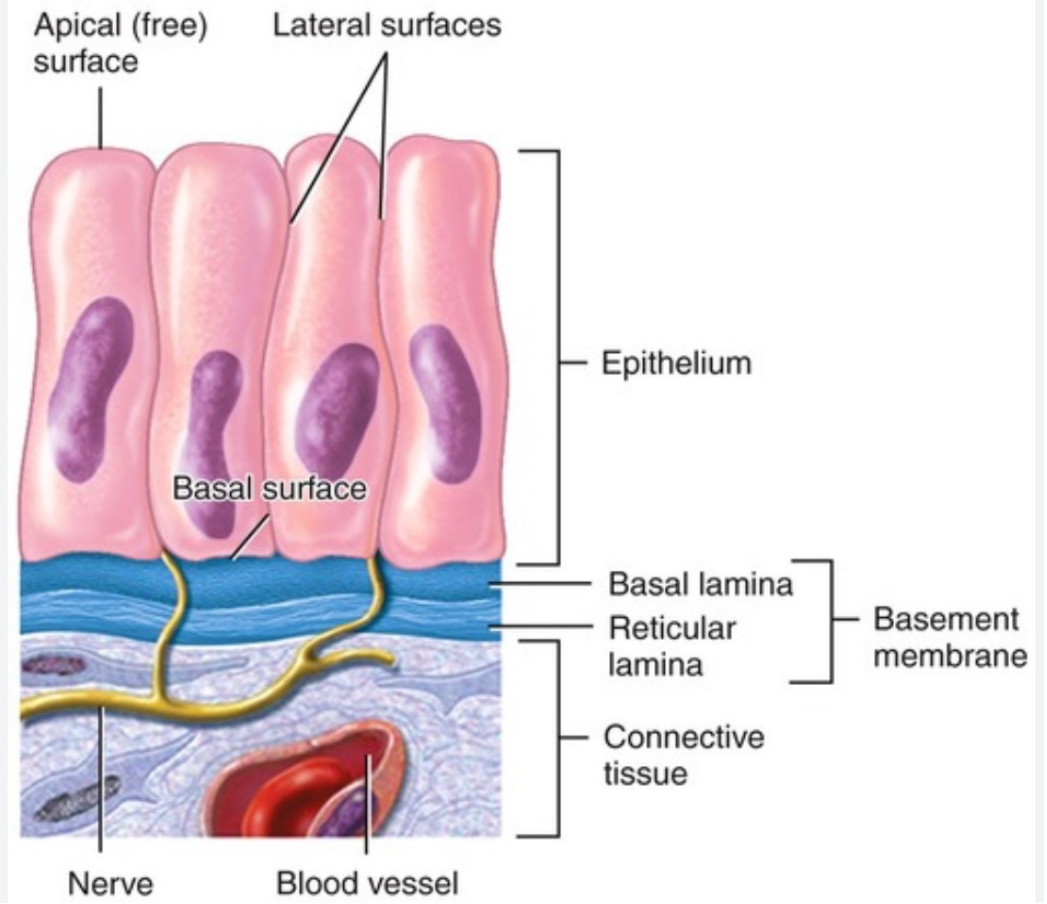
EPITHELIUM

Epithelium

- Continuous sheets of cells adhering strongly to one another and to the underlying ECM. They line internal surfaces and cover the external surfaces
- It is a selective barrier that cover, lines , and protects tissues and is often involved in absorption or secretion.
- Separated from the adjacent connective tissue by a **basement membrane**



Characteristics of epithelium

- Supported by the underlying connective tissue.
- Innervated (has nerves).
- Avascular (no blood vessels) ; blood supply is in supporting connective tissue.
- Has a **good regeneration capacity but varies widely; GIT every week—or quite slow as in large glands.**

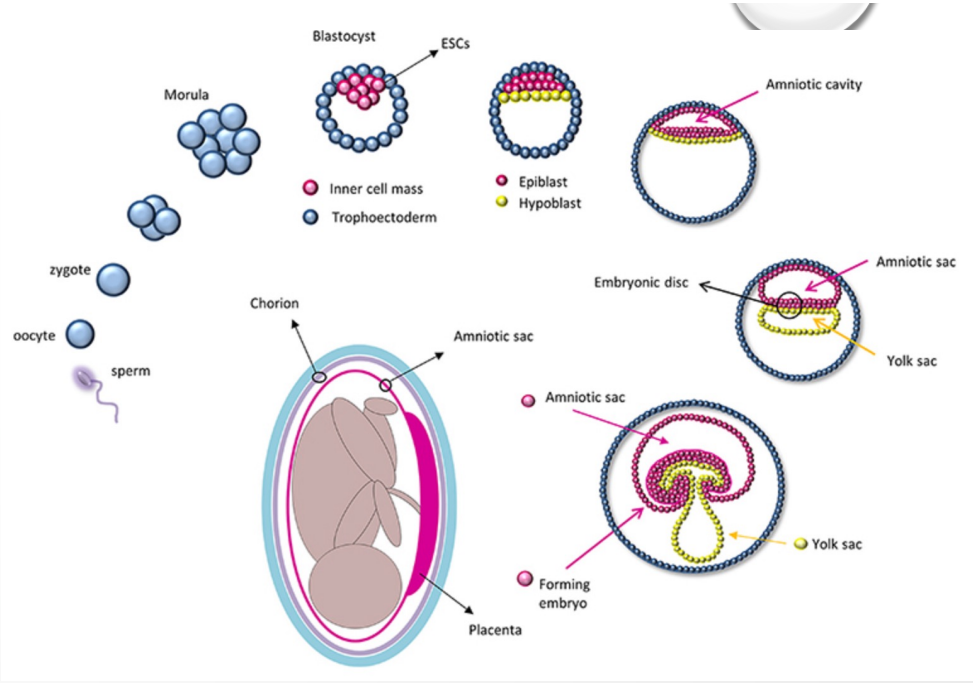
Functions of epithelium

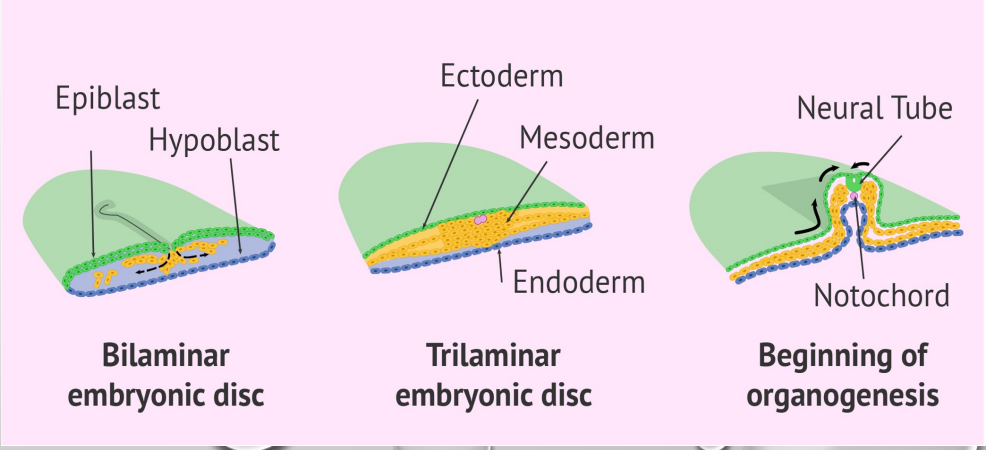
- Protection/covering—lining—epidermis.
- Secretion—glandular tissue
- Absorption—intestines.
- Detection of sensations.—inner ear, taste buds.
- Contraction---specialized cells---myoepithelial cells (glands)

Embryogenesis of epithelium

Epithelium arises from all germinal layers: mesoderm, endoderm, ectoderm

1. **Ectoderm**: epidermis(stratified squamous keratinized).
2. **Mesoderm**: endothelium.
3. **Endoderm**: GIT tract (not all), lungs.

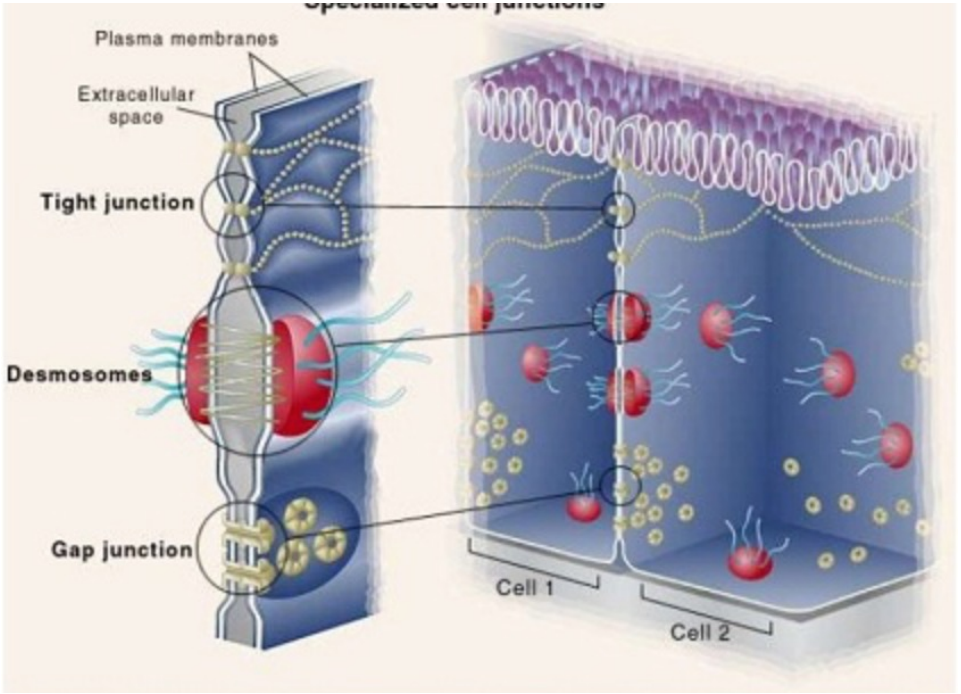




Features

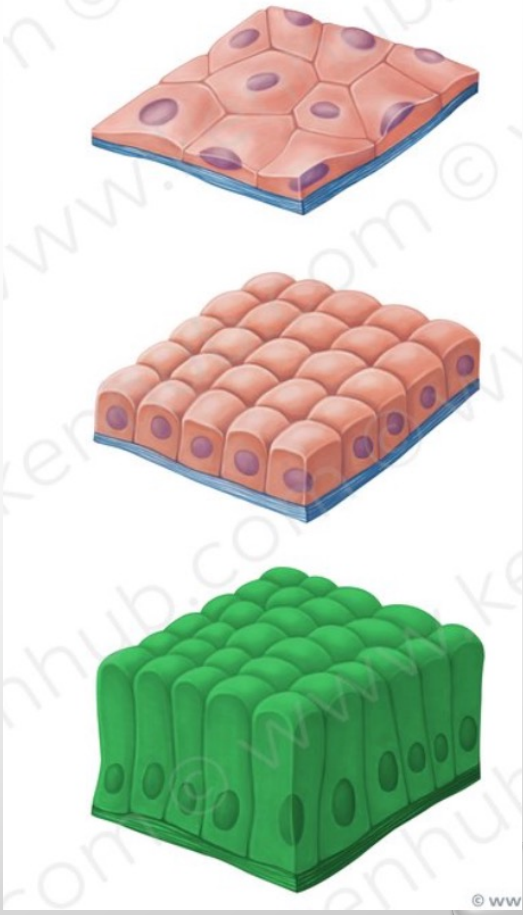
Epithelial cells are highly polarized:

- **Apical surface** - faces the lumen or the external environment
  - Microvilli, cilia, stereocilia
- **Lateral surface** - faces the sides of adjacent cells
  - Tight junctions, desmosomes, gap junctions (intercellular junction)
- **Basal surface** - attaches to the basement membrane
  - Basement membrane, hemidesmosomes



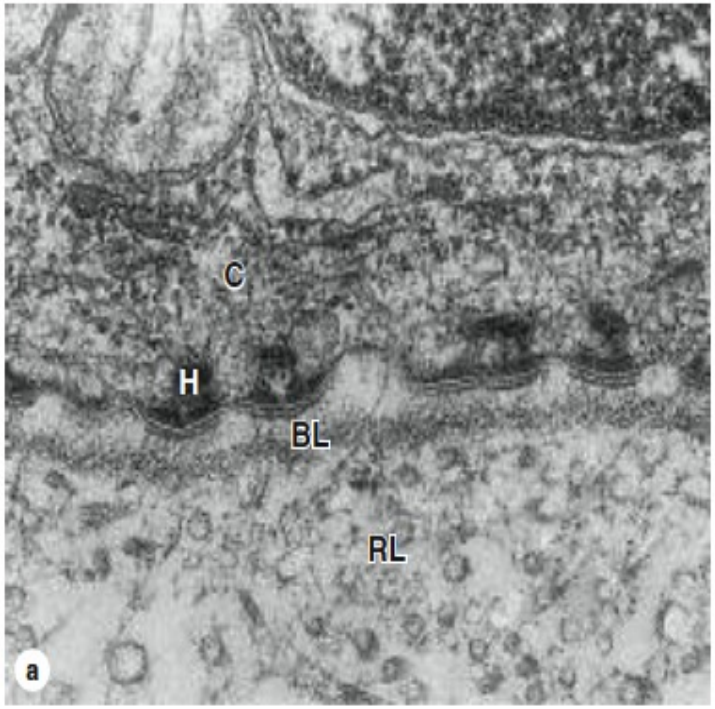
Features

- Cells' shape: columnar cuboidal and squamous----function.
- Nucleus shape: elliptic (oval), spherical, or flattened---cell shape.
- Most epithelia are adjacent to connective tissue-----receive nutrients and O_2--lamina propria (digestive, respiratory, urinary).



Basement membrane

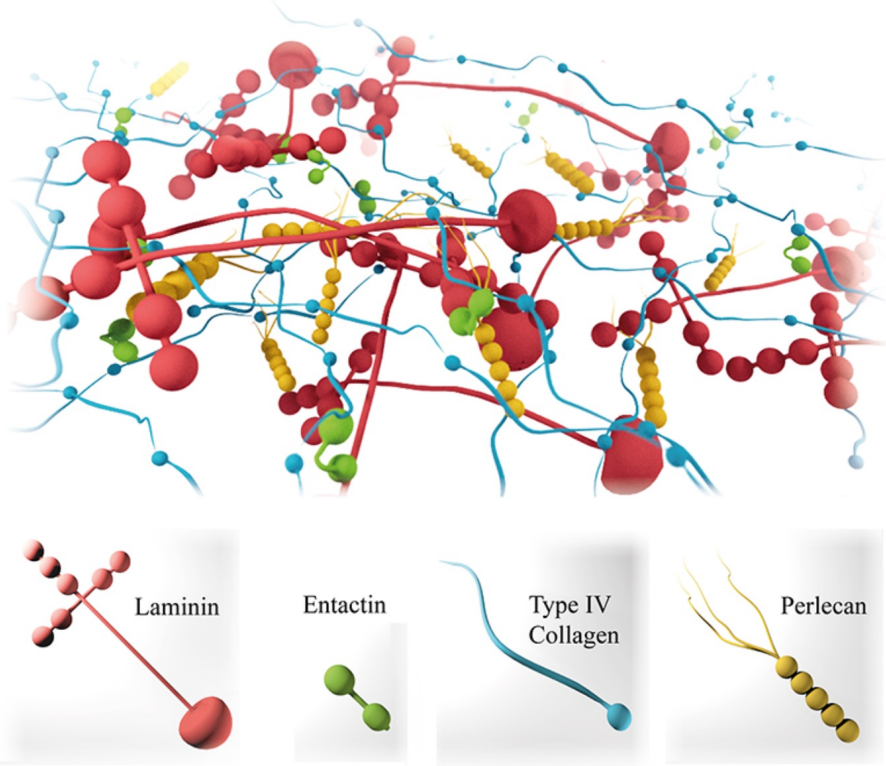
- Thin extracellular, felt-like sheet of macromolecules.
- A semipermeable filter for substances reaching epithelial cells from below
- Electron microscope: basal lamina (epithelium), reticular lamina(CT).



