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Integrated Academic Studies of Medicine
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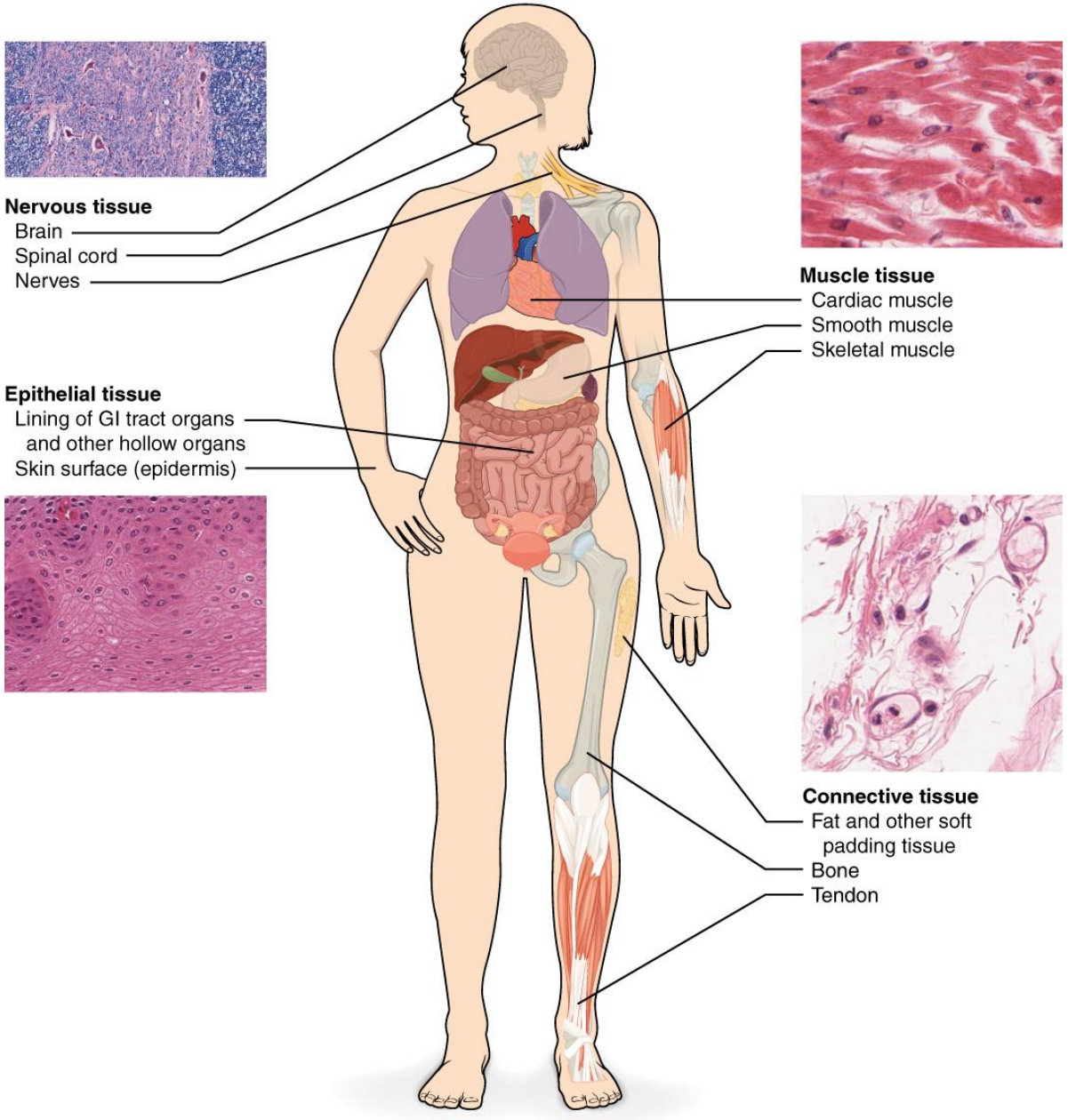
Epithelial Tissue

