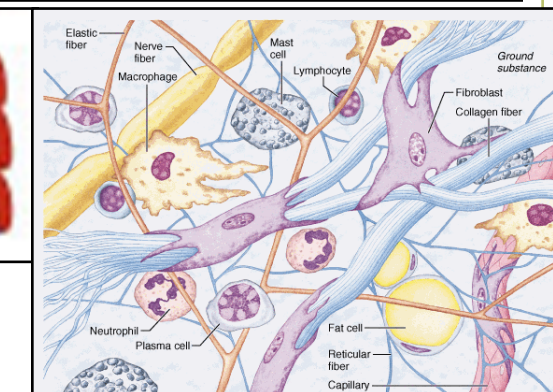
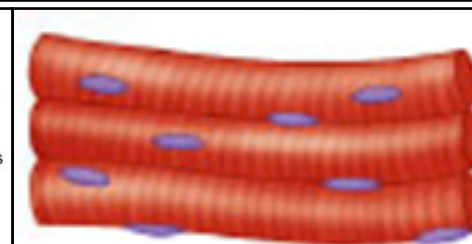
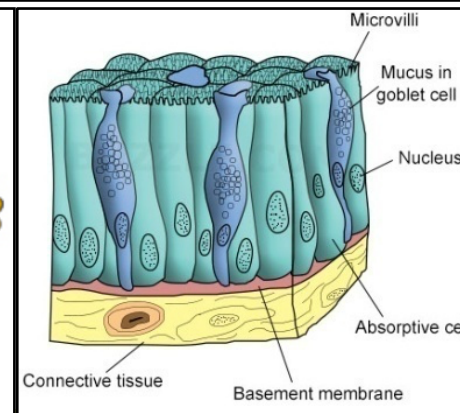
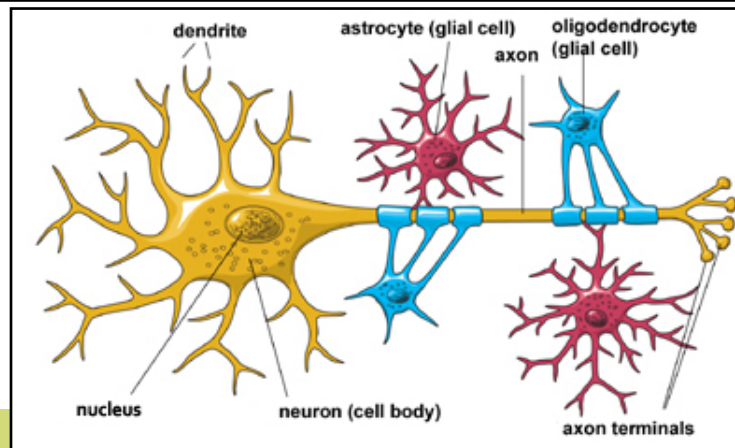
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(2021)

A tissue is a collection of cells with a common embryologic origin that work together to perform specialized activity. In addition to the cells, a tissue contains the extracellular matrix (ECM) which's found between the cells.

- Body tissues can be generally divided into 4 main types according to the *type of cells* and the *amount and content of the ECM* they possess.
- The main types of body tissues are:
 1. Epithelial tissue
 2. Connective tissue
 3. Muscular tissue
 4. Nervous tissue

Table 1: Types of tissues and their characteristics

<i>Tissue</i>	<i>Nervous</i>	<i>Epithelial</i>	<i>Muscular</i>	<i>Connective</i>
<i>Cells</i>	Have intertwining elongated processes	Aggregated polyhedral cells	Elongated contractile cells	Several types of fixed and wandering cells
<i>Amount of ECM</i>	Very small	Small	Moderate	Abundant
<i>Main Function</i>	Transmission of nerve impulse	Lining, Secretion	Movement	Support, protection



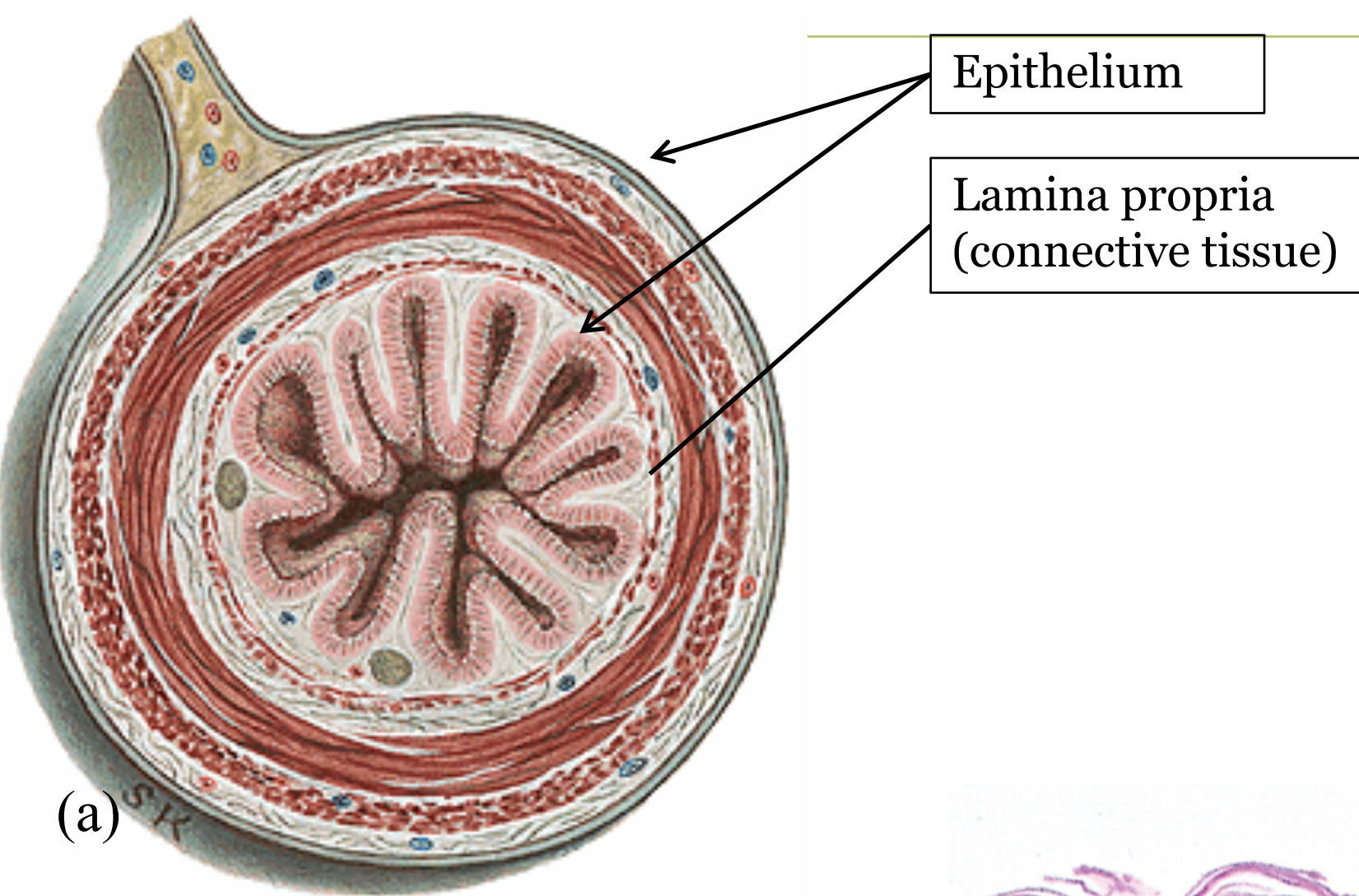


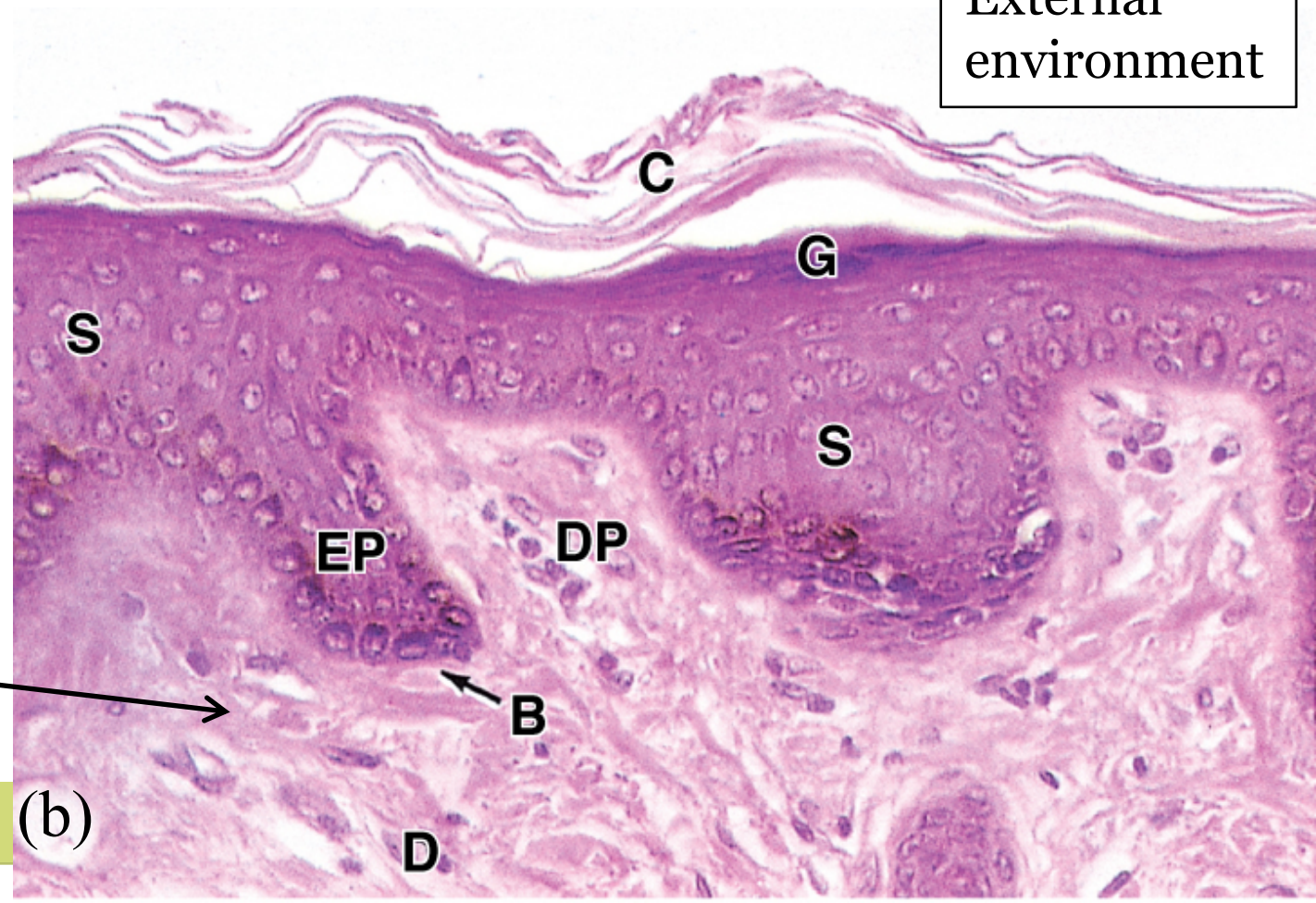
Fig.1: Characteristics of Epithelial tissue. (a) Cross section of small intestine. (b) Section through the skin.