Basal Lamina

- Molecules of basal lamina:

1. Type IV collagen: a two-dimensional network of evenly spaced subunits.
2. Laminin: large glycoproteins that attach to integrins, and project through the network of collagen IV.



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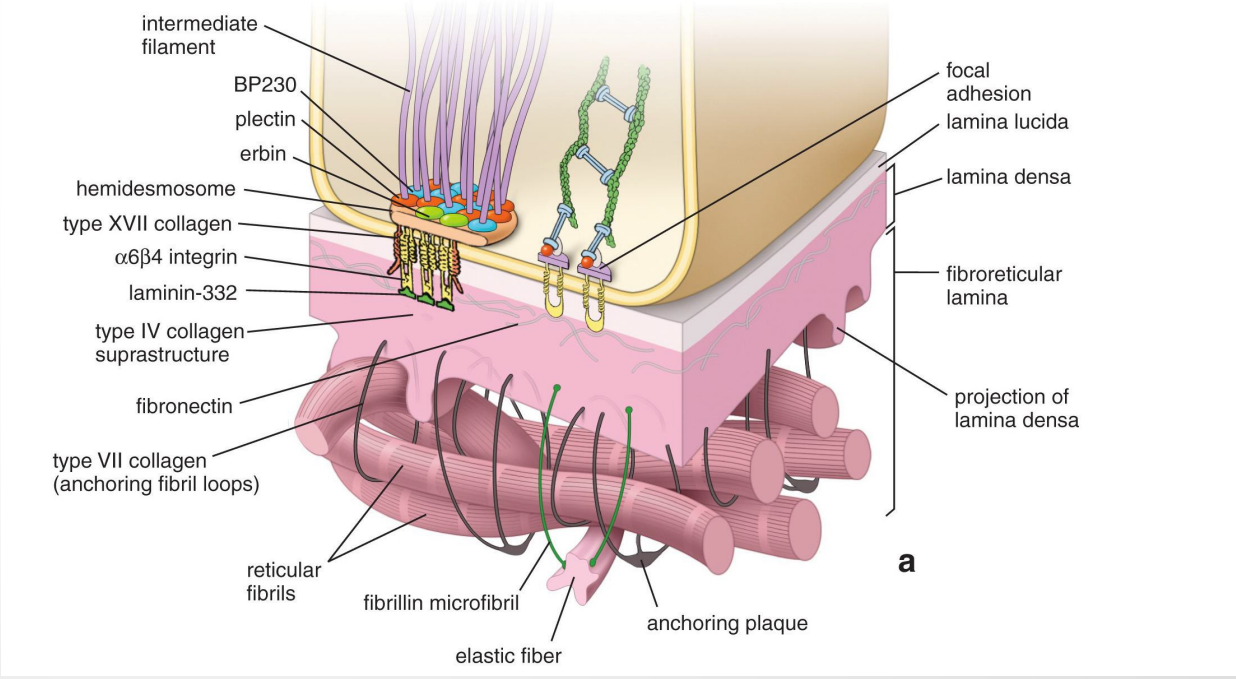
3. Nidogen (entactin) and perlecan: protein and a proteoglycan, cross-link laminin to the collagen network and help determine the porosity of the basal lamina and the size of molecules able to filter through it.

Reticular lamina: contains collagen type III which is bound to basal lamina by collagen type VII.

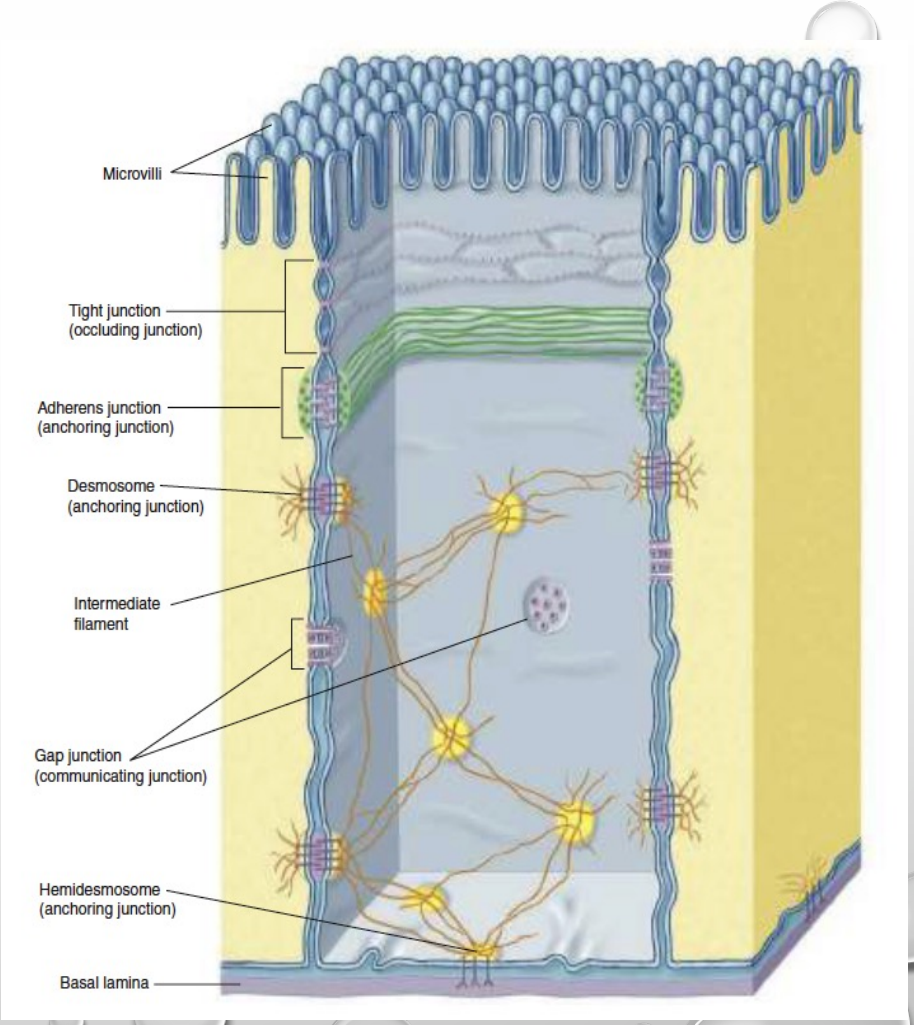
Reticular lamina



- Contain reticular fibers (collagen type III)
- Anchoring fibrils of type VII collagen link the basal lamina with the reticular fibers of the reticular lamina
- Product of the connective tissue.

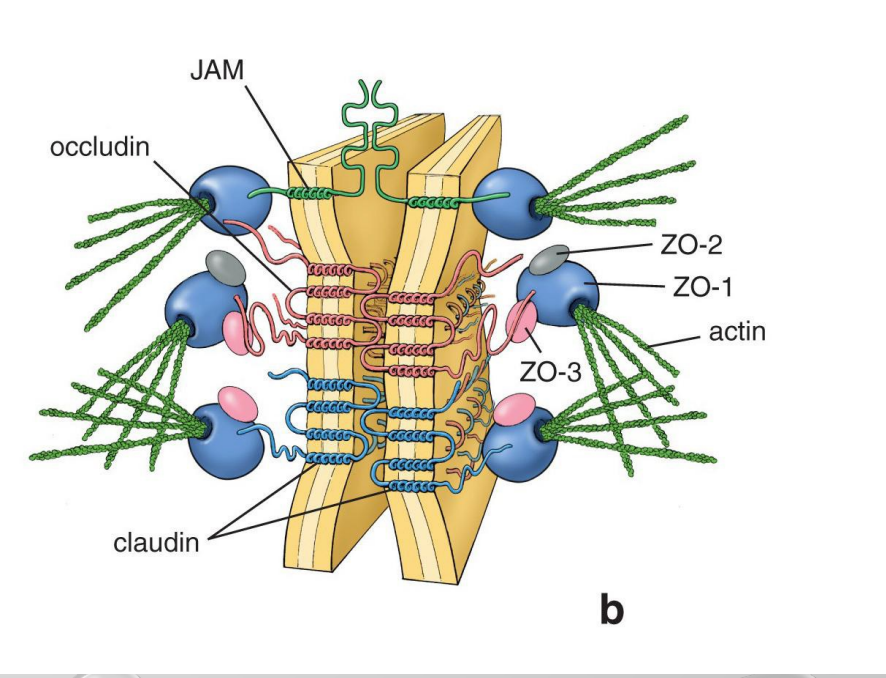
Junctional Complexes

- Membrane-associated structures provide adhesion and communication between cells
- Epithelial cells adhere strongly to neighboring cells and basal laminae
- Tight or occluding junctions form a seal between adjacent cells.
- Adherent or anchoring junctions are sites of strong cell adhesion.
- Gap junctions are channels for communication between adjacent cells.
- Desmosome or macula adherens are disc-shaped structures at the surface of one cell that are matched with identical structures at an adjacent cell surface.



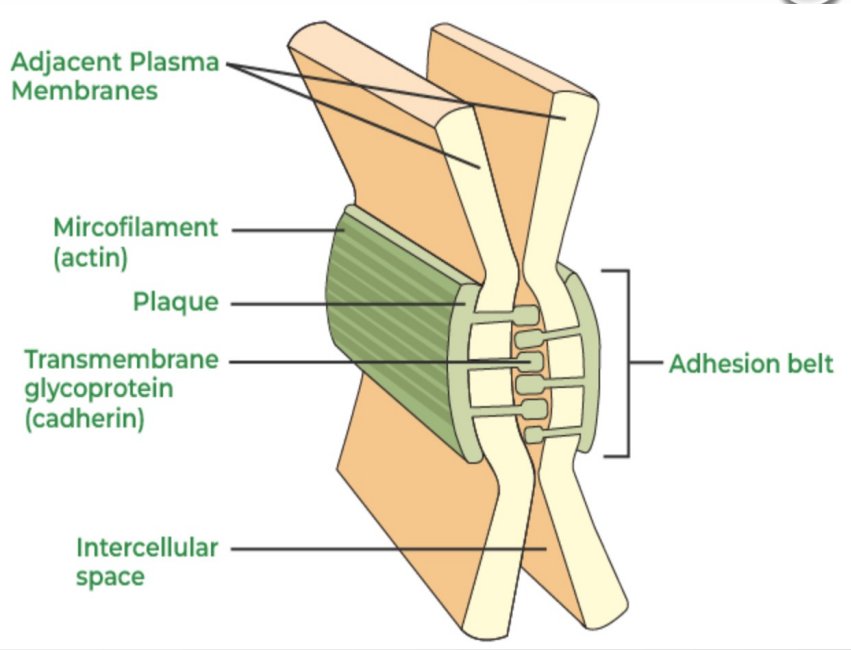
Tight Junction
Zonula occludens

- Tight or occluding junctions form a seal between adjacent cells.
- They are the most apical
- The seal between the two cell membranes is due to tight interactions between the transmembrane proteins claudin and occluding.
- The intercellular seal of tight junctions ensures that molecules crossing an epithelium in either direction do so through transcellular route not the paracellular one .



Adherent Junctions
Zonula adherens

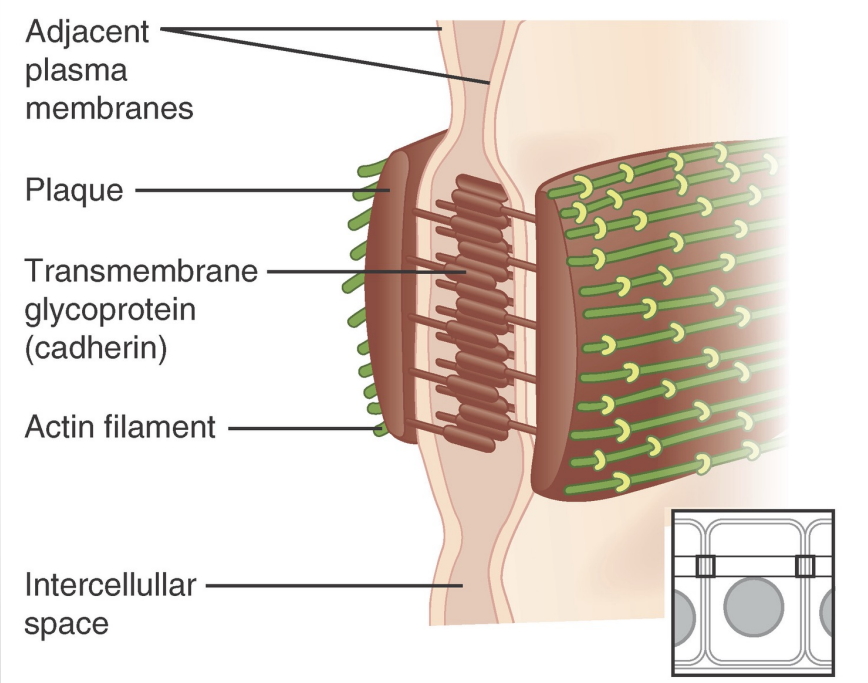
- Encircle the epithelial cell, usually below the tight junction.
- Firmly anchoes cells to neighboring ones.
- Cell adhesion is mediated by **e-cadherin** (transmembrane glycoproteins) of each cell that bind each other in the presence of Ca^{2+}.



At their cytoplasmic ends, cadherins bind **catenins** that link to actin filaments with actin-binding proteins.
The actin filaments linked to the adherens junctions form part of the "terminal web," a cytoskeletal feature at the apical pole in many epithelial cells.

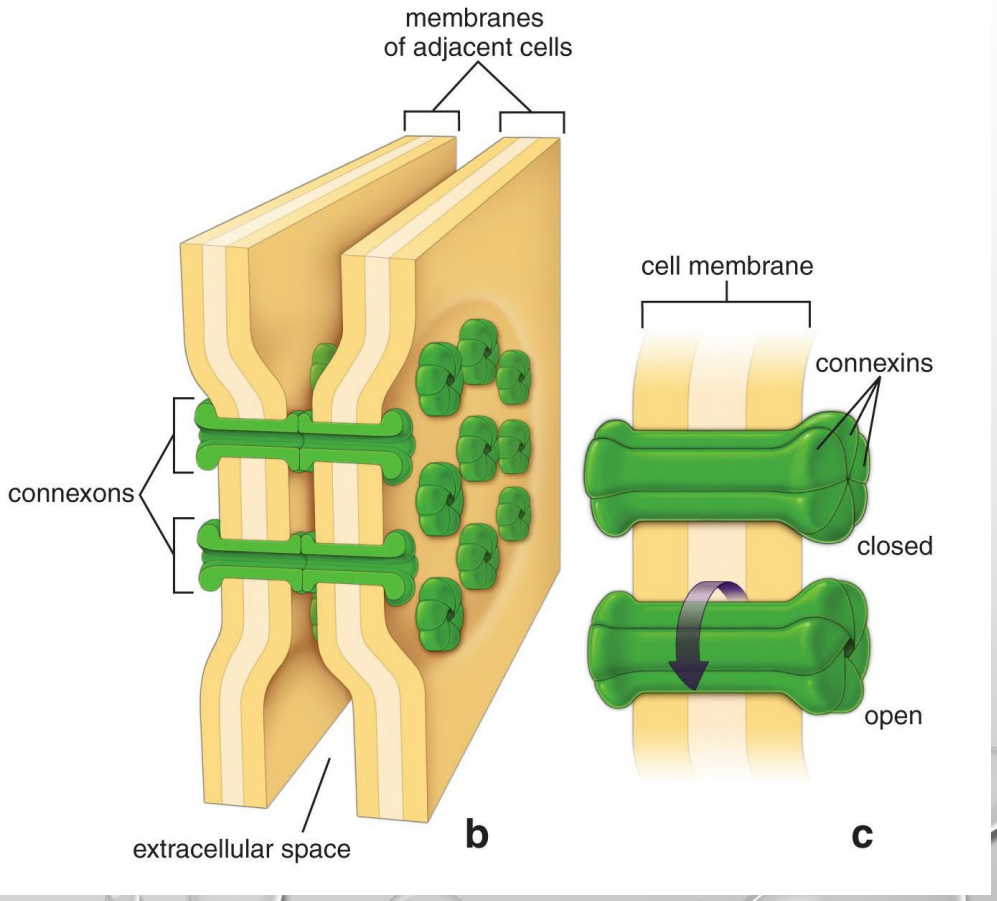
Desmosomes

- Disc-shaped structures that are matched with identical structures at an adjacent cell surface
- Desmosomes contain larger members of the cadherin family called desmogleins and desmocollins.
- The cytoplasmic ends of these transmembrane proteins bind a catenin-like protein which bind intermediate filament proteins rather than actins.