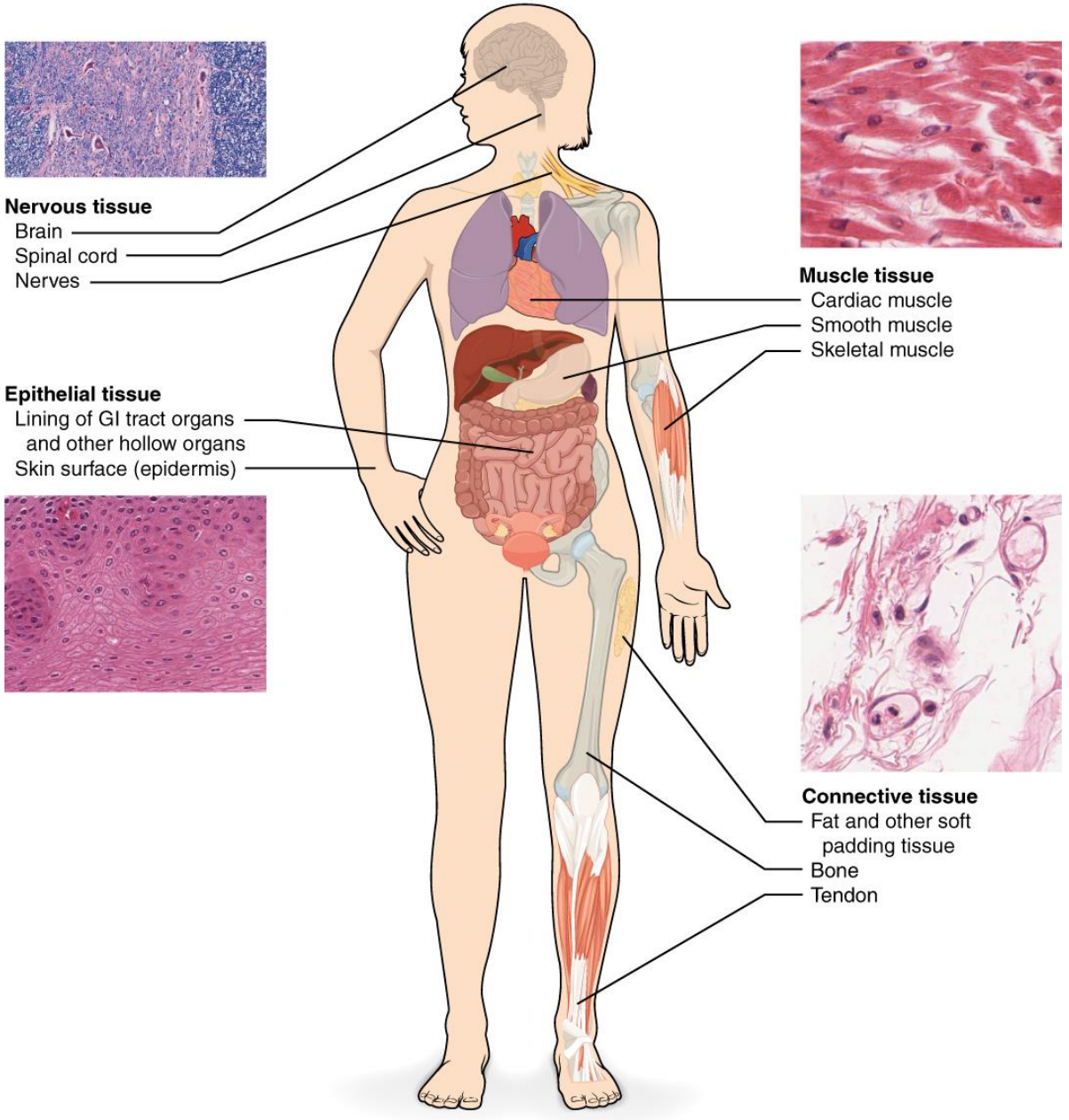
Body tissues

- **Tissues:** Groups of cells with similar structure and function
- **Four primary types of tissues:**
  - epithelial (covering)
  - connective (support)
  - muscle (movement)
  - nervous (control)