(a)

External environment

Epithelium = epidermis

Dermis (connective tissue)



(b)

Epithelial Tissue

- Epithelial tissues have the following characteristics:
 - 1) Cover surfaces or line cavities.
 - 2) Rapid turn-over (time from the birth of a cell till its death), because it's exposed to the external environment.
 - 3) Formed of sheets of closely packed cells.
 - 4) The cells are polar.
 - 5) The epithelium rests upon a sheet of extracellular matrix called the *Basal Lamina*. The epithelium, also, have a connective tissue layer under it.
 - 6) ***Epithelial tissues lack blood vessels***. They receive their nutrients from the underlying vascular connective tissue.

Basement Membrane

- Basement membrane is formed of the *basal lamina* and the *reticular lamina*. The reticular lamina is the upper part of the connective tissue that's usually located under the epithelium which is rich in reticular fibers.
- It supports the epithelium.

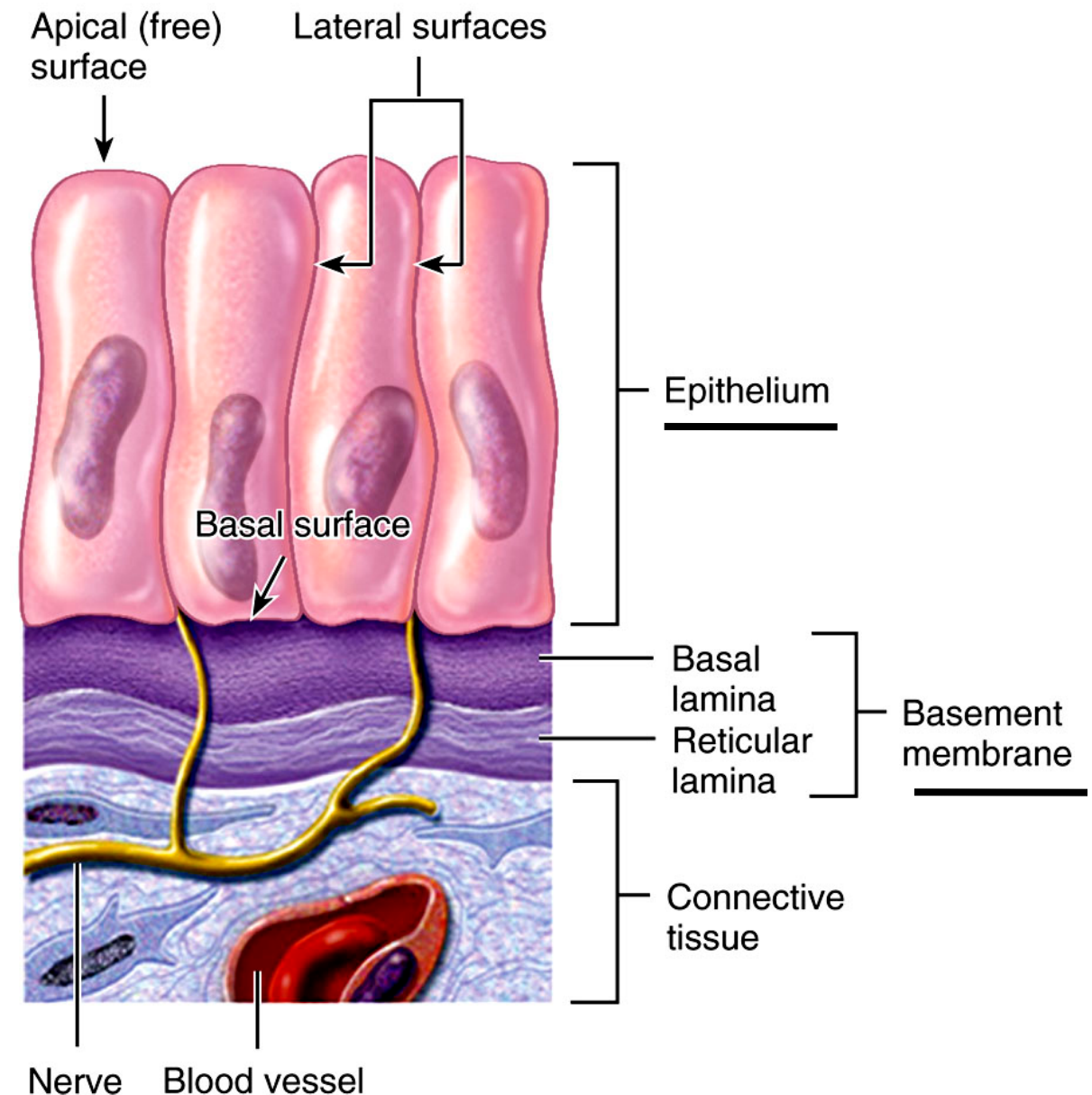


Fig.2: Difference between basal lamina and basement membrane.

Types of Epithelium

- Epithelium can be divided into two general groups:
 - 1) Lining or covering epithelium
 - 2) Glandular epithelium → Main function is secretion
- However, some lining epithelial cells secrete (like those in the stomach) and some glandular cells are present between lining cells (like goblet cells of small intestine)

Lining or covering epithelium

According to number of layers

Simple
(1 layer)

Stratified
(≥ 2 layers)

Pseudostratified
epithelium

According to shape of cell

Squamous

Cuboidal

Columnar

According to shape of cell in upper layer

Squamous

Cuboidal

Columnar

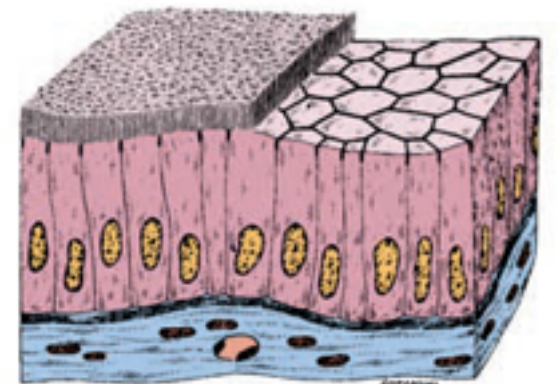
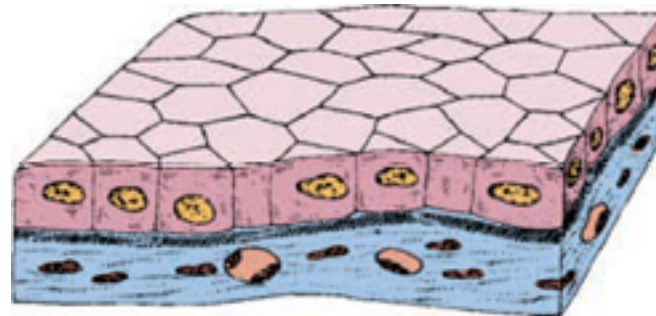
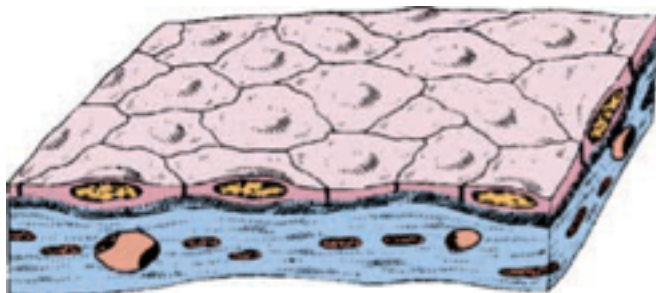
Transitional

Keratinized

Non-
keratinized

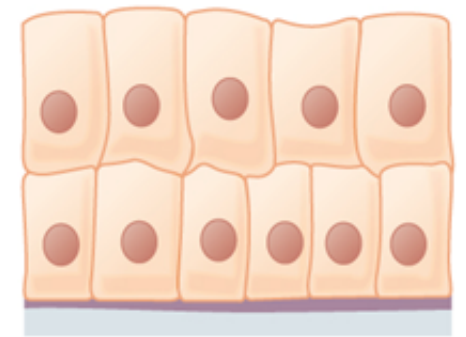
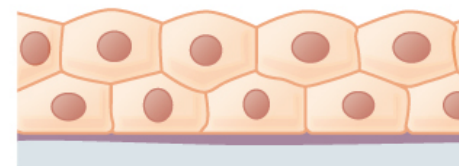
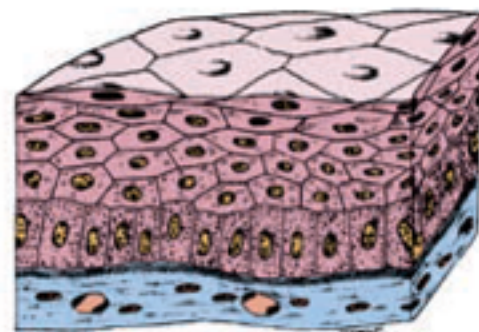
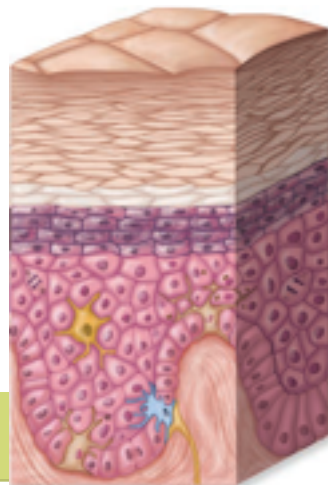
Simple Epithelium

	Simple Squamous	Simple Cuboidal	Simple Columnar
Number of Layers	Single	Single	Single
Cells	Flattened squamous	Cuboidal	Tall columnar
Location	• Line blood vessel • Line body cavities	• Line renal tubules • Cover ovaries	• <i>Ciliated</i>: Uterine tube • <i>Non-ciliated</i>: Stomach
Function	• Easy passage of substances • Secretion	• Active transport • Cover organs	• Secretion • Absorption



Stratified Epithelium

	Stratified Squamous		Stratified Cuboidal	Stratified Columnar
	Keratinized	Non-keratinized		
Number of layers	Multiple	Multiple	Multiple	Multiple
Top-most layer	Squamous cells covered by keratin layer	Squamous cells not covered by keratin layer	Cuboidal	Columnar
Location	Skin	Esophagus	Large ducts of salivary glands	Conjunctiva
Function	- Protection - Prevent water loss	Protection	- Protection - Secretion	- Protection - Secretion



Transitional epithelium (Urothelium):

❖ The topmost cells of this stratified epithelium are dome-like (called *Umbrella Cells*).