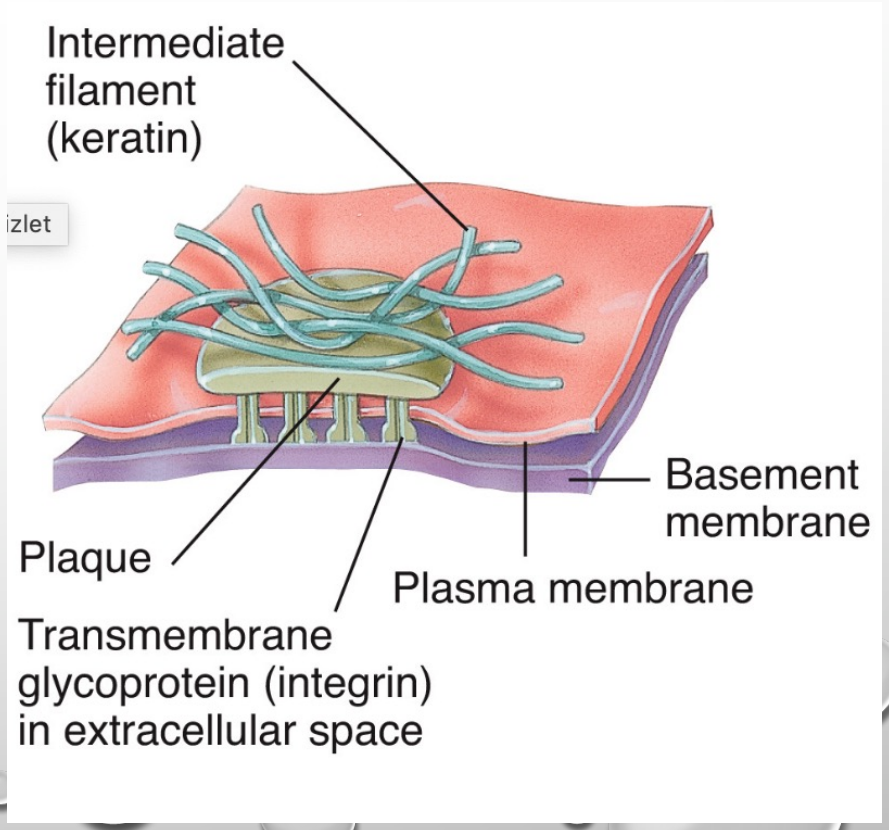
Gap Junctions

- Mediate intercellular communication.
- Present in many other cells.
- Connexins (transmembrane proteins) form hexameric complexes called connexons, each of which has a central hydrophilic pore about 1.5 nm in diameter.
- Permit intercellular exchange of molecules with small molecules < 1.5 nm in diameters.



Hemidesmosomes

- Located on the basal epithelial surface.
- Attach cells to the basal lamina.
- Resemble a half-desmosome ultra structurally, but unlike desmosomes the transmembrane proteins that indirectly link to cytokeratin intermediate filaments are integrins rather than cadherins.
- The integrins of hemidesmosomes bind primarily to laminin molecules in the basal lamina.



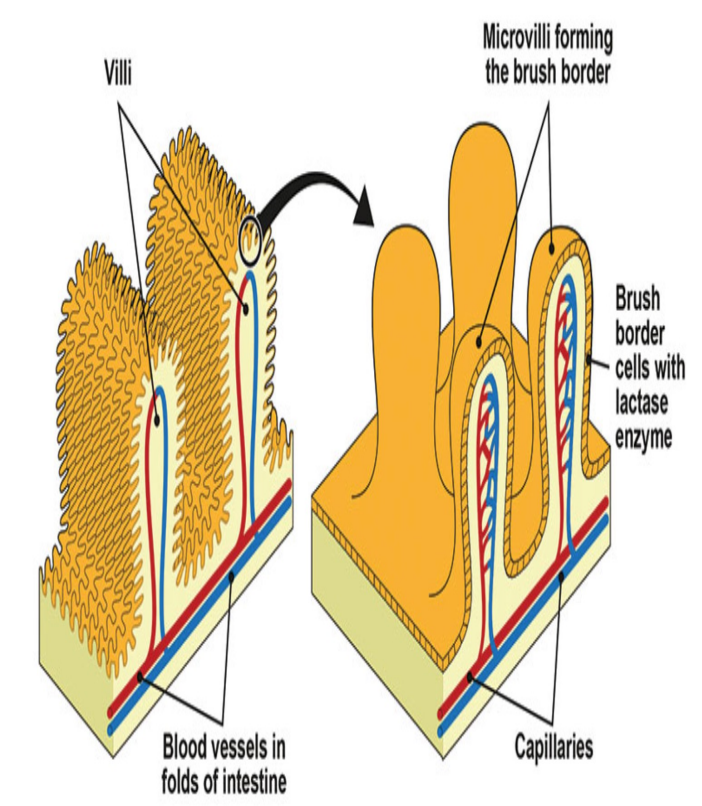
Junction	Tight Junction (Zonula Occludens)	Adherent Junction (Zonula Adherens)	Desmosome (Macula Adherens)	Hemidesmosome	Gap Junction (Nexus)
Major transmembrane link proteins	Occludins, claudins, ZO proteins	E-cadherin, catenin complexes	Cadherin family proteins (desmogleins, desmocollin)	Integrins	Connexin
Cytoskeletal components	Actin filaments	Actin filaments	Intermediate filaments (keratins)	Intermediate filaments	None
Major functions	Seals adjacent cells to one another, controlling passage of molecules between them; separates apical and basolateral membrane domains	Provides points linking the cytoskeletons of adjacent cells; strengthens and stabilizes nearby tight junctions	Provides points of strong intermediate filament coupling between adjacent cells, strengthening the tissue	Anchors cytoskeleton to the basal lamina	Allows direct transfer of small molecules and ions from one cell to another
Medical significance	Defects in occludins may compromise the fetal blood-brain barrier, leading to severe neurologic disorders	Loss of E-cadherin in epithelial cell tumors (carcinomas) promotes tumor invasion and the shift to malignancy	Autoimmunity against desmoglein I leads to dyshesive skin disorders characterized by reduced cohesion of epidermal cells	Mutations in the integrin-β4 gene are linked to some types of epidermolysis bullosa, a skin blistering disorder	Mutations in various connexin genes have been linked to certain types of deafness and peripheral neuropathy

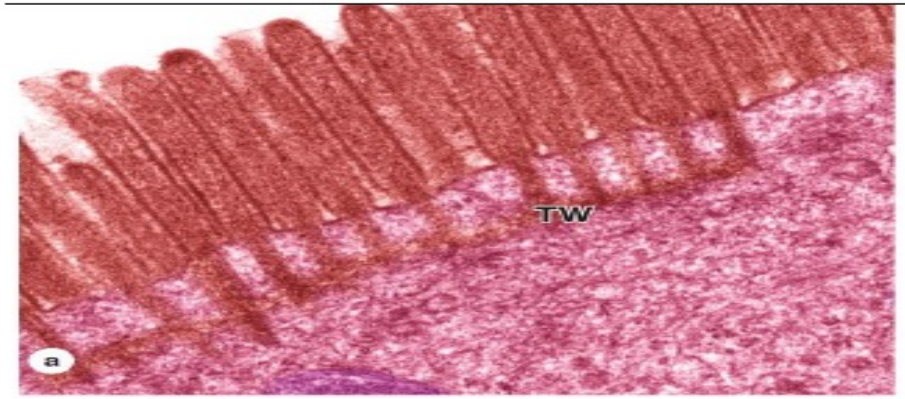
Specialized apical structures

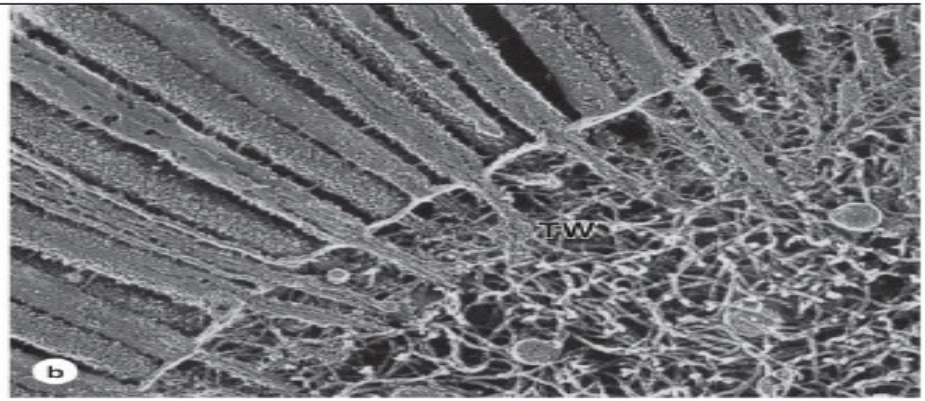
- Microvilli
- Cilia
- Stereocilia

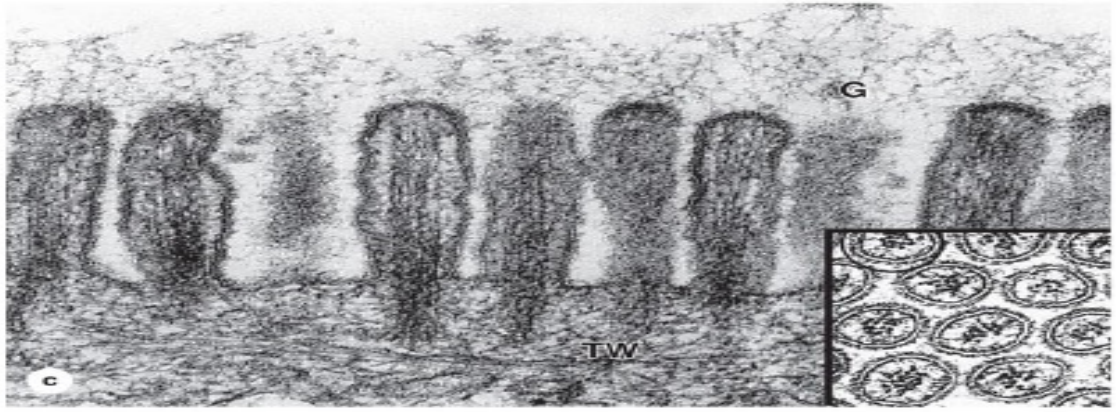
Microvilli

- Finger-like extensions of plasma membrane of apical epithelial cell.
- Present mainly in **absorptive cells (columnar/cuboidal)**.
- Main function is the absorption of nutrients from intestines and glomerular filtrate:
  Striated border in the intestine.
  Bruch border in the kidney).
- **Increase the surface area for absorption.**



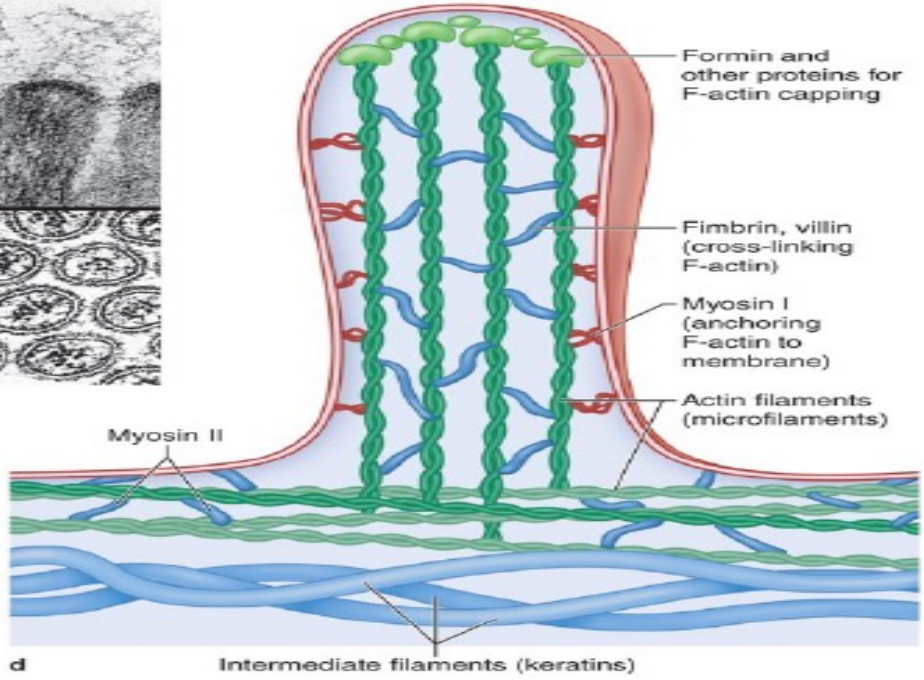




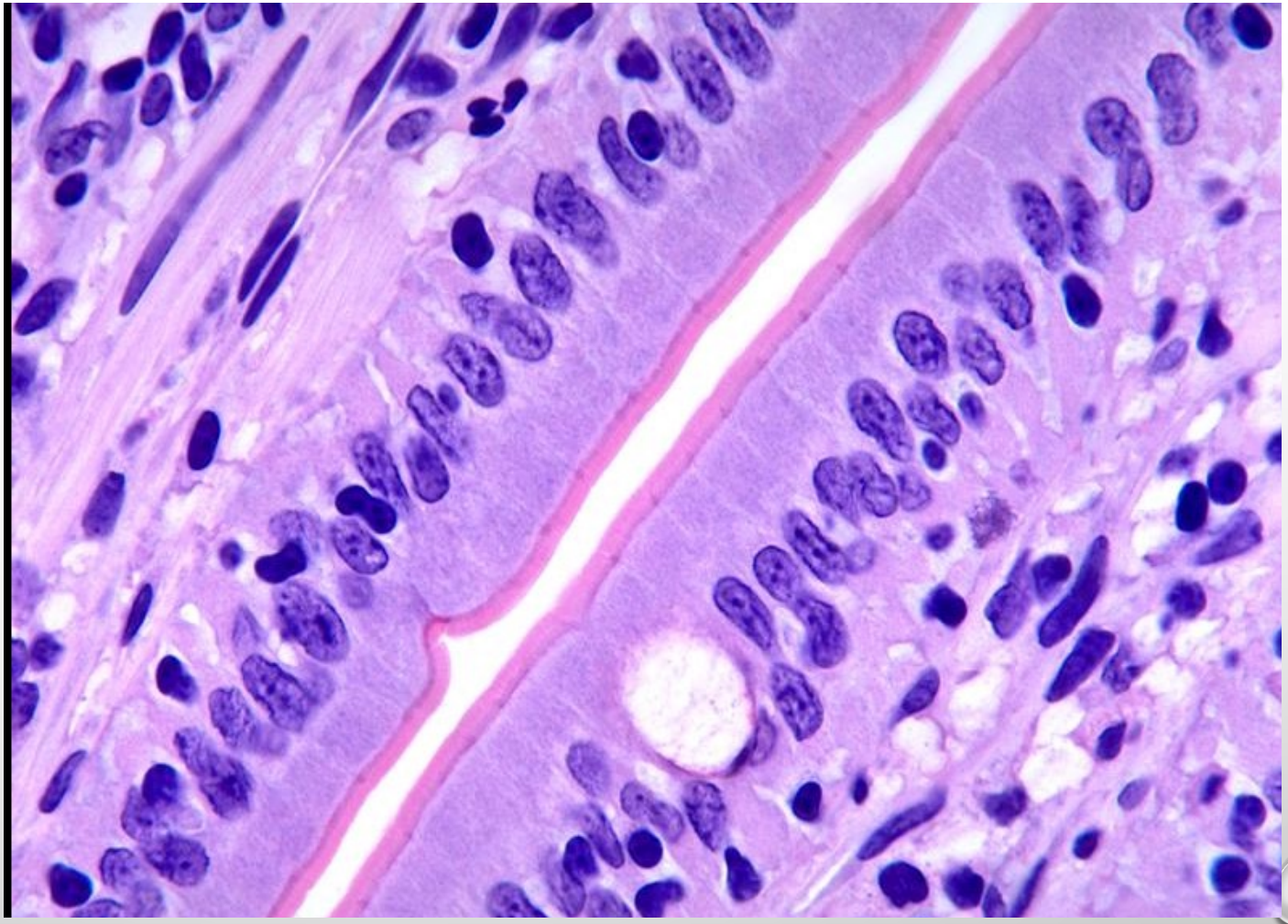


Microvilli

- Increase surface area
- Absorption.



