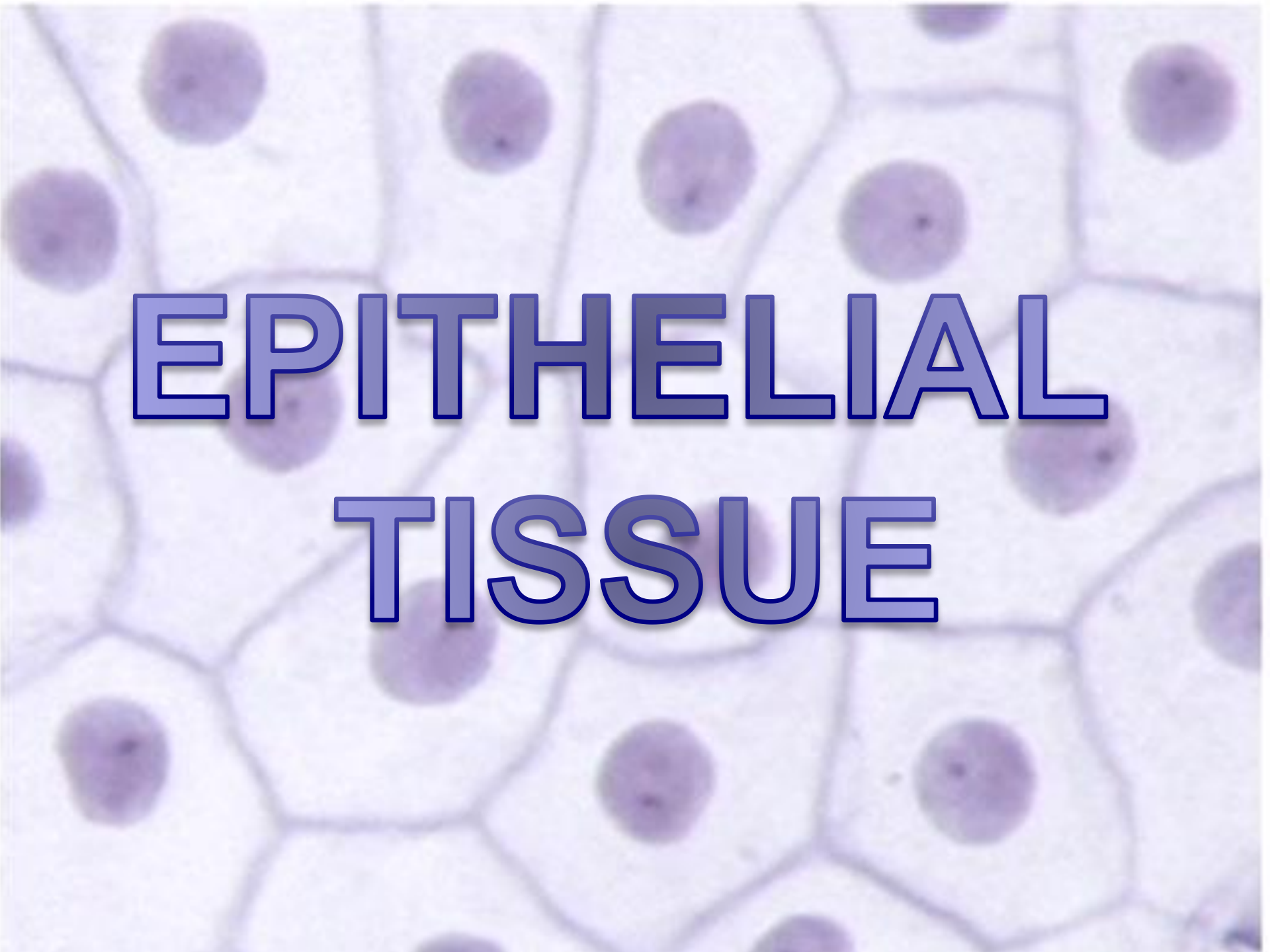


A microscopic image of epithelial tissue, showing a layer of cells with prominent, dark purple nuclei and light purple cytoplasm. The cells are arranged in a regular, brick-like pattern, typical of simple cuboidal or columnar epithelium. The text "EPITHELIAL TISSUE" is overlaid in the center in a large, blue, outlined font.

# EPITHELIAL TISSUE

# Epithelial tissue

## 1. Epithelia

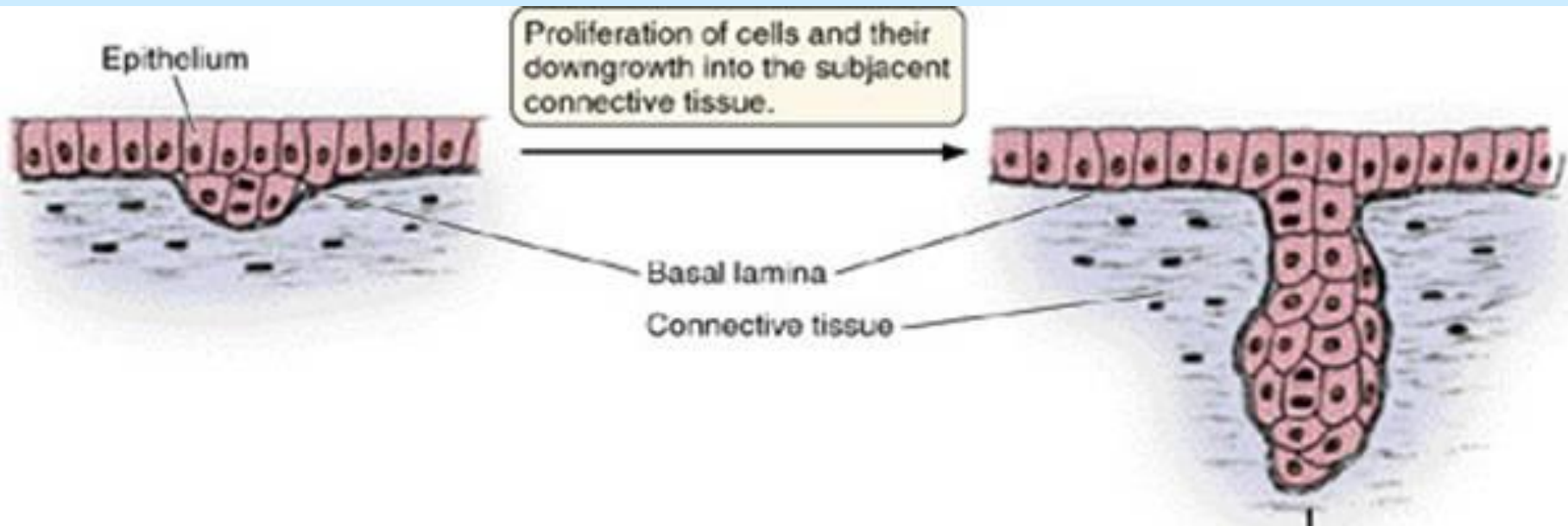
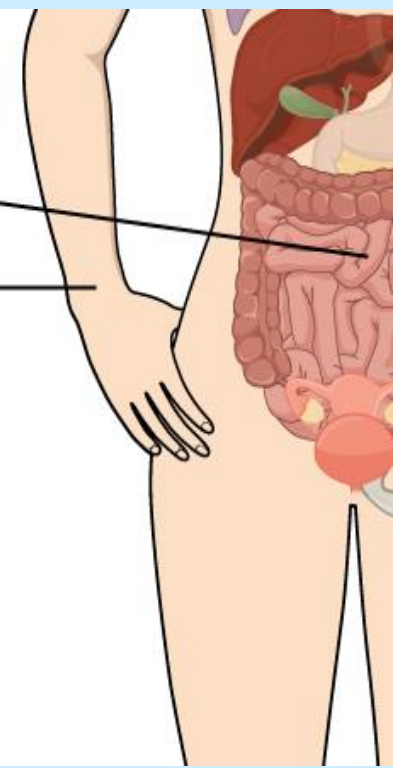
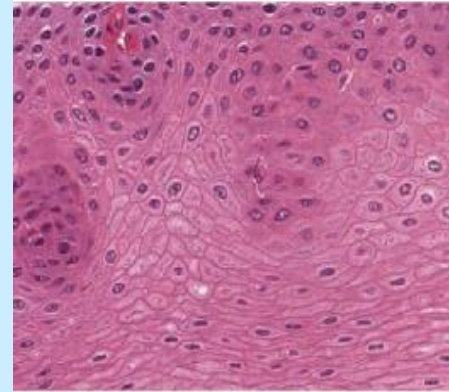
- cover external surface of the body and line the body on its internal surface

## 2. Glands

- originate from invaginated epithelial cells

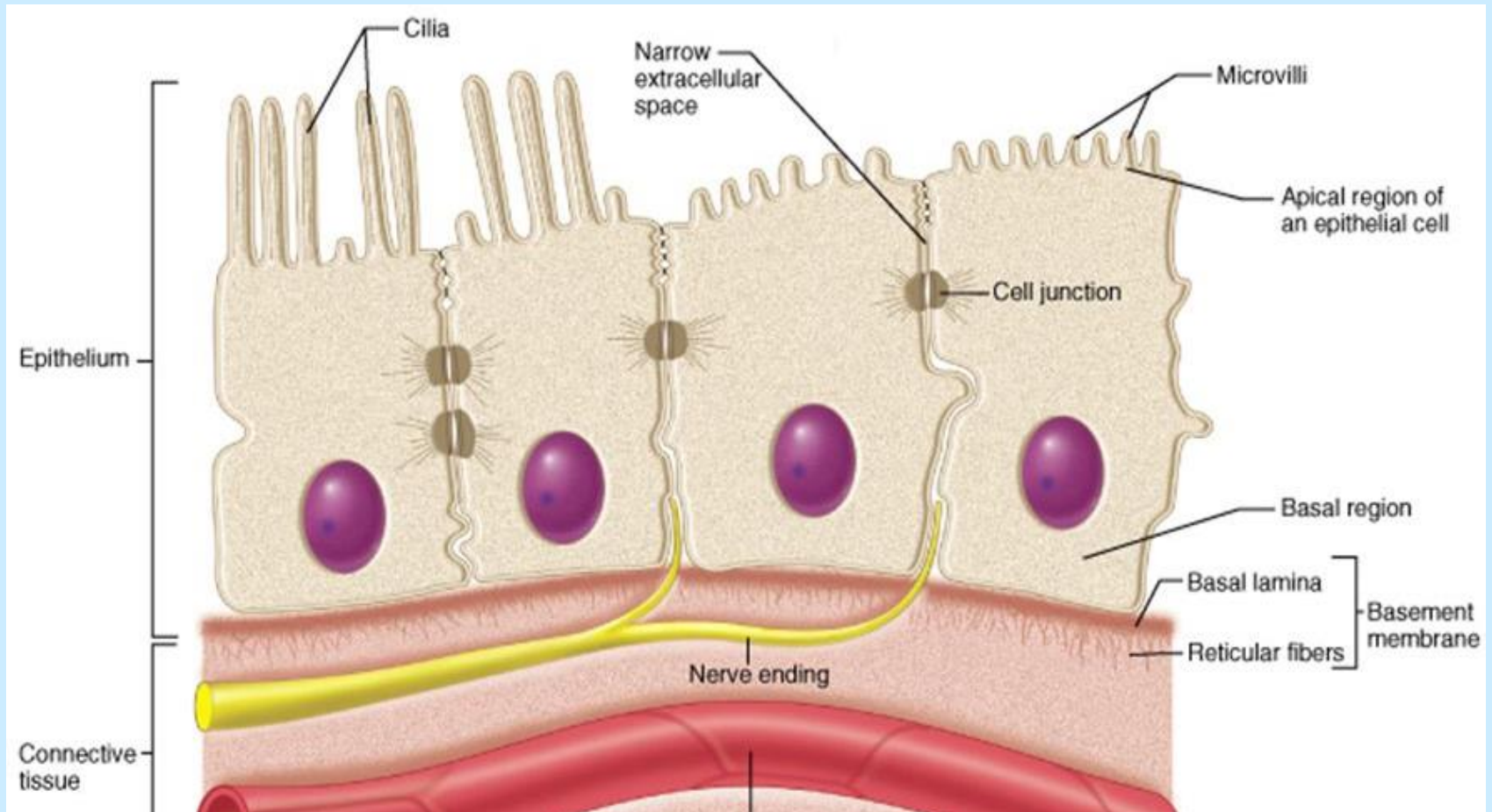
### Epithelial tissue

Lining of GI tract organs  
and other hollow organs  
Skin surface (epidermis)



# Basic characteristic of epithelia

- cells - tightly bound by junctional complexes
- small amount of extracellular matrix
- cells - arranged in one or more layers, separated from the underlying tissue by a **basal lamina**.



# Functions of epithelial tissue

- Protection – Skin, lining of internal organs
- Absorption – intestines
- Filtration – Kidney
- Secretion – Hormones, mucus, sweat, etc.
- **Detection of sensations (taste buds of the tongue, retina of the eye)**

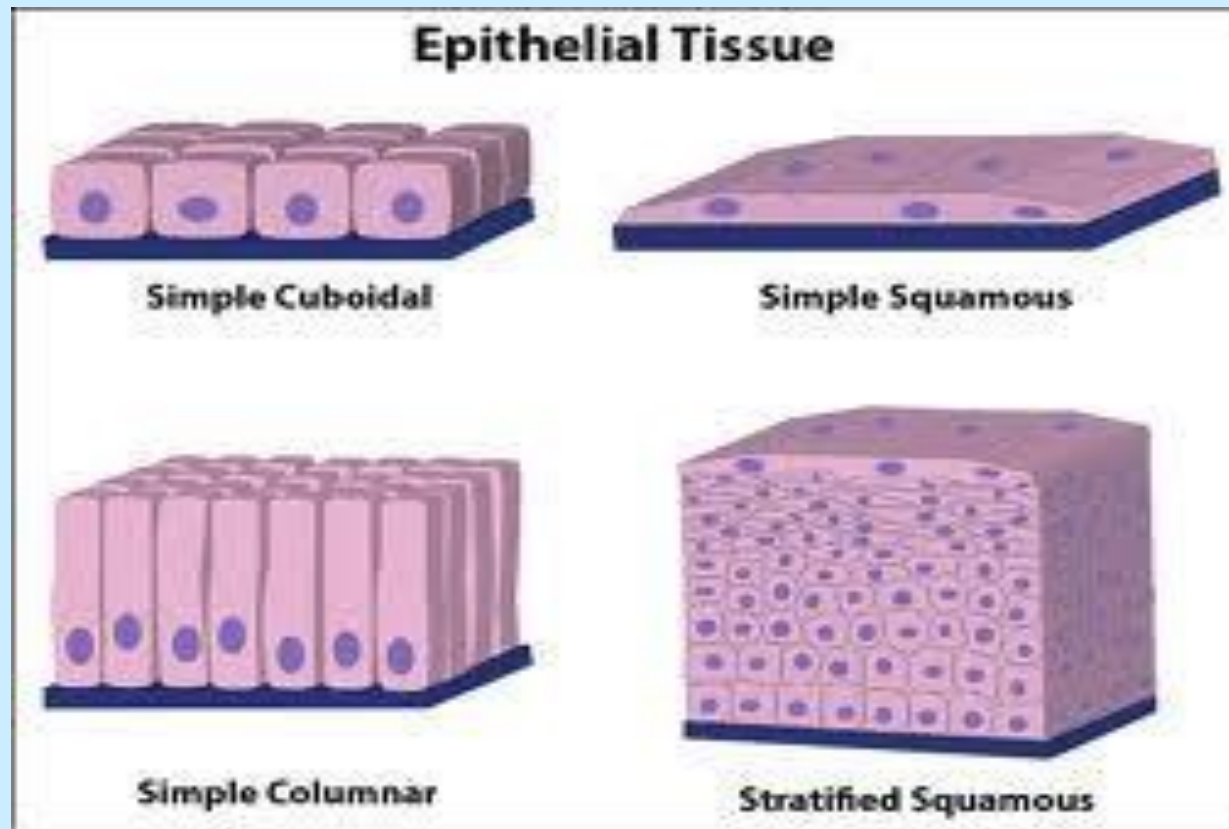
# Classification of epithelia

According to;

✓ the number of cell layers between the basal lamina and the free surface - **simple epithelium, stratified epithelium**

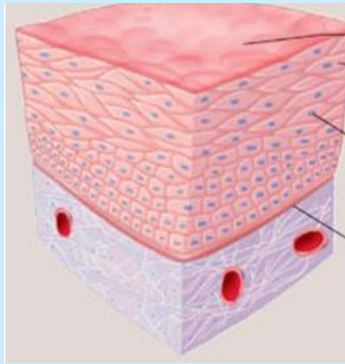
✓ the morphology (shape) of the epithelial cells

- **squamous (flat)**
- **cuboidal**
- **columnar**



# Stratified epithelia – classification

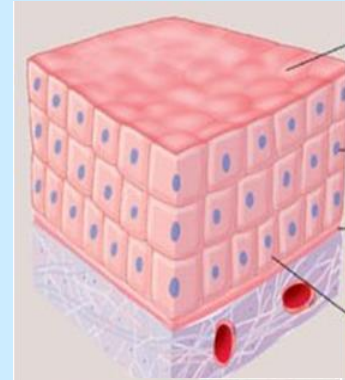
- by the morphology of the cells in superficial layer



**stratified  
squamous  
epithelium**



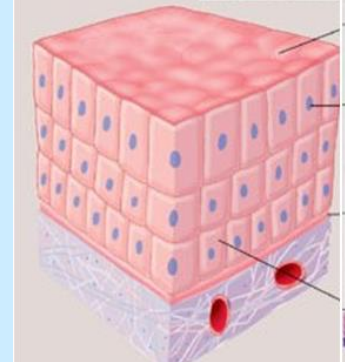
**epidermis of  
skin, esophagus**



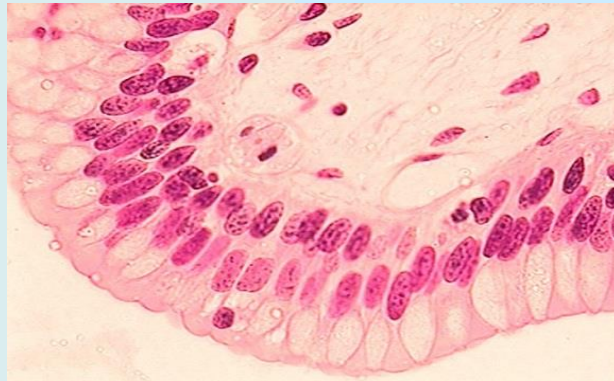
**stratified  
cuboidal  
epithelium**



**ducts of sweat  
glands usually  
two layers**



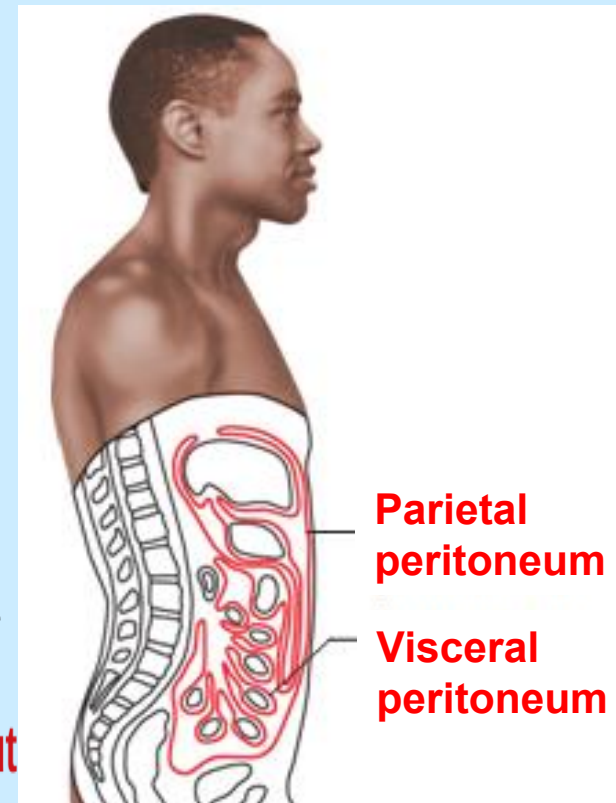
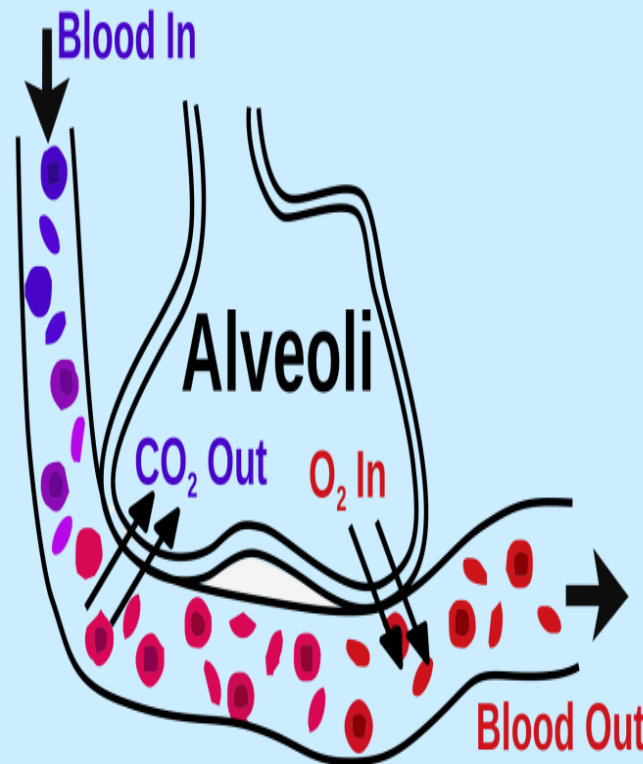
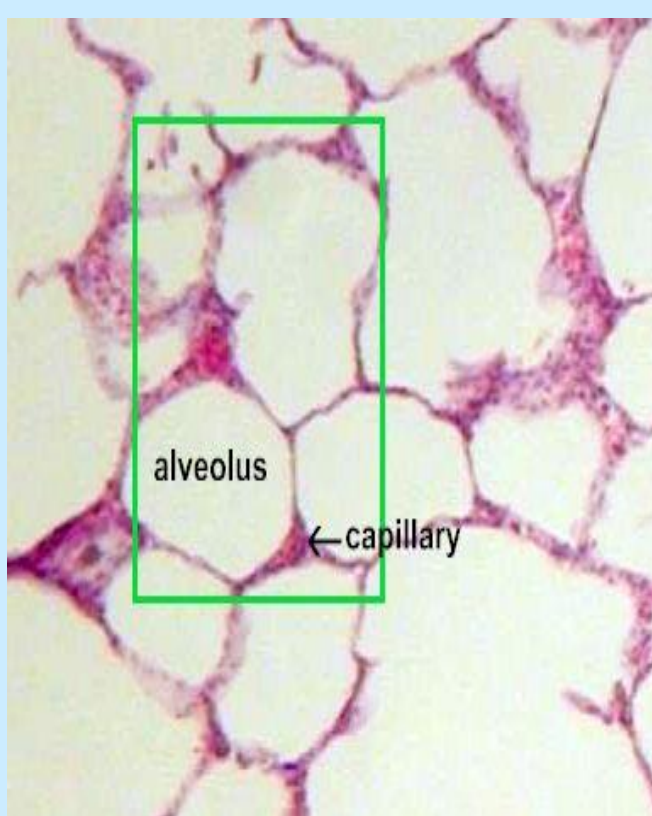
**stratified  
columnar  
epithelium**



**male urethra**

# Simple Squamous:

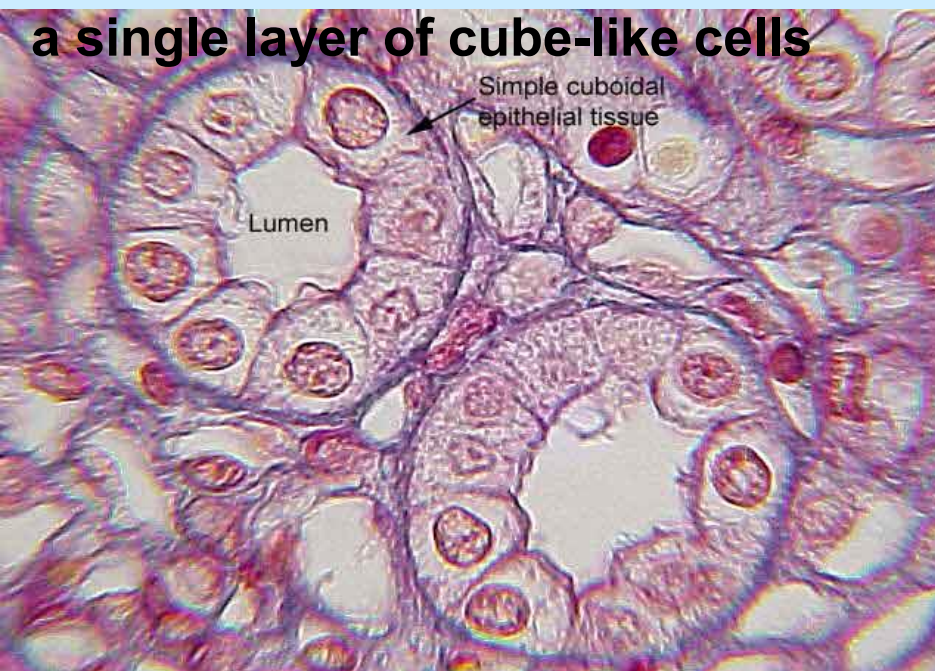
- a single layer of flat cells - allows materials to diffuse through it - in the alveolar sacs in lungs (exchange of  $\text{CO}_2$  and  $\text{O}_2$ ).
- covers organs (serous membranes - **peritoneum**) in abdominal cavity



endothelium of capillary

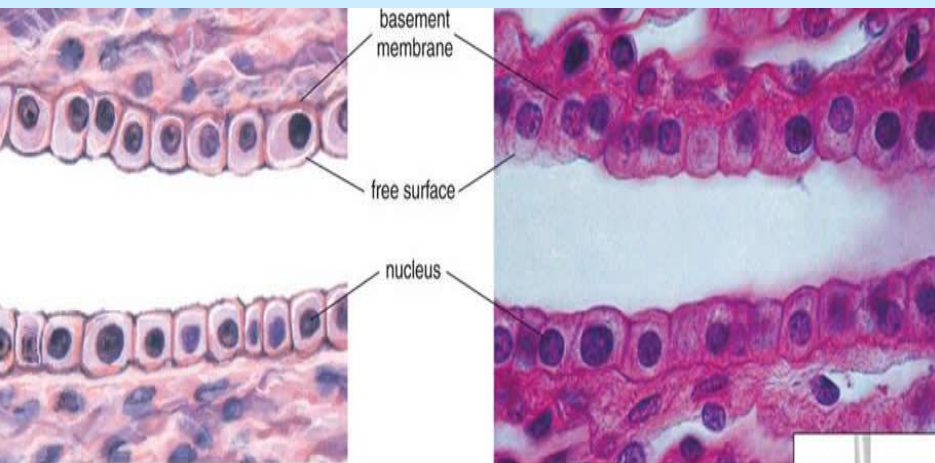
**Simple Squamous epithelium - forms  
endothelial lining of blood vessels**

**a single layer of cube-like cells**



## Simple Cuboidal:

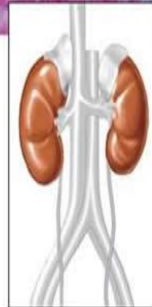
- a greater volume than squamous cells - more organelles.
- cells - carrier proteins - active transport and facilitated diffusion of material
- in the kidney - cells excrete the waste products of metabolism and reabsorb any needed materials from urine before it's excreted.