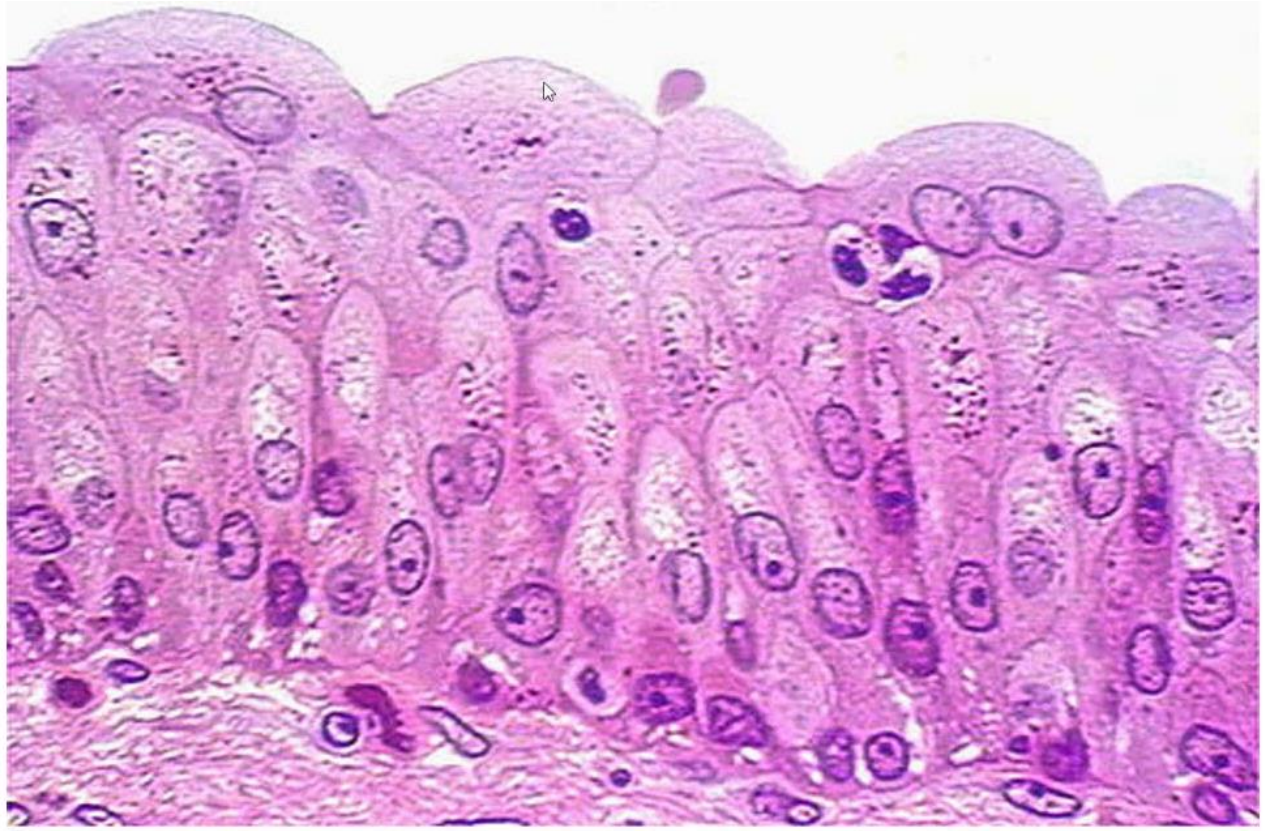
Body tissues

- The basic tissues, each containing extracellular matrix (ECM) as well as cells, associate with one another in the variable proportions and morphologies characteristic of each organ