Microvilli

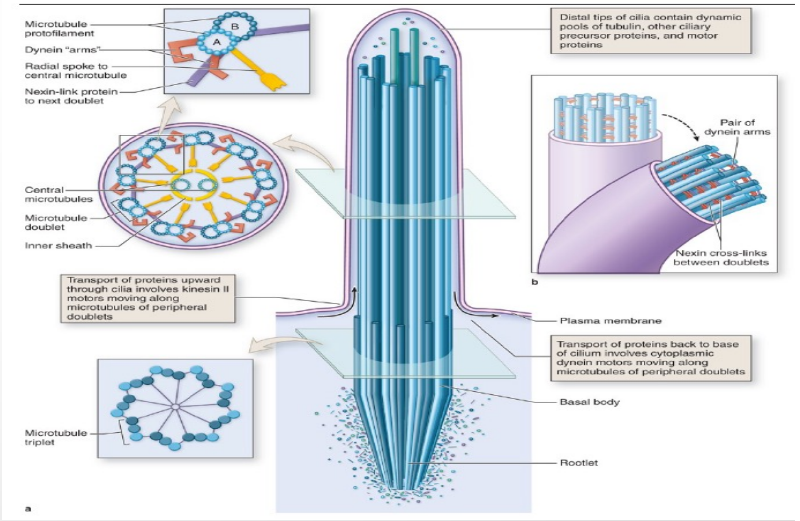


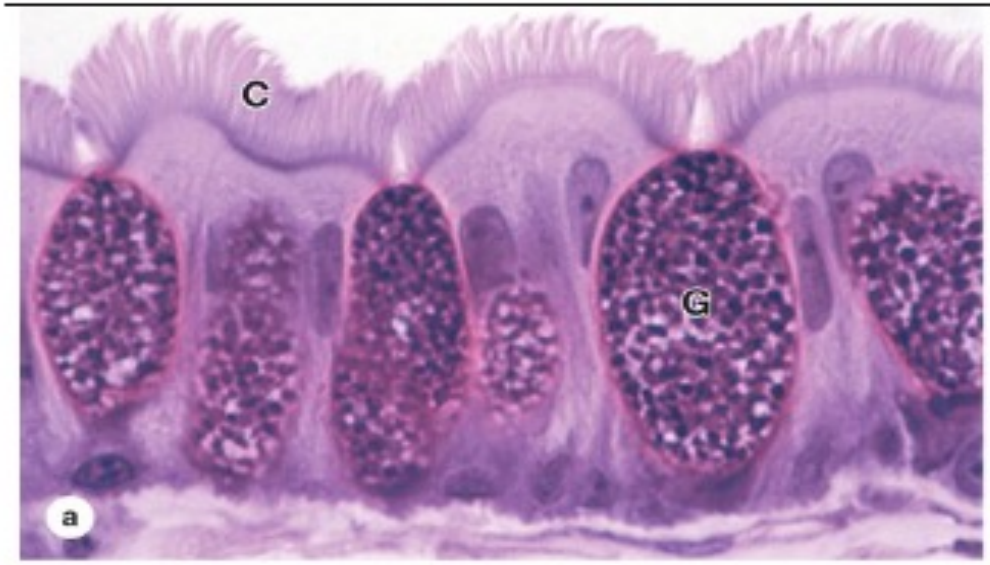
Cilia

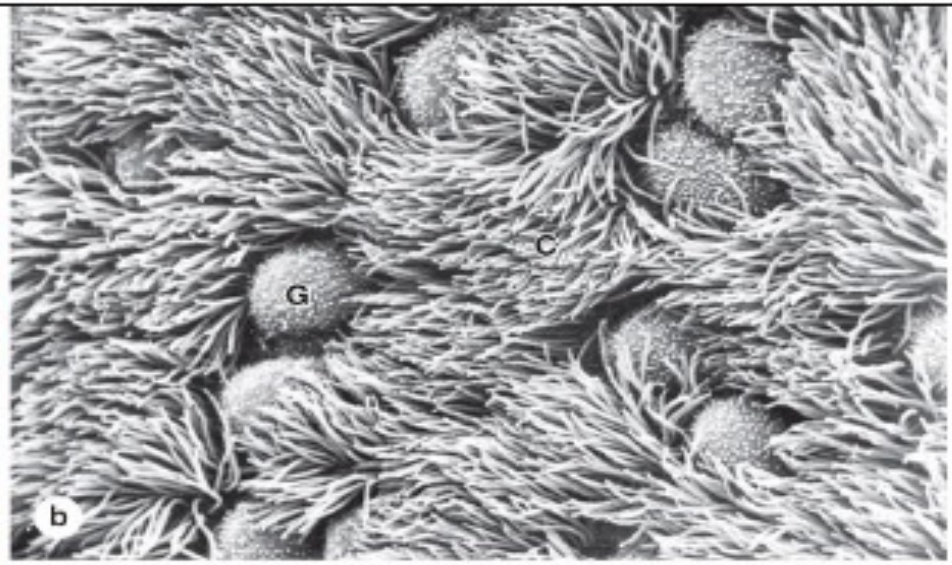
- Motile cytoplasmic hair like projections capable of moving fluid and particles along epithelial surfaces.
- Line cells in the respiratory organs, uterine tubes, and efferent ducts in testes.
- They move rhythmically and rapidly in one direction (motor proteins).
- Abundant on cuboidal or columnar cells
- Each cilium has a core structure consisting of nine peripheral microtubule doublets arrayed around two central microtubules---9 + 2 assembly---is called an axoneme

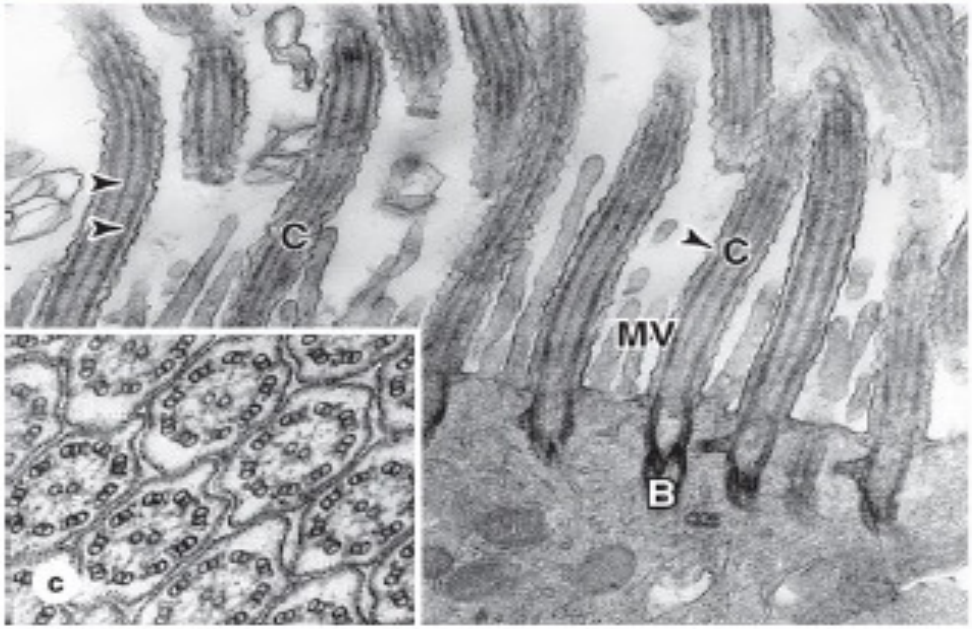
CILIA

- **A microtubule** of the doublet is composed of **13** tubulin dimers arranged in a side-by-side configuration.
- **B microtubule** is composed of **10** tubulin dimers and shares the remaining dimers with those of the A microtubule.
- The **dynein arms** extend from the A microtubule and make temporary cross-bridges with the B microtubule of the adjacent doublet.
- The basal body is anchored by the striated rootlet within the cell cytoplasm.
- A cross section of the basal body shows the arrangement of nine microtubule triplets.