❖ Location:

– Urinary bladder and ureters.
That's why it's also called *Urothelium*.

❖ The umbrella cells are dome-shaped when the bladder is empty. Once it's full, these cells will become flattened (hence the name transitional).

❖ Functions: Protection against the adverse effects of urine.
Allows the bladder to change size.

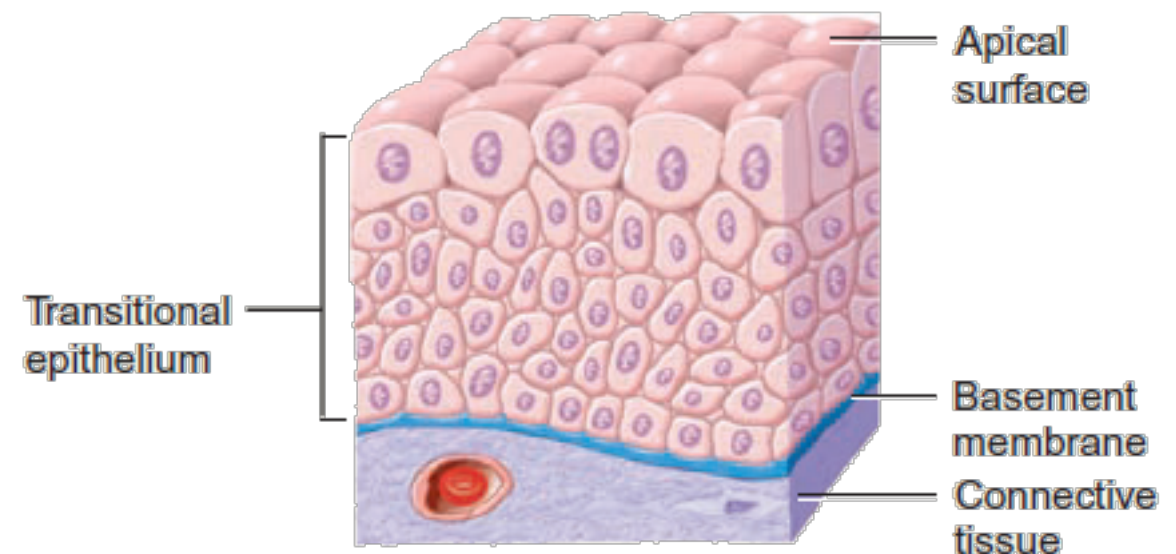


Fig.3: Relaxed transitional epithelium.

Pseudostratified columnar ciliated epithelium:

- In this epithelium, the cells have different heights. All cells rest on the same basal lamina, but not all of them reach the surface. This makes the nuclei occupy different levels giving the epithelium a false stratified appearance, but this epithelium is, actually, simple.

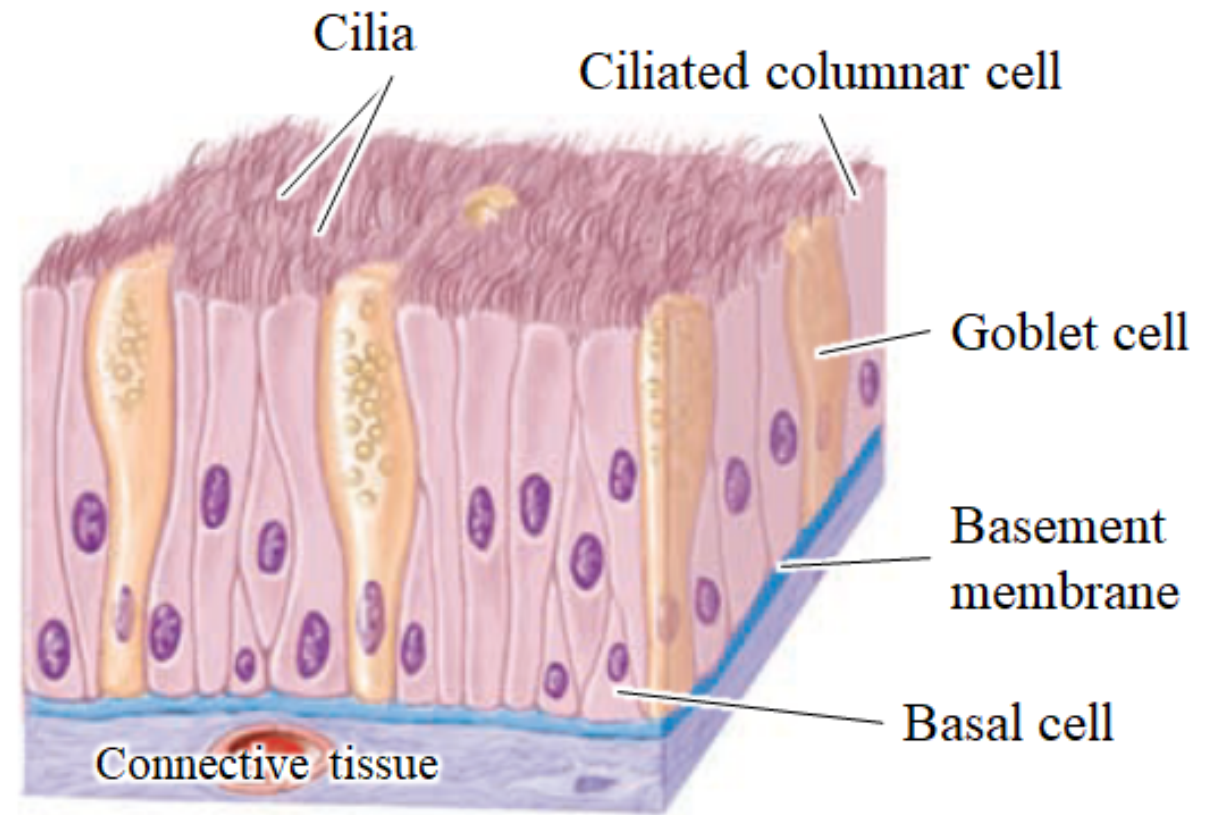


Fig.4: Pseudostratified columnar ciliated epithelium.

- Location:
 - Trachea, bronchi, and nasal cavity (that's why it's also called *Respiratory Epithelium*).
- Functions: Protection, secretion. Ciliary movement removes particles from the airway passages.

Glandular Epithelium

- Is an epithelium specialized for secretion.

Classification of glandular epithelium:

1) According to number of cells:

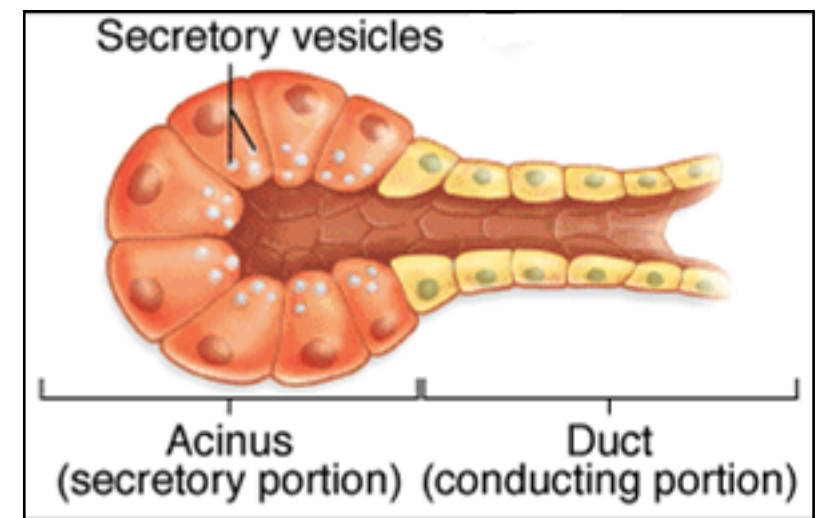
- [?] Unicellular** glands: formed of a single cell, like Goblet cells of digestive and respiratory tracts.
- [?] Multicellular** glands: formed of clusters of cells, like: salivary and sweat glands.

2) According to presence of ducts:

- ❑ **Exocrine** glands: possess ducts that transfer the secretion to the outside of the body, like: salivary glands.
- ❑ **Endocrine** glands: they lack ducts. Their secretions are transferred to the target organs, usually, by blood. Example: Pancreatic Islets, Pituitary gland.

3) Exocrine glands classified according to morphology of duct and secretory portion:

- ❑ Each exocrine gland has a secretory portion that produces the secretion and a duct that carries this secretion.
- ❑ The duct and the secretory portion could be branched or unbranched.
- ❑ The secretory portion could acinar (ball-shaped), tubular, or coiled.