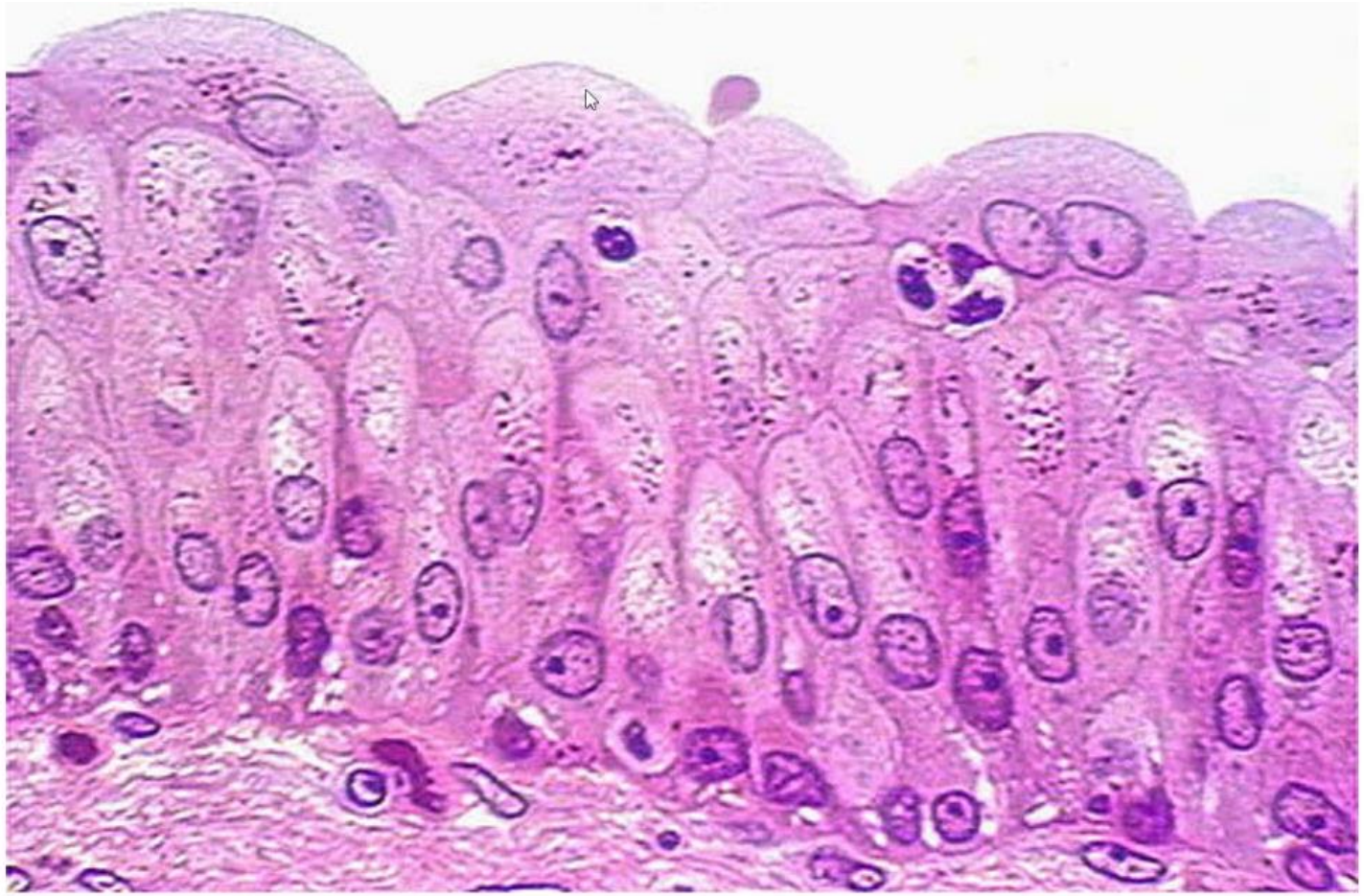
Epithelial tissue

- Epithelial tissues are composed of closely aggregated polyhedral cells adhering strongly to one another and to a thin layer of ECM, forming cellular sheets that line the cavities of organs and cover the body surface. Epithelia (Gr. epi, upon + thele, nipple) line all external and internal surfaces of the body and all substances that enter or leave an organ must cross this type of tissue.



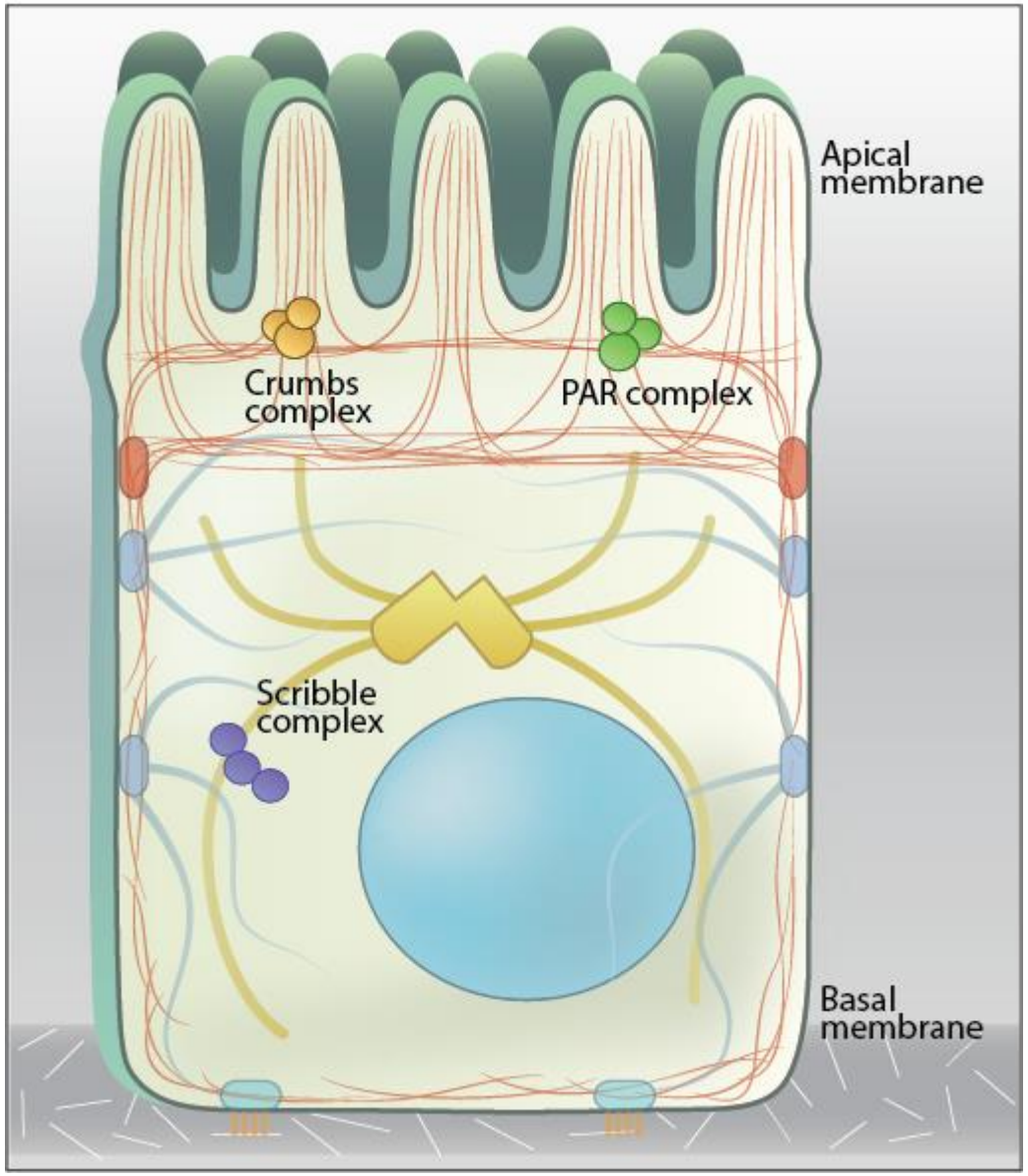
Epithelial tissue

- **Location:**
  - Body coverings
  - Body linings
  - Glandular tissue
- **Function:**
  - Protection
  - Absorption
  - Filtration
  - Secretion



Epithelial tissue

- **Characteristics:**
  - Cover and line body surfaces
  - Avascular
  - Regenerates easily



Epithelial tissue

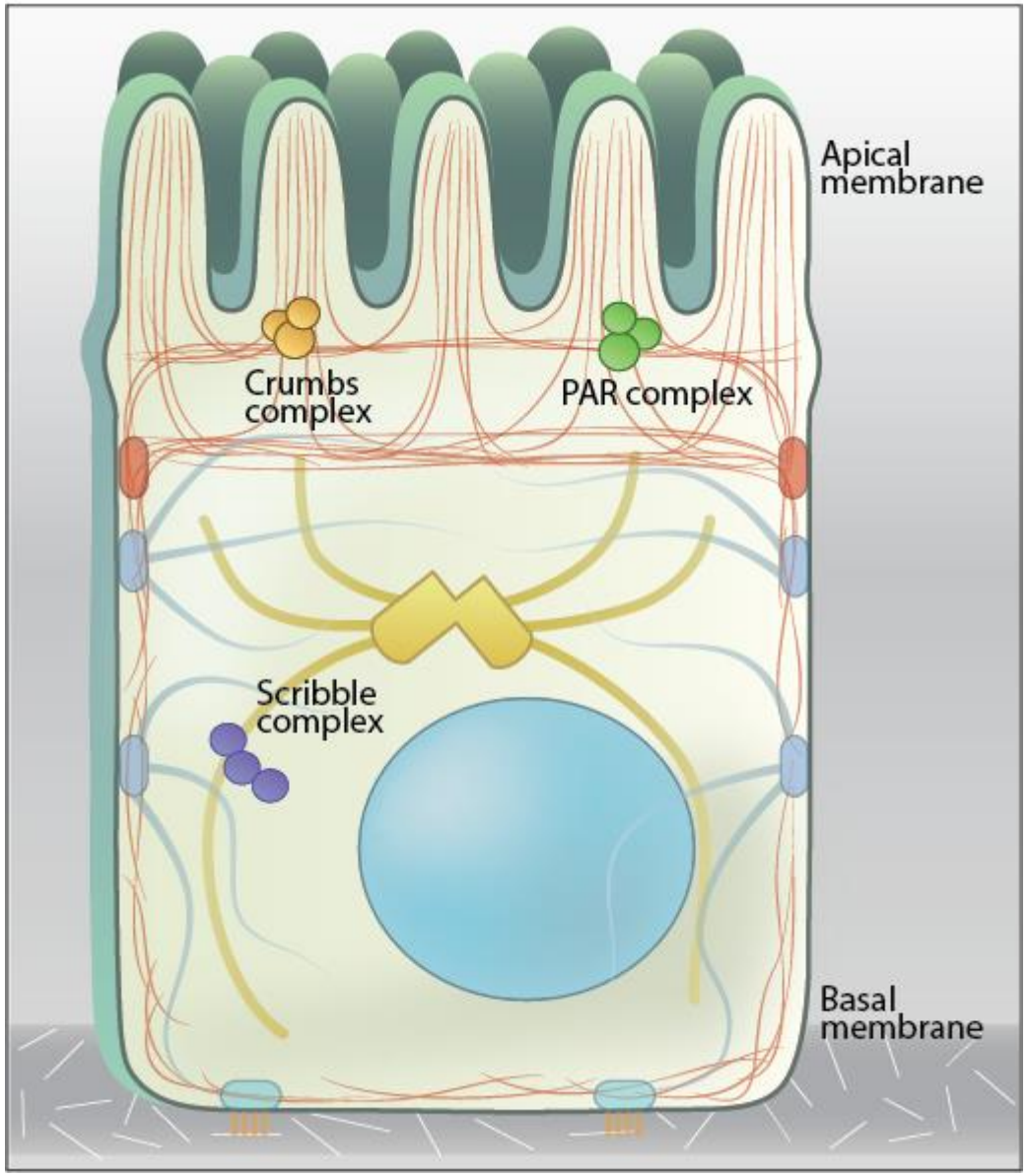
- The shapes and dimensions of epithelial cells are quite variable, ranging from tall columnar to cuboidal to low squamous cells. The cells' size and morphology are generally dictated by their function.
- Most epithelia are adjacent to connective tissue containing blood vessels from which the epithelial cells receive nutrients and O2. Even thick epithelia do not themselves normally
- contain blood vessels. The connective tissue that underlies
- the epithelia lining the organs of the digestive, respiratory, and urinary systems is called the lamina propria. The area of contact between the two tissues may be increased by small evaginations called papillae (L. papula, nipple) projecting from the connective tissue into the epithelium.

Epithelial tissue

- Epithelial cells generally show polarity, with organelles and membrane proteins distributed unevenly within the cell.
- The region of the cell contacting the ECM and connective tissue is called the basal pole and the opposite end, usually facing a space, is the apical pole, with the two poles differing significantly in both structure and function. Regions of cuboidal or columnar cells that adjoin neighboring cells comprise the cells' lateral surfaces; cell membranes here often have numerous folds that increase the area and functional capacity of that surface.

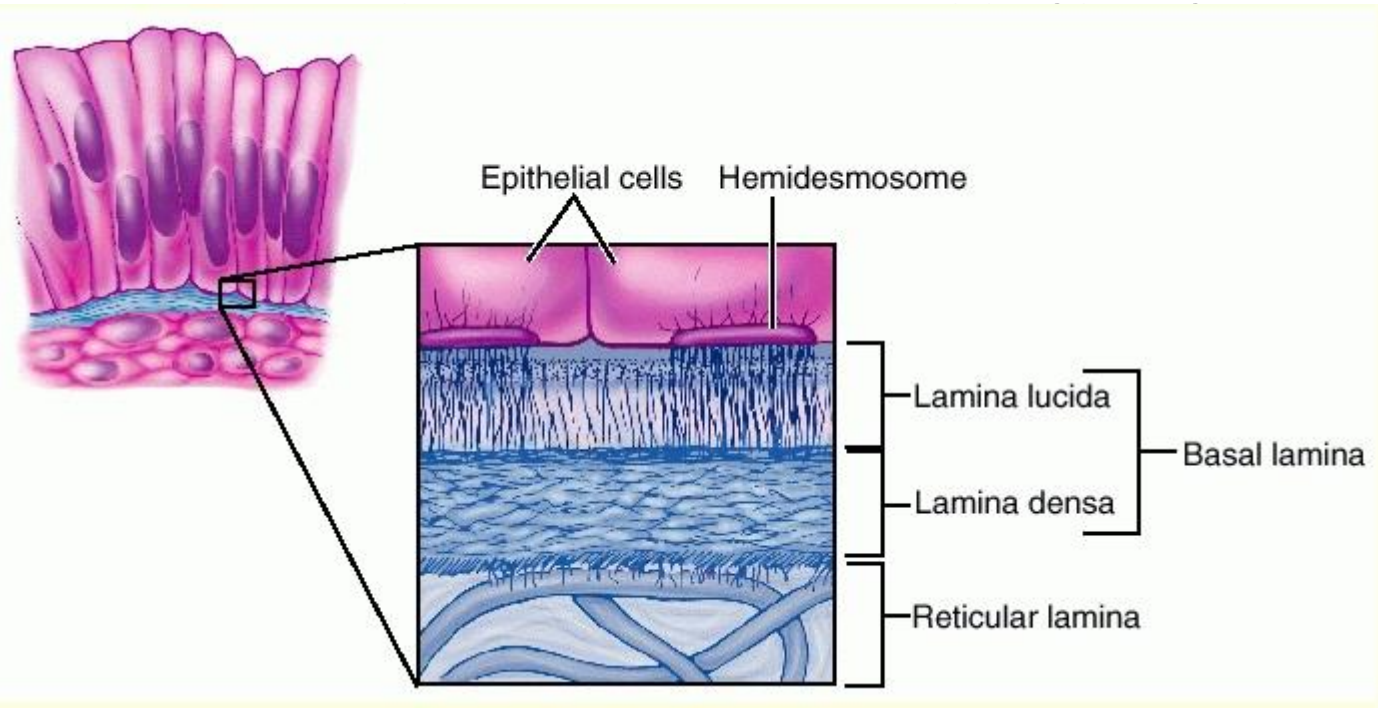
Epithelial tissue - cells

- **Polarised cells**
- Apical part of the cell
- Lateral part of the cell
- Basal part of the cell



Basement Membranes

- The basal surface of all epithelia rests on a thin extracellular, felt-like sheet of macromolecules referred to as the l
sub- stances reaching epithelial cell
- With the transmission electron mic
membrane may be resolved. Neare
electron-dense, sheetlike layer of fi
and fibrous reticular lamina
- “basement membrane” and “basal
“basal lamina” usually denotes the
“basement mem- brane” the entire
the light microscope



Basement Membranes

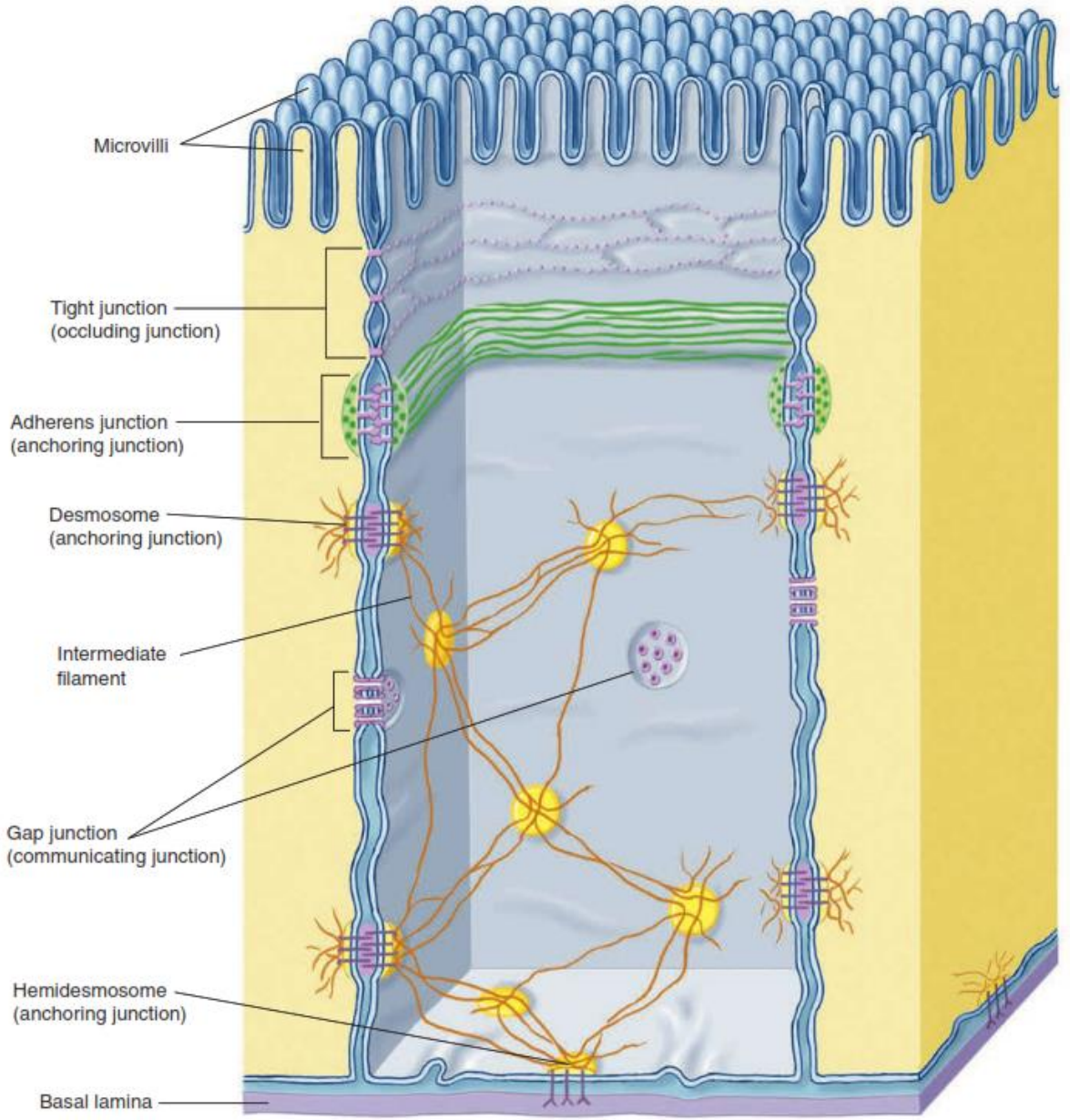
- Type IV collagen: Monomers of type IV collagen self- assemble into a two-dimensional network of evenly spaced subunits resembling the mesh of a window screen.
- ■ Laminin: These are large glycoproteins that attach to transmembrane integrin proteins in the basal cell mem- brane and project through the mesh formed by the type IV collagen.
- ■ Nidogen and perlecan: Respectively a short, rodlike protein and a proteoglycan, both of these cross-link lami- nins to the type IV collagen network, helping to provide the basal lamina’s three-dimensional structure, to bind
- the epithelium to that structure, and to determine its porosity and the size of molecules able to filter through it.

Basement Membranes

- The more diffuse