Simple Cuboidal Epithelium

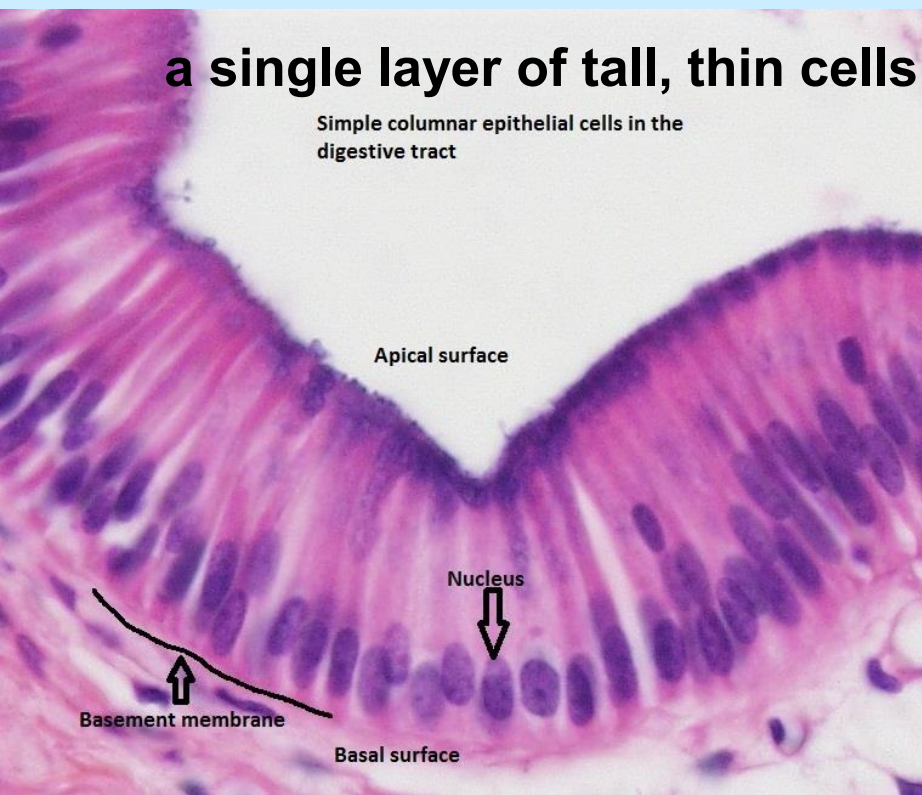
Location:  
Lines kidney tubules; ducts of many glands; covers surface of ovaries

Function:  
Secretion; absorption



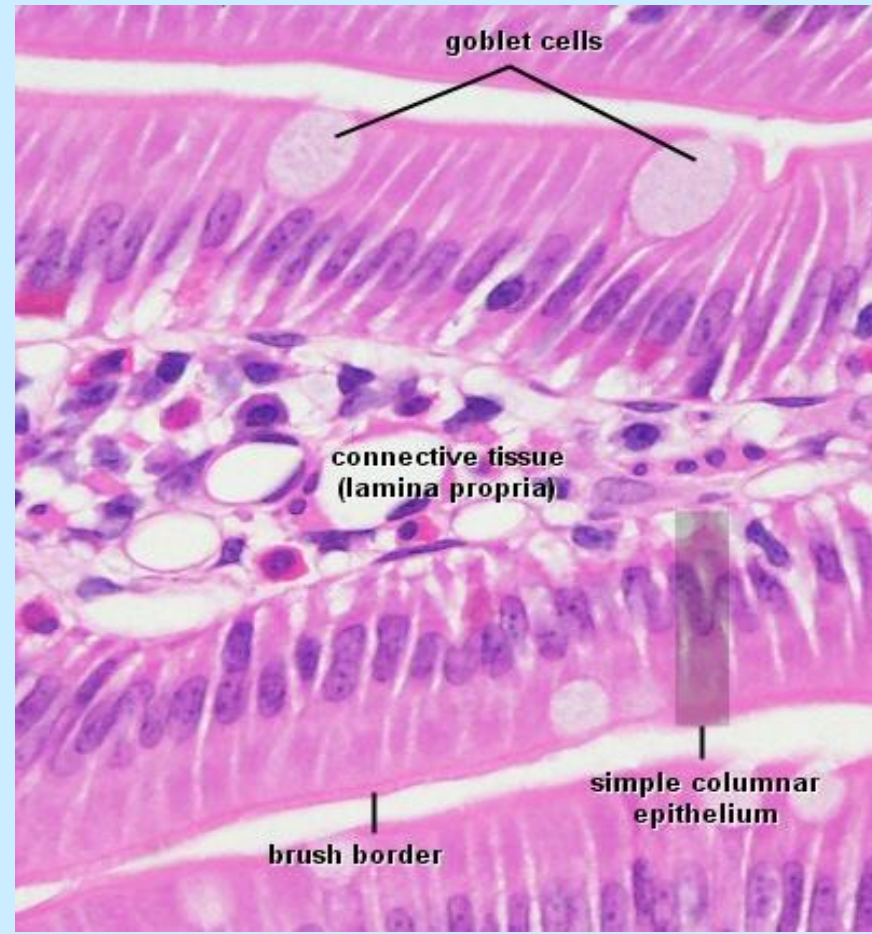
## a single layer of tall, thin cells

Simple columnar epithelial cells in the digestive tract

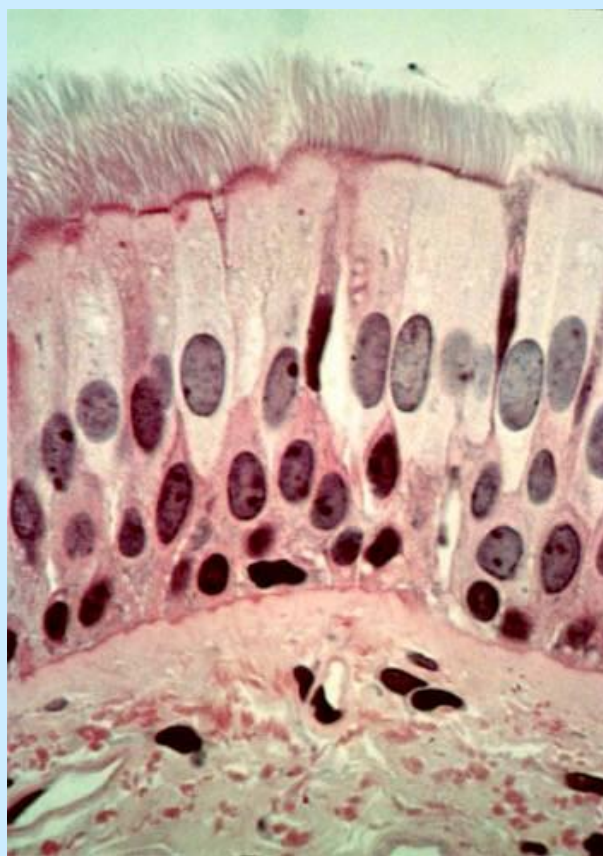


## Simple Columnar:

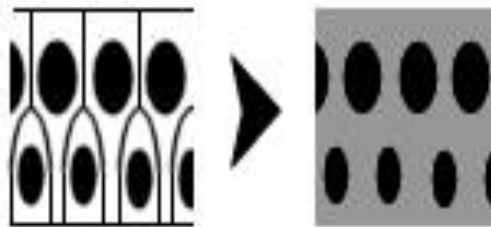
- in the intestine – production of digestive enzymes, absorption of nutrients



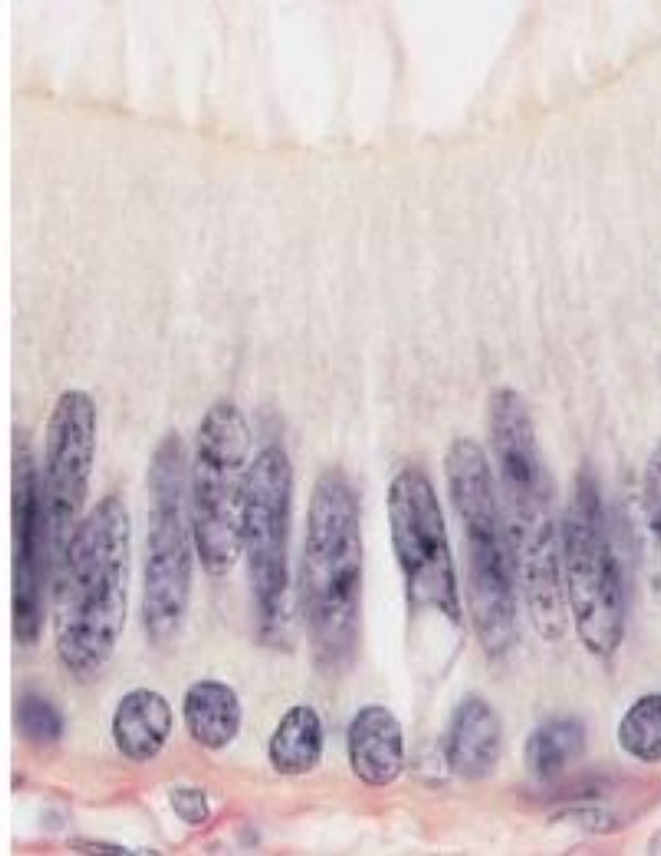
A **goblet cell** - a simple gland  
- secretes gel forming mucins  
- the major component of **mucus** (covers the surface of digestive tract)



pseudostratified  
epithelium

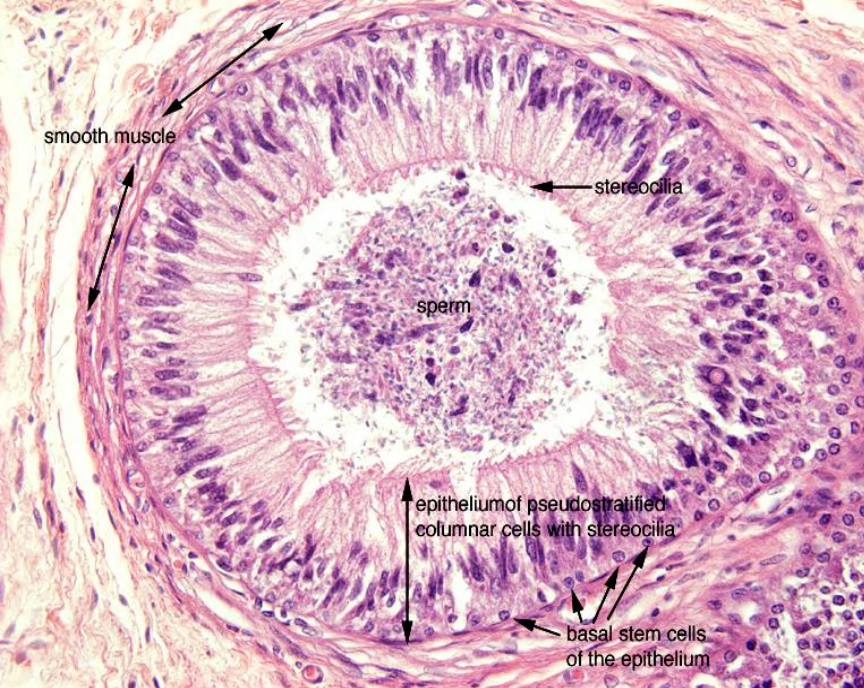


**Simple epithelium**



**Pseudostratified Columnar** - appears to be stratified but is simple

- one layer of cells - all cells attached to the basement membrane, but not all cells have a free surface - short cells are covered by tall cells - two, or more layers of nuclei

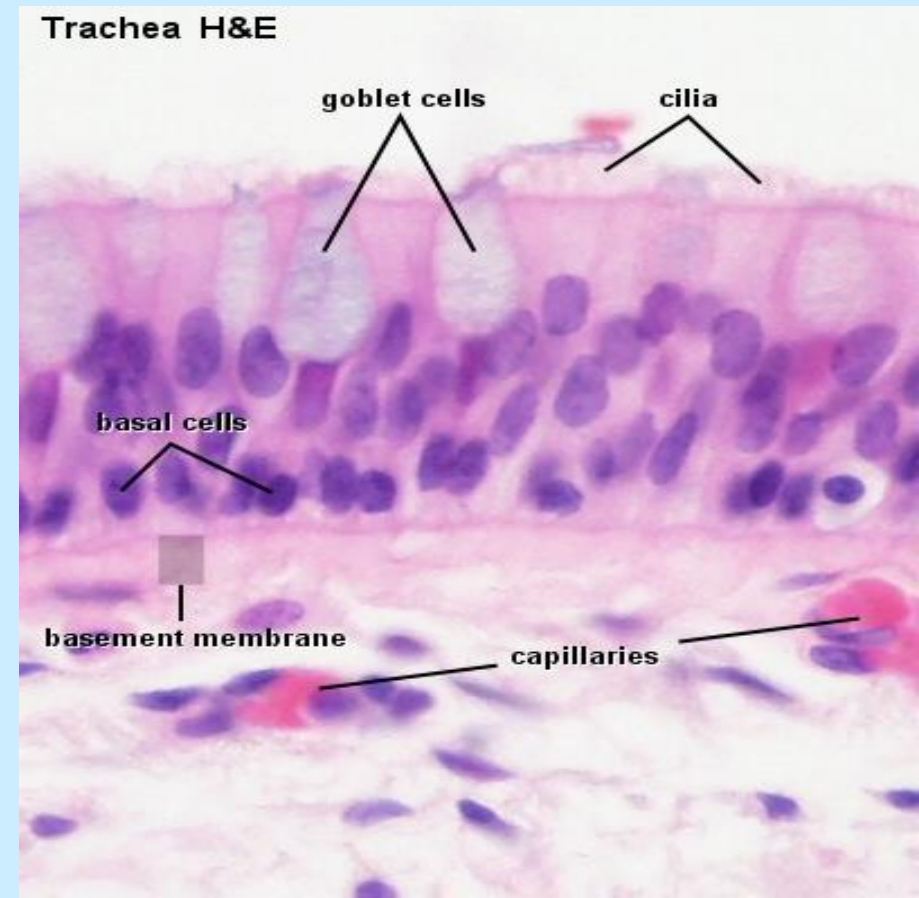


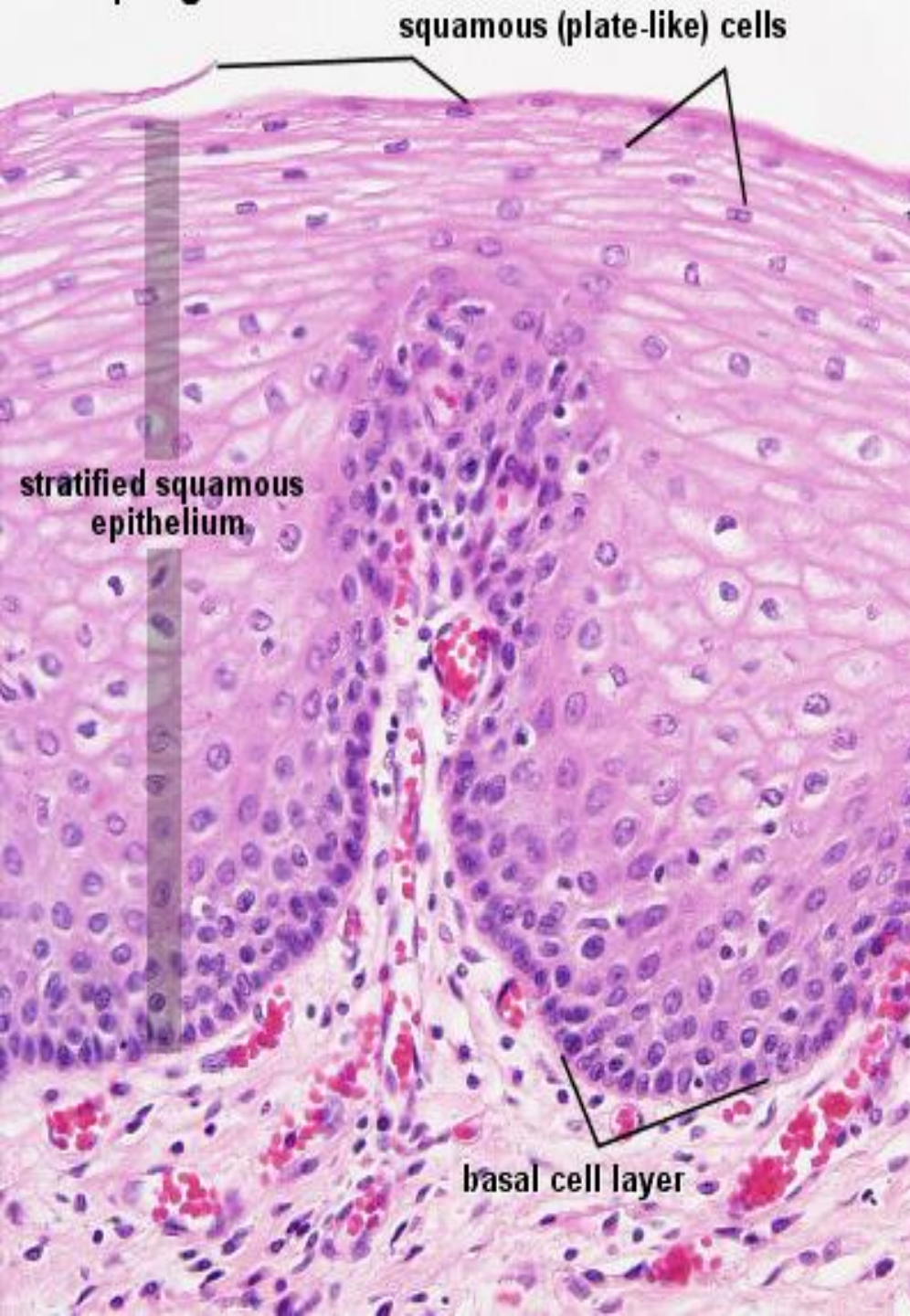
## Pseudostratified columnar epithelium- a single layer of cells

- in the male urethra and epididymis

## Pseudostratified ciliated columnar epithelium

- cells with cilia on the apical surface
- **in respiratory tract:**  
trachea, primary bronchi and nasal cavity





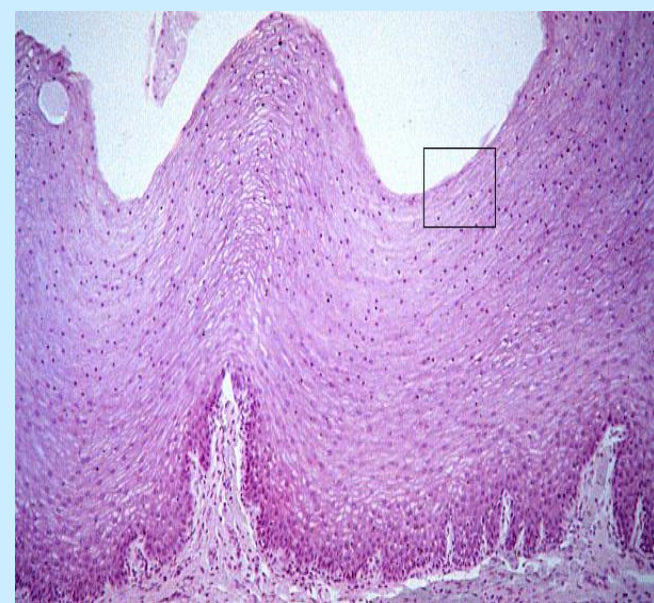
**Stratified Squamous:** a multilayered epithelium

- the deepest (basal) cells - columnar
- the outer layer squamous.
- columnar cells divide, as outer cells get damaged, new cells below are produced, replacing damaged cells.

# Types of stratified squamous epithelium

- Nonkeratinized
- Parakeratinized
- Keratinized

cells of superficial layer nucleated - are alive



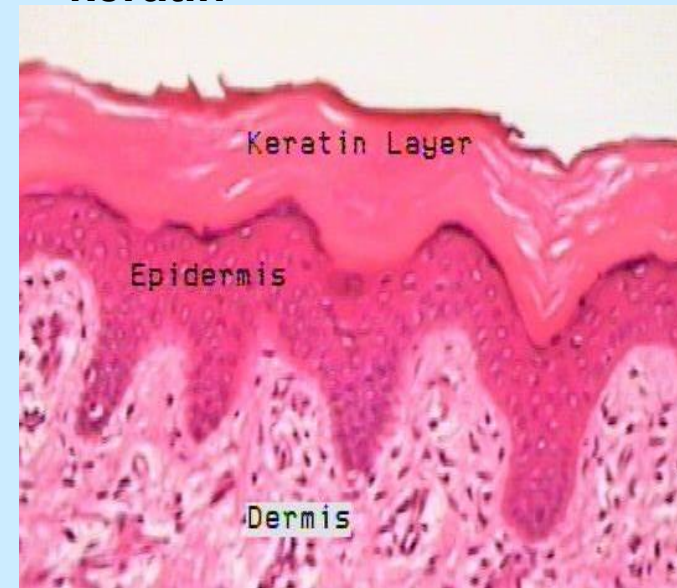
**Nonkeratinized**  
- mouth, esophagus, vagina

cells of superficial layer have nuclei (\*) but are filled with keratin



**Parakeratinized** -  
gingiva

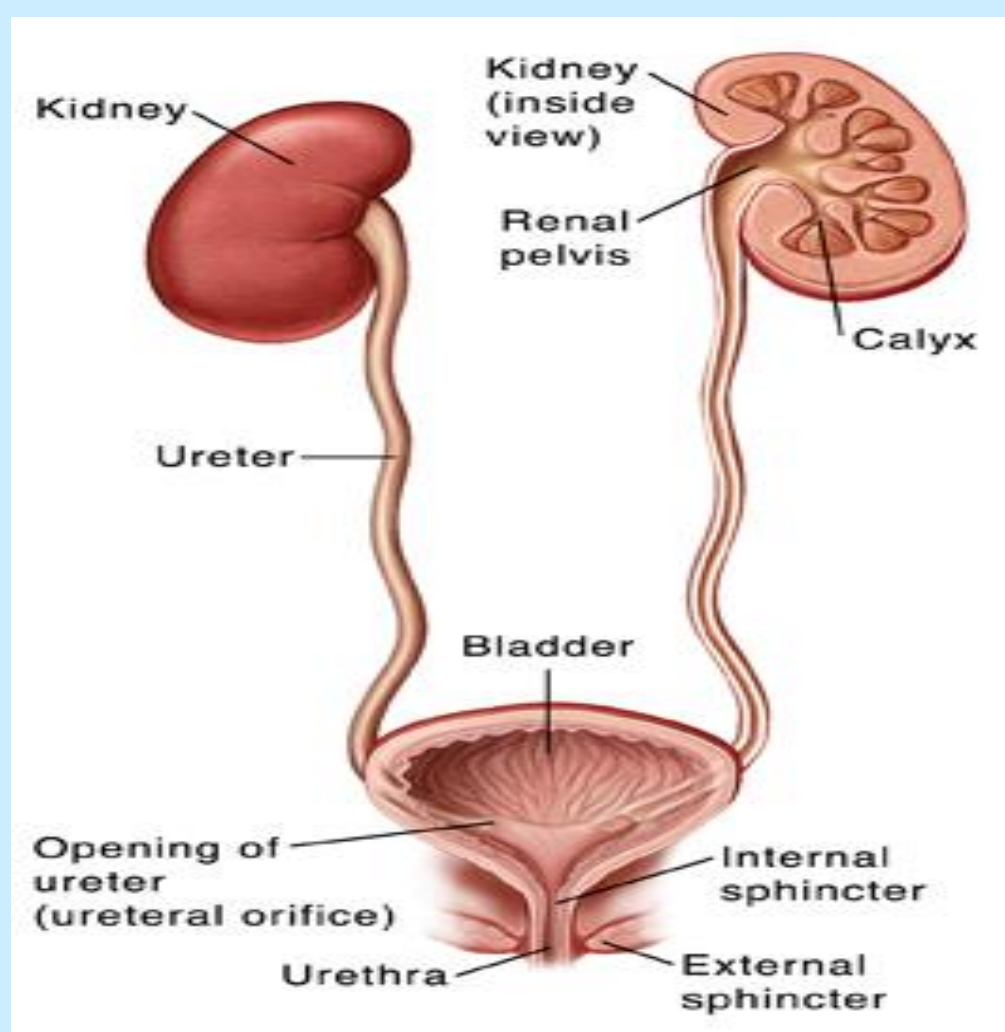
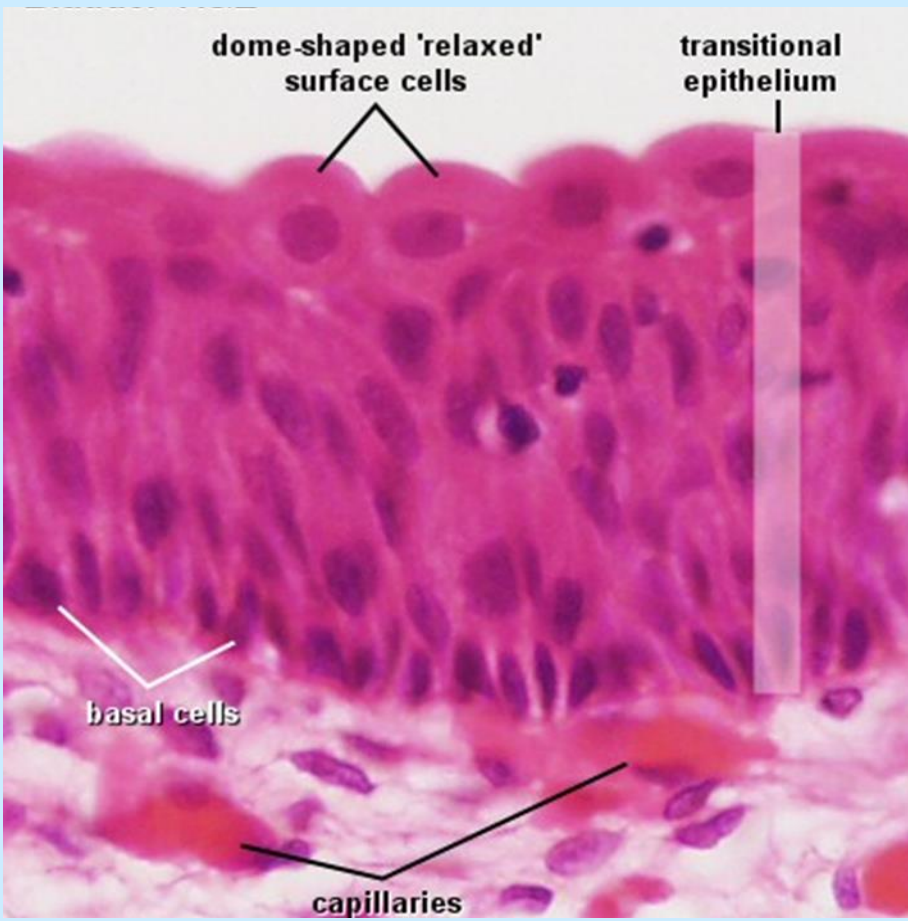
cells of superficial layers - dead - nuclei are invisible, cytoplasm - keratin