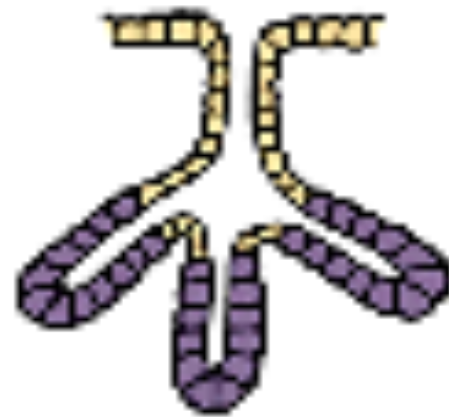


Exocrine Gland Types

simple
types



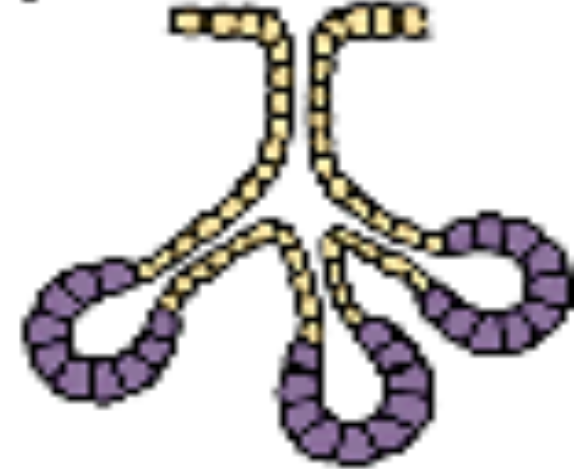
tubular



branched
tubular

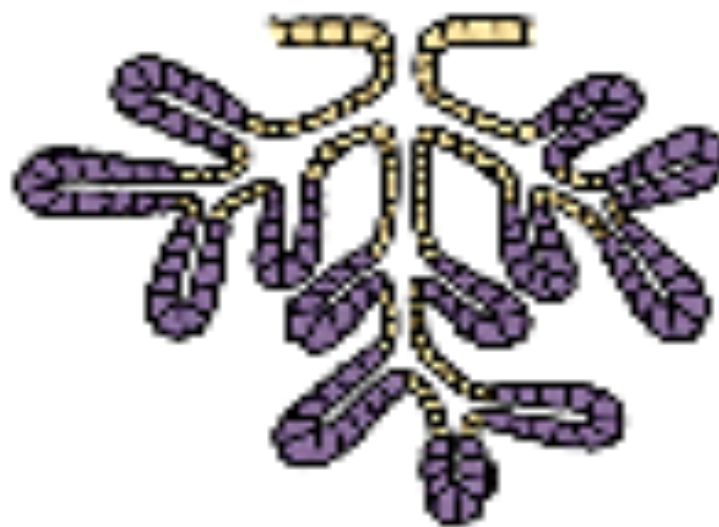


coiled
tubular

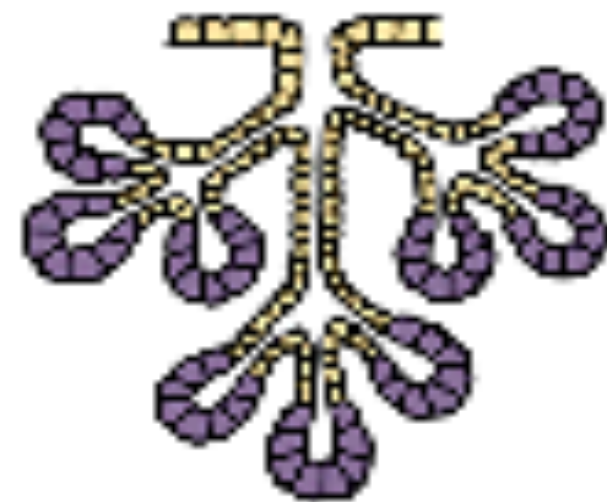


branched
alveolar

compound
types



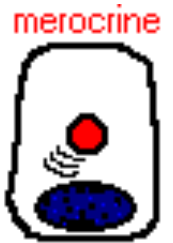
tubular



alveolar

4) Exocrine glands classified according to method of secretion:

❑ **Merocrine**: only the product is secreted by exocytosis. As in salivary glands.



❖ Merocrine glands are either serous (excrete a watery solution) or mucous (excrete a thick solution).

❑ **Apocrine**: the product and the apical part of the cell is shed. As in mammary gland.



❑ **Holocrine**: the whole cell disintegrates and is shed with the secretion. As in sebaceous glands of the skin.



Epithelial Cell Polarity

- ❖ Polarity means that various regions of a cell have specialized structural features because they perform different functions.
- ❖ Epithelial cells can be generally divided into 3 regions:
 1. **Apical (Luminal) region:** close to the lumen of the organ.
 2. **Lateral regions:** adjacent to other cells.
 3. **Basal region:** lying on the basal lamina.

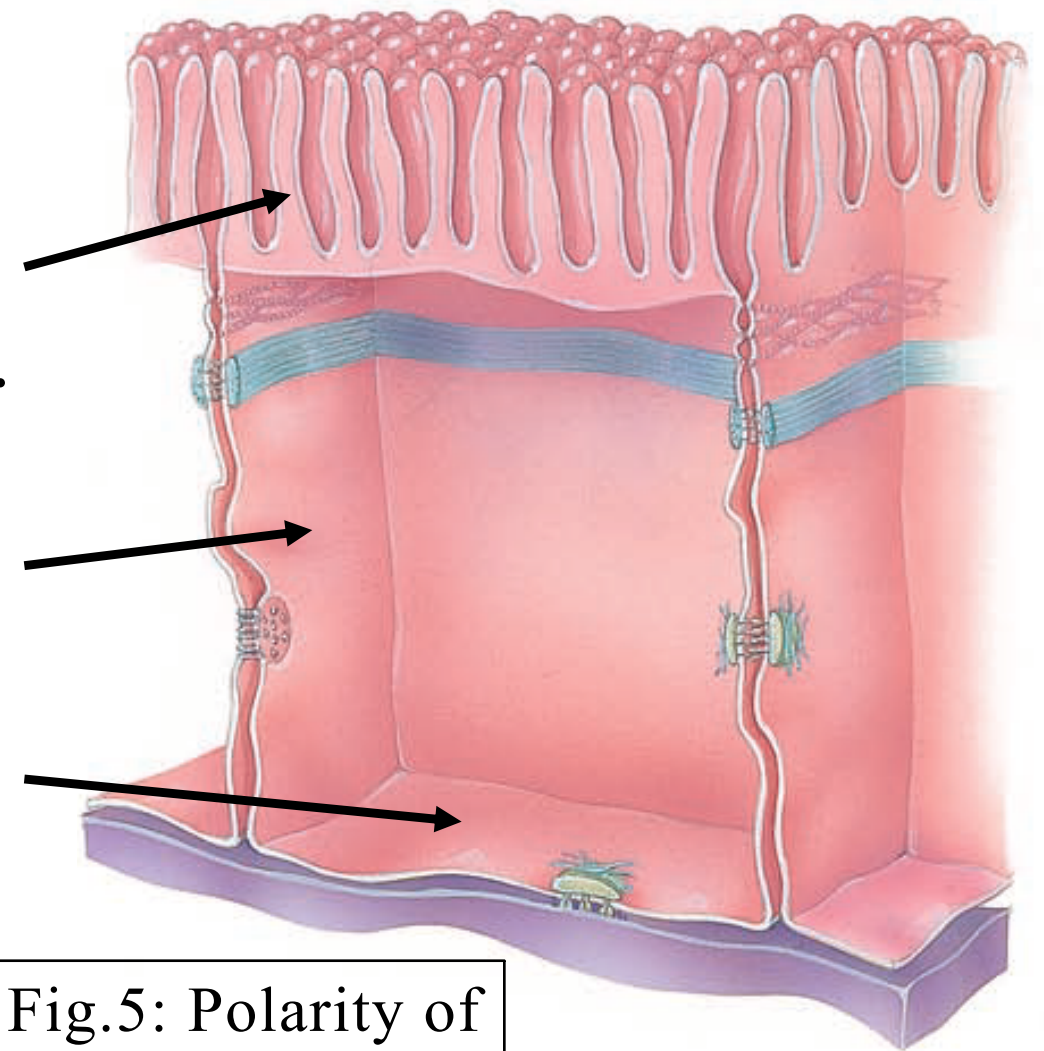
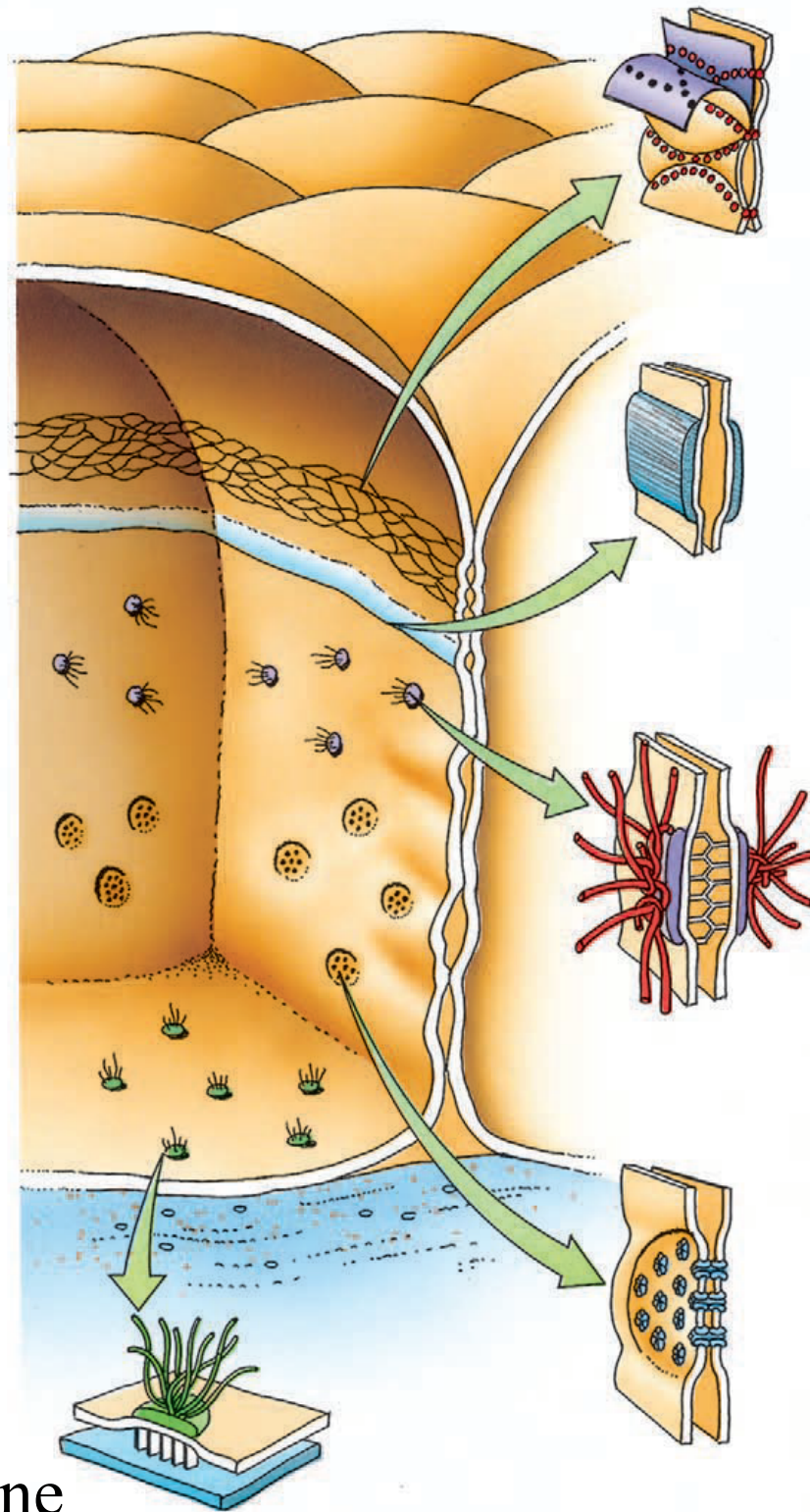


Fig.5: Polarity of epithelial cells.