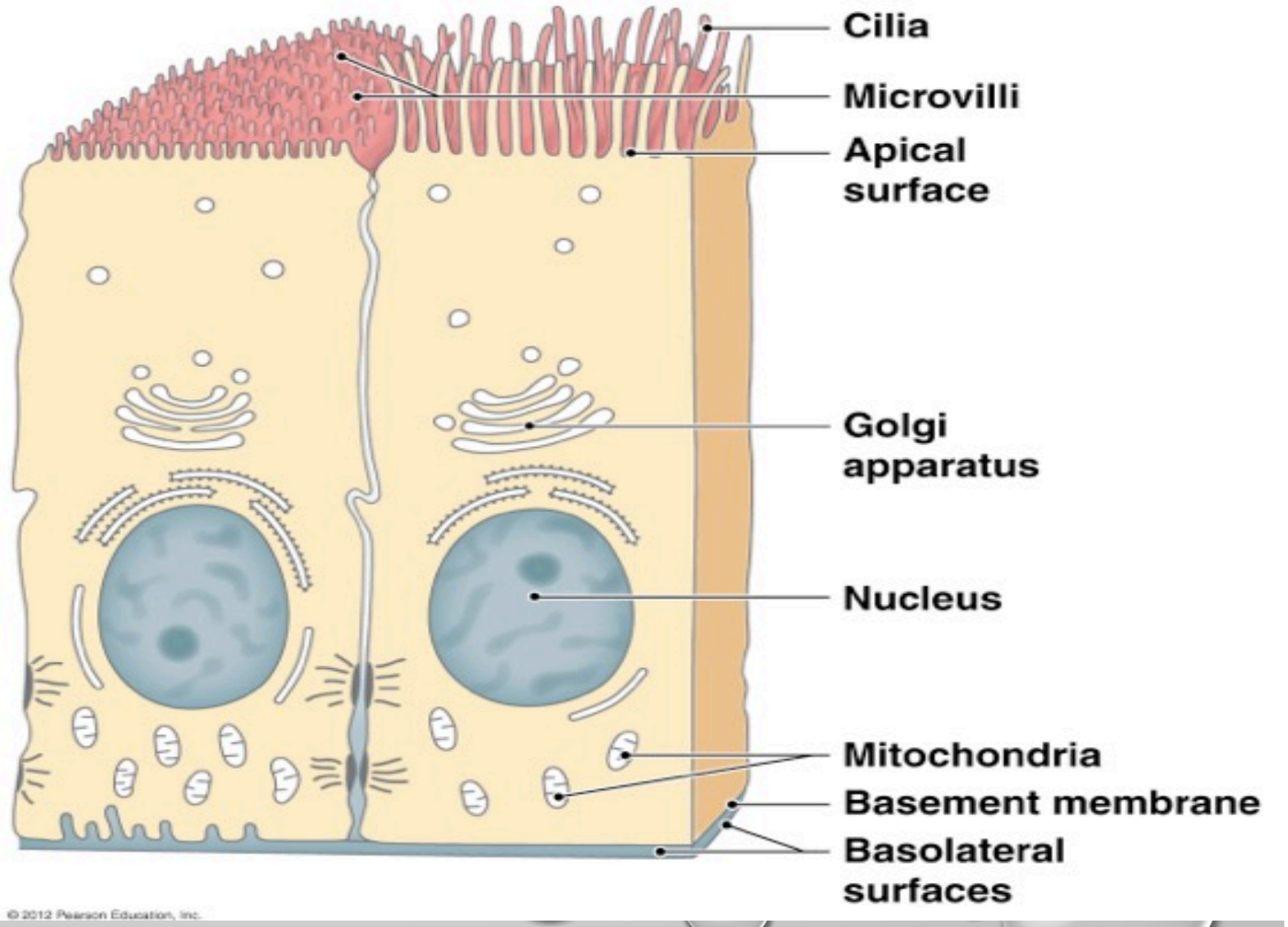






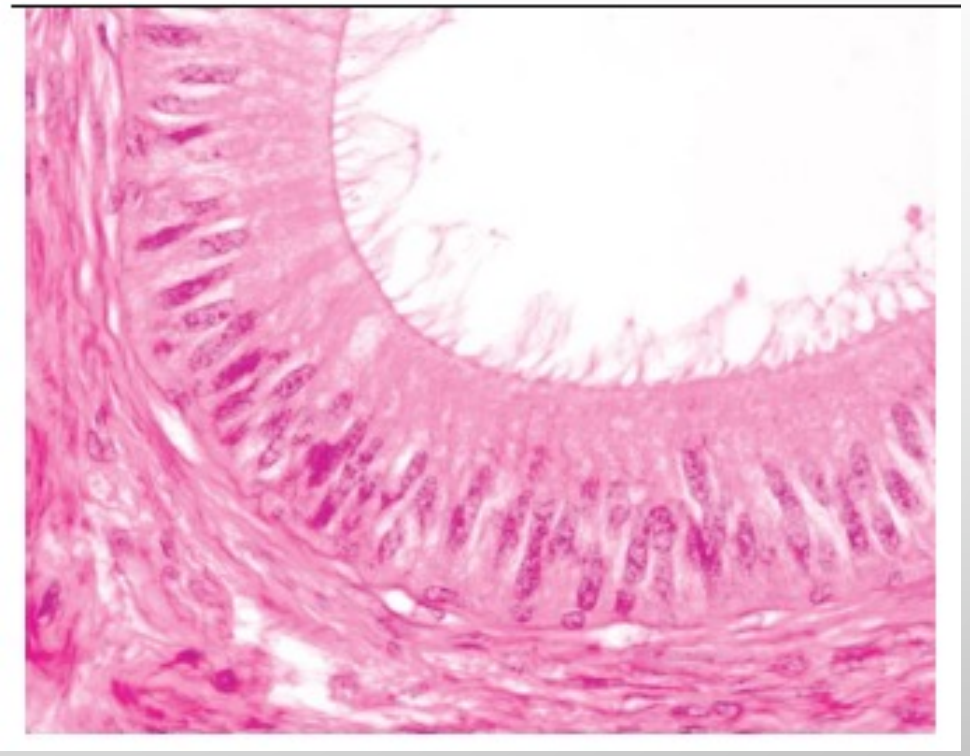
CILIA

Cilia And Microvilli

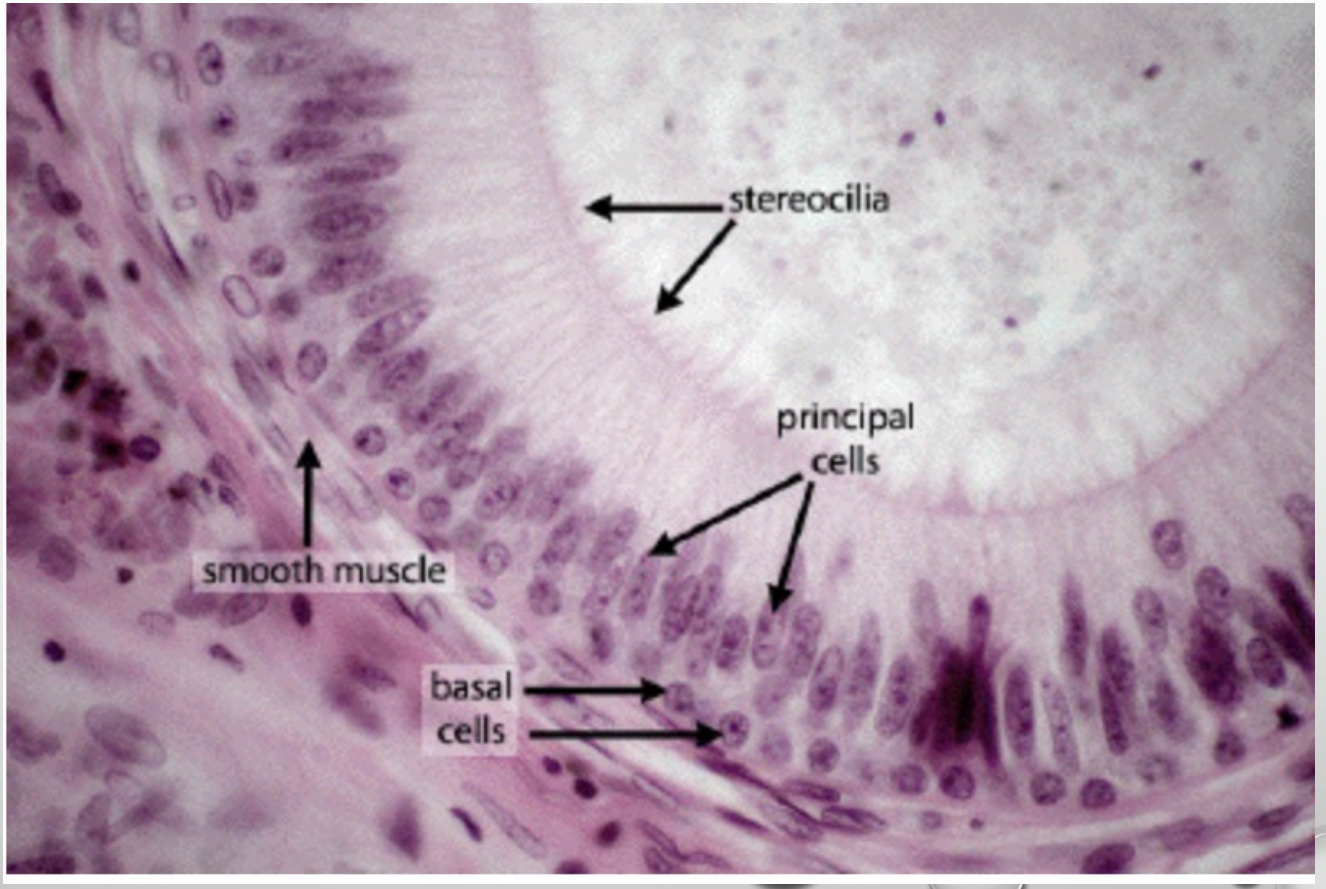


Stereocilia

- They are similar to microvilli BUT longer.
- Branched.
- Found in epididymis and ductus deferens (males)
- They have an absorptive function.
- In the internal ear they have a sensory function—detection of motion.

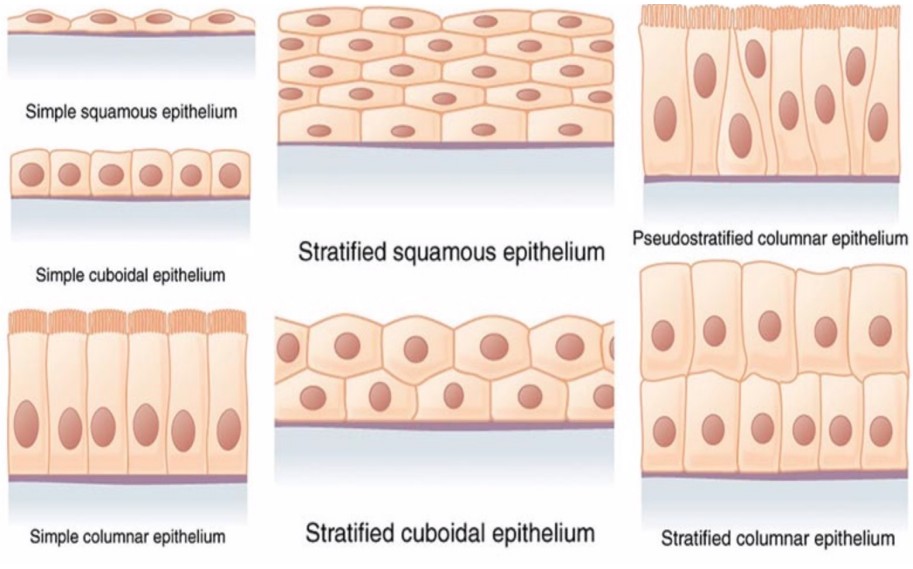


Stereocilia

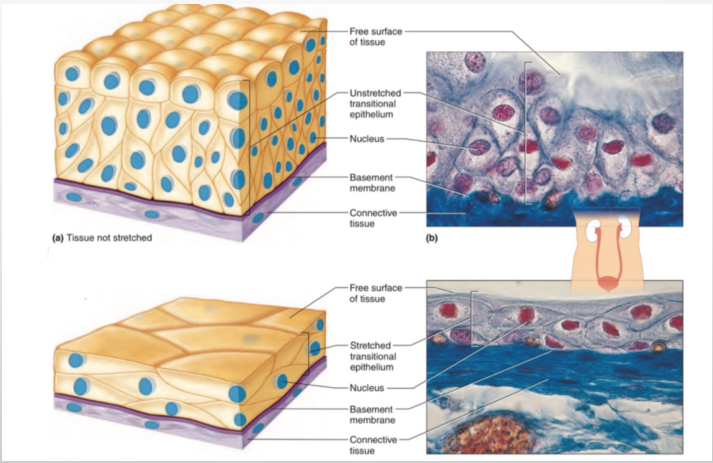


Types of epithelium

- Divide into covering/lining or glandular
- Epithelium.
- Covering/ lining: simple (one cell layer) or
- Stratified (two or more cell layers):

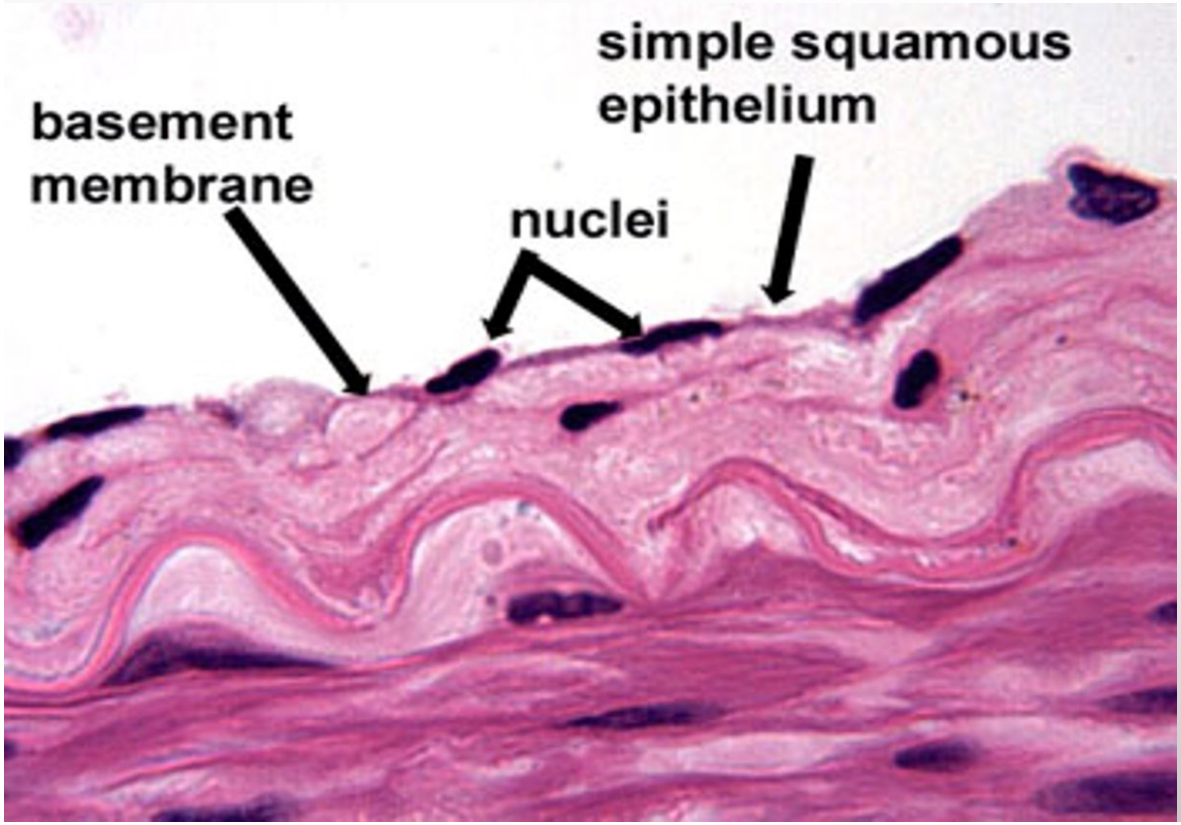


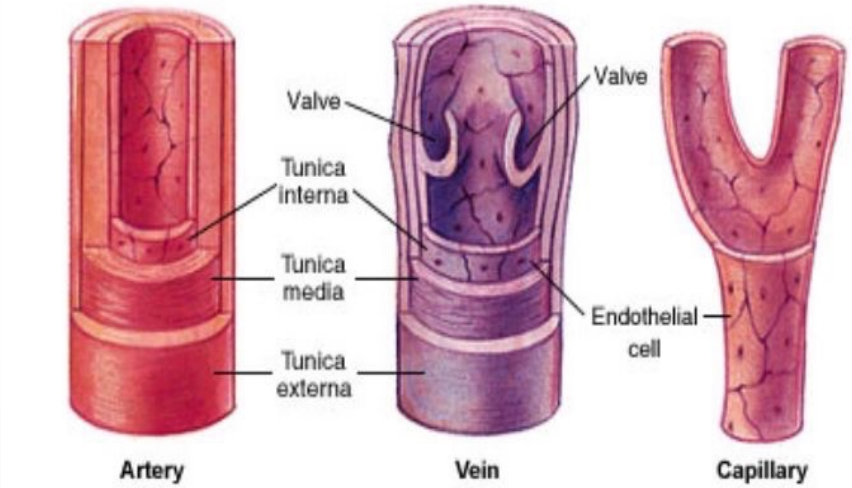
- Simple squamous epithelium
- Simple cuboidal epithelium
- Simple columnar epithelium
- Pseudostratified columnar epithelium



- Stratified squamous epithelium
- Stratified cuboidal epithelium
- Stratified columnar epithelium
- Transitional epithelium

Simple squamous epithelium:
1. Endothelium

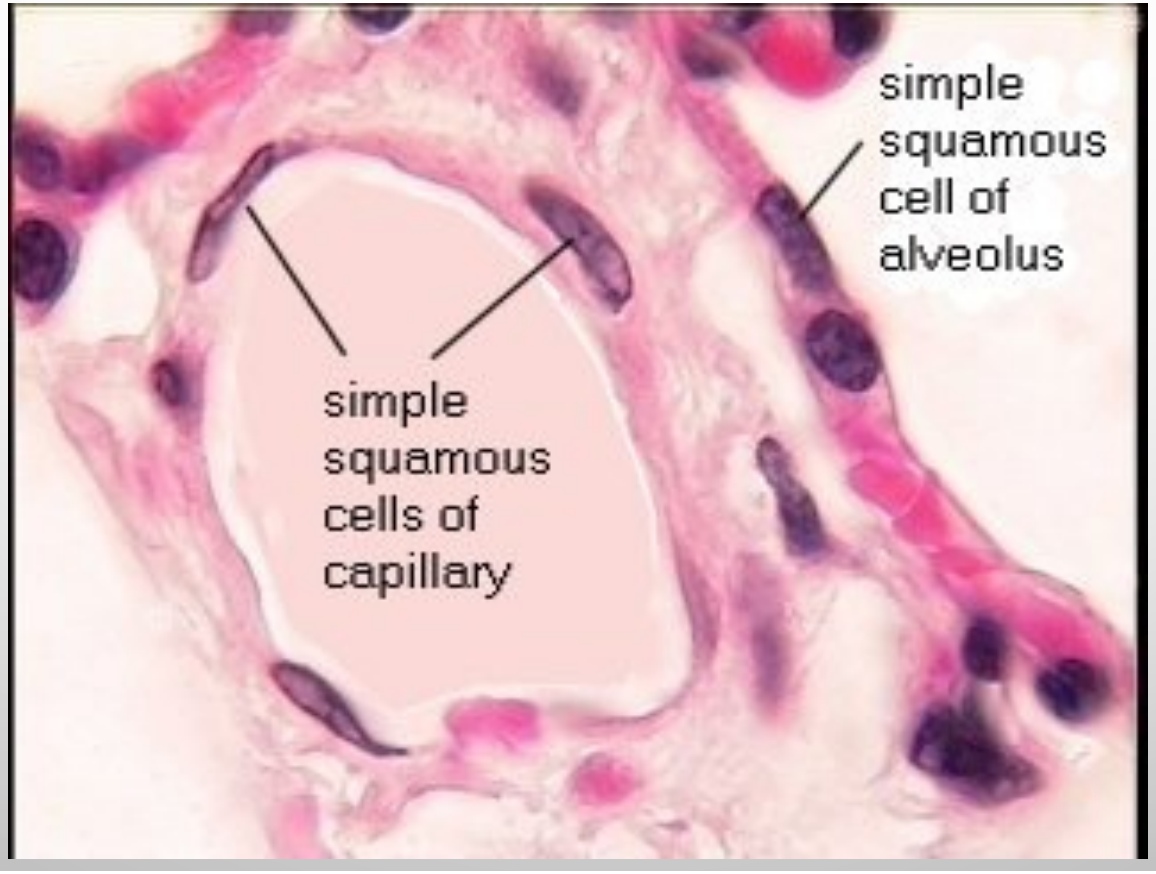




Blood vessels

- Thin cells
- Nuclei are the thickest structure and most noticeable
- Regulate passages of substances.

Simple squamous epithelium
2. lung alveoli



3. Mesothelium

Simple squamous epithelium.