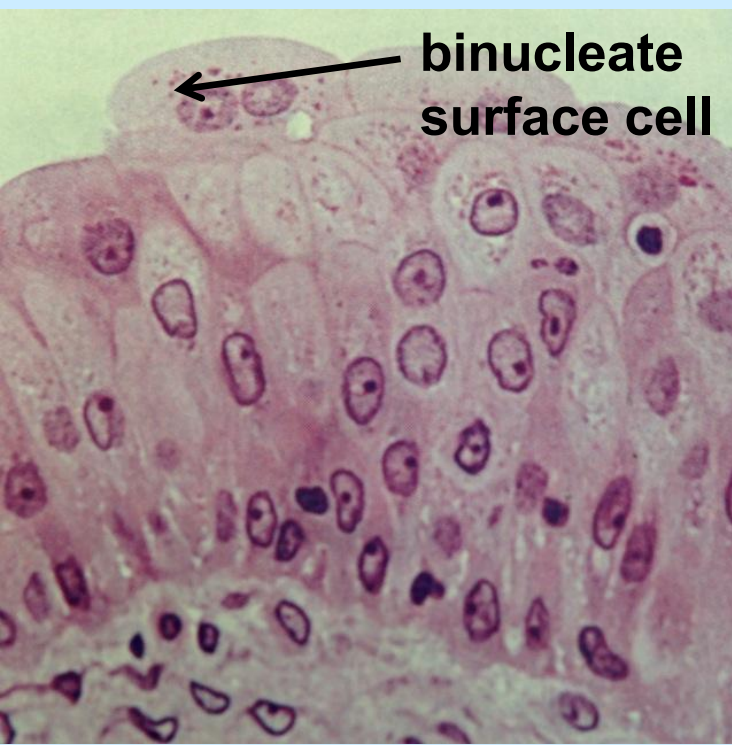
**Keratinized**  
- epidermis of skin

# Transitional epithelium- stratified epithelium

- the urinary tract from the renal calyces to the urethra

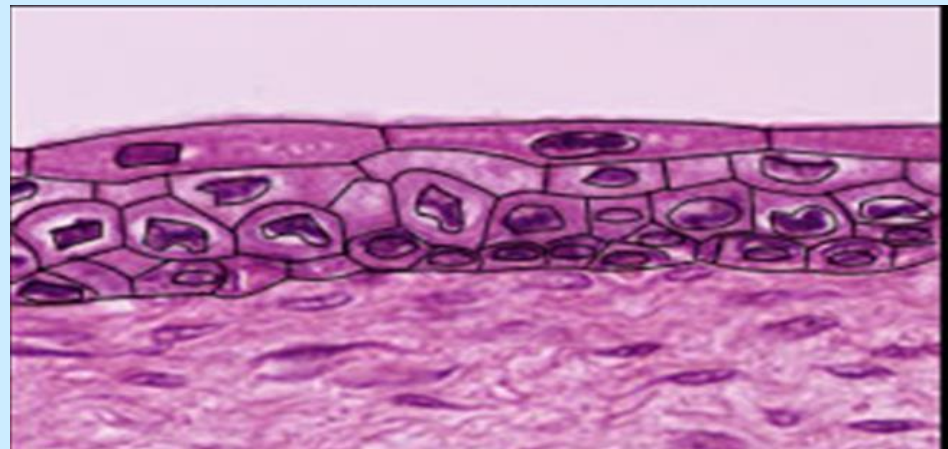
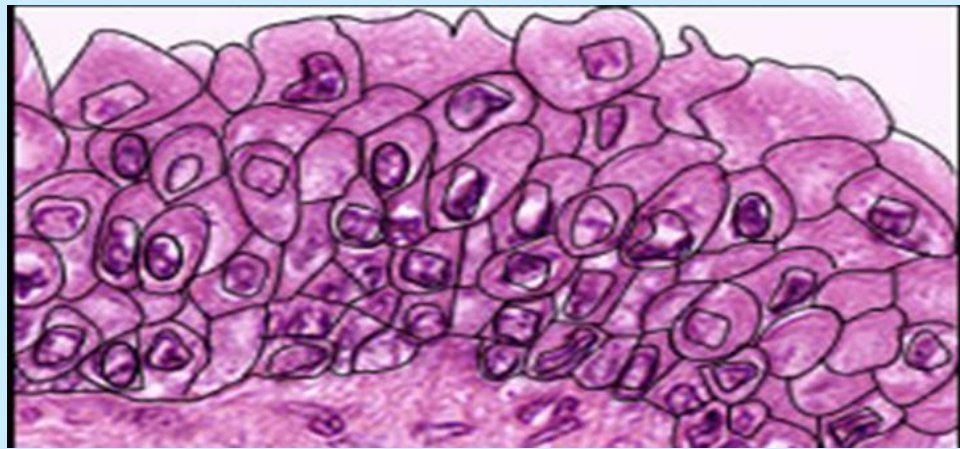


- many layers of low-columnar or cuboidal cells



## Transitional epithelium:

- capable of stretching and changing shape.
- when the tissue is stretched, cells are flat to cover more area, and resemble squamous cells.



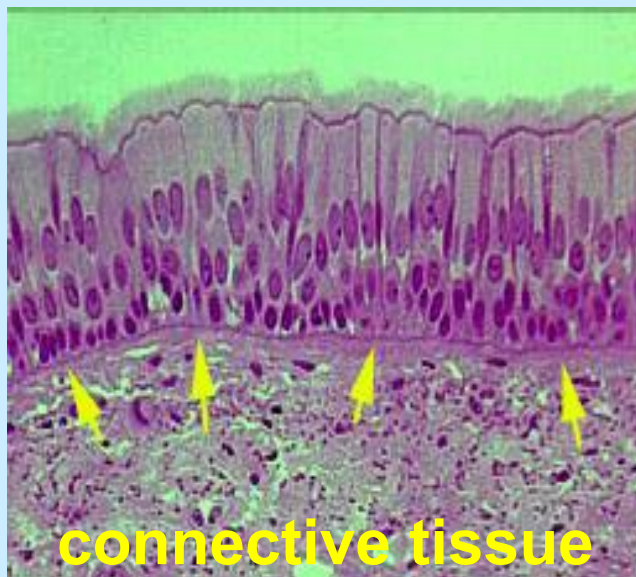
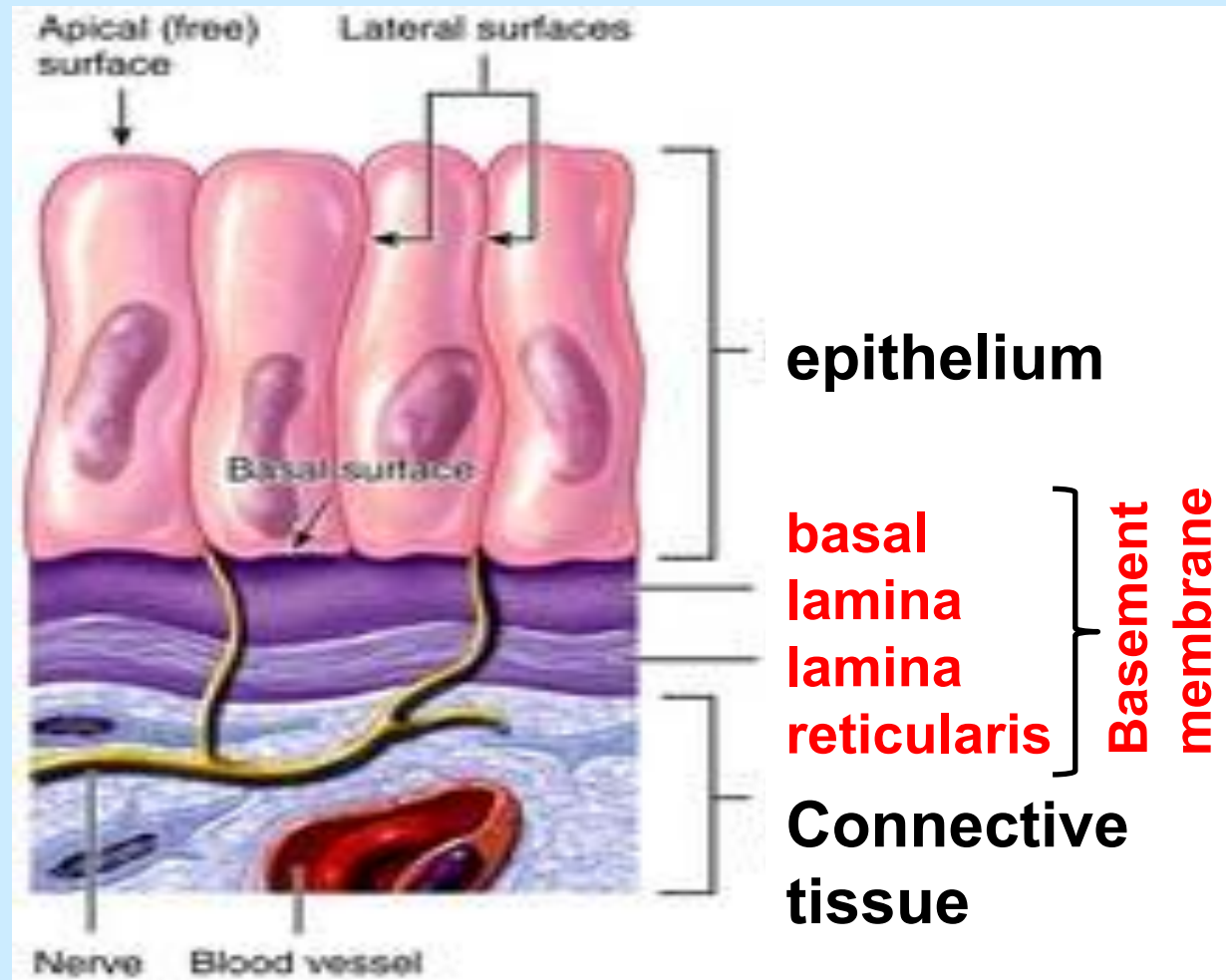
**empty urinary bladder** – superficial cells large and dome-shaped  
**bladder distended** - superficial cells flattened,

# Basement membrane

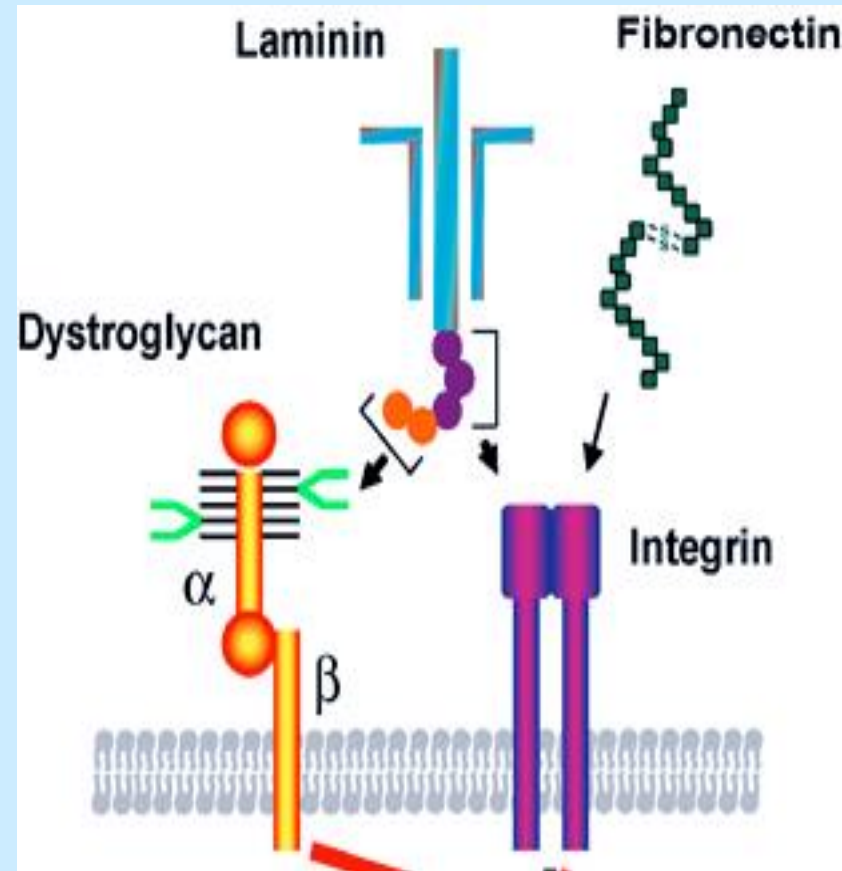
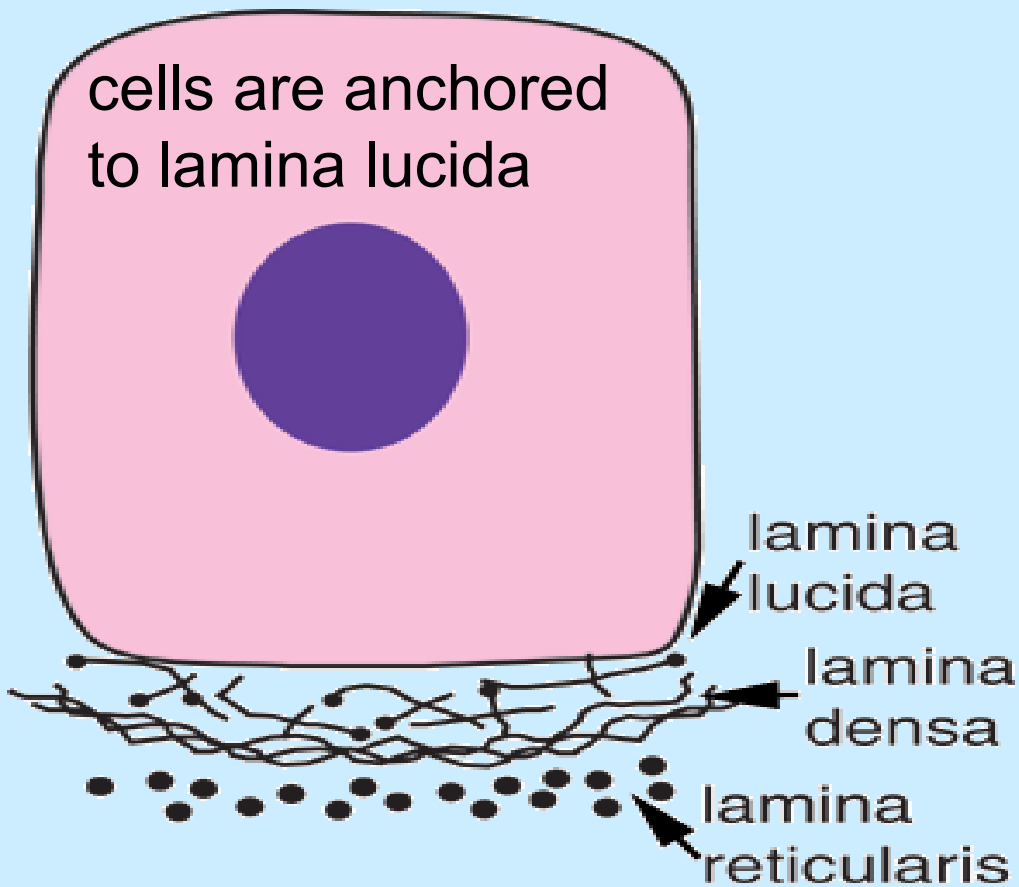
- anchors the epithelium to connective tissue

1. **basal lamina** - manufactured by epithelial cells

2. **lamina reticularis** - produced by cells of connective tissue



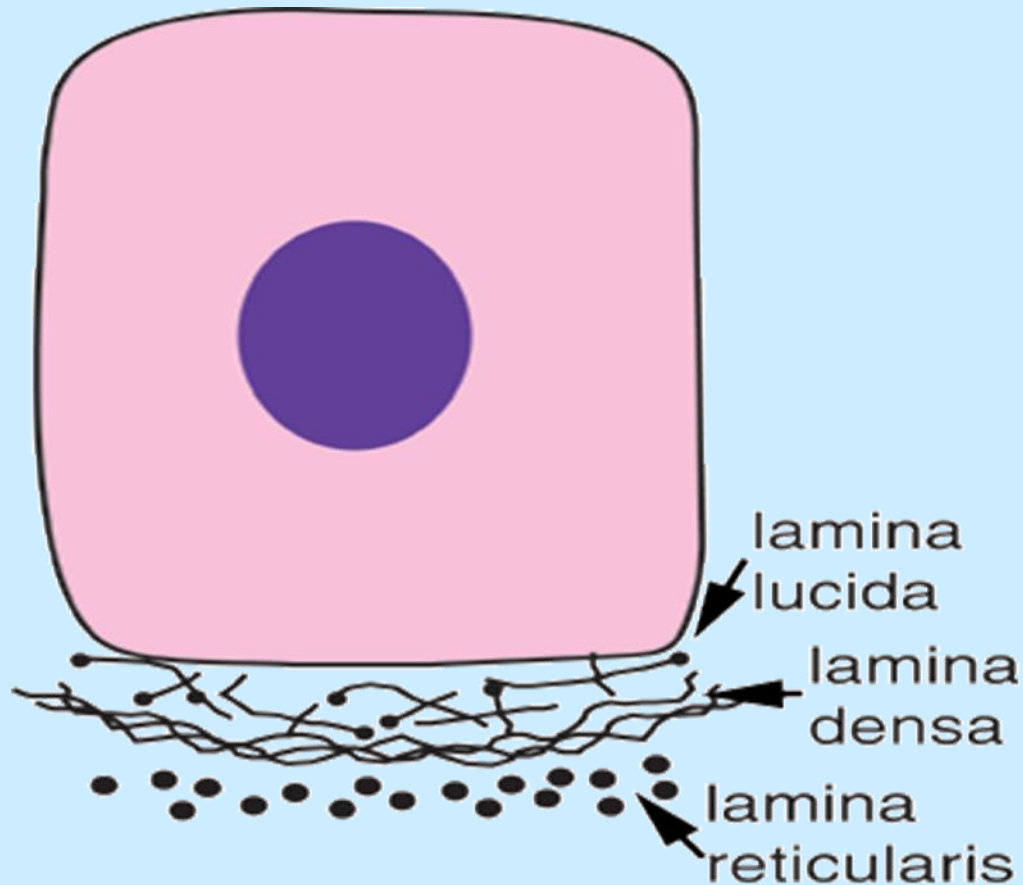
# Basal lamina = lamina lucida (rara) + lamina densa



## lamina lucida

- glycoproteins (**laminins**, **fibronectin**), **integrins** and **dystroglycans** (laminin receptors)

# Basal lamina - lamina lucida (rara) + lamina densa

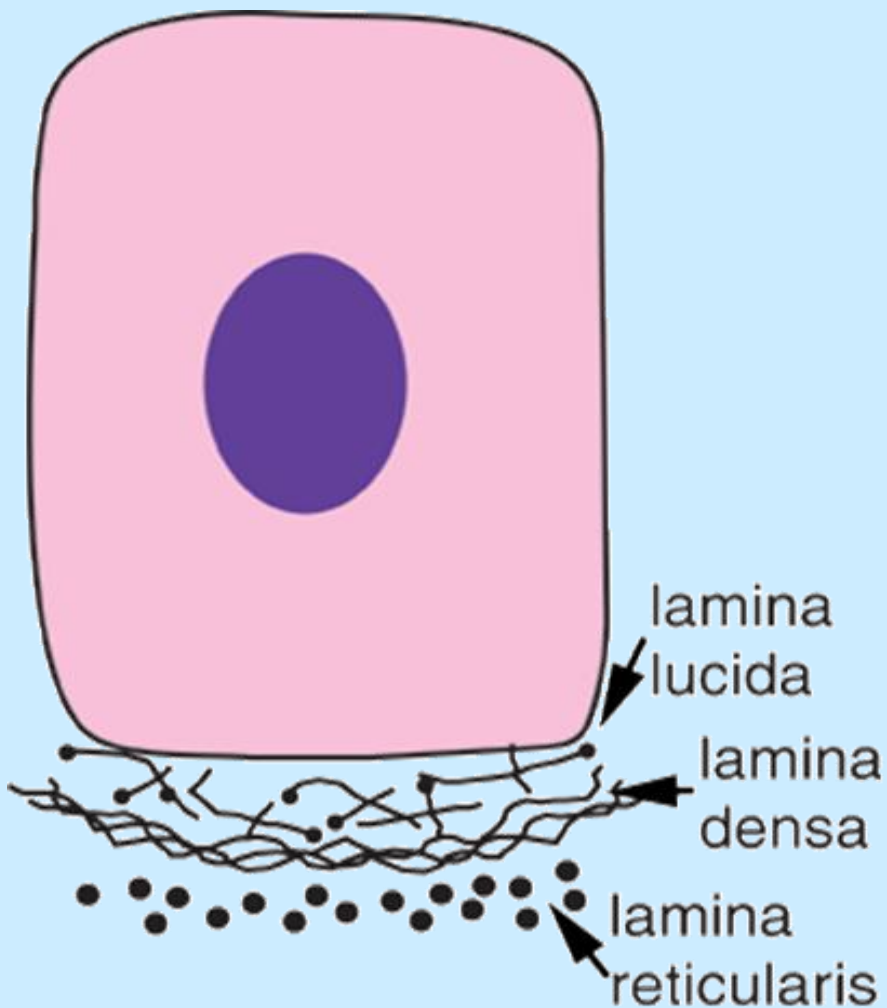


## lamina densa

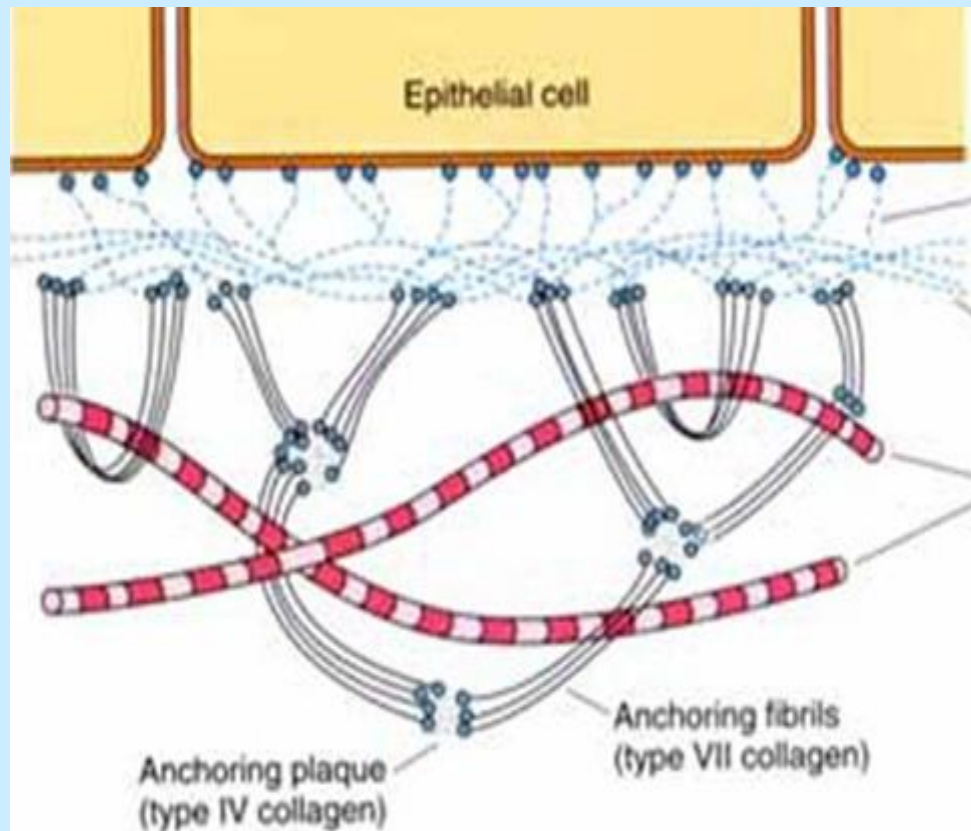
- a meshwork of **type IV collagen**, proteoglycans (perlecan, heparan sulfate)

- Laminins from lamina lucida - bind to collagen IV of lamina densa

**Basal lamina (lamina lucida (rara) + lamina densa) is attach to the lamina reticularis by collagen type VII fibers**

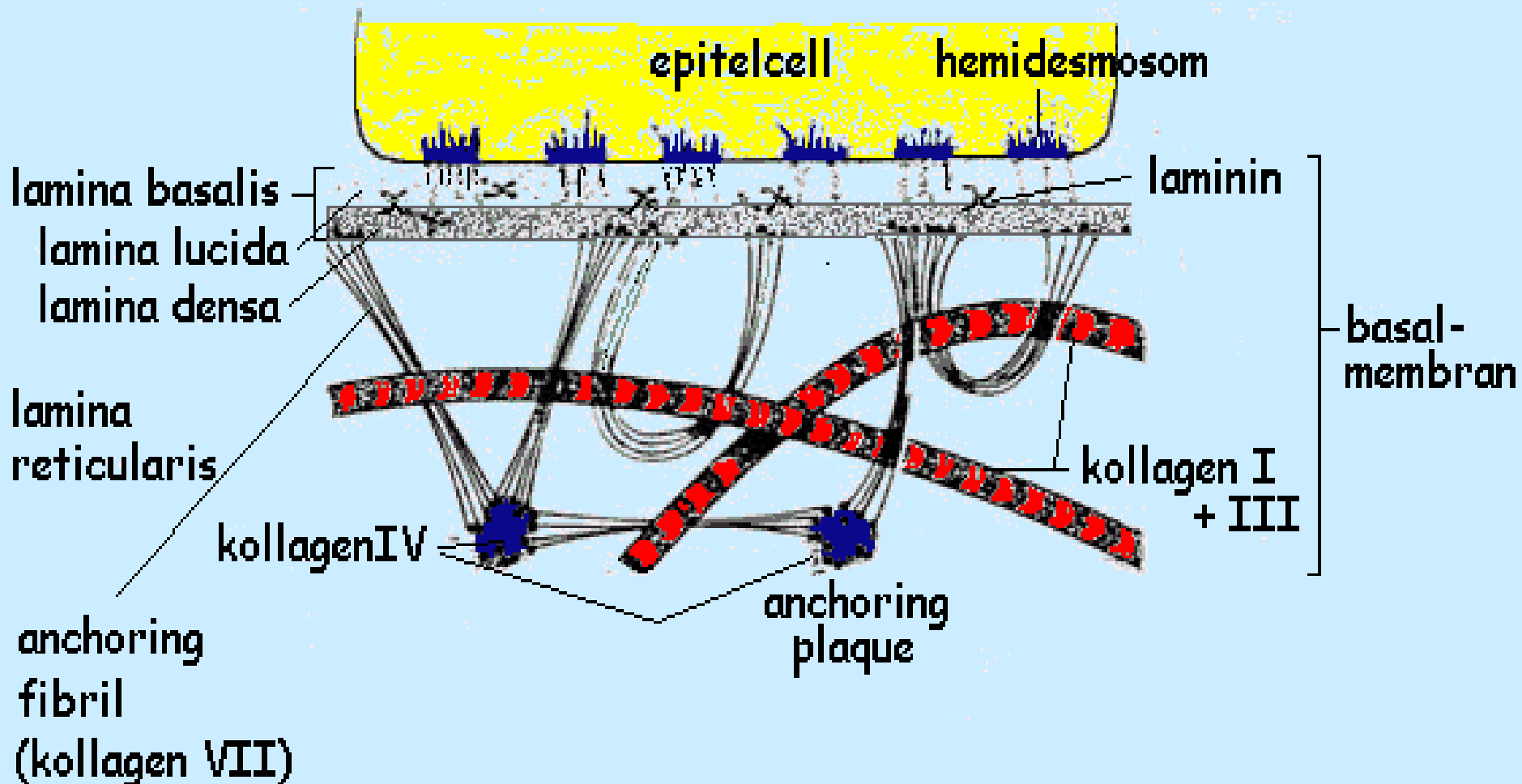


**Anchoring fibers - collagen type VII fibers**



# Lamina reticularis

- manufactured by fibroblasts (cells of connective tissue), **type I, III and VII collagen**
- affixes the basal lamina to the connective tissue