Cellular Junctions

- ❖ Cell-membrane structures.
- ❖ Located on the lateral and basal surfaces.

Hemidesmosomes: area of adhesion between cell membrane and basal lamina.



Tight Junction: area of fusion of cell membrane. Seals the space between two cells.

Adherent Junction: area of adhesion between two cell membrane.

Desmosomes: area of stronger adhesion between two cell membrane.

Gap Junction: porous area in the cell membrane of two cells that allow passage of substances between them.

Features of the apical surface of the cell

- **1) Microvilli (single = microvillus):**
- Finger-like cytoplasmic projections that are present in absorptive epithelium, most prominently in the small intestine. They increase the surface area.

Fig.6a: Microvilli of small intestinal cells



- **2) Stereocilia**
- They're similar in structure to microvilli; however, they're longer and less motile. They may act as mechanoreceptors as in the inner ear hair cells.

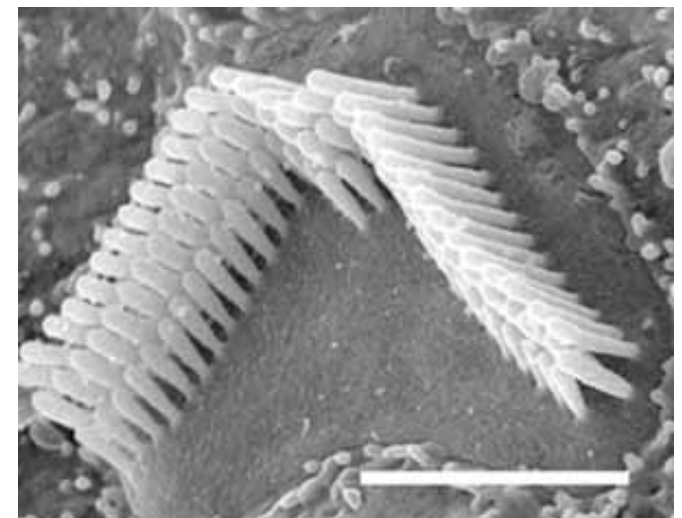


Fig.6b: Stereocilia of a hair cell

- **3) Cilia**

- Thick, elongated, motile structures on the surface of some epithelial cells, like those of the trachea. There are, usually, many cilia on the surface of a single cell. They move in rhythmic fashion backwards and forwards removing fluids and debris in a certain direction.

- **4) Flagella**

- They're similar to cilia in structure but are much longer and, usually, only one flagellum is present on a cell. The movement of the flagellum is rotational. In humans, only sperms possess a flagellum.

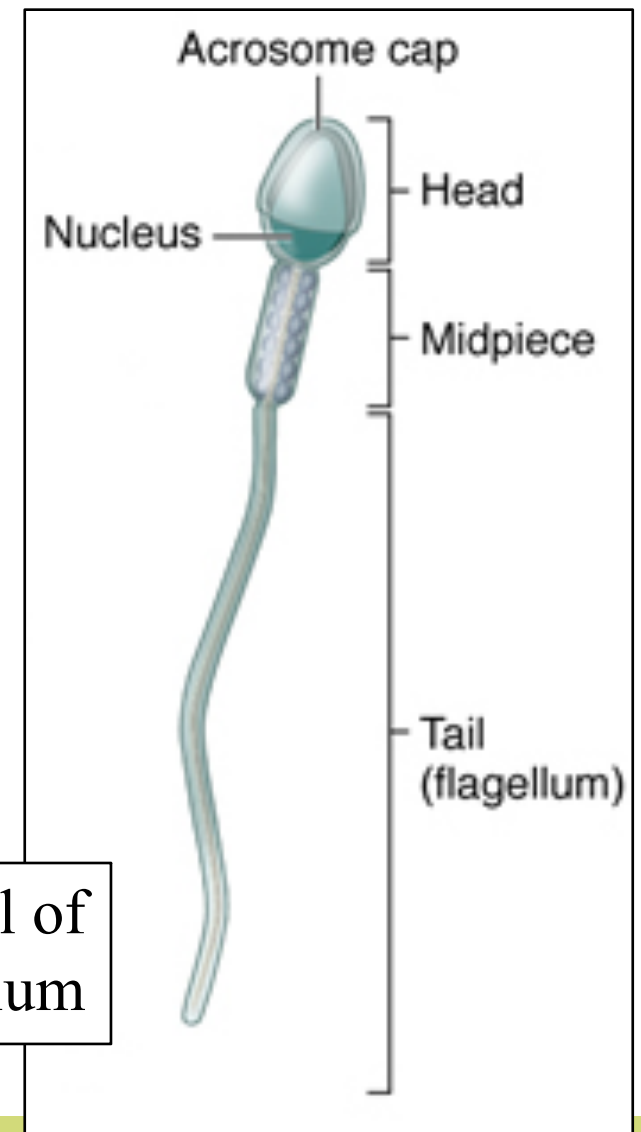
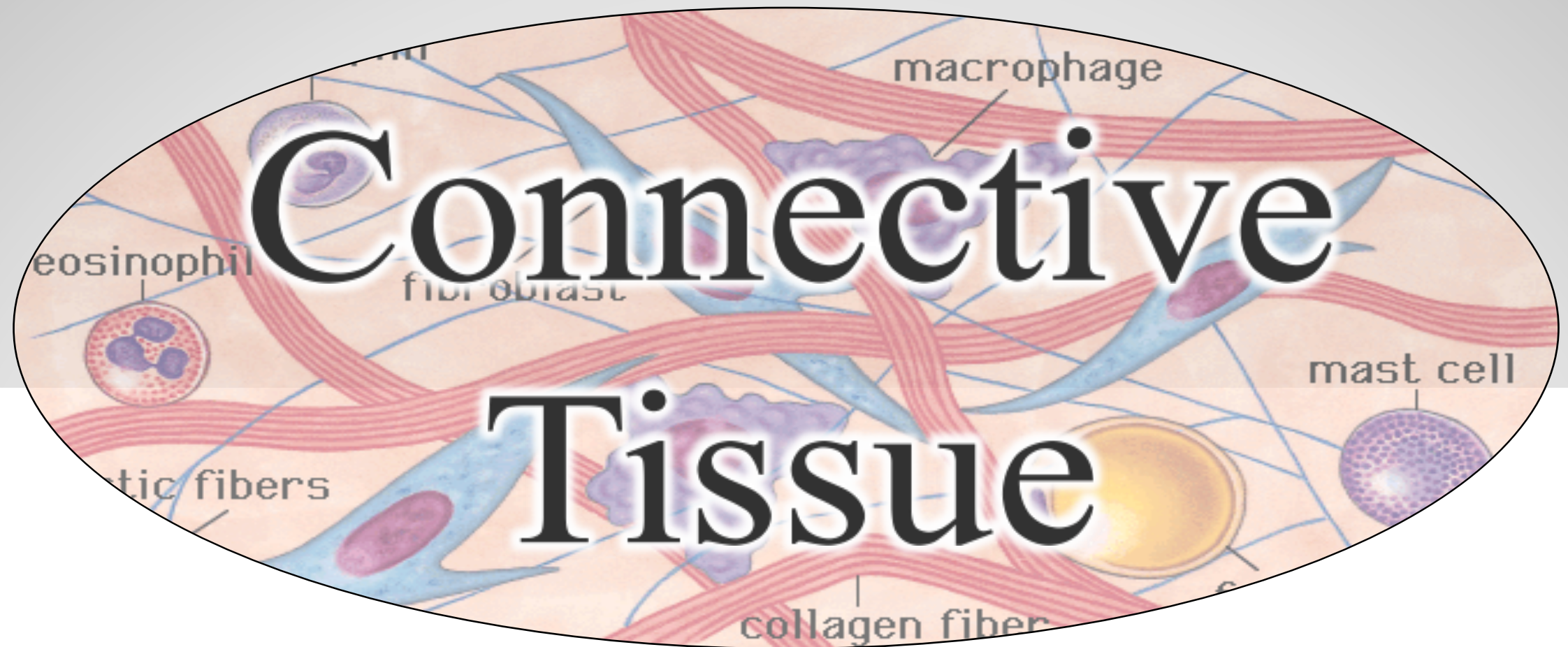


Fig.6c: Sperm. The tail of the sperm is a flagellum



Connective tissue (CT) is a type of body tissue characterized by the presence of an abundant extracellular matrix within which are dispersed different types of cells and fibers.

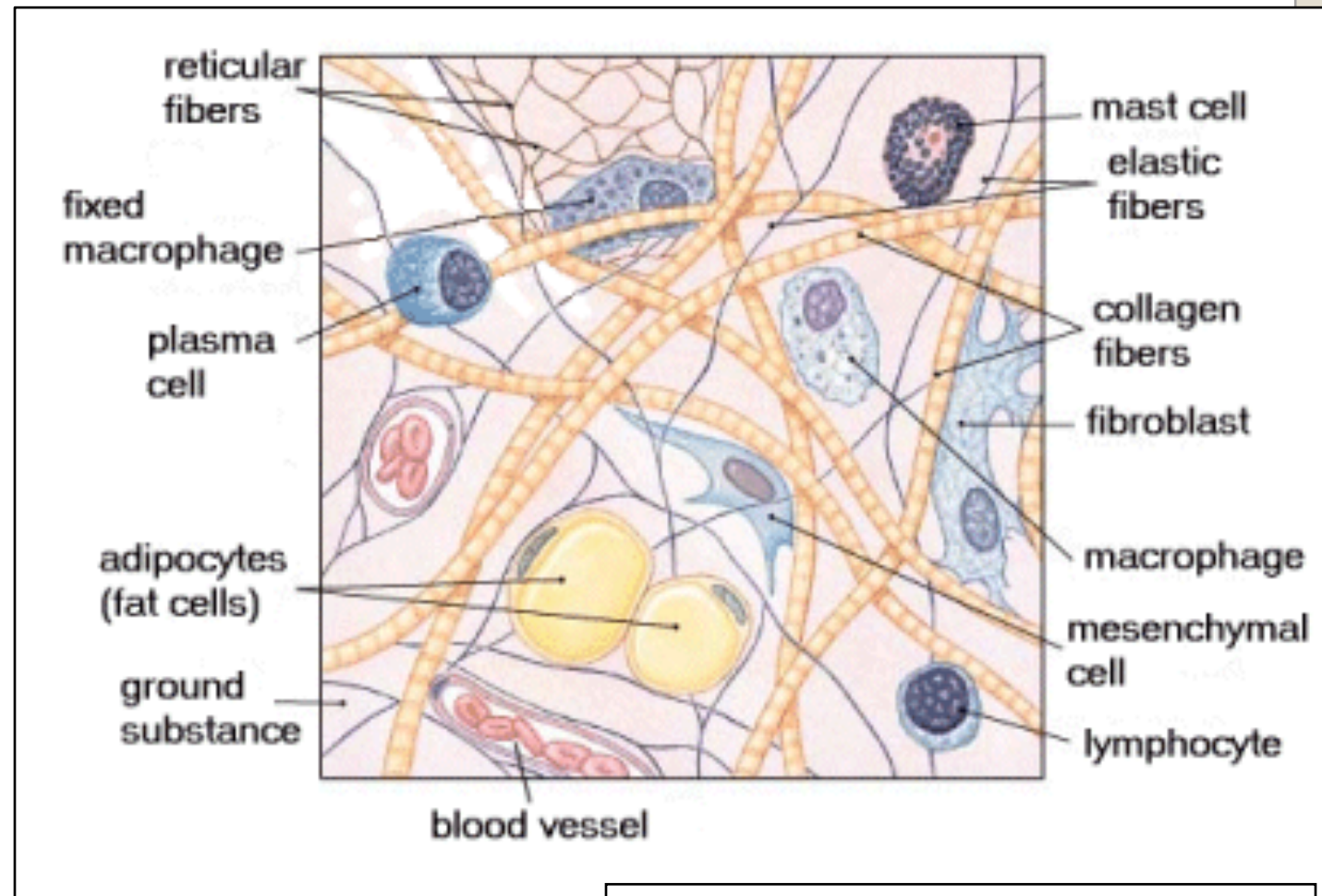


Fig.7: Components of CT.

Functions:

1. Provide form of organs.
2. Support of different organs → fatty tissue.
3. Connect and bind different structures → cartilage, bone.
4. Provide a medium for diffusion of nutrients and waste products → connective tissue proper, blood.

The Cells Of The Connective Tissue

Fibroblasts – *most common type of cell in the CT*

- **Function:** *Synthesizes fibers and produces components of extracellular matrix.*
- **Main Features:**
 - ✓ Abundant irregularly branched cytoplasm.
 - ✓ Large, pale-staining nucleus with a prominent nucleolus and a well developed rough endoplasmic reticulum and Golgi apparatus (*features of protein producing cells*).

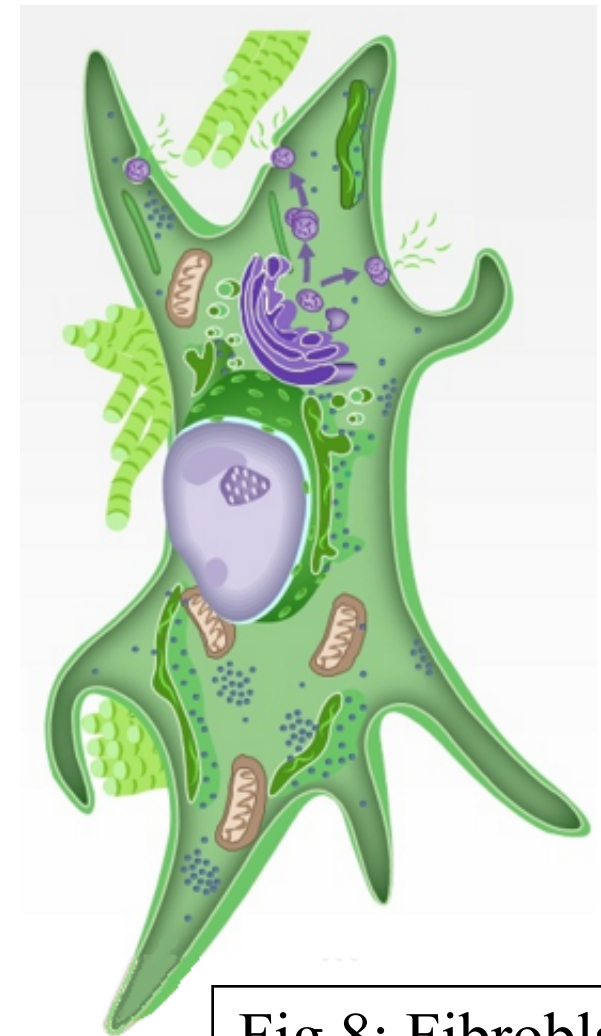
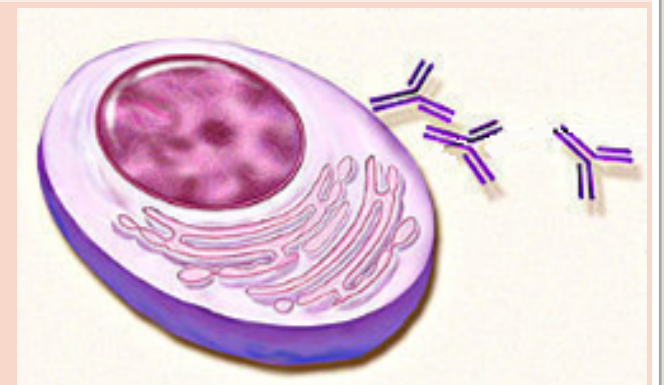
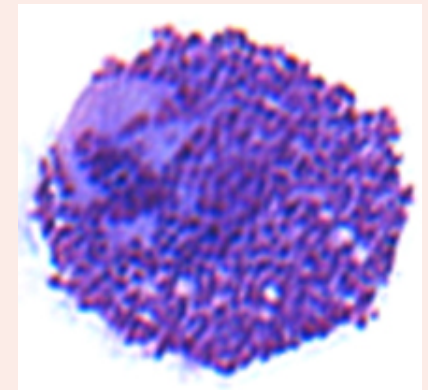
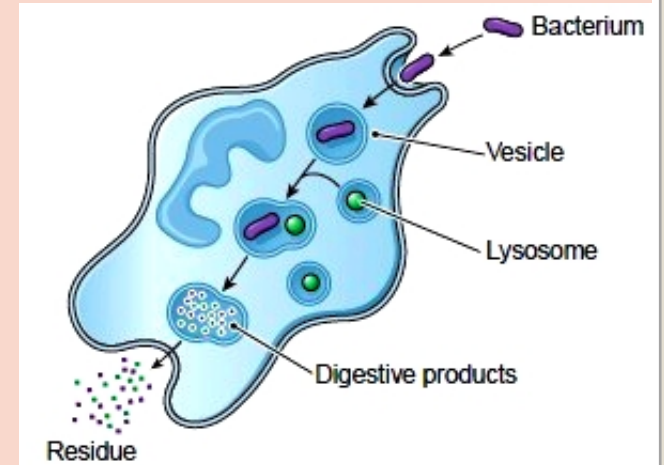


Fig.8: Fibroblast.

Cell	Important feature	Function
Macrophages	Cell surface has indentations and protrusions	Phagocytosis
Mast cells	Cytoplasm filled with dark staining secretory granules	Secretion of histamine (allergy), heparin, and others
Plasma cells	Nucleus has alternating dark and light regions (clock-face appearance)	Production of antibodies



Extracellular Matrix

Formed of:

A. Fibers: these are elongated protein structures and they include:

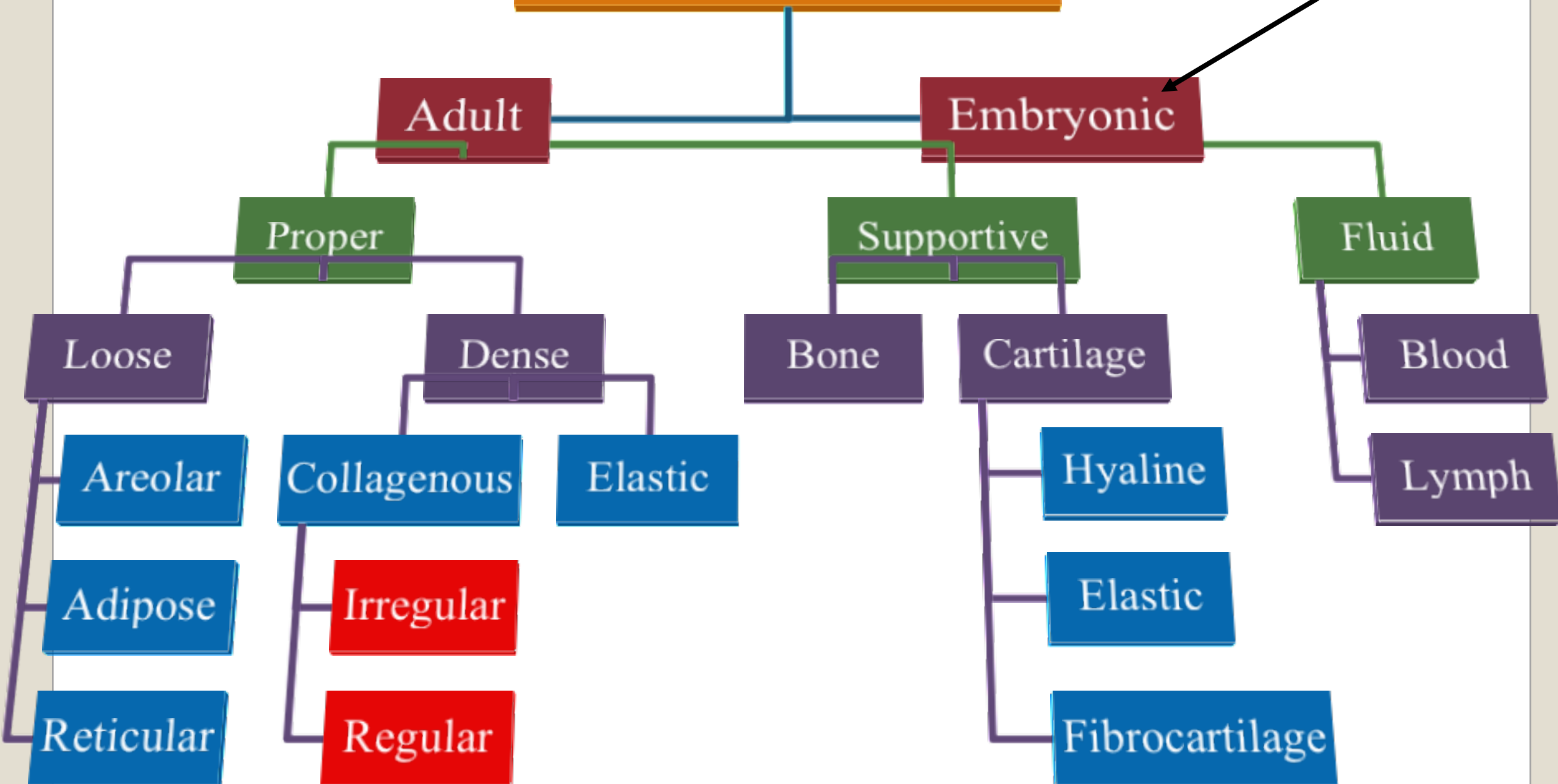
- 1) *Collagen fibers*: give strength to the tissue.
- 2) *Elastic fibers*: give elasticity to the tissue.
- 3) *Reticular fibers*: form a net that surrounds the different parts of the tissue holding them together.

B. Ground substance: formed of various large molecules with water.

Classification

Connective Tissue

Mainly in
embryos

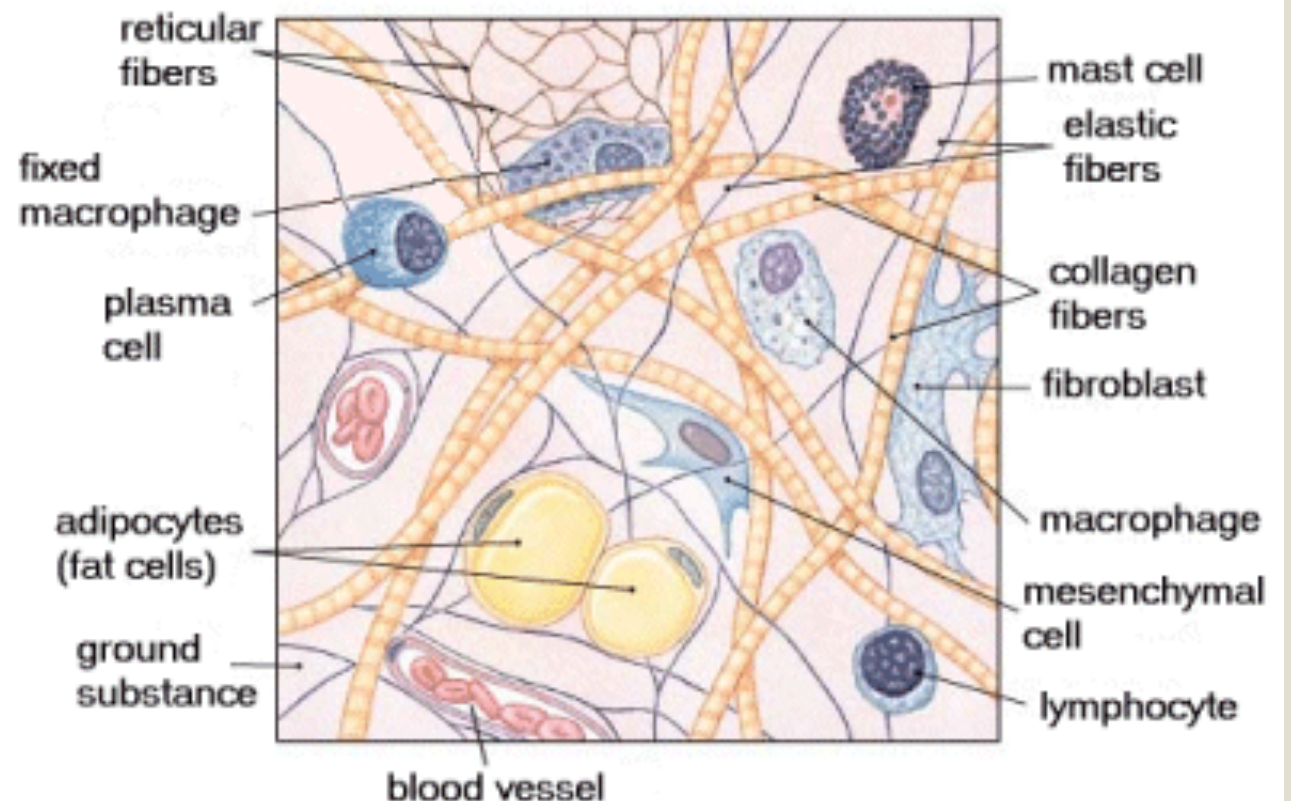


- ❑ *Proper connective tissue* is the connective tissue in which the cells that form the ECM is the fibroblast or cells derived from fibroblasts.
- ❑ *Loose connective tissue*: the fibers are loosely arranged forming a network.
- ❑ *Dense connective tissue*: the fibers are numerous and densely packed.

Loose Areolar Connective Tissue:

- ❑ A very common type of connective tissue. It gives some support to organs and tissues.
- ❑ Features:
 - Contain all three types of fibers arranged loosely.
 - All types of connective tissue cells (especially fibroblasts and macrophages) are present here.
 - All these components are embedded in an abundant semi-fluid ground substance.
 - It's highly vascular.

Fig.9: Areolar connective tissue.



❑ Found:

1. Under epithelia.
2. Around glands.
3. In the spaces between muscle and nerve fibers.
4. Around blood and lymphatic vessels.
5. It fills many small spaces making it the '*packing material*' of our body.

❑ Functions:

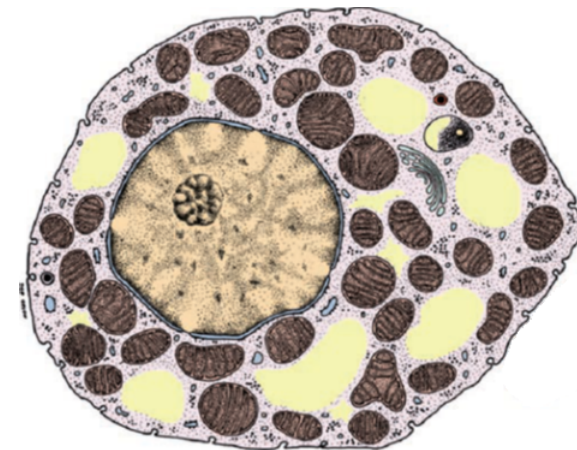
1. It gives organs their shape.
2. It is a medium for the diffusion of gases, nutrients, and waste product.
3. It is usually the first tissue where microorganisms and foreign particles enter the body; therefore, it's an important site for immune and inflammatory responses.

Adipose Tissue

- ❑ Is a type of loose connective tissue characterized by the abundance of a specific type of cells called adipocytes.
- ❑ It is of two types:

	<i>White Adipose Tissue</i>	<i>Brown Adipose Tissue</i>
Type of adipocyte	White	Brown
Gross color	White to yellow (due to presence of fat)	Brown due to abundance of blood vessels
Main function	Storage of energy	Production of heat
Location	• Present throughout life • All over the body	• Abundant in infants • Decrease with age • In adults found in few areas

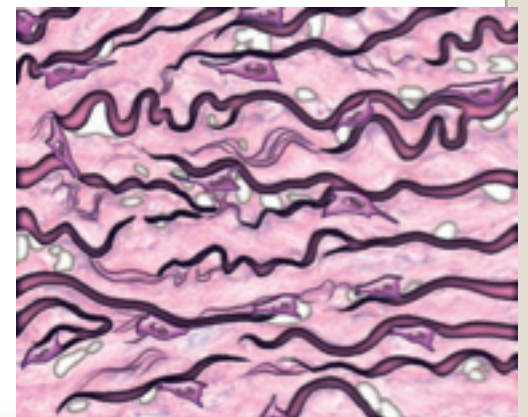
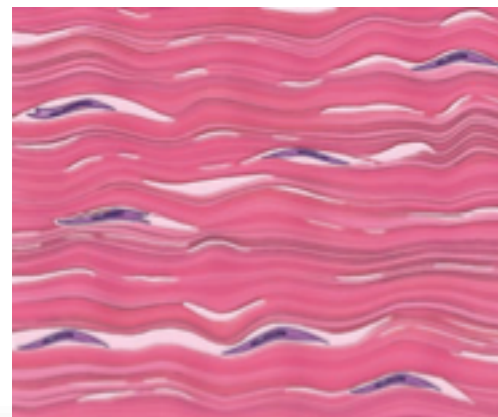
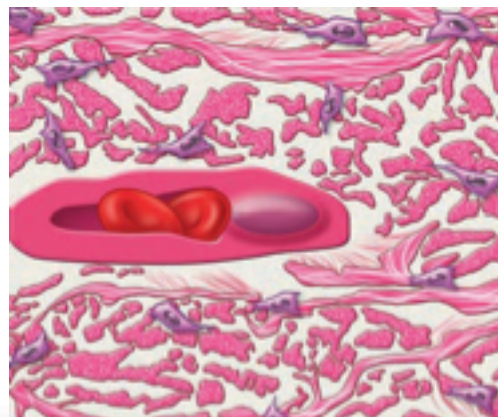
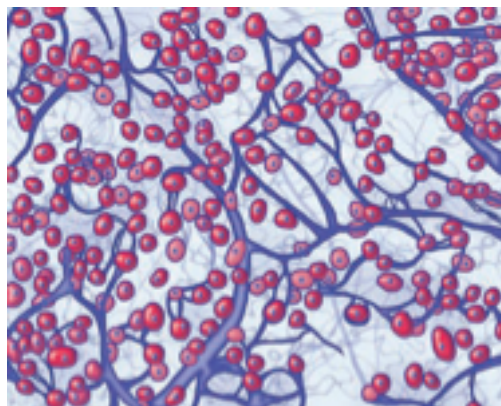
	White Adipocyte	Brown Adipocyte
Shape	Spherical	Polygonal
Size	Larger	Smaller
Fat droplet	Single (unilocular)	Multiple (multilocular)
Nucleus	Peripheral	Central
Mitochondria	Numerous	Numerous



- White adipocytes secrete the hormone Leptin, which is a satiety factor.