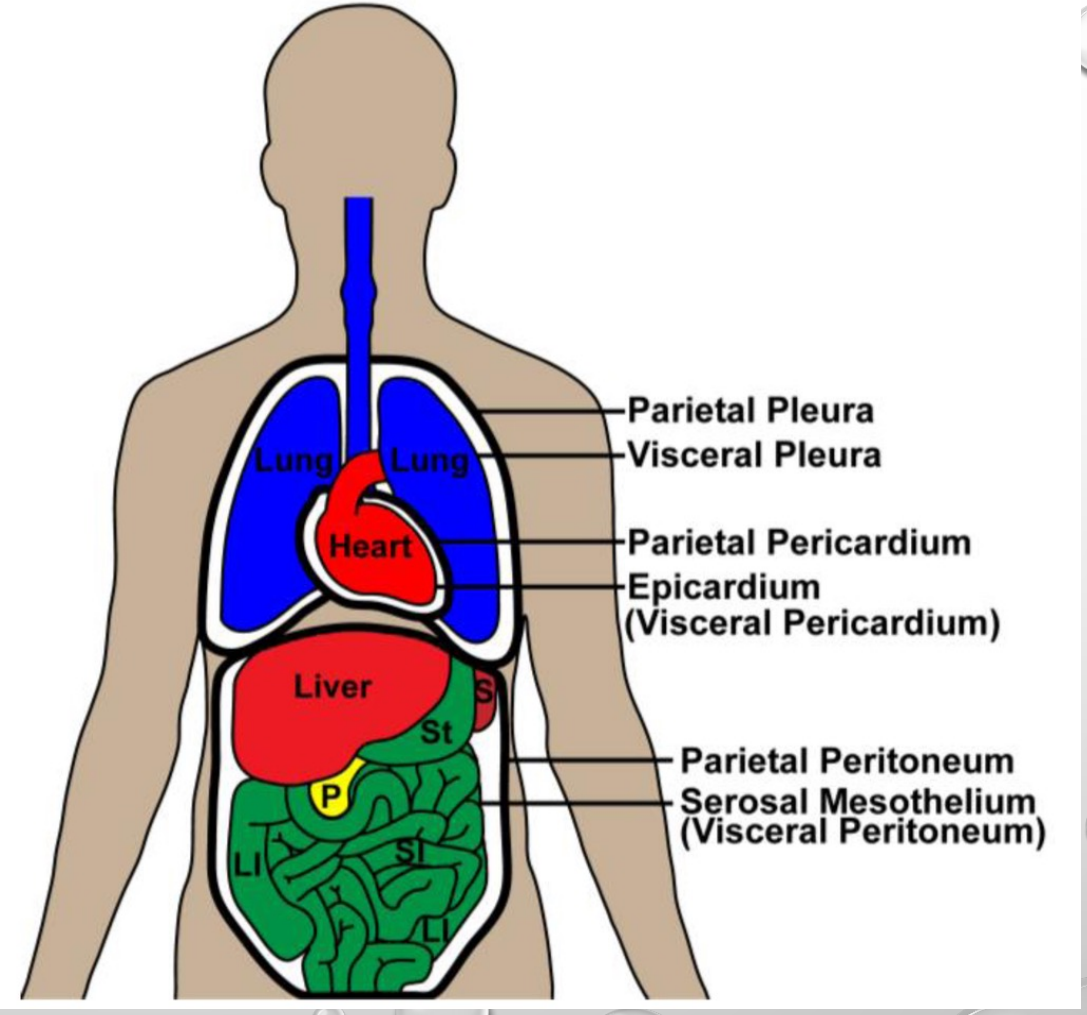
Covering of organs and lining of cavities--visceral and parietal layers.

1- Pleura

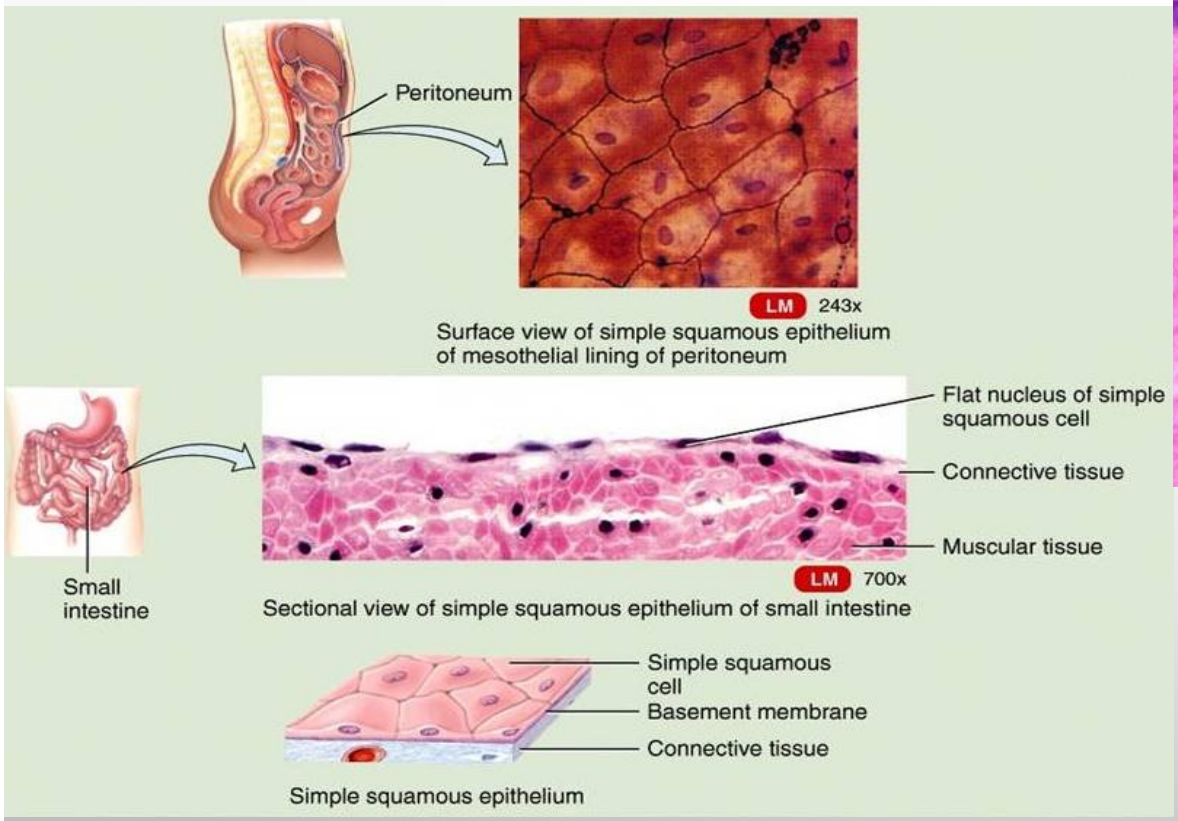
2- Peritoneum

3- Pericardium

4- Mediastinum



Mesothelium

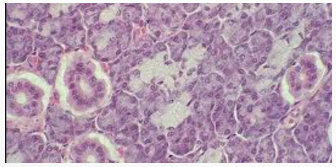


Simple cuboidal epithelium

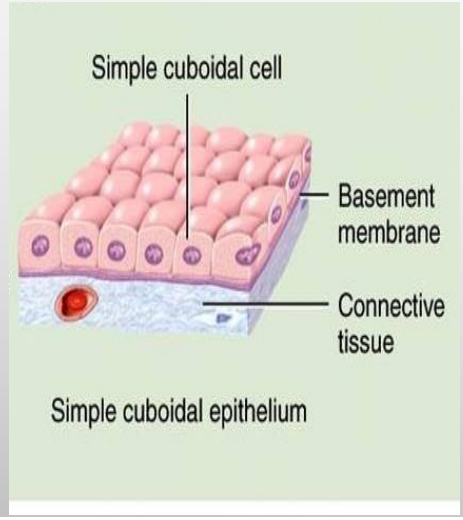
- Width and height are similar.
- Rich with organelles.
- High level of active transport.

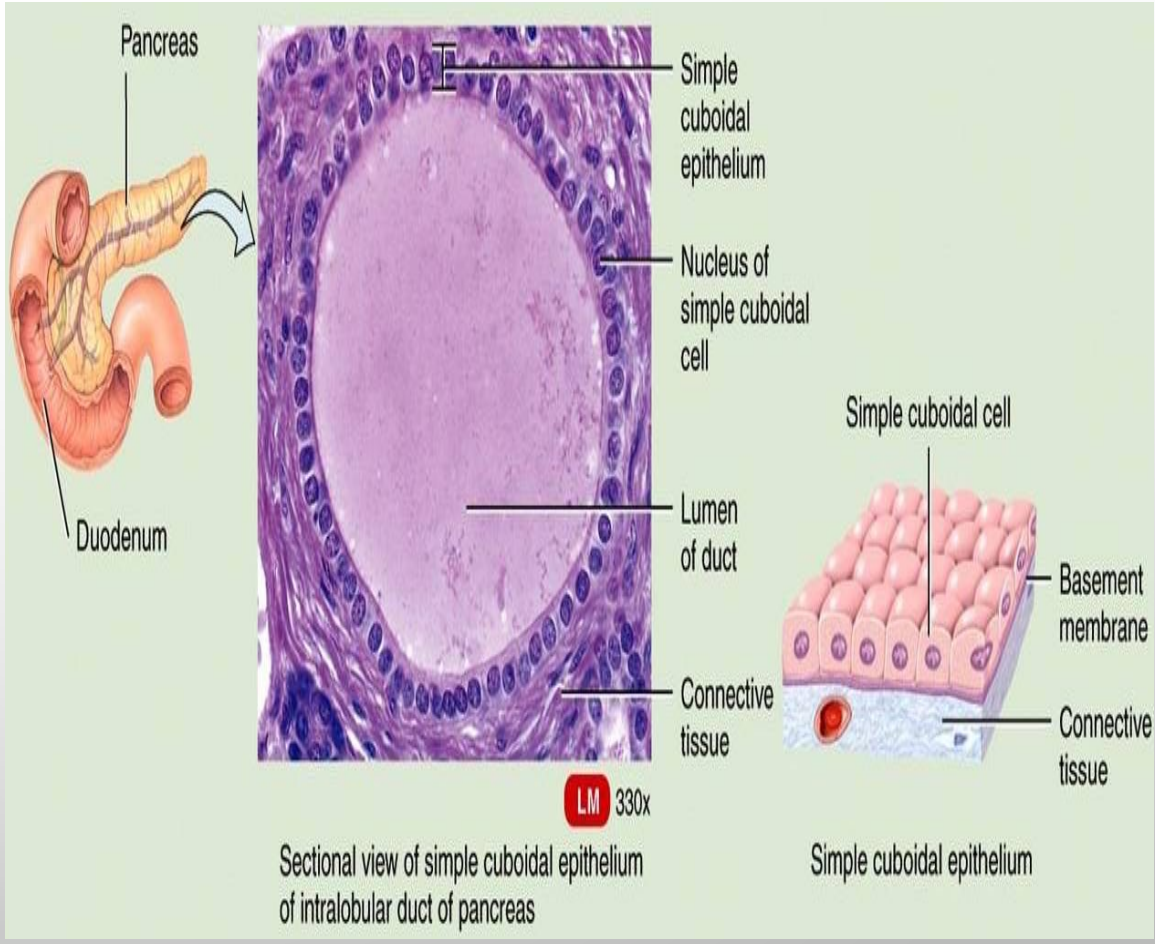
Location

- Small collecting ducts of kidney

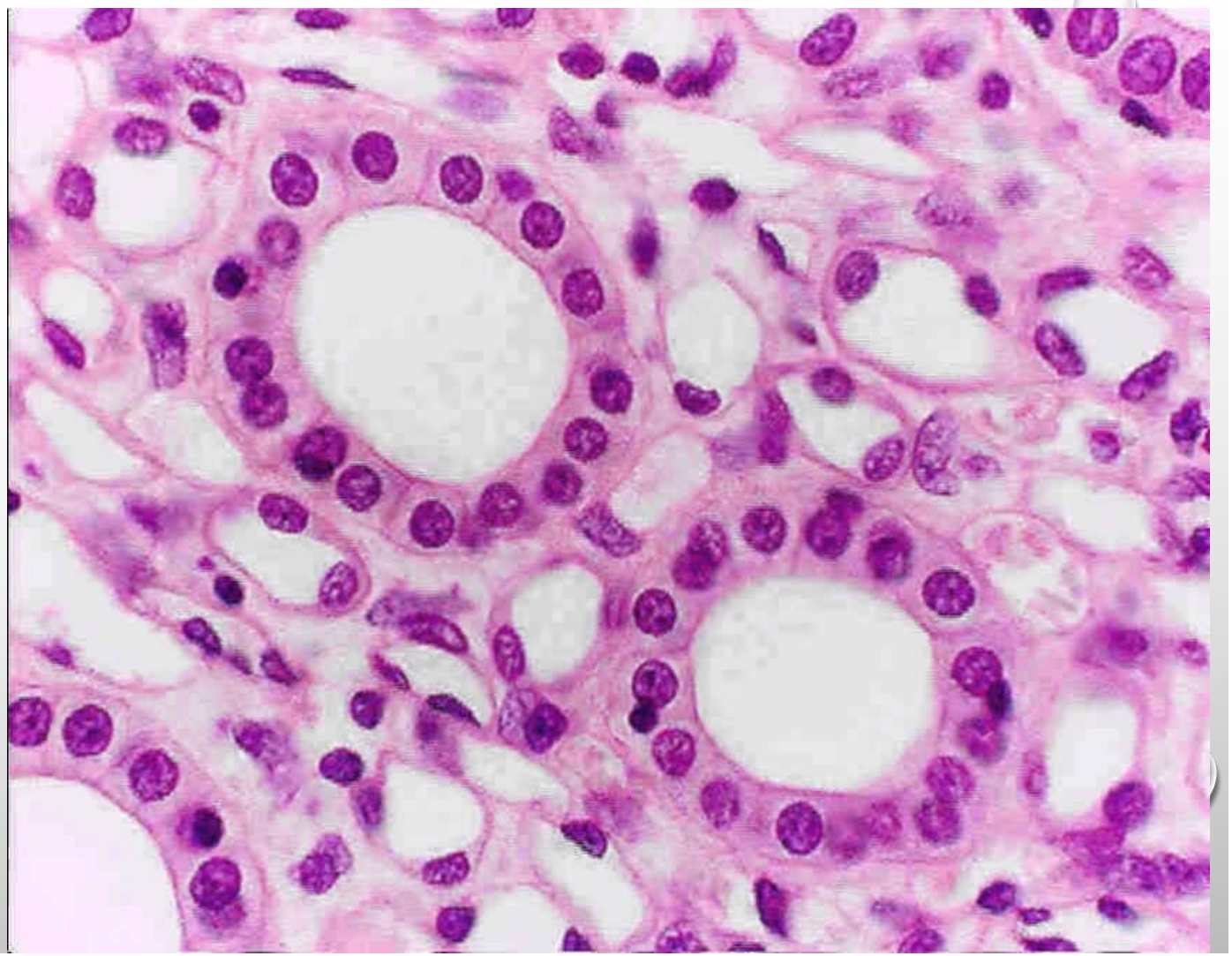


- Glands and ducts :
- (pancreas & salivary)
- Kidney tubules
- Covering of ovaries
- Thyroid glands