# Polarity of the cell

- epithelial cells have distinct morphological, biochemical and functional domain

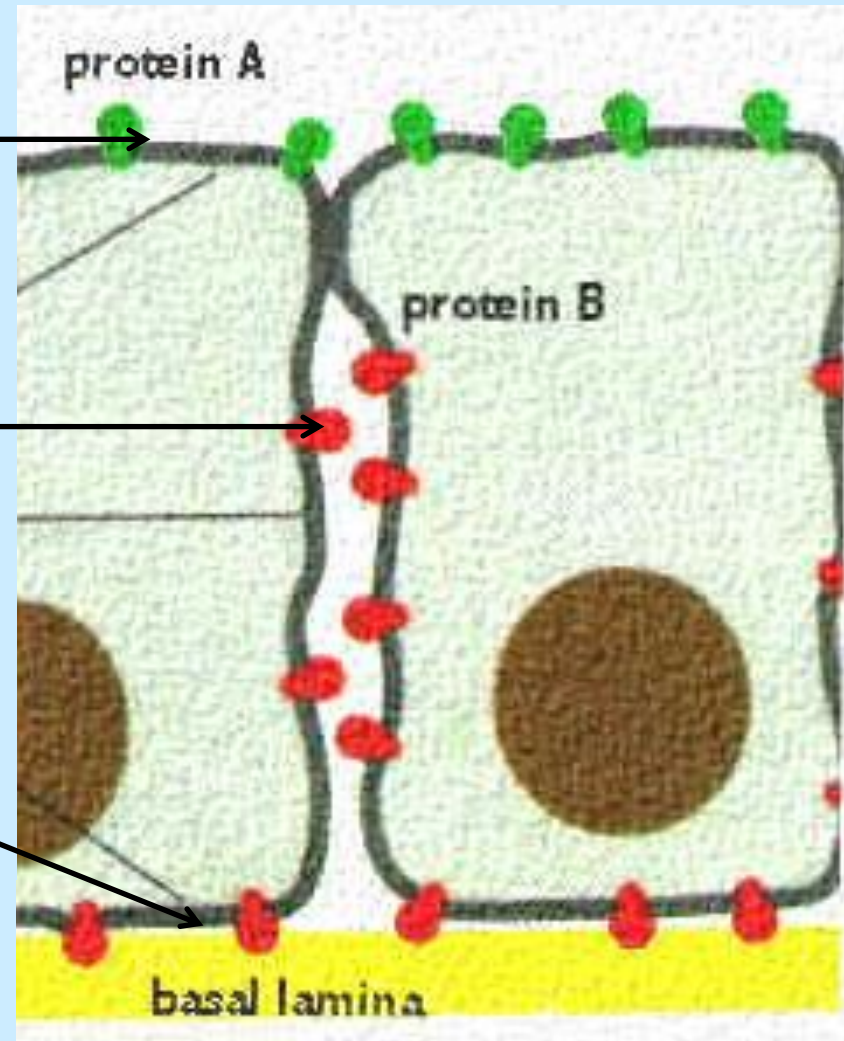
## apical domain

- faces a lumen
- **microvilli or cilia**

## lateral domain

- basolateral domain
- **junctional complexes**

## basal domain

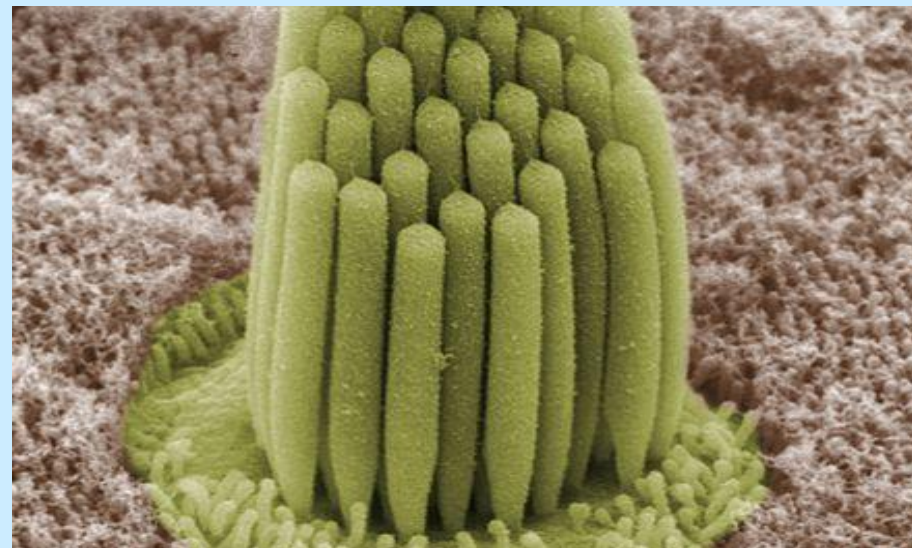


- **apical surface - absorption and secretion** - requires a large surface area - finger-shaped extensions - increase the surface area of epithelial cells
- **microvilli** (small intestine)
- **stereocilia** (epididymis)
- microvilli are much shorter than stereocilia.
- stereocilia and microvilli are immovable

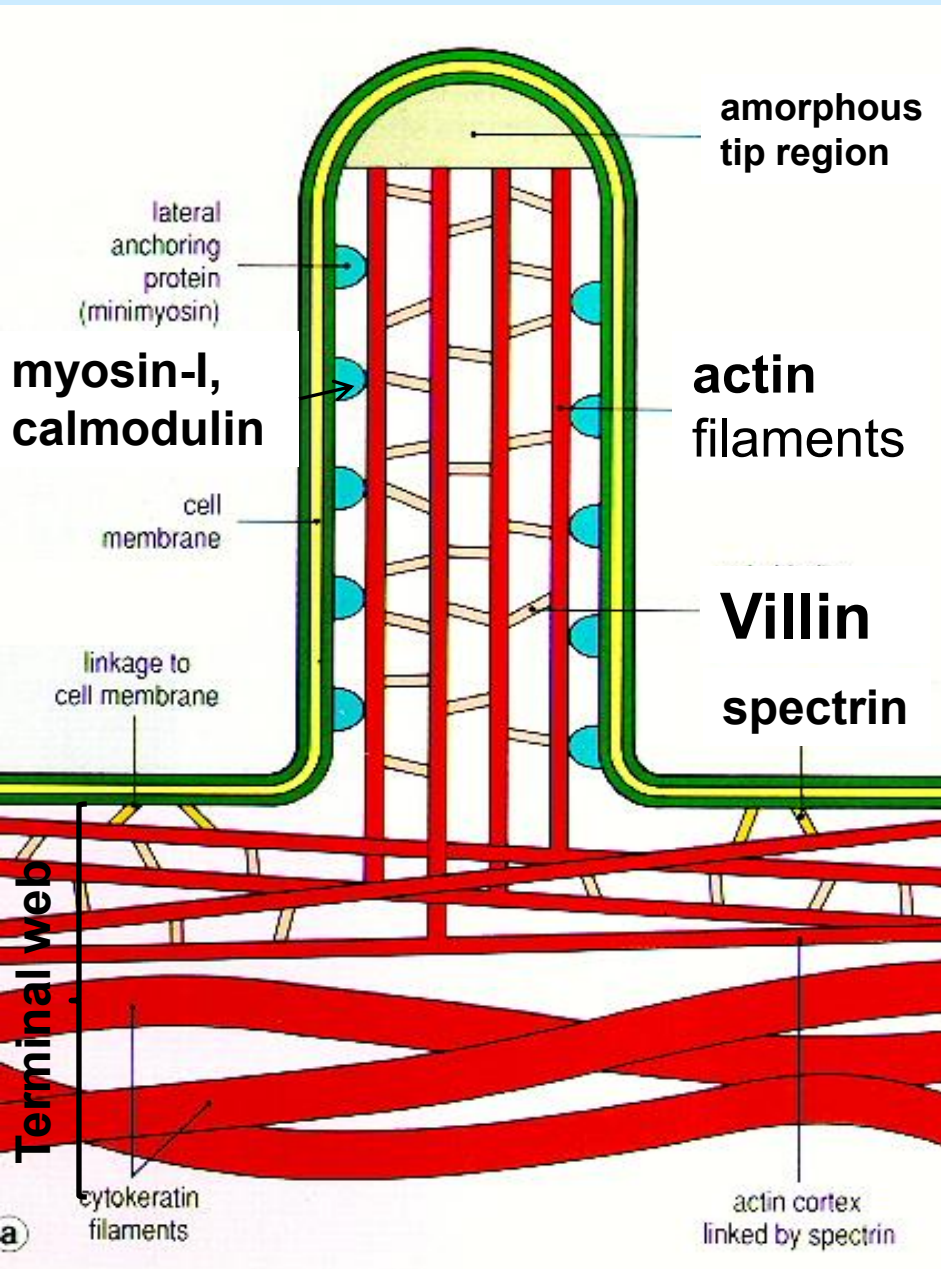
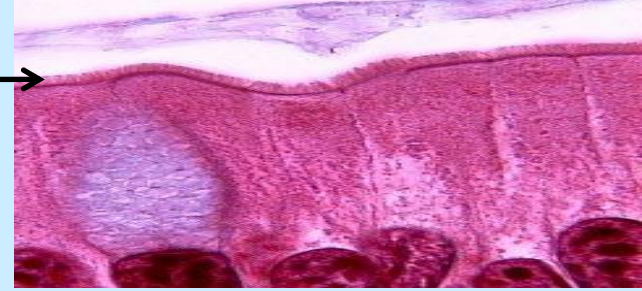
**microvilli**



**stereocilia**



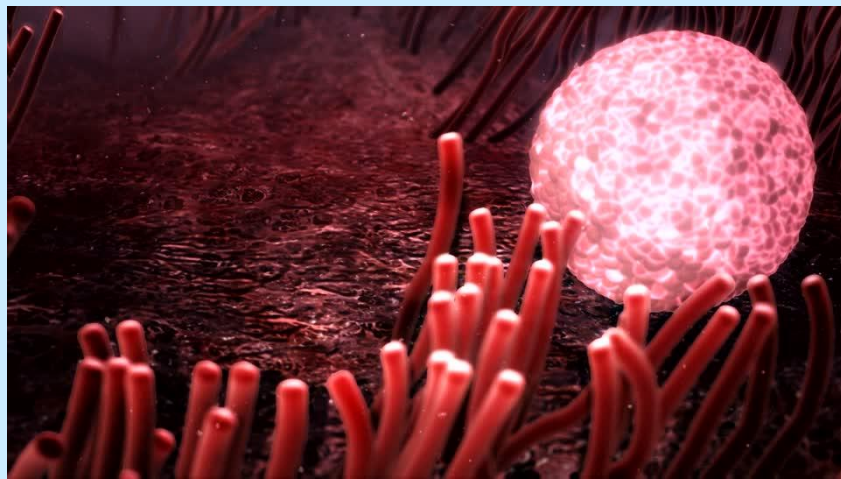
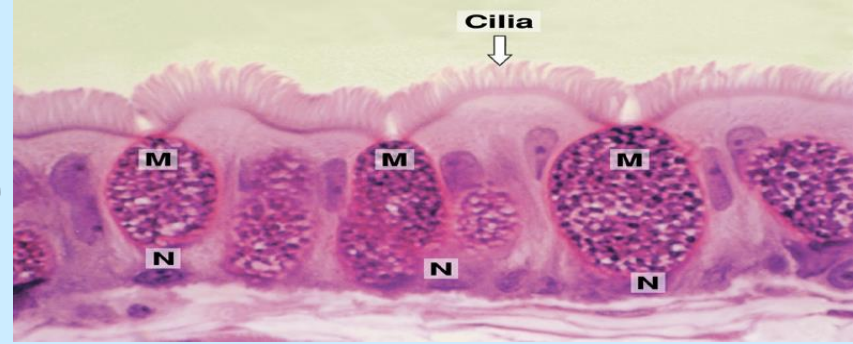
# Microvilli – striated (brush) border →



## Microvillus

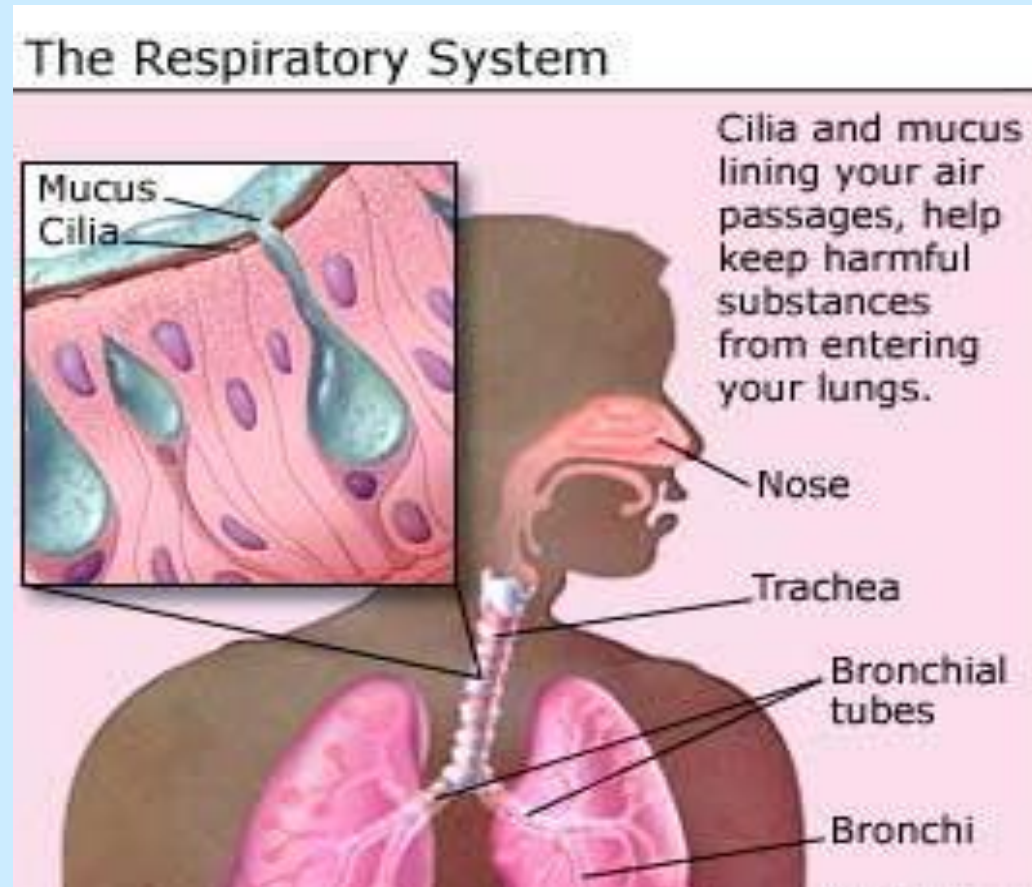
- a core - **actin** filaments - cross-linked by **villin**
- actin filaments - attached to the terminal web (complex of actin, spectrin and intermediate filaments)
- **myosin** and **calmodulin** connect the actin filaments to the plasma membrane

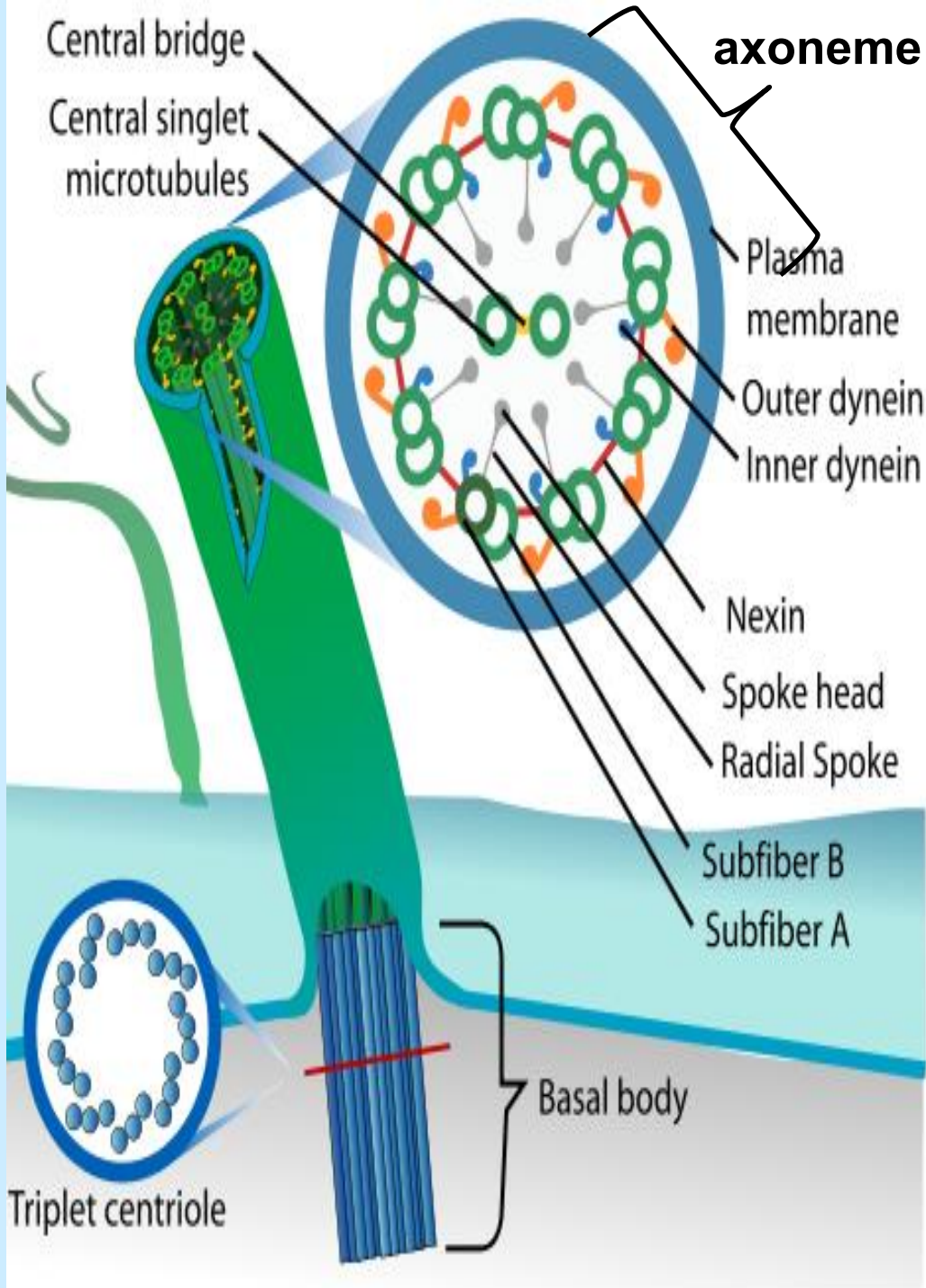
**Cilia** – Long, motile structures (respiratory tract, in the oviduct)  
- a rhythmic waving or beating motion



**The egg travels along the oviduct**

- work to keep the airways clear of mucus and dirt,



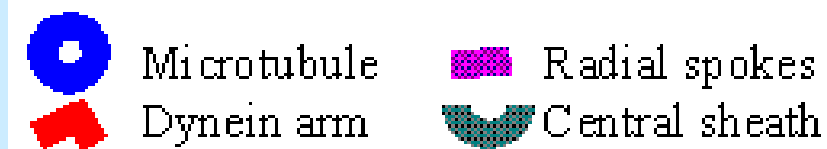
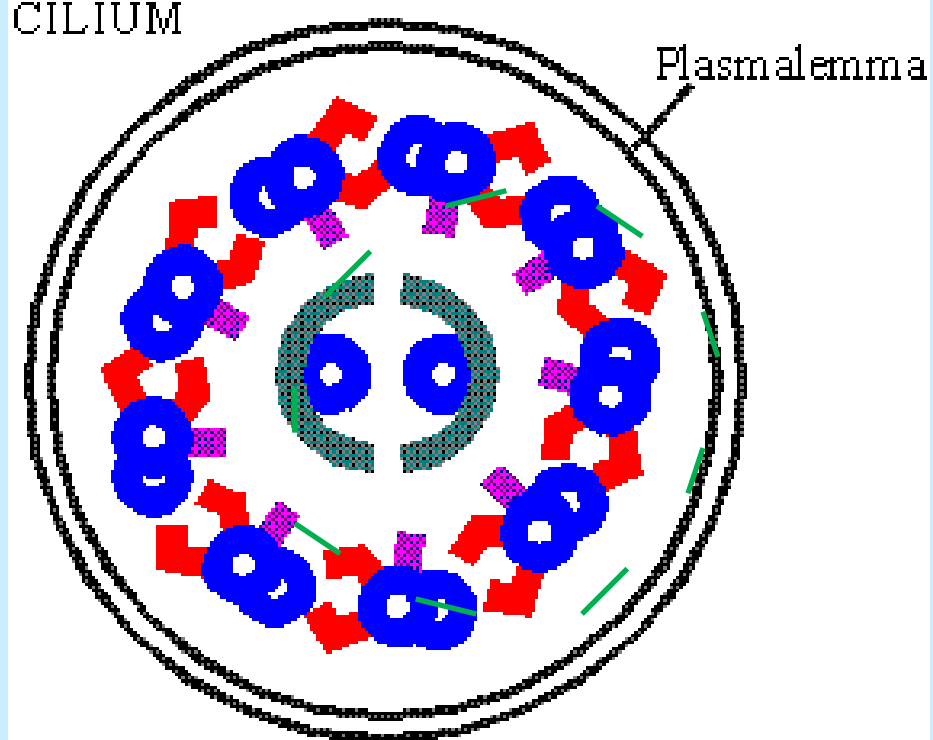


## cilia

- the core - microtubules – **axoneme** - constant number of longitudinal microtubules arranged in **9 + 2** organization.
- two centrally placed microtubules (singlets) surrounded by nine doublets

**Basal body** - the growth of the axoneme - **9 triplets and no singlets**

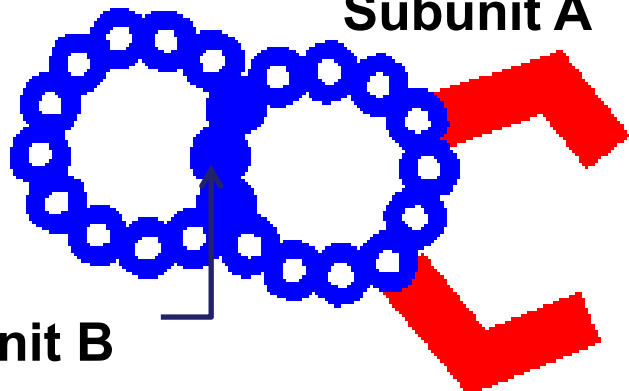
# CILIUM



- two microtubules in the center - separated from each other - each - 13 protofilaments.
- each of the nine doublets - two subunits.
- subunit A - a microtubule - 13 protofilaments - circular profile.
- subunit B - 10 protofilaments - an incomplete circular profile - shares three protofilaments of subunit A.

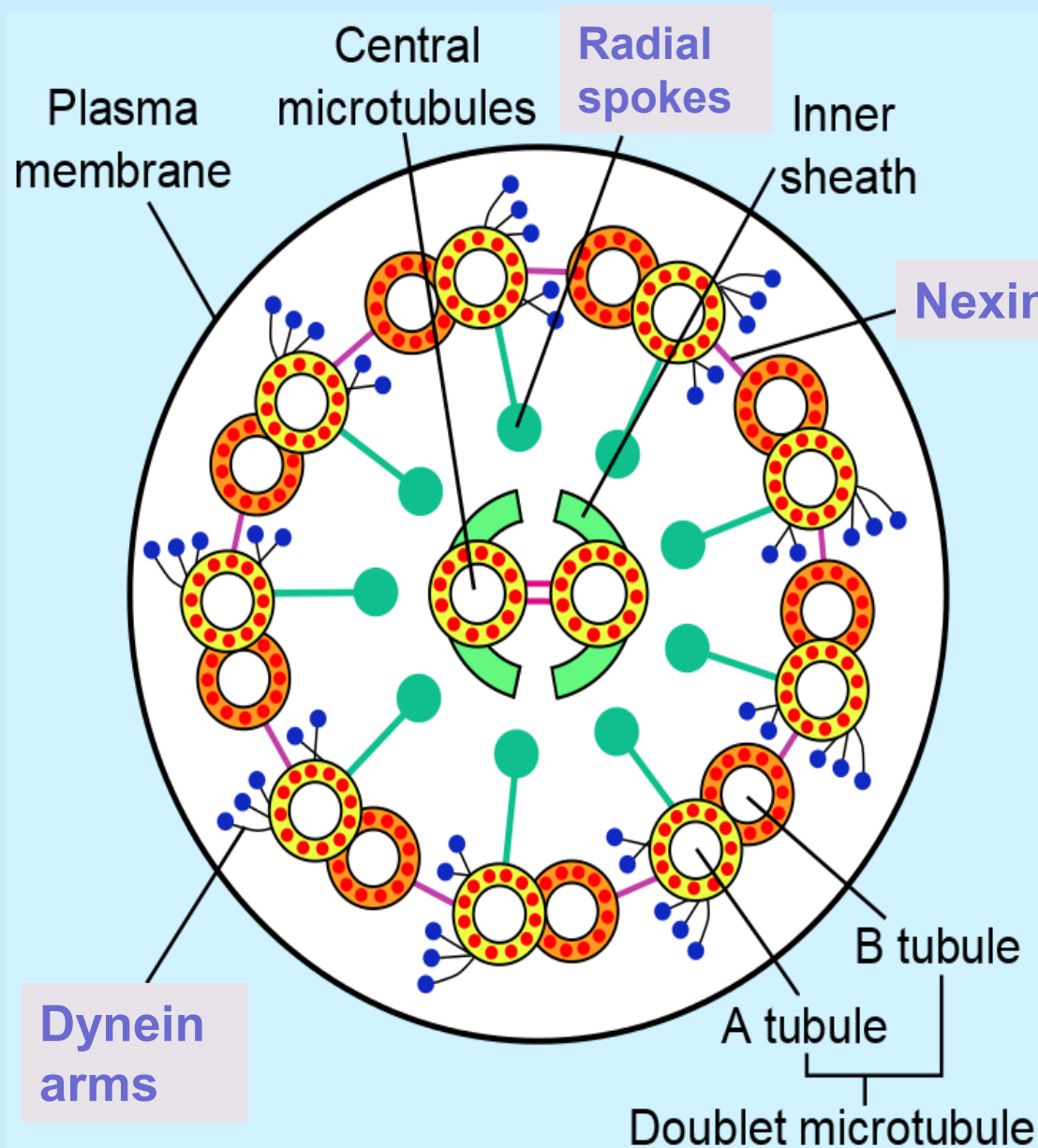
Enlarged microtubule doublet

**Subunit A**



**Subunit B**

# Proteins associated with the axoneme

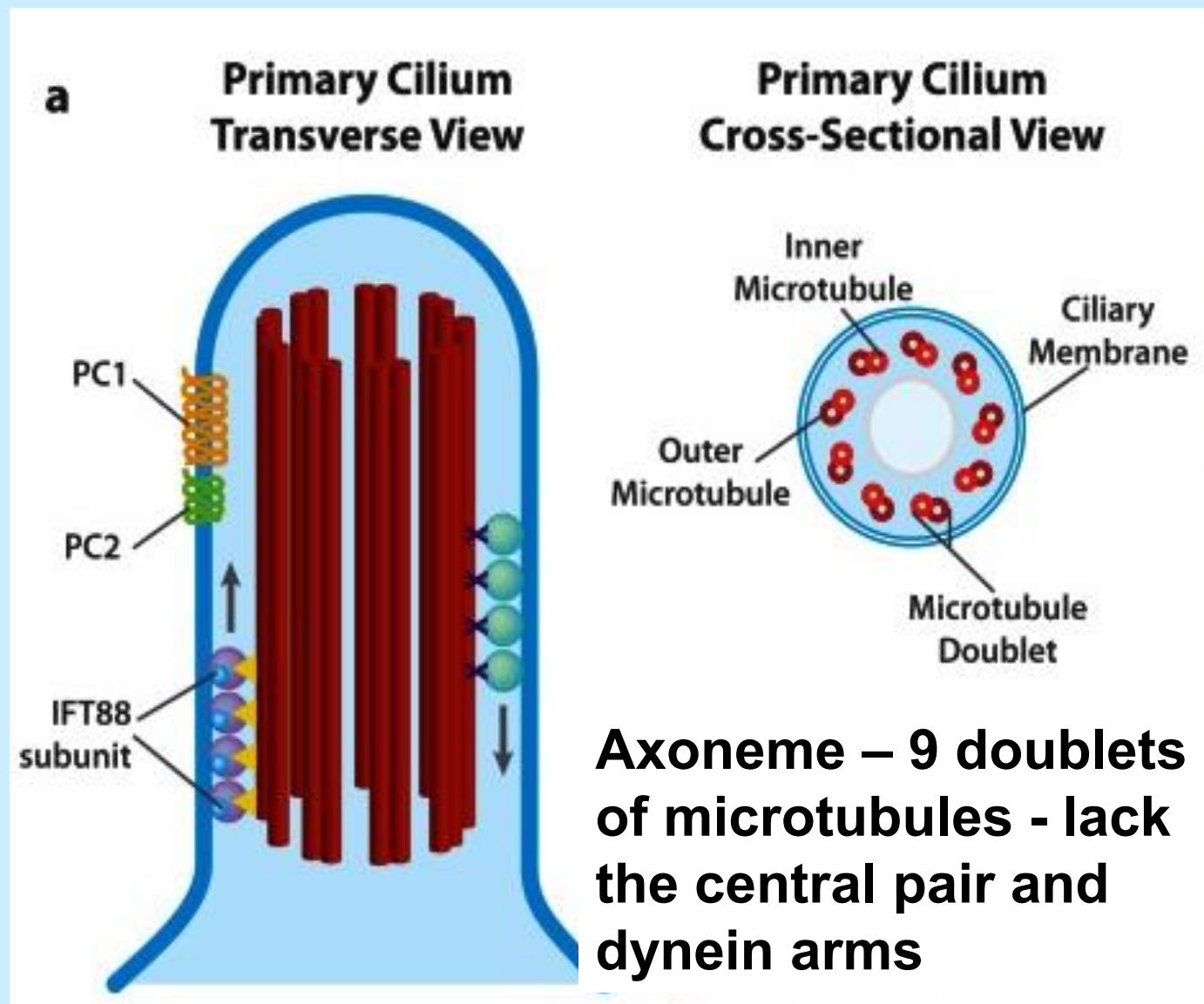


**Nexin** - connects neighboring doublets

**Dynein** - ATP-ase activity - energy for movement

**Radial spokes** - T-shaped structures - different proteins - interact with both the central pair microtubules and the dynein arms

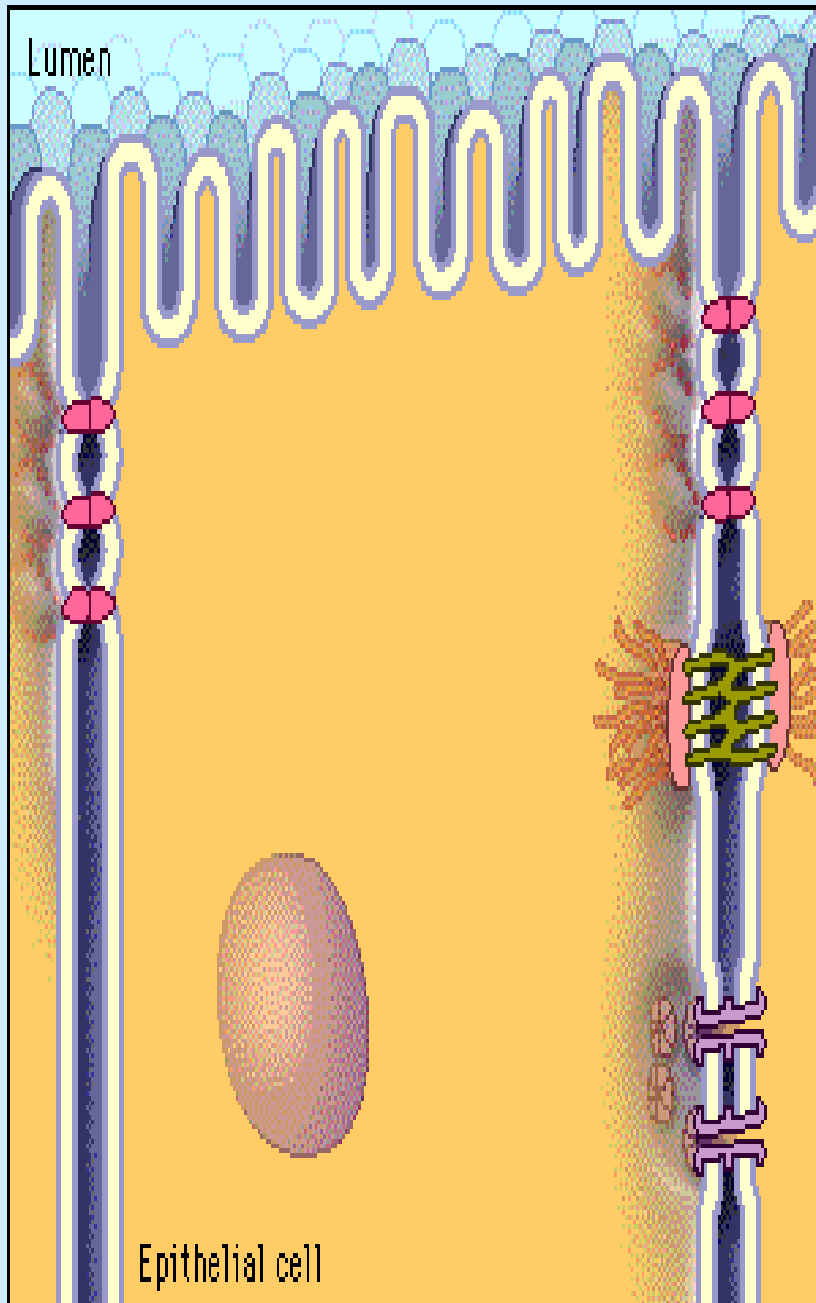
**Primary cilia** - short, immotile cilia, on nearly every cell, one per cell



**Functions:**

- sensory organelles - respond to mechanical and chemical stimuli

# Intercellular junctions (lateral domain)



## Occluding junctions

- seal cells together - **zonulae occludentes**)

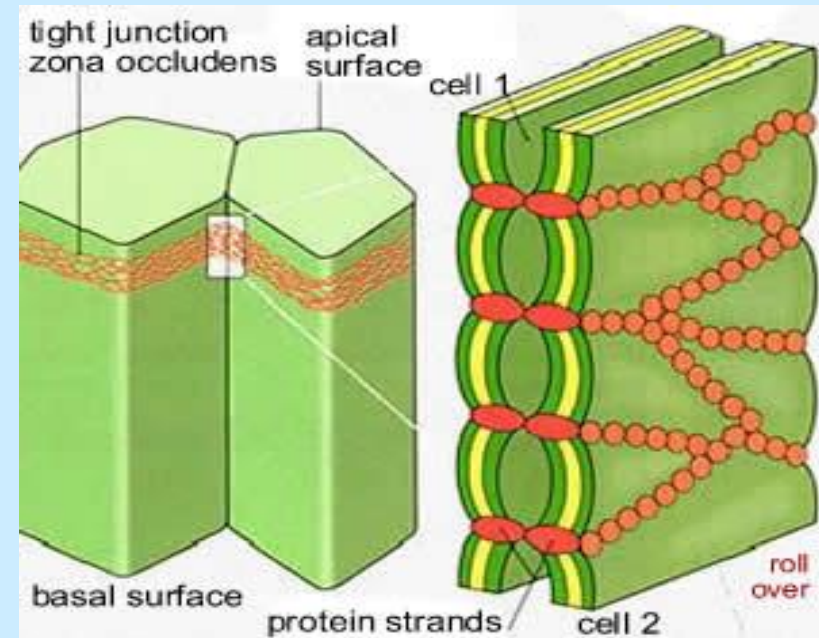
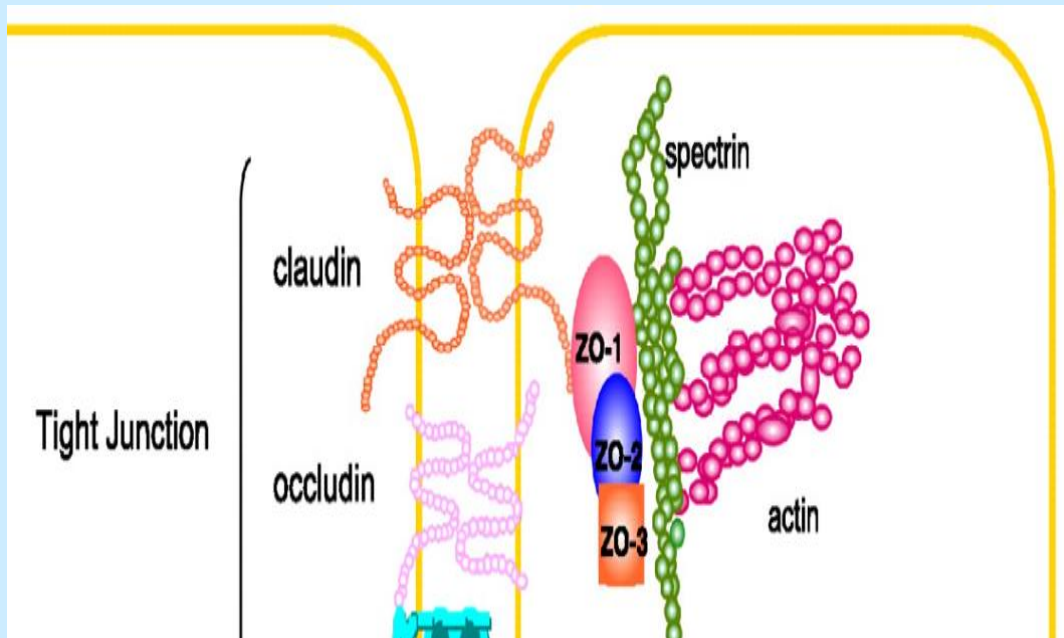
## Anchoring junctions

- mechanically attach cells - **zonulae adherentes, desmosomes**

## Communicating junctions

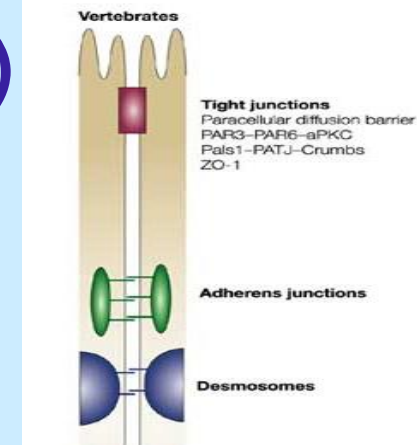
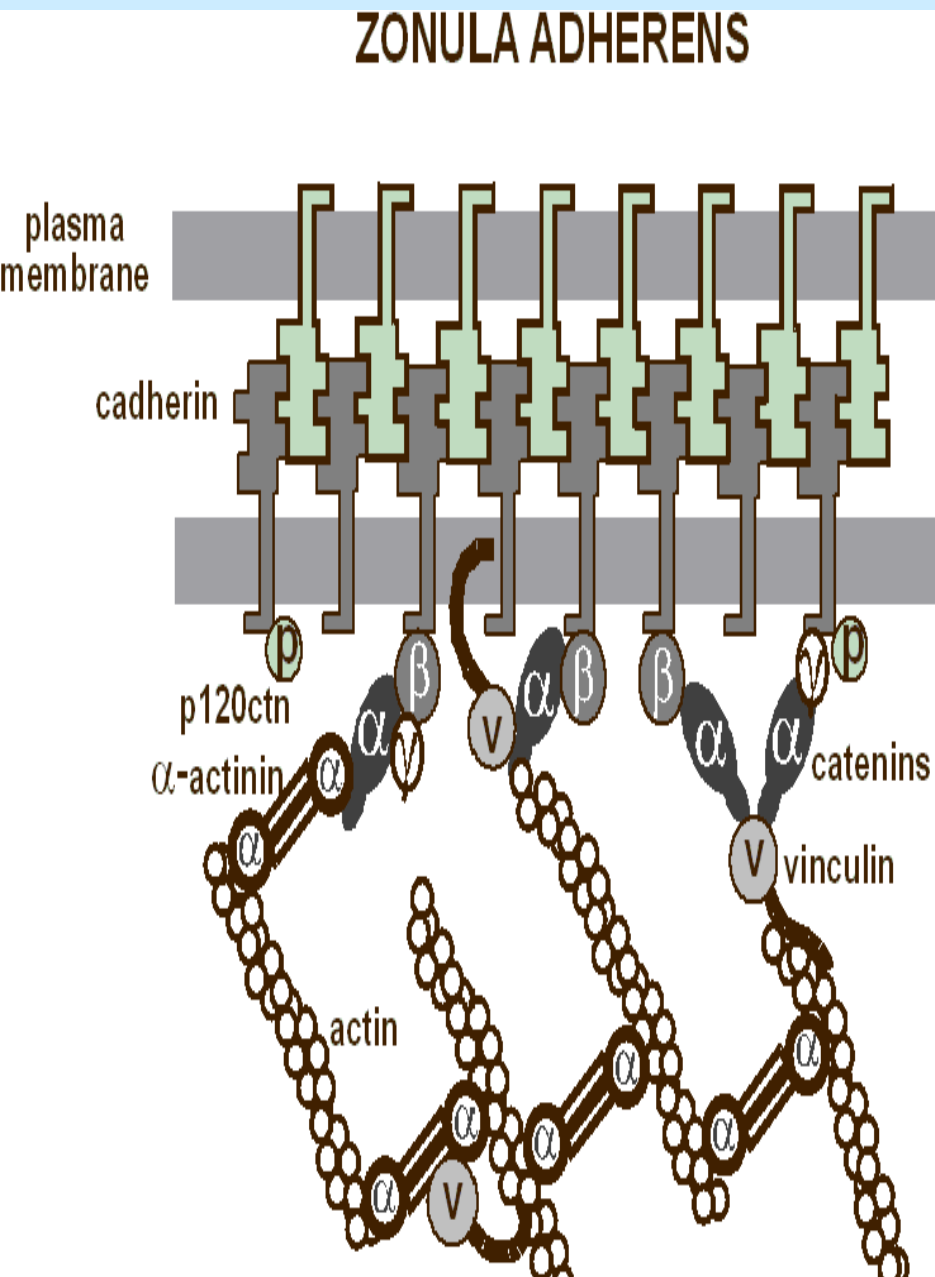
- mediate the passage of molecules - **gap junctions**

# Zonulae Occludentes or Tight junctions (Occluding junction) - the most apically located junction



- transmembrane proteins – **claudins** and **occludins**
- prevent the movement of membrane proteins from the apical domain to the basolateral domain
- prohibit molecules from passing between cells

# Zonulae Adherentes (anchoring junction)

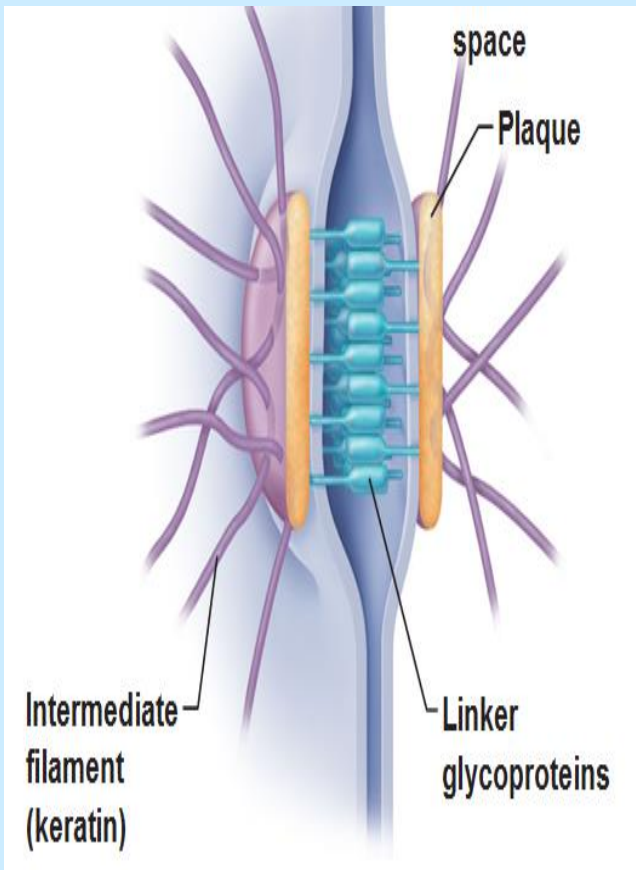
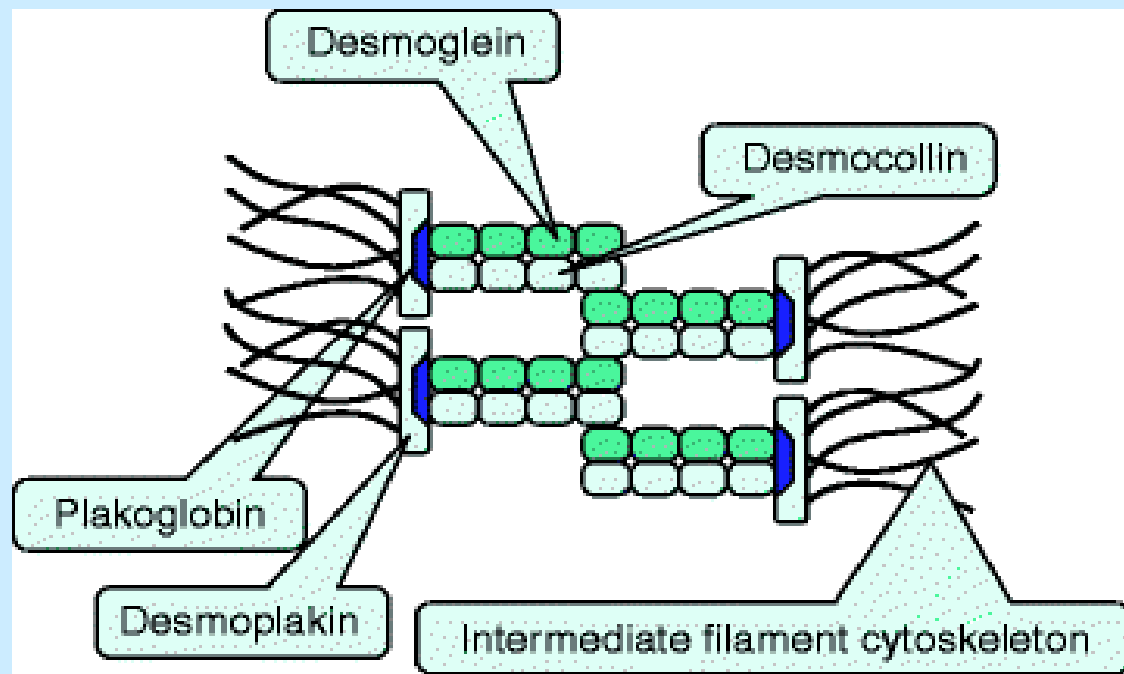


- **cadherins** ( $\text{Ca}^{2+}$  dependent proteins of the cell membrane) - bind to **actin** filaments
- Actin filaments are attached to each other and to the cell membrane by **catenin, vinculin and alpha actinins**

# DESMOSOMES

## (anchoring junction)

- randomly distributed along lateral cell membranes (epidermis)



- two plaques – in membranes of adjacent cells
- plaque - **desmoplakin** and **plakoglobin** - bound intermediate filaments to plaques
- **desmoglein** and **desmocollin** (**catherins**) - bridge the space between adjacent cells

**Pemphigus** (*Pemphigus vulgaris*) – an autoimmune disease - affect the skin and mucous membranes.

- autoantibodies against desmoglein destroy desmosomes.
- the cells become separated from each other - **acantholysis**

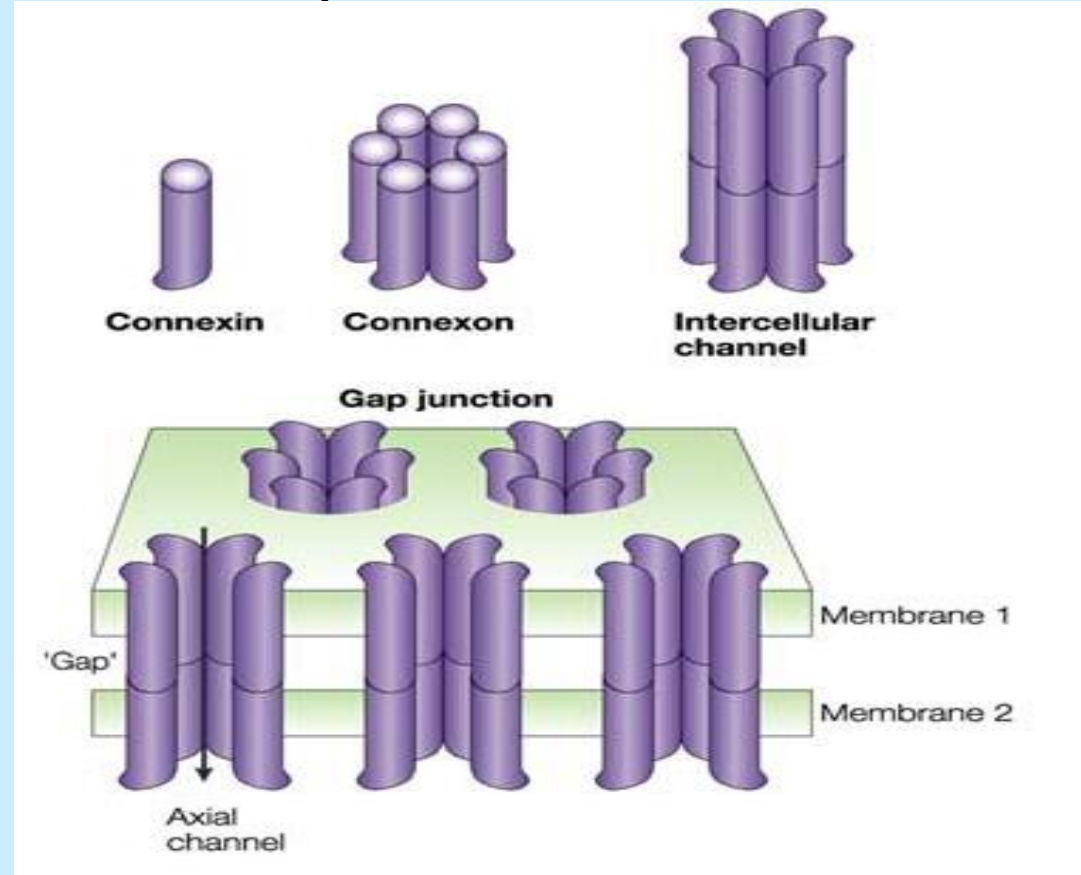
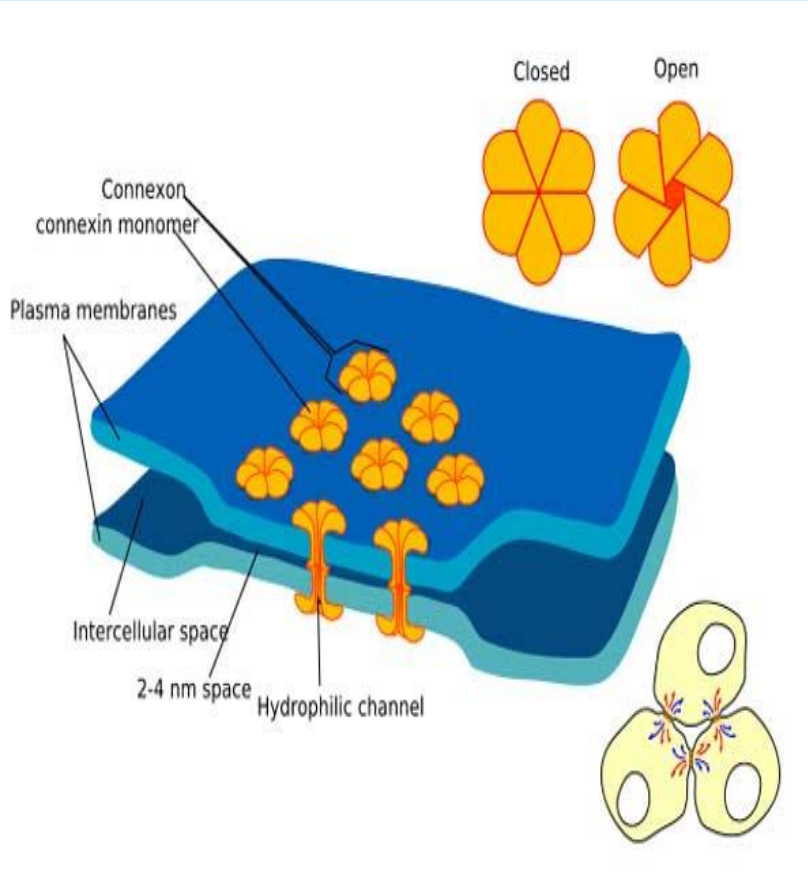


If not treated, **pemphigus** can be fatal from an infection. The most common treatment is the administration of oral steroids, especially prednisone, often in high doses.



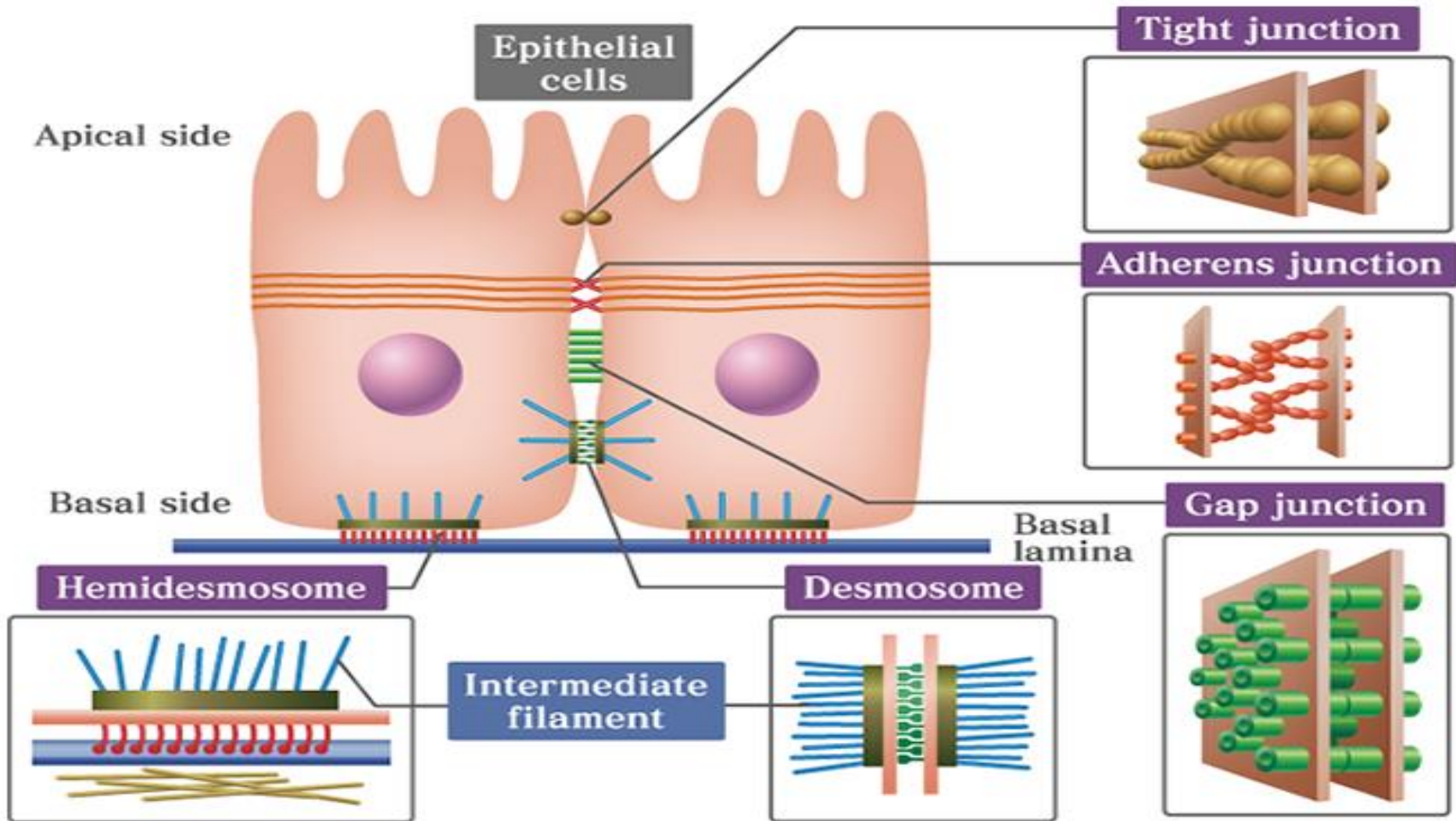
# Gap junctions (communicating junction)

- intercellular channels (electrical synapses) - channel - 2 connexons. Each **connexon** - 6 proteins - **connexins**.
- Transport of ions and small molecules, up to 1500 daltons.



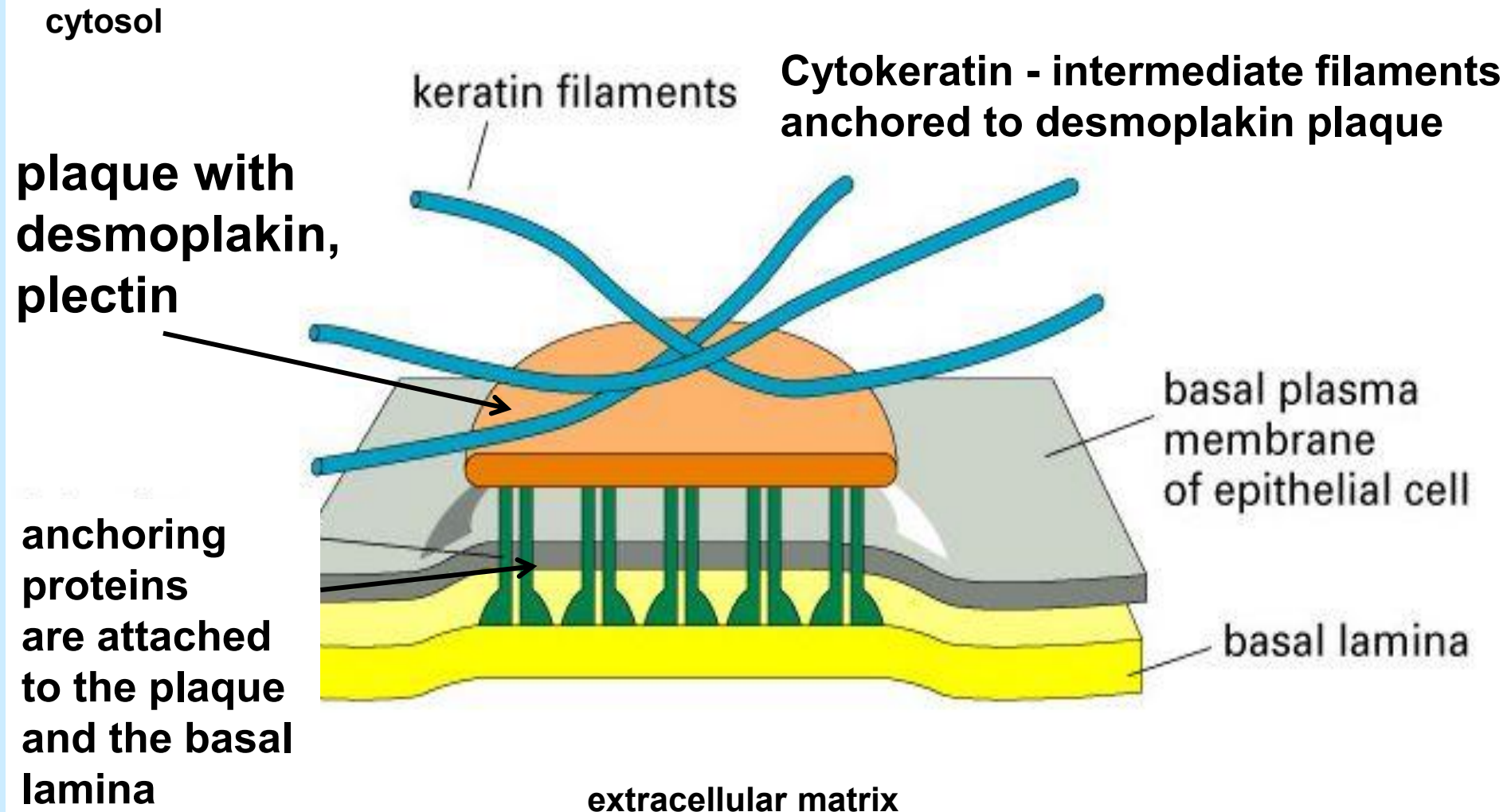
# Basal surface specializations

- **Hemidesmosomes** - attach the basal cell membrane to the basal lamina



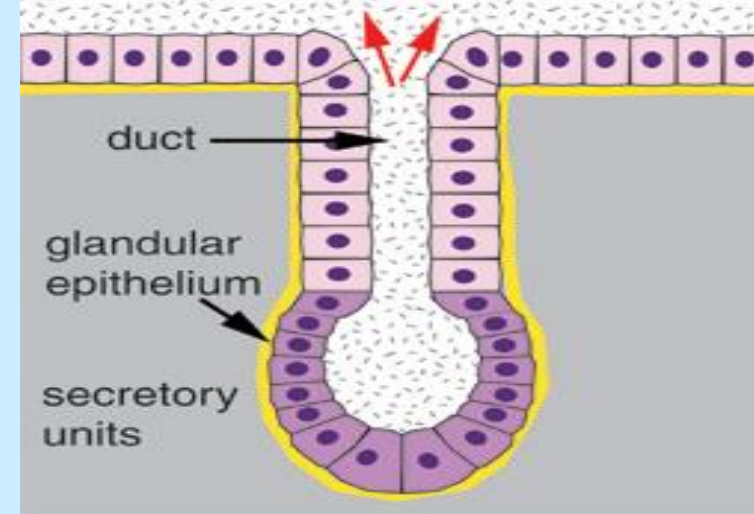
# Hemidesmosomes - resemble half desmosomes

- attach the basal cell membrane to the underlying basal lamina



# GLANDS

- from invaginated epithelial cells
- function - secretion.

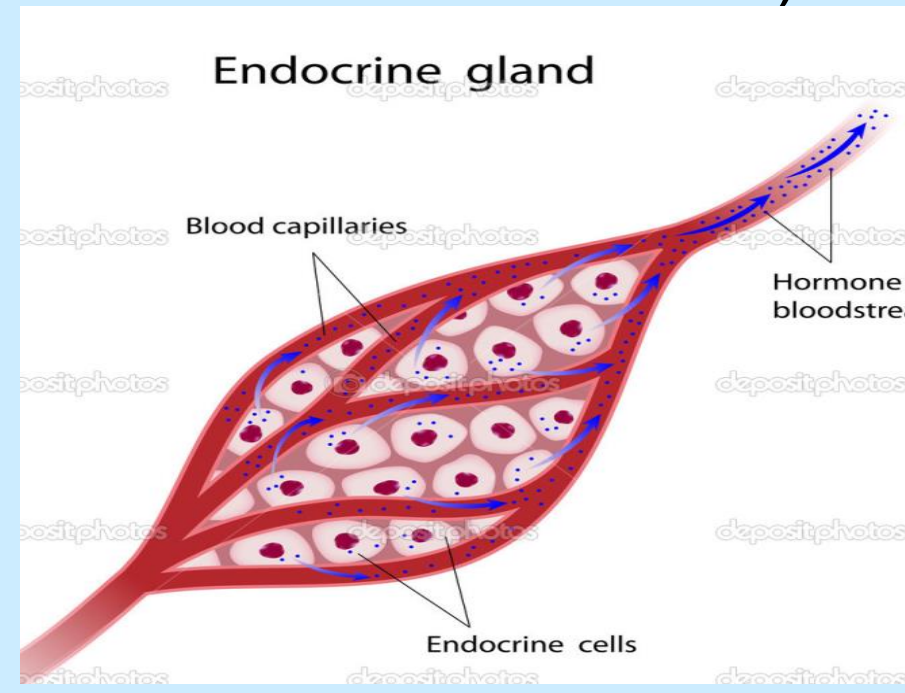


## Exocrine glands

- release the secretory product via ducts that open at the surfaces of the body (skin, gastrointestinal tract etc.)

## Endocrine glands

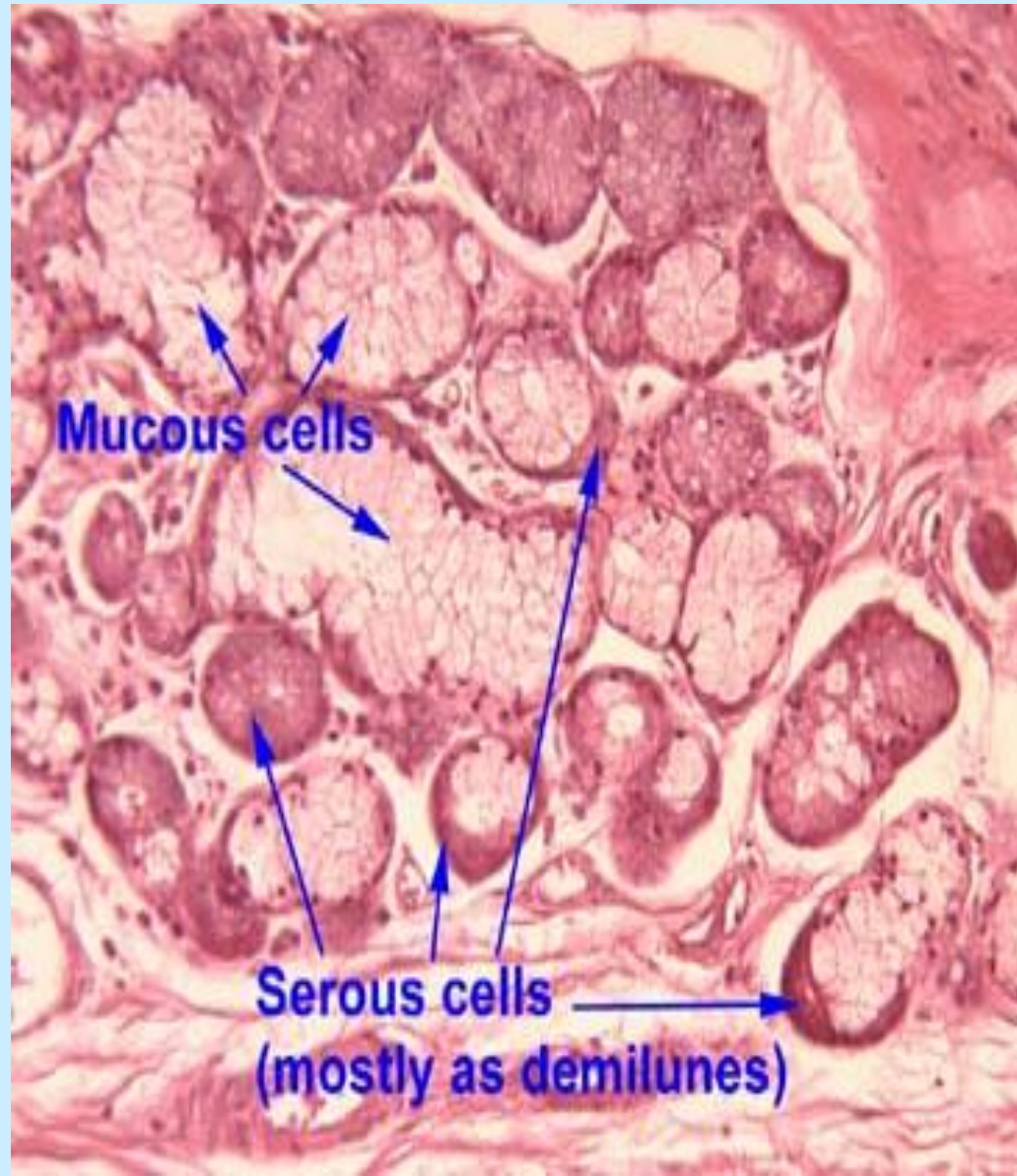
- release secretory product (hormone) into the blood.



# Classification of exocrine glands

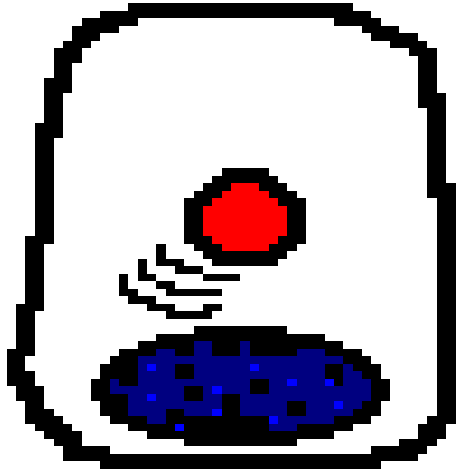
According to:

- **nature of secretion**
  - mucous glands
  - serous glands
  - mixed glands
- **mode of secretion**
  - merocrine glands
  - apocrine glands
  - holocrine glands
- **number of cells**
  - unicellular
  - multicellular

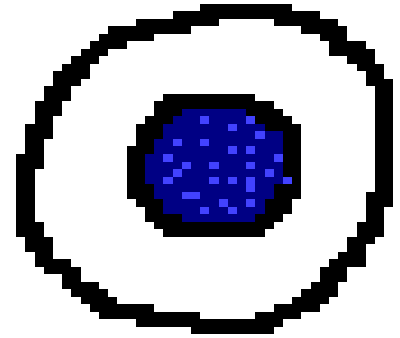
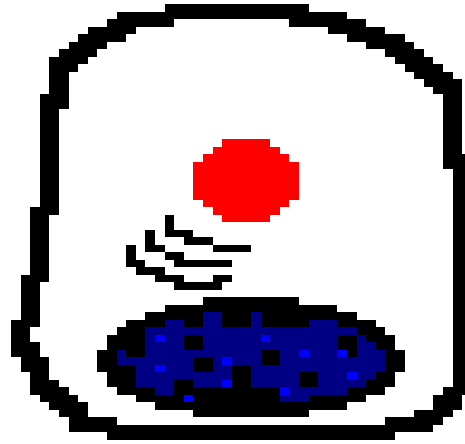


# Mechanisms of secretion of exocrine glands

merocrine



apocrine



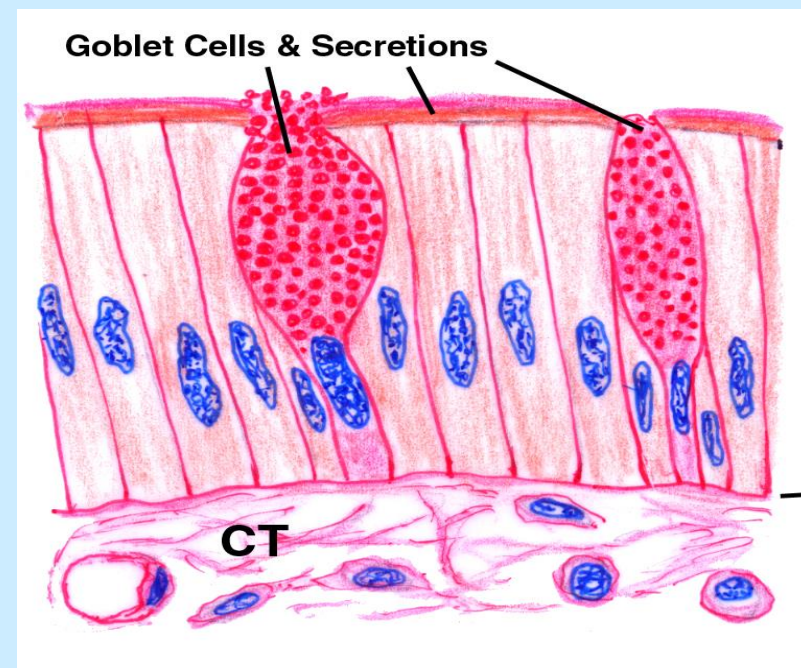
**Merocrine gland** – secretion is released via exocytosis, the cell is not damaged - **sweat gland**

**Apocrine gland** – a small portion of the apical cytoplasm is released with the secretory product - **mammary gland**

**Holocrine gland** – secretory cell dies and becomes the secretory product - **sebaceous glands**

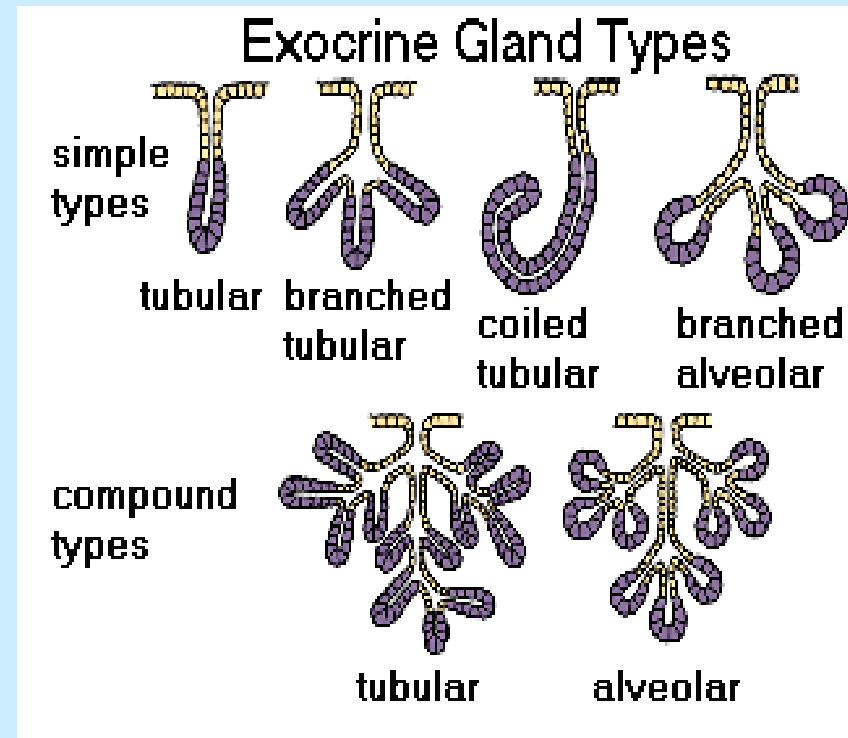
# Unicellular glands

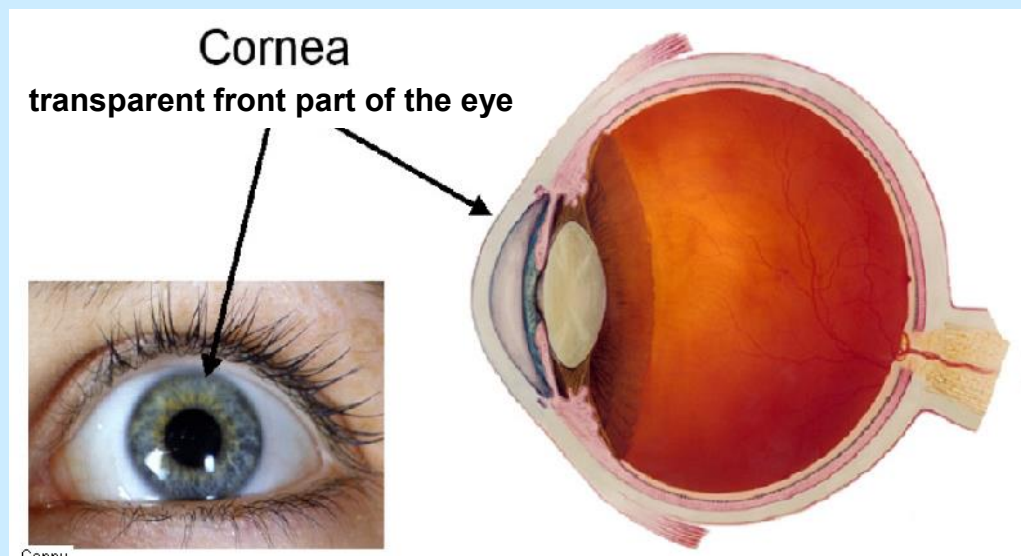
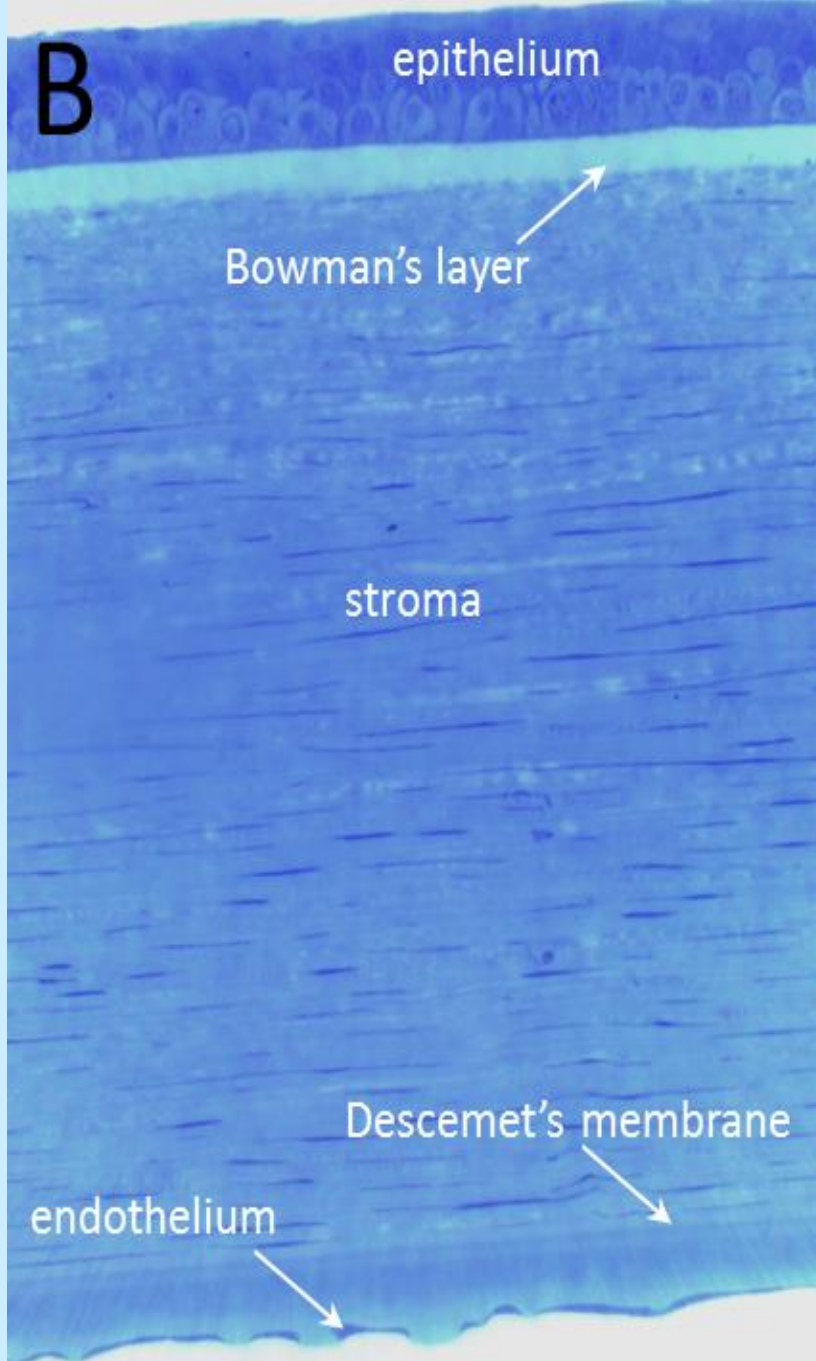
- the simplest form of exocrine glands - a single secretory cell
- **goblet cells** - in the epithelium of **simple columnar epithelium, pseudostratified epithelium**.



# Multicellular exocrine glands

- secretory portion embedded in the connective tissue
- the secretory portions - different shapes - tubes, acini or alveoli





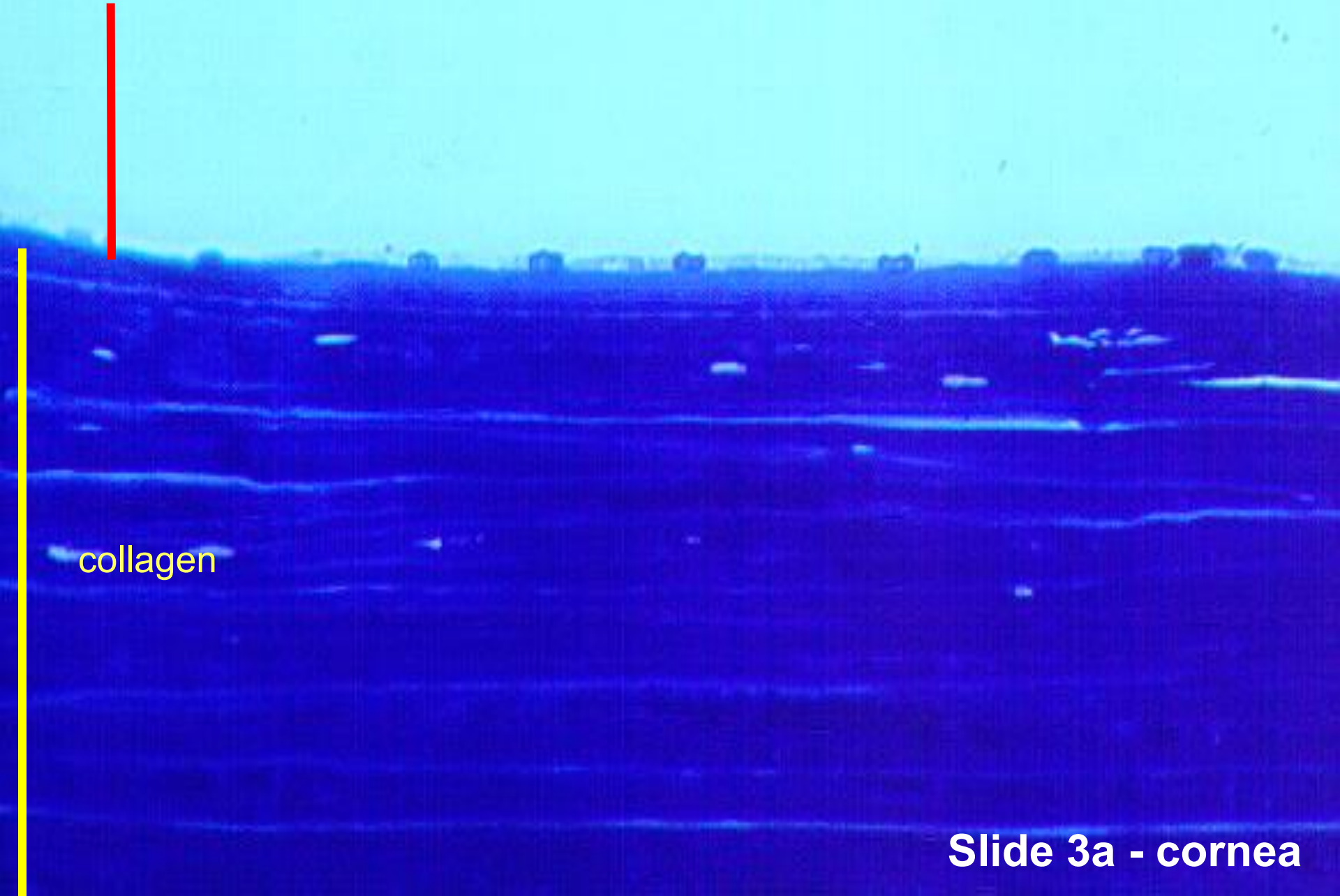
**Corneal epithelium  
(nonkeratinized  
stratified squamous epithelium)**

**Corneal stroma**

**Corneal endothelium ( simple  
squamous epithelium**

**Slide 3a - cornea**

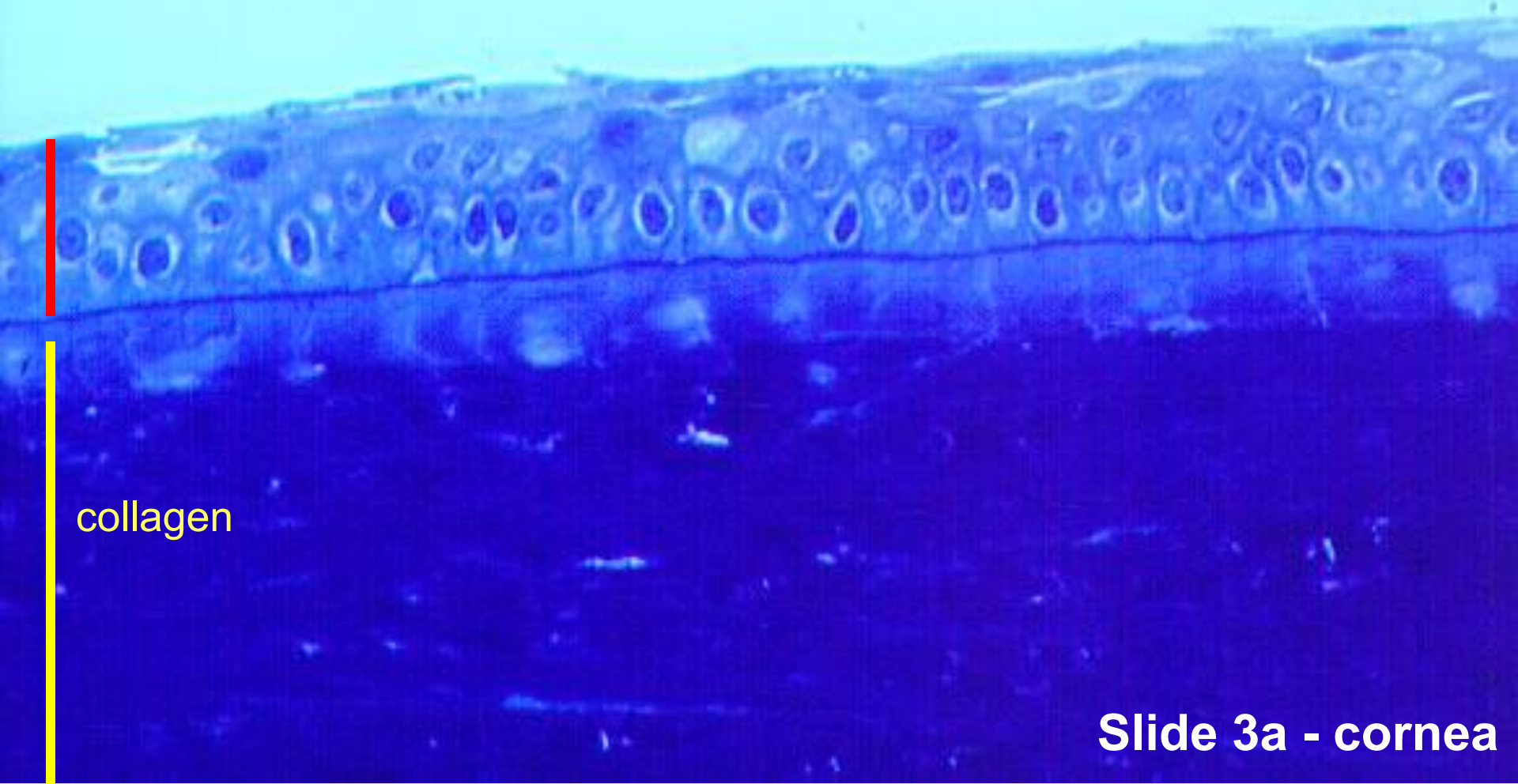
# Simple squamous epithelium



collagen

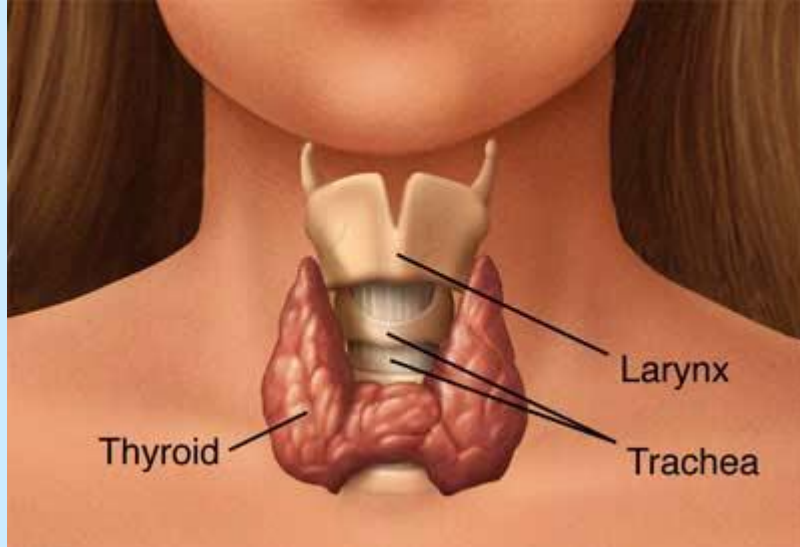
Slide 3a - cornea

**stratified squamous epithelium**



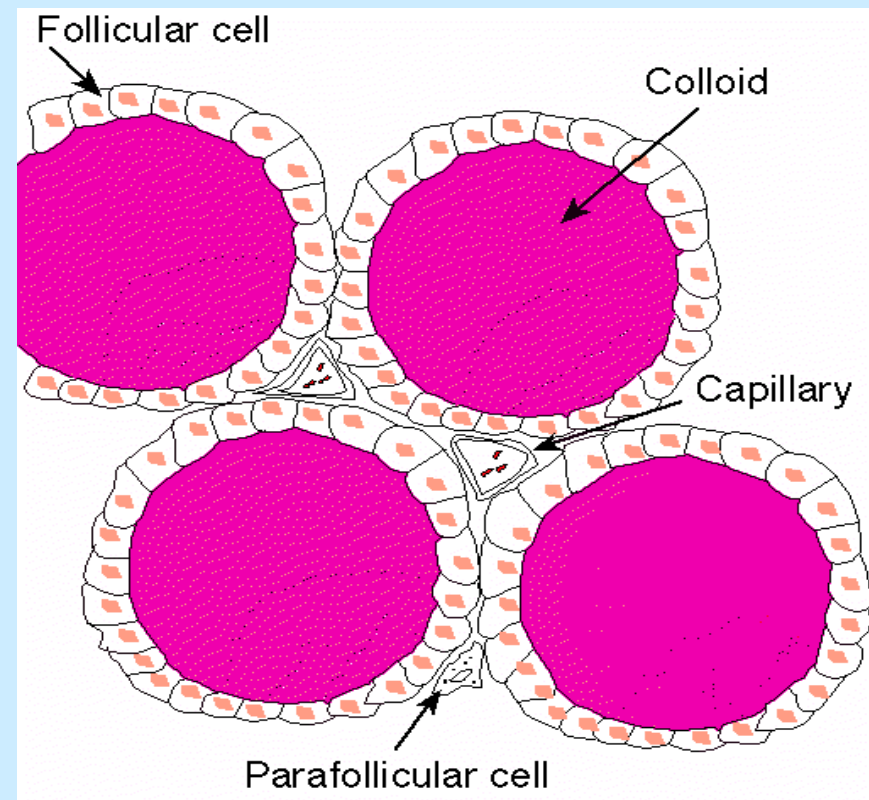
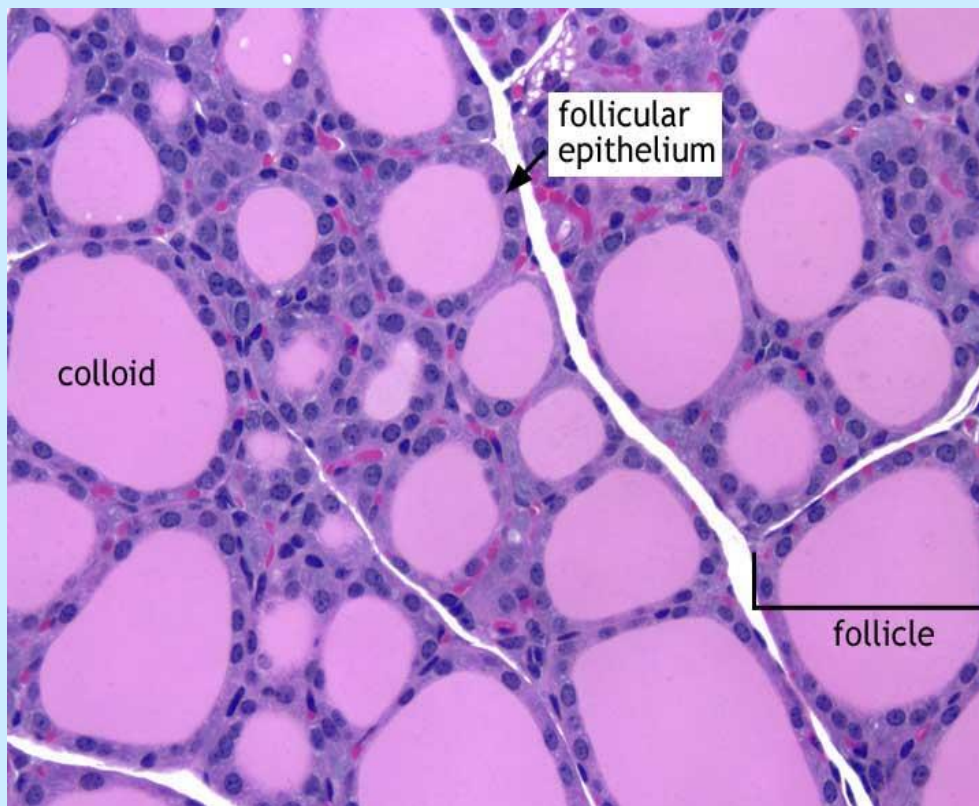
collagen

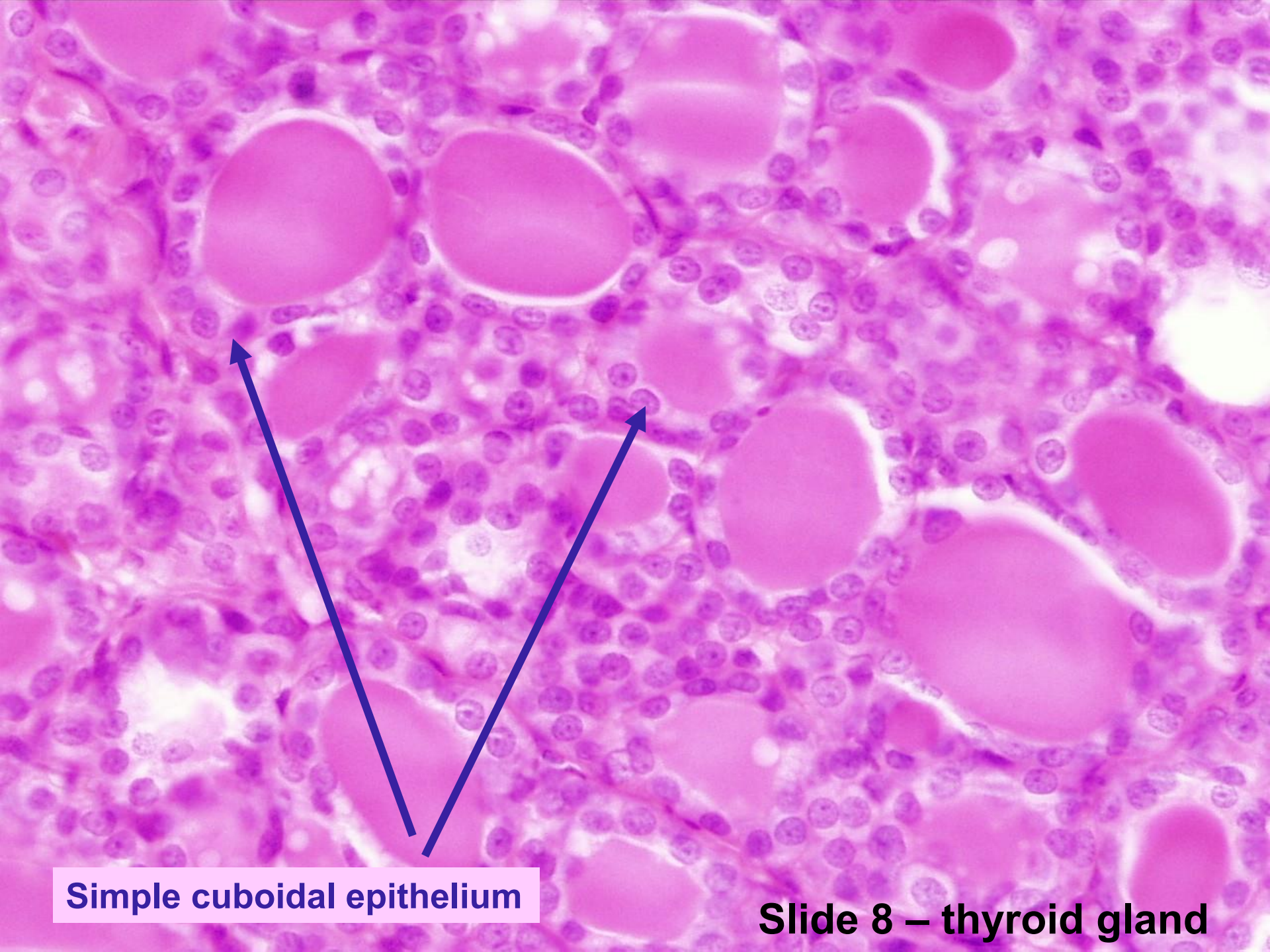
**Slide 3a - cornea**



- Thyroid gland** - endocrine gland.
- Follicles - surrounded by a single layer of epithelial cells.

## Slide 8

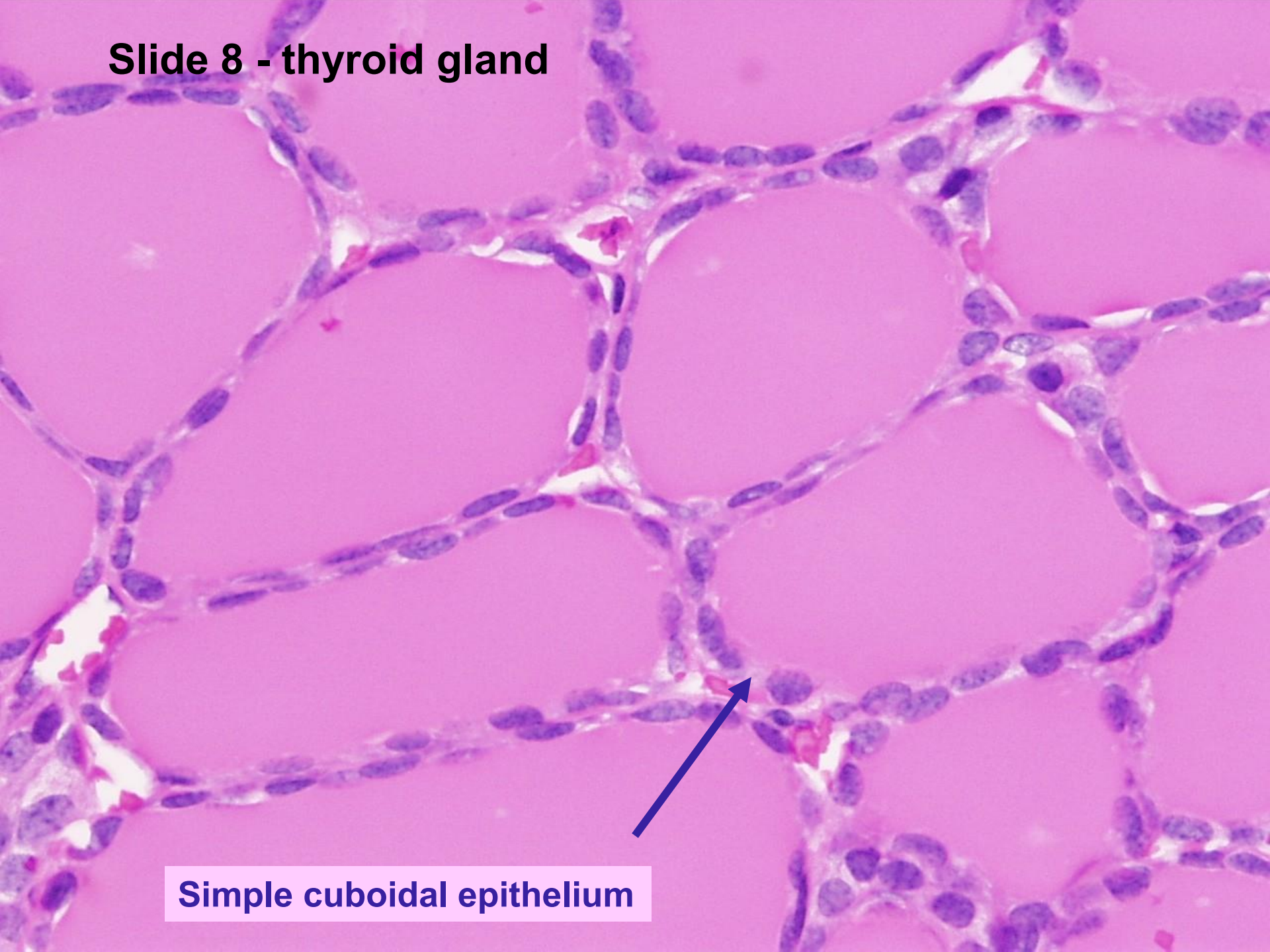




**Simple cuboidal epithelium**

**Slide 8 – thyroid gland**

## Slide 8 - thyroid gland



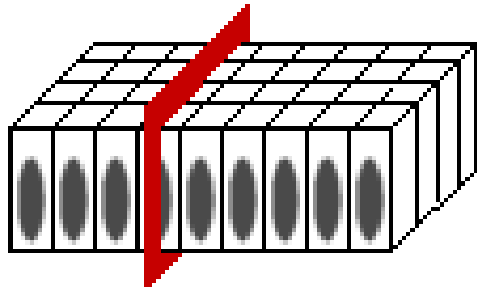
Simple cuboidal epithelium



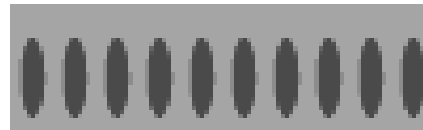
**Jejunum** – a part of the small intestine. The surface area of a jejunum is enlarged by **villi** - lined by – **simple columnar epithelium**

**Slide 51a - jejunum**

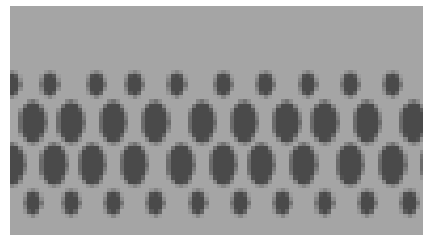
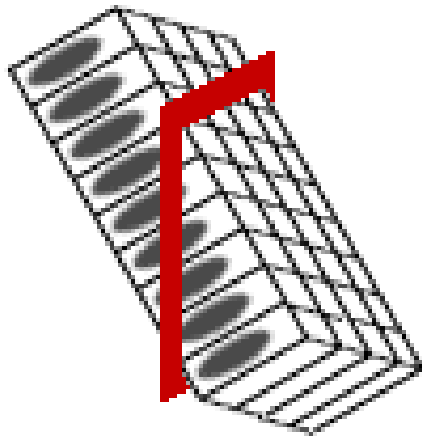




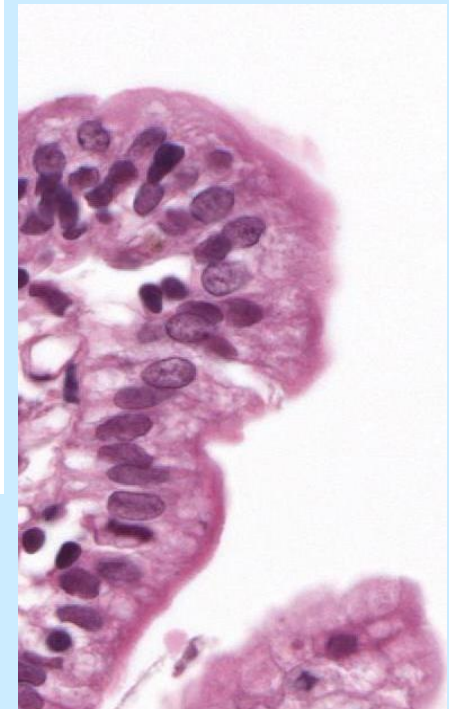
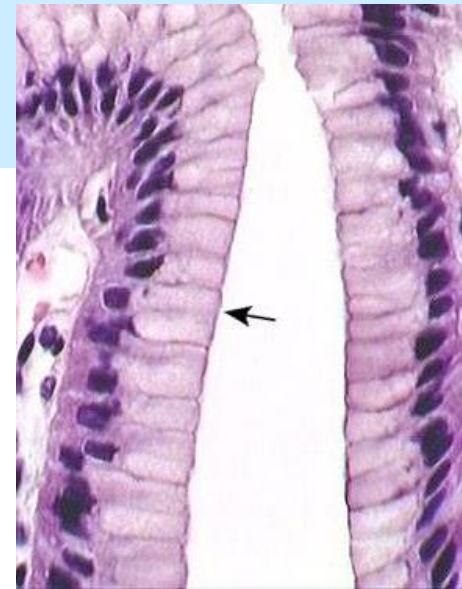
**perpendicular section**



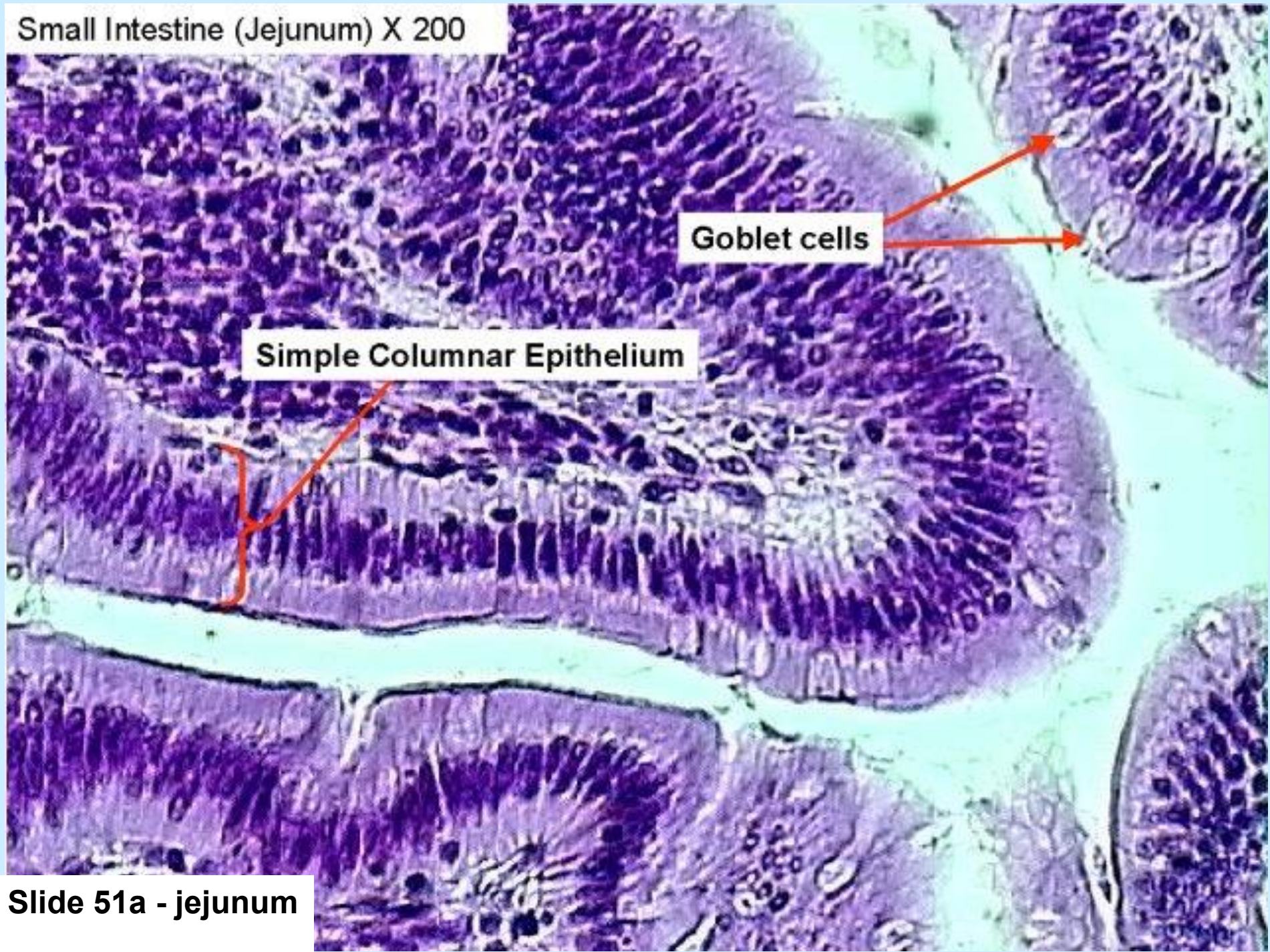
**simple columnar epithelium**



**oblique section**



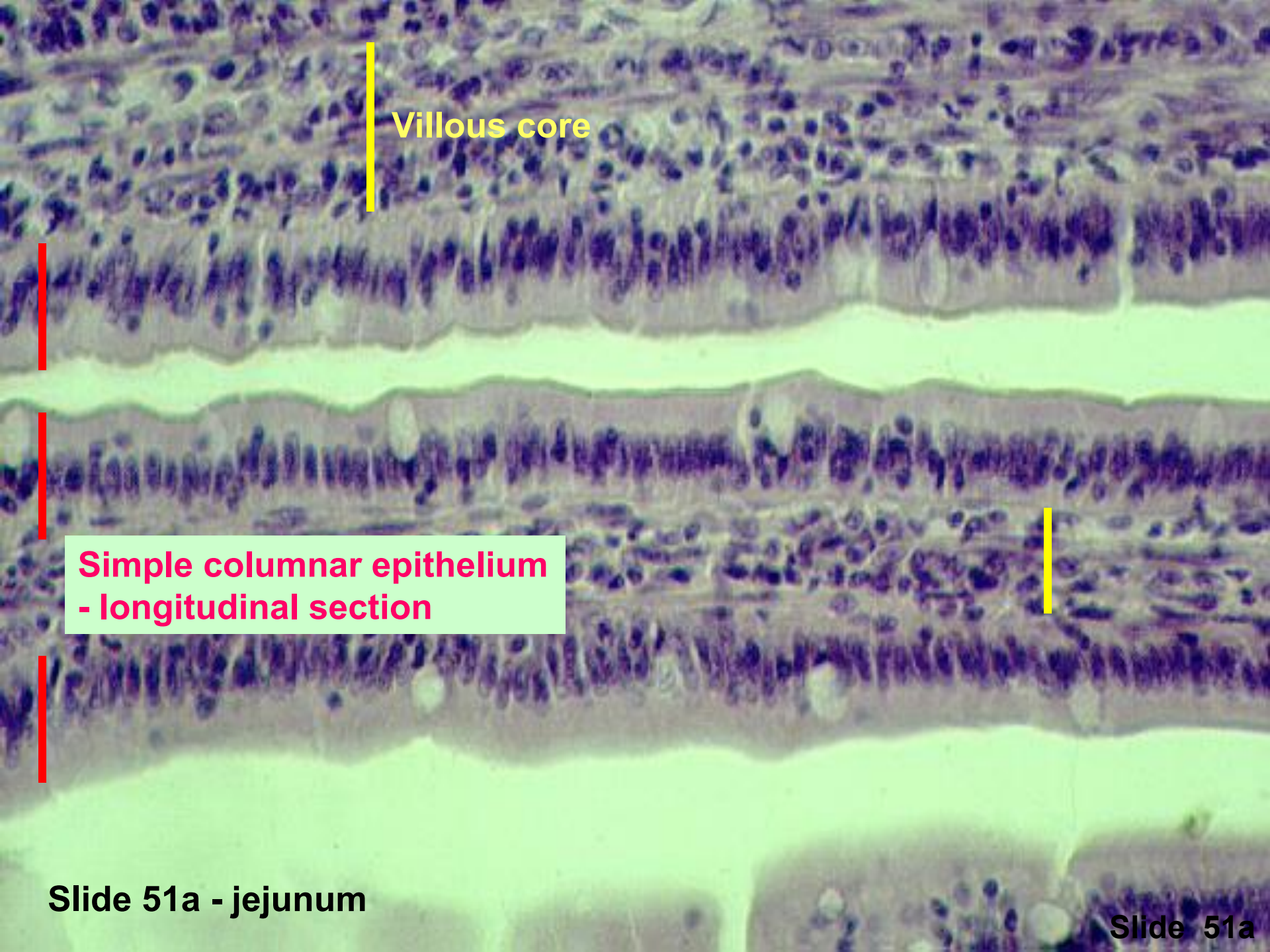
Small Intestine (Jejunum) X 200



Goblet cells

Simple Columnar Epithelium

Slide 51a - jejunum



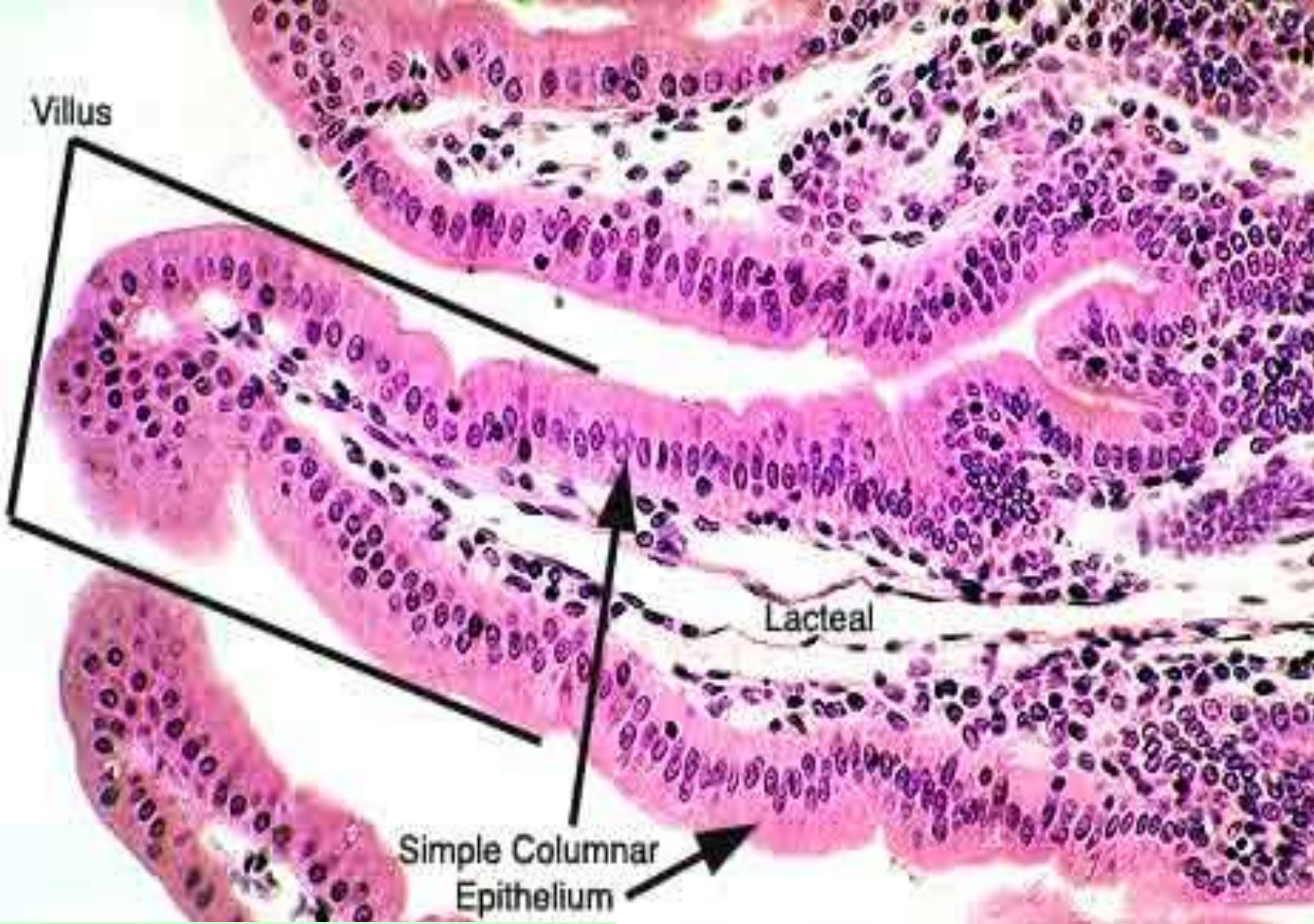
Villous core

This histological image shows a longitudinal section of the jejunum. The villi are finger-like projections of the mucosa, each containing a central villous core. The villi are separated by deep, narrow crypts. The epithelium is simple columnar, with cells having a rectangular shape and a central nucleus. The overall structure is highly organized and repetitive.

Simple columnar epithelium  
- longitudinal section

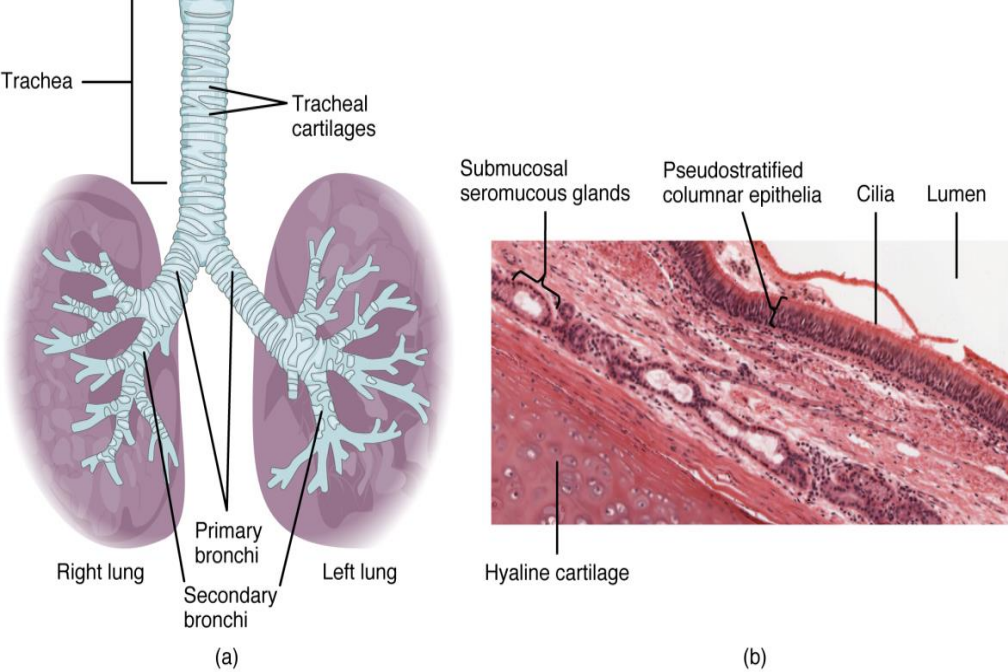
Slide 51a - jejunum

Slide 51a



**Simple columnar epithelium**

**Slide 51a - jejunum**



Connective Tissue  
(lamina propria)

Epithelium  
(pseudostratified columnar)

blood vessels

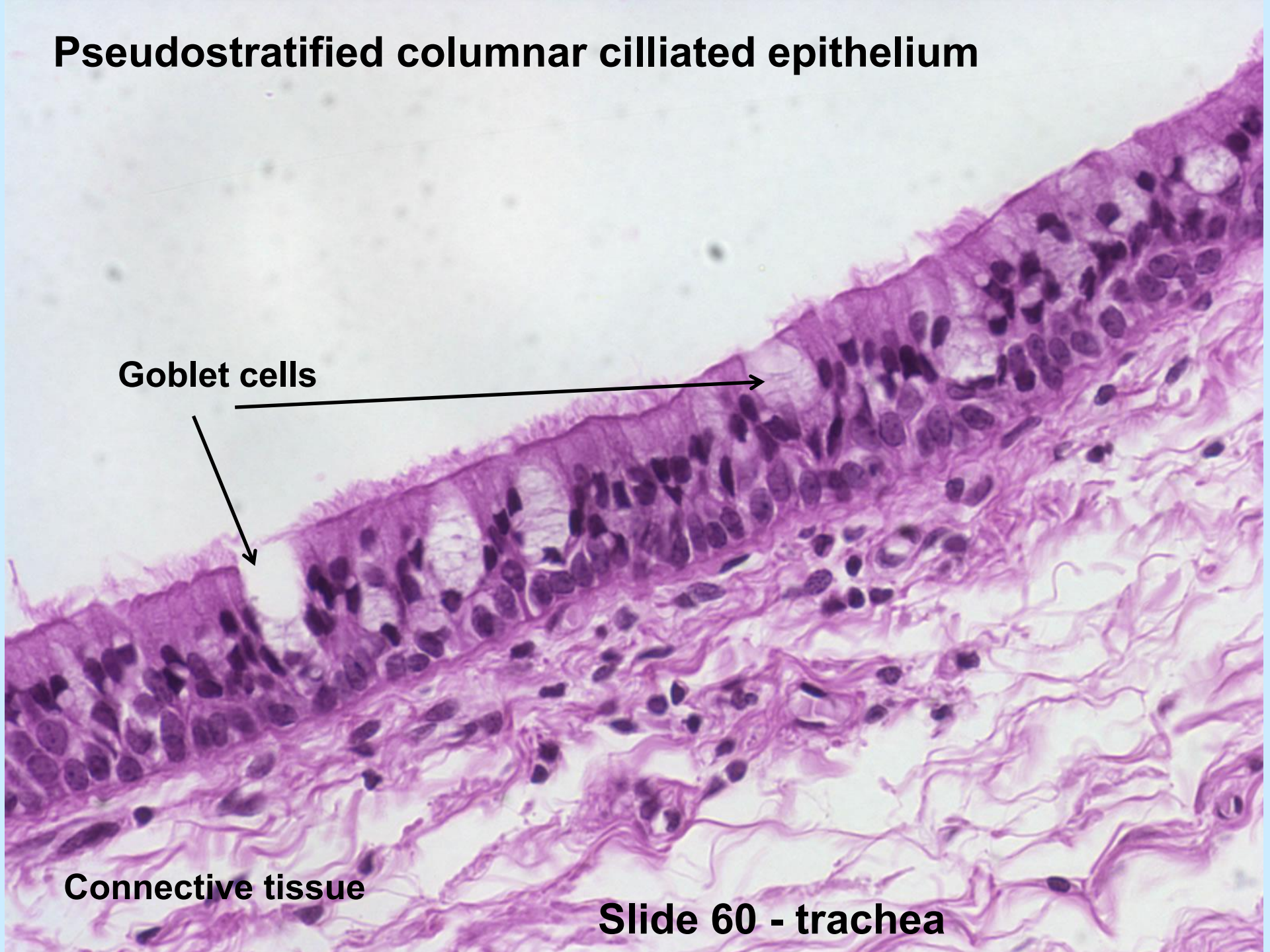
Slide 60 - trachea

# Pseudostratified columnar ciliated epithelium

Goblet cells

Connective tissue

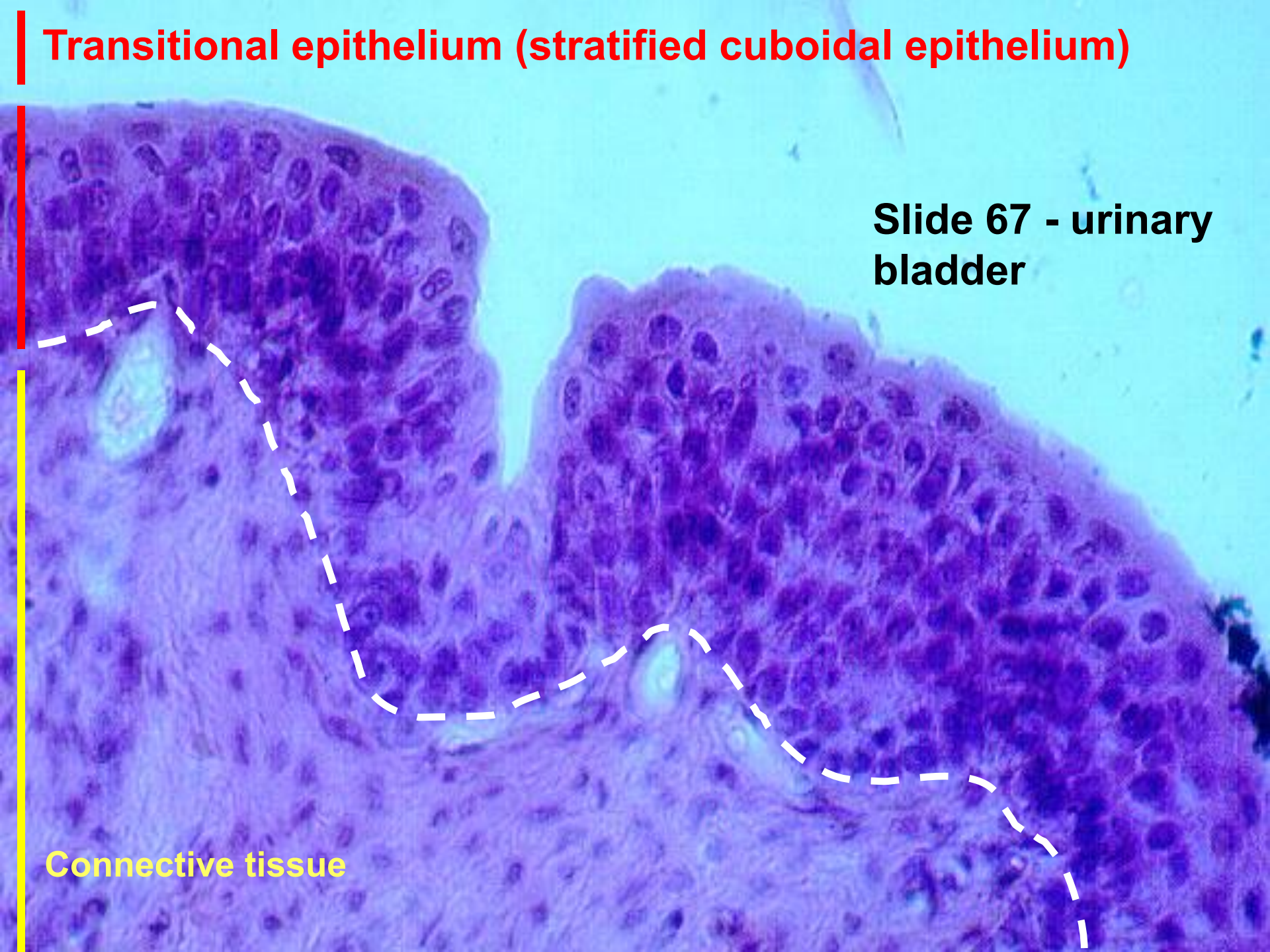
Slide 60 - trachea

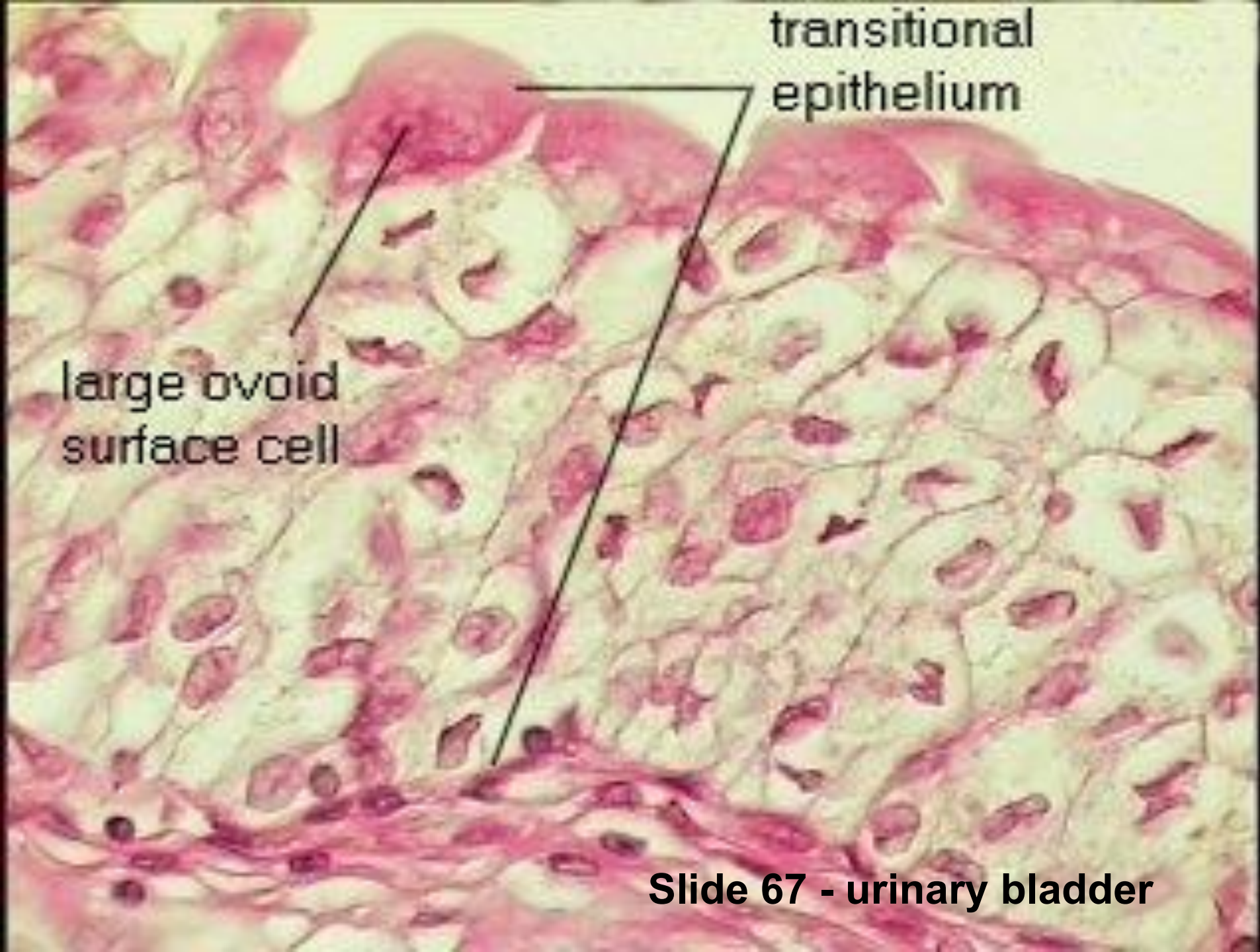


# Transitional epithelium (stratified cuboidal epithelium)

Slide 67 - urinary  
bladder

Connective tissue

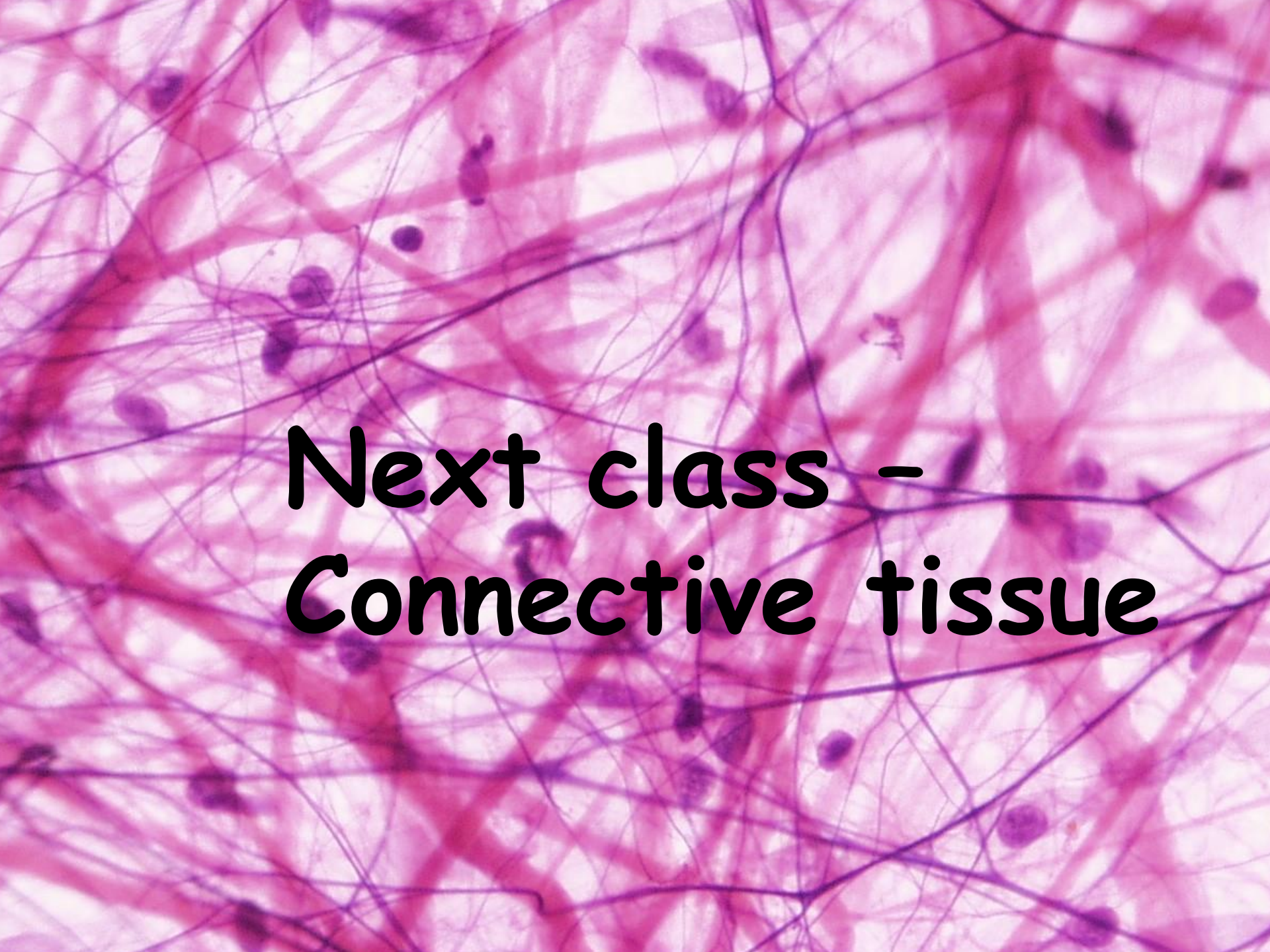




transitional  
epithelium

large ovoid  
surface cell

Slide 67 - urinary bladder

A microscopic image of connective tissue, showing a dense network of pink-stained collagen fibers and scattered purple-stained nuclei of cells.

**Next class -  
Connective tissue**