Other types of connective tissue proper:

Type	<i>Loose</i>		<i>Dense</i>		
	<i>Reticular</i>		<i>Collagenous</i>		<i>Elastic</i>
			<i>Irregular</i>	<i>Regular</i>	
Fibers	Reticular		Collagen, passing in all directions	Collagen, passing in one direction	Elastic
Function	Holds parts of organs together		Resists forces from all directions	Resists traction forces	Provides elasticity
Location	Lymph node, spleen		Dermis of skin	Tendons, ligaments	Aorta, vocal cords



Cartilage

- *Cartilage is a supportive type of connective tissue whose ECM is of a firm consistency which allows the cartilage to bear mechanical stresses.*
- *Cartilage has no vascular or nervous supply.* Nutrients and stimuli reach this tissue by diffusion from the perichondrium or from the nearby synovial fluid.
- **Perichondrium:**
 - Is a layer of dense connective tissue that covers all hyaline cartilage (except in joints) and all elastic cartilage. It's richly vascular and contains collagen fibers and fibroblast cells.

Functions of Cartilage:

1. Support of soft tissues, as in the larynx and trachea.
2. Acts as a shock absorber as in the intervertebral discs.
3. Hyaline cartilage is important for development and growth of bones before and after birth.

Chondrocytes:

- ☐ Oval or round cells.
- ☐ Located inside spaces in the surrounding matrix called *lacunae*.
- ☐ Each lacuna may contain 1-8 chondrocytes.
- ☐ **Function:** production of the extracellular matrix of cartilage.

	Hyaline	Elastic	Fibrocartilage
ECM rich in	Hyaluronic acid	Elastic fibers	Collagen fibers
Arrangement of cells in lacunae	Clusters	Clusters	Axially
Perichondrium	Yes (except in joints)	Yes	No
Location	Most common: • Articular surfaces of some joints • Cartilages of the nose and trachea • Thyroid and cricoid cartilages of the larynx • Costal cartilages • The epiphyseal growth plate	• Auricle of the ear • Wall of external auditory canal • Auditory tube • Epiglottis and cuneiform cartilages of the larynx	• Intervertebral discs • Pubic symphysis

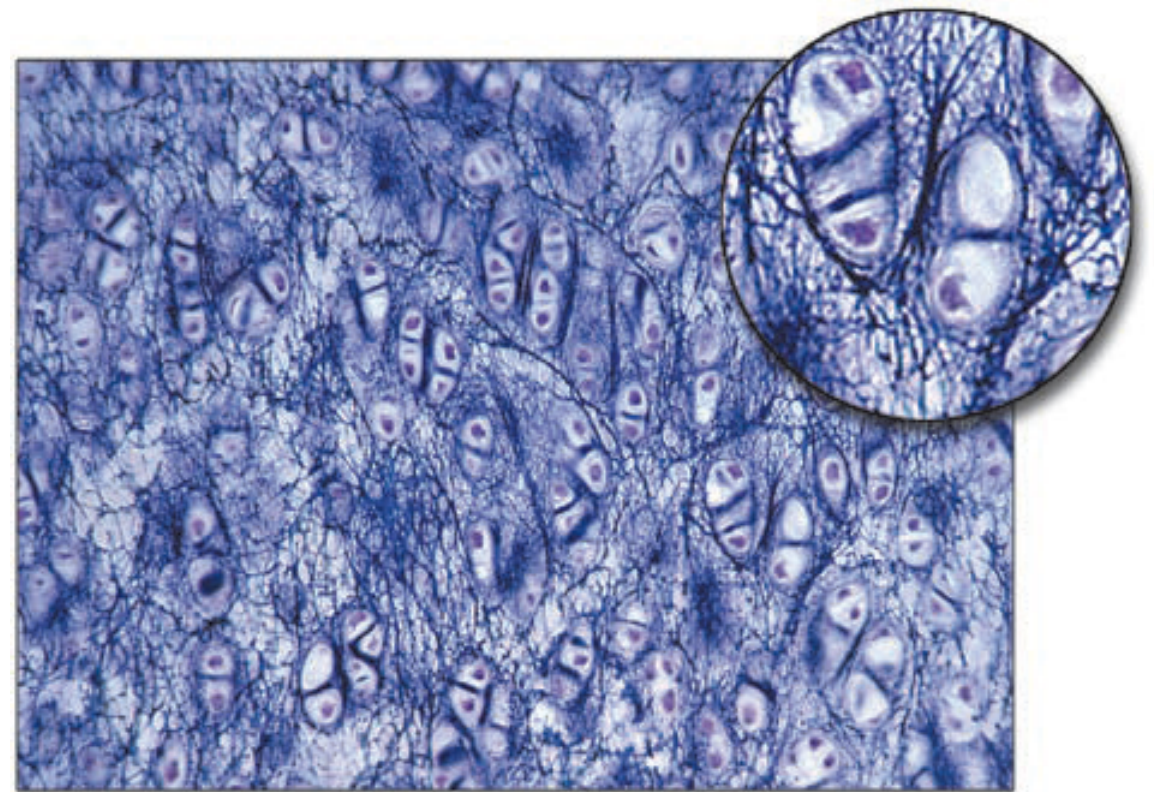
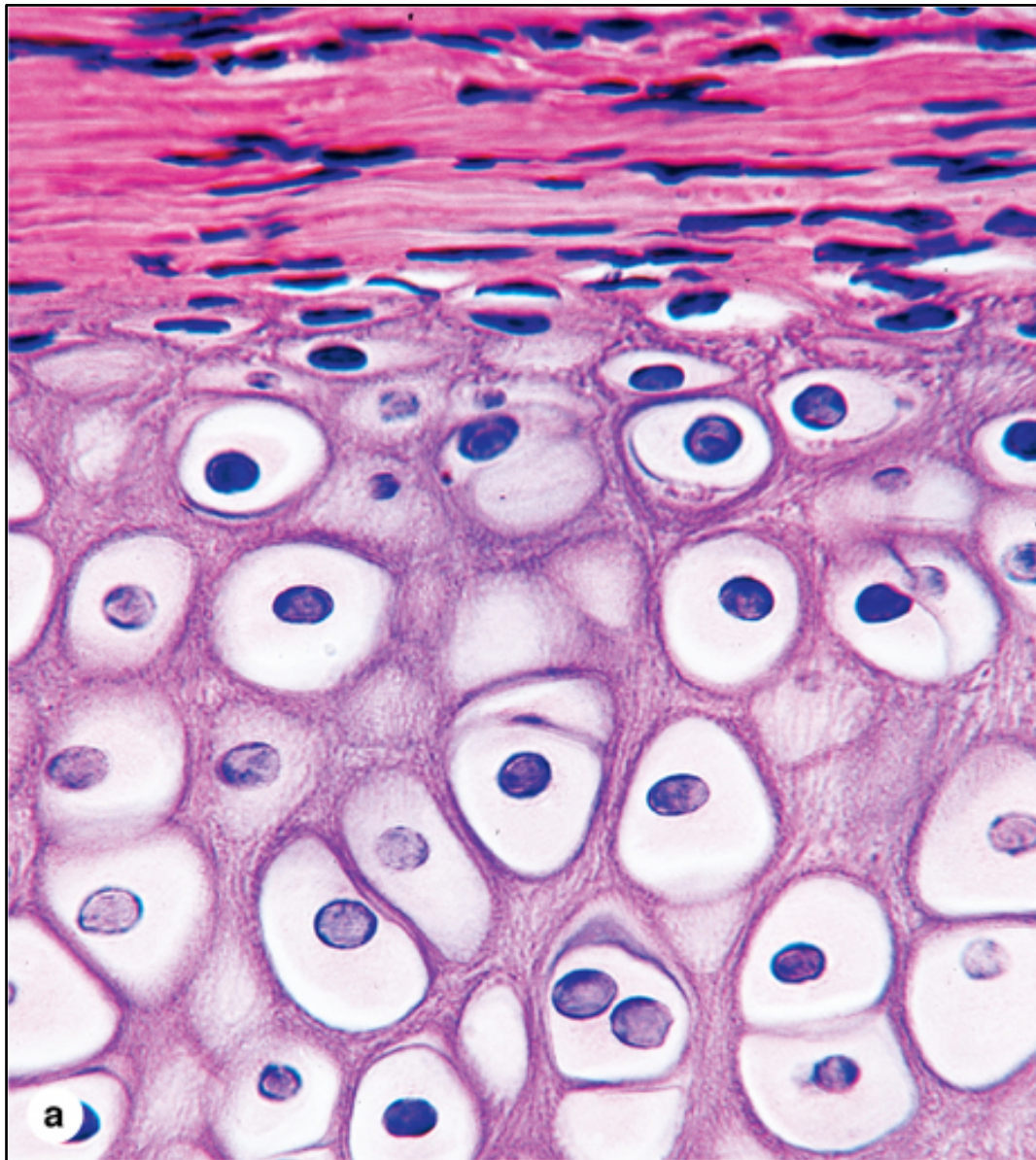


Fig.10: Left, hyaline cartilage. Above, elastic cartilage. Below, fibrocartilage.