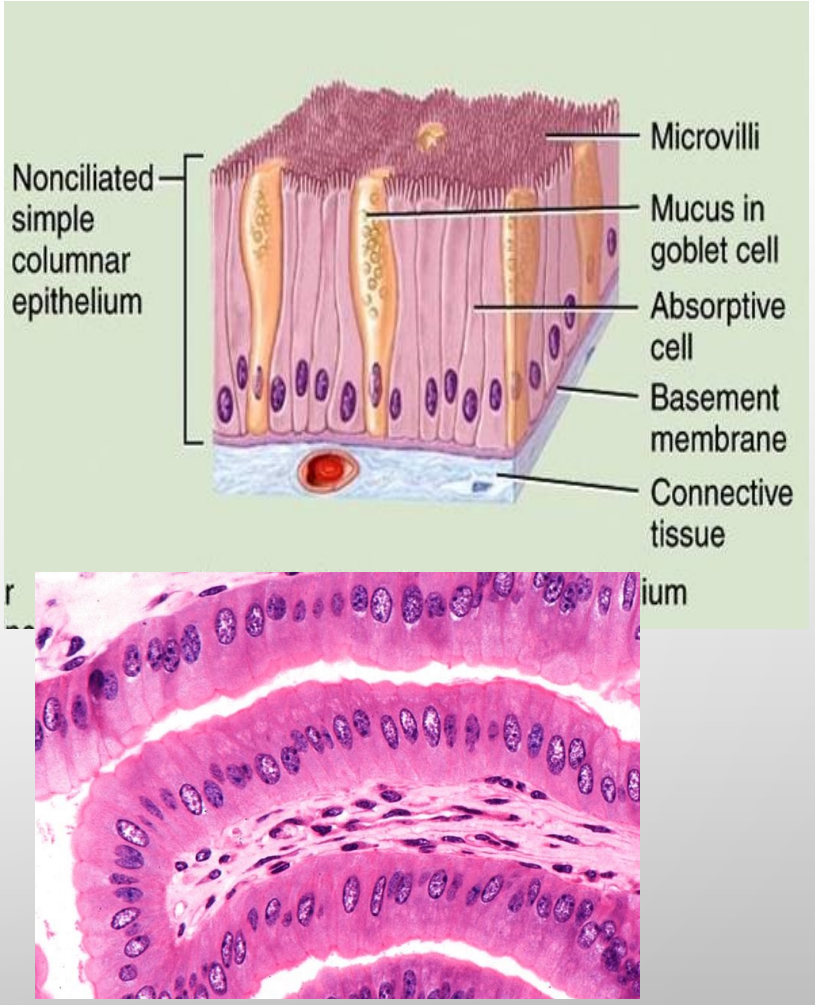


Simple cuboidal Epithelium



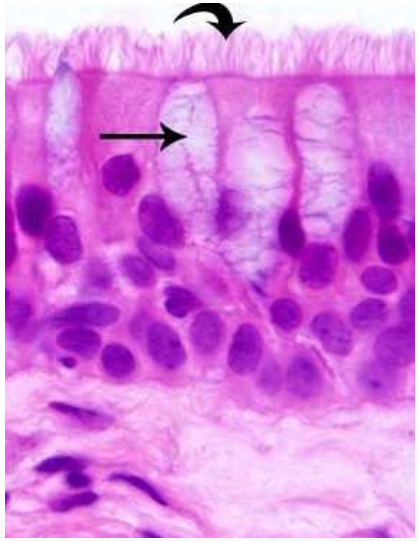
Simple columnar epithelium

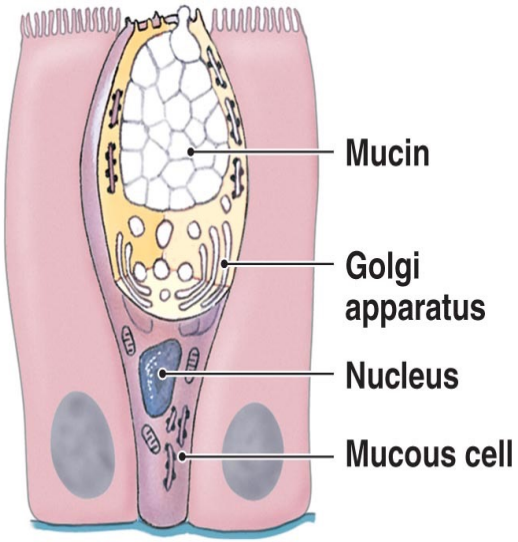
- Cells are tall.
- Usually with microvilli or cilia.
- Engaged in the protection of wet surfaces, absorption (microvilli) and secretion.
- Forms major ducts of exocrine glands.
- When ciliated (**fallopian tube, uterus)**, it helps in movement of fluid in the female genital tract.
- **Location**
  - Small intestine
  - Stomach
  - Gall bladder
  - Oviduct lining
  - Renal collecting ducts

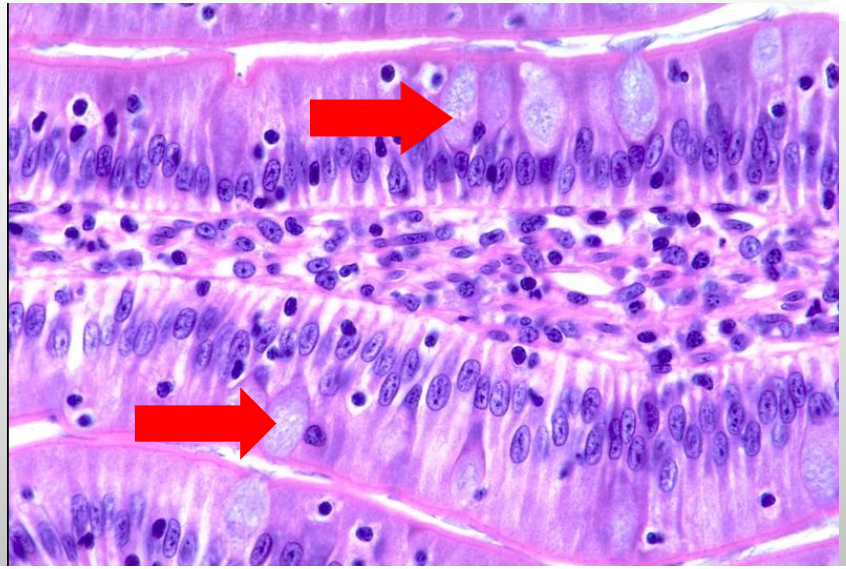


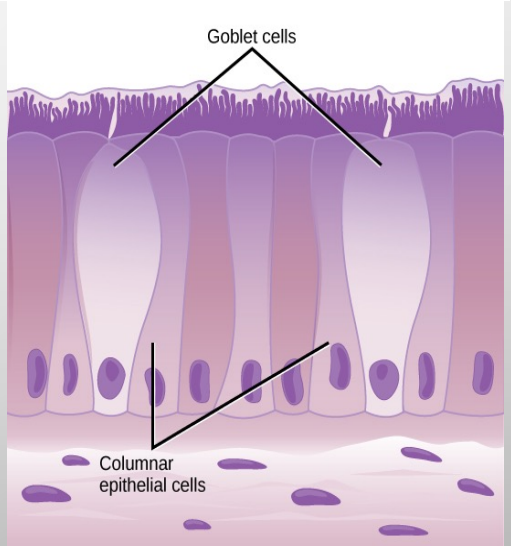
Goblet Cells

- **Goblet cells:** produce mucus.
- **Cilia** (larger than microvilli): sweep mucus.
- Associated mainly with columnar, pseudostratified, and stratified columnar (conjunctiva) epithelia



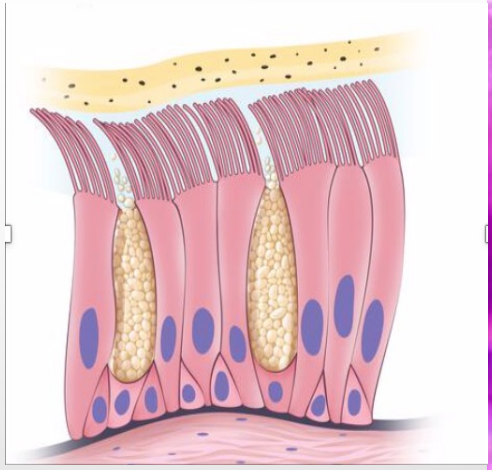


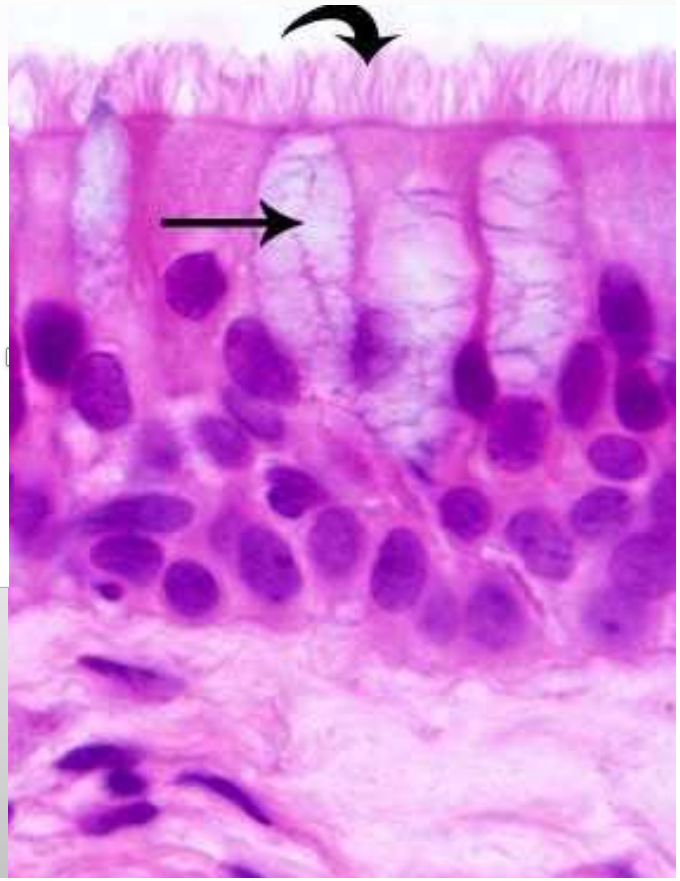




Pseudostratified columnar epithelium

- Small basal cells and taller apical ones; nuclei
- At different levels----false stratifications.
- All cells are attached to the basement membrane.
- **Locations**:
- 1. Respiratory tract (trachea and bronchi; Ciliated with goblet cells)
- 2. Male genital tract.
- Goblet cells: are usually seen in respiratory tract to produce mucus mucous: it entraps foreign particles in the respiratory tract





Stratified Epithelium

- Classified based on the shape of the most superficial layer.

➢ Stratified squamous epithelium: Keratinized and non-keratinized

➢ Stratified cuboidal epithelium

➢ Stratified columnar epithelium

➢ Transitional epithelium

Stratified squamous non-keratinized

- Apical layers are squamous but the basal is polyhedral.
- Protection
- Location:

➢Oral cavity

➢ Pharynx

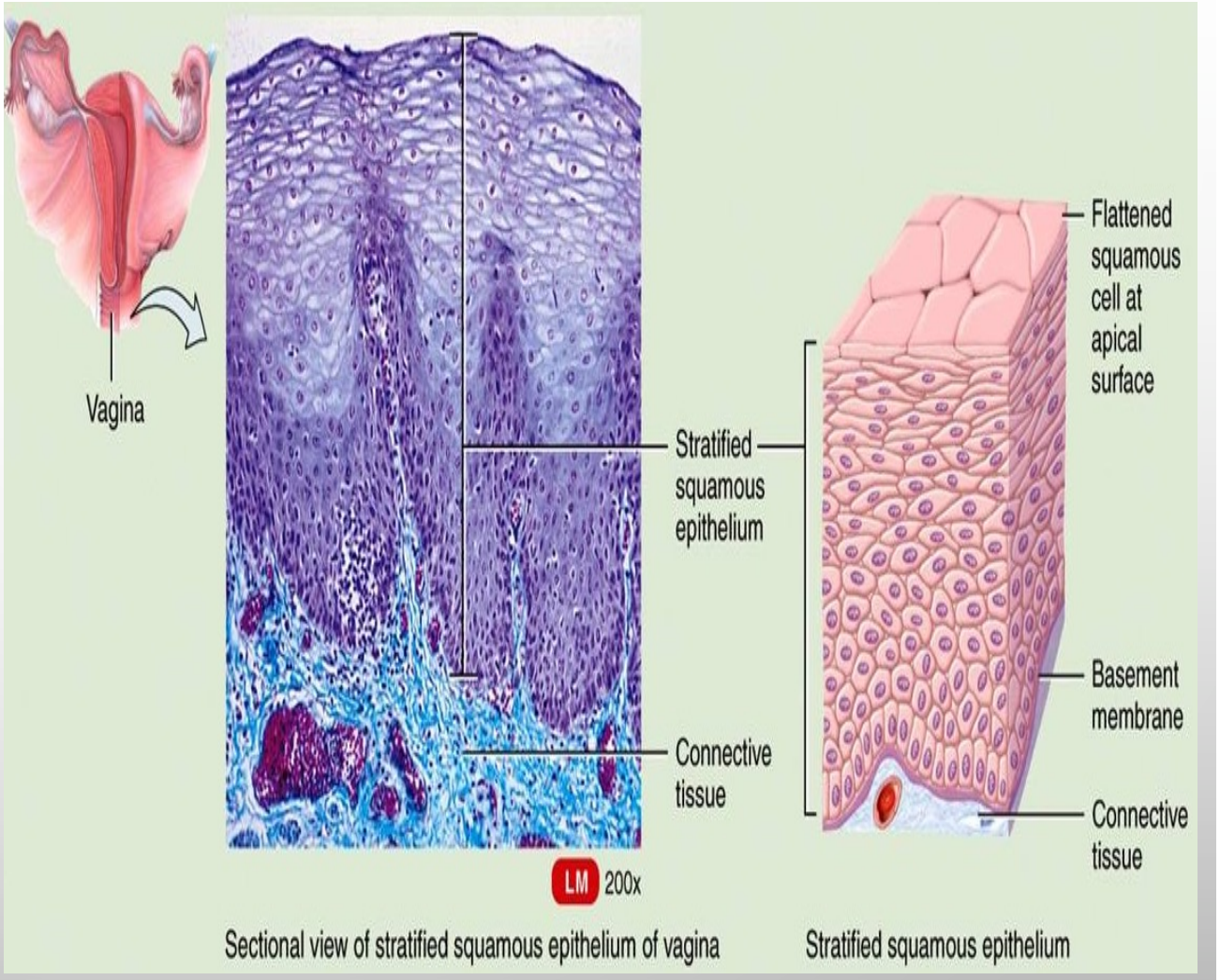
➢Esophagus

➢ Anal canal

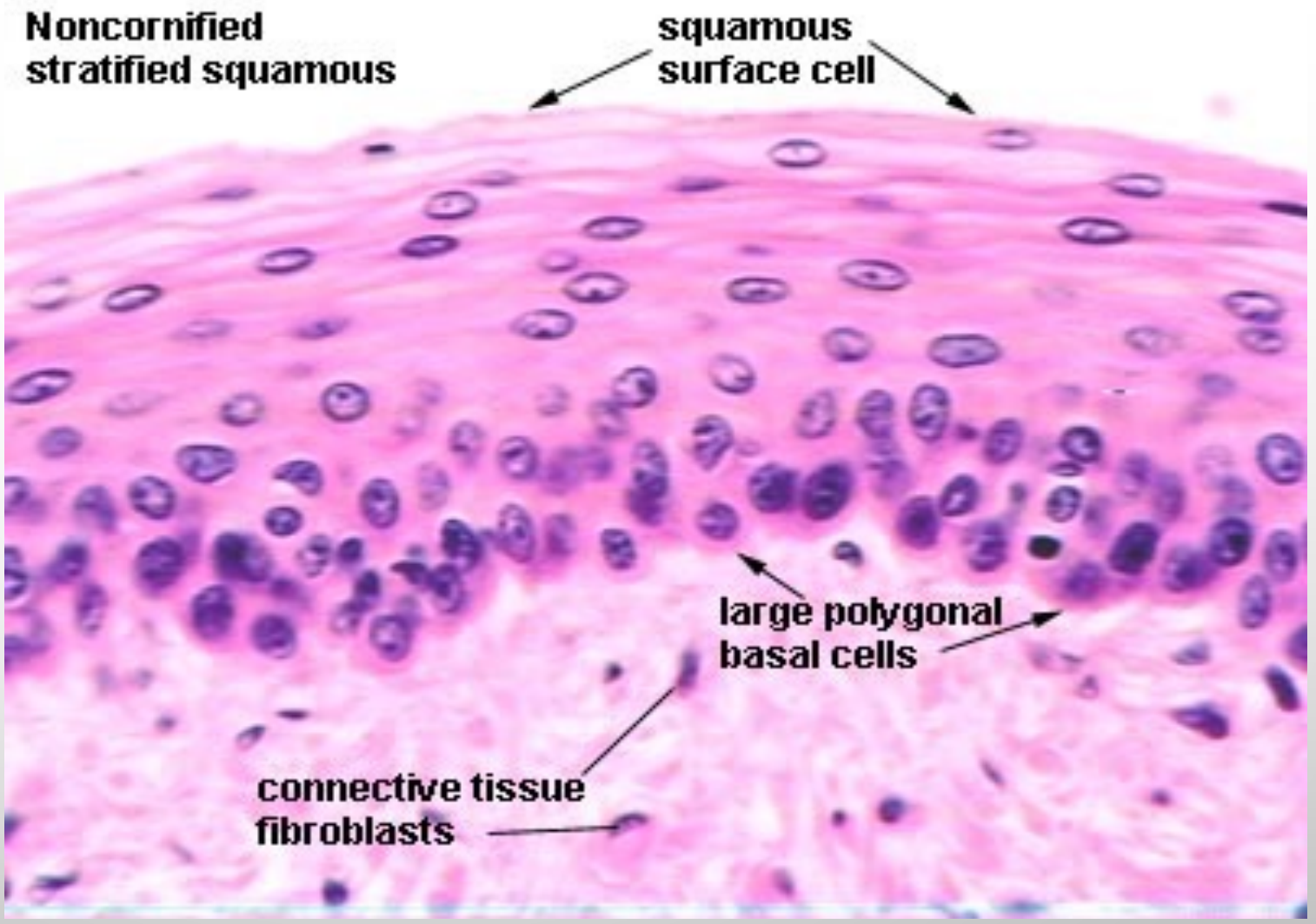
➢Uterine cervix

➢ Vagina

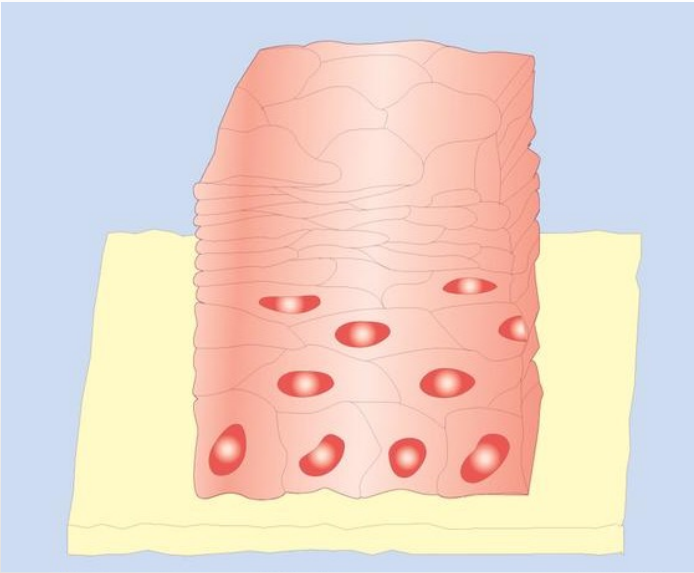
➢Cornea.

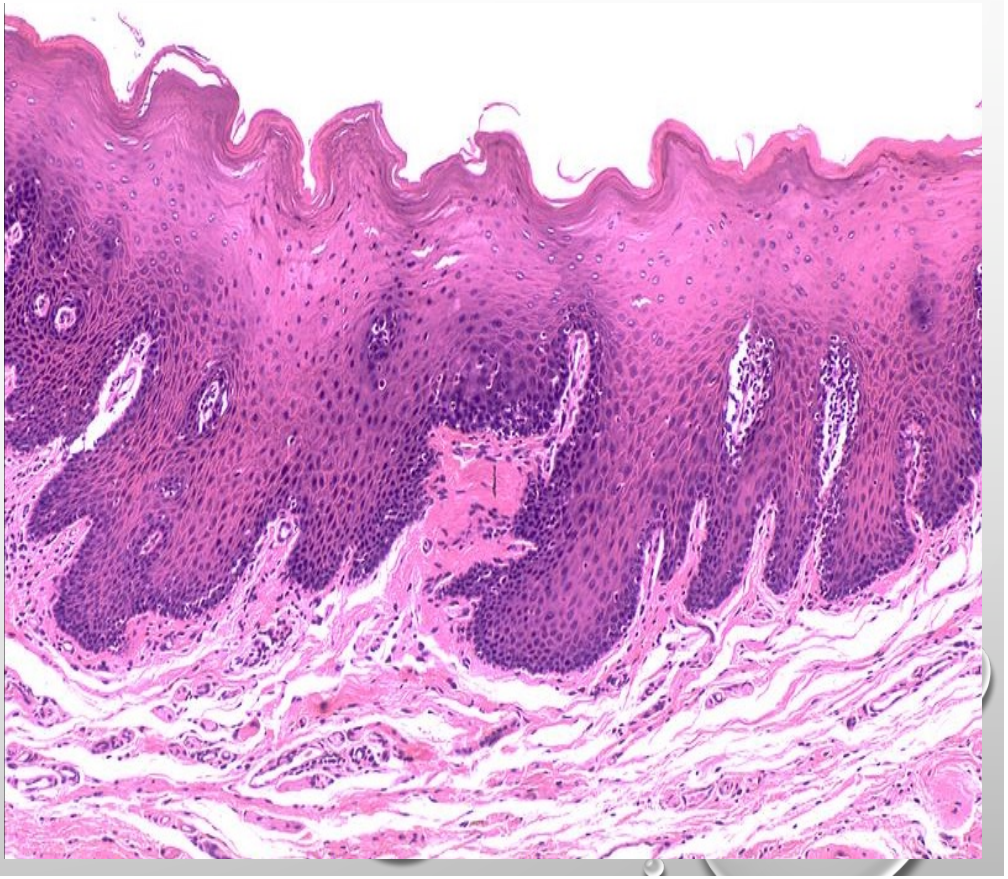


Stratified squamous non-keratinized



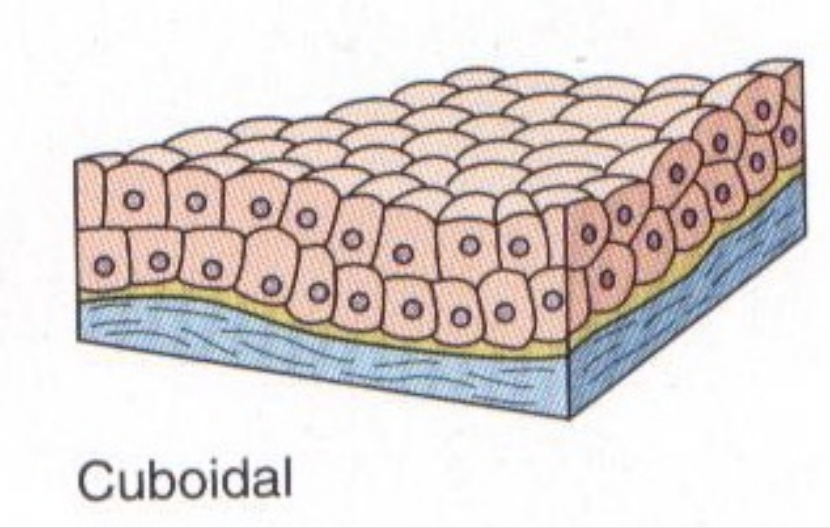
Stratified squamous keratinized epithelium (dry)

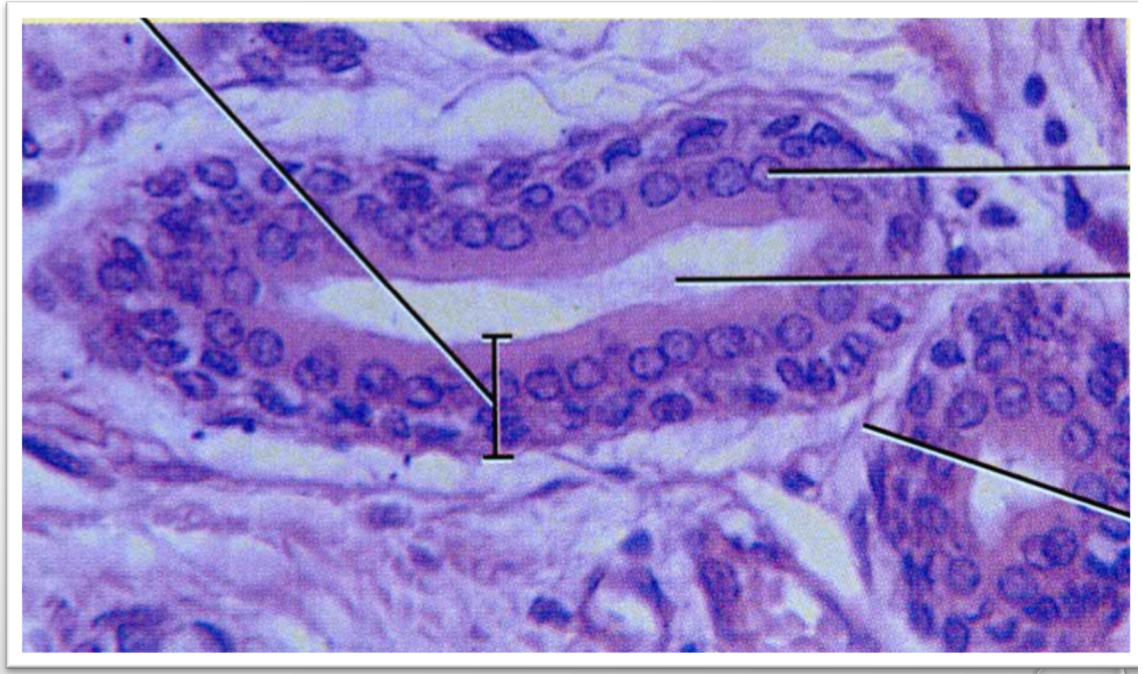




- The superficial layers are cells filled with keratin filaments
- **Location:** Epidermis of skin.

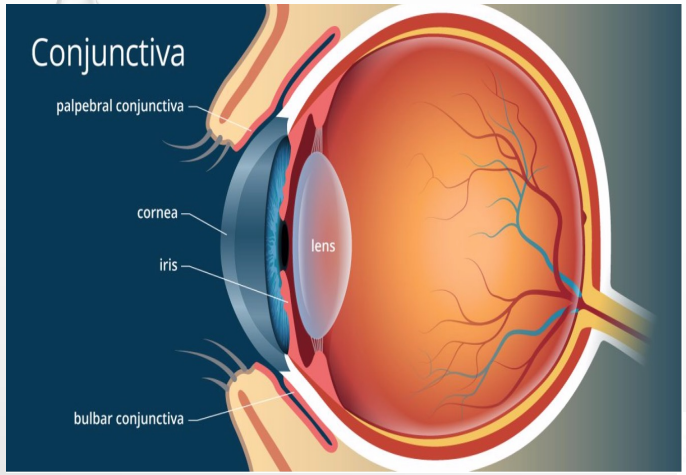
Stratified cuboidal epithelium

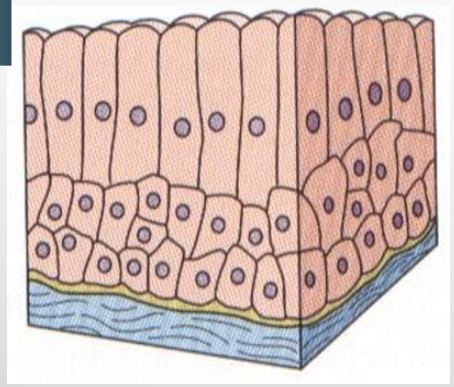


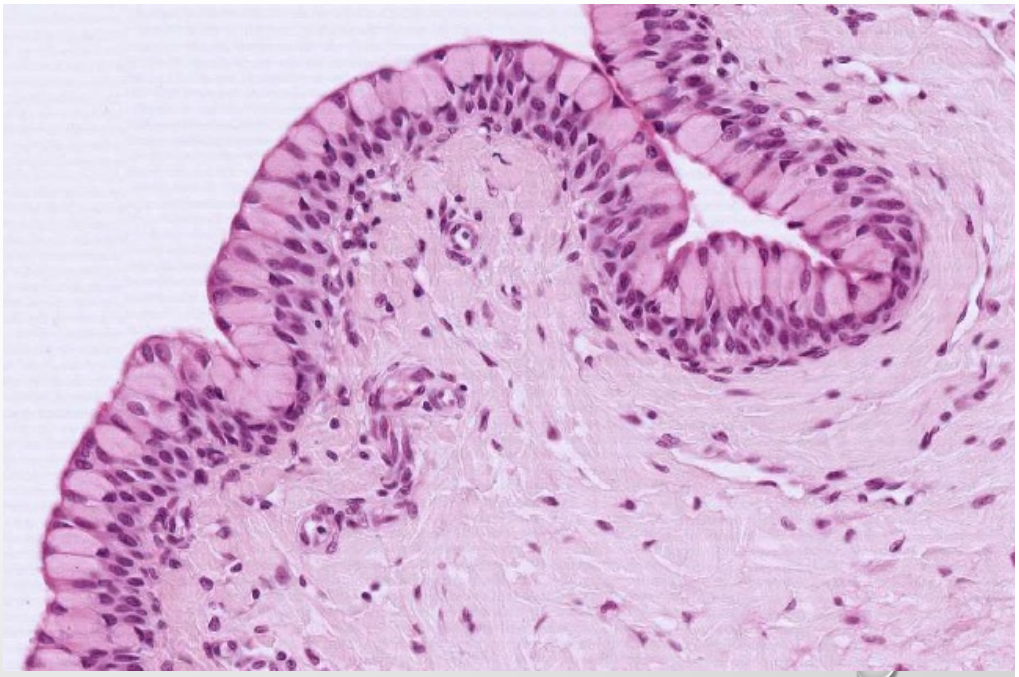


- Rare type.
- Superficial layer is cuboidal.
- Location : larger ducts of exocrine glands such as salivary glands

Stratified columnar epithelium







Rare type.
Protection.
Location: Conjunctiva with Goblet cells

Transitional epithelium

- Appears cuboidal when relaxed and squamous when stretched.
- Also called urothelium.
- Location: most of the urinary tract.
- Function: allows stretching, protection.

Transitional epithelium

- A single layer of small basal cells resting on a very thin basement membrane,
- An intermediate region containing from one to several layers of cuboidal or low columnar cells, and
- A superficial layer of large bulbous or elliptical umbrella cells, sometimes binucleated, which are highly differentiated to protect the underlying cells against the potentially cytotoxic effects of hypertonic urine.

Major Feature	Cell Form	Examples of Distribution	Main Function
Simple (one layer of cells)	Squamous	Lining of vessels (endothelium); Serous lining of cavities: pericardium, pleura, peritoneum (mesothelium)	Facilitates the movement of the viscera (mesothelium), active transport by pinocytosis (mesothelium and endothelium), secretion of biologically active molecules (mesothelium)
	Cuboidal	Covering the ovary, thyroid	Covering, secretion
	Columnar	Lining of intestine, gallbladder	Protection, lubrication, absorption, secretion
Stratified (two or more layers of cells)	Squamous keratinized (dry)	Epidermis	Protection; prevents water loss
	Squamous nonkeratinized (moist)	Mouth, esophagus, larynx, vagina, anal canal	Protection, secretion; prevents water loss
	Cuboidal	Sweat glands, developing ovarian follicles	Protection, secretion
	Transitional	Bladder, ureters, renal calyces	Protection, distensibility
	Columnar	Conjunctiva	Protection
Pseudostratified (layers of cells with nuclei at different levels; not all cells reach surface but all adhere to basal lamina)		Lining of trachea, bronchi, nasal cavity	Protection, secretion; cilia-mediated transport of particles trapped in mucus out of the air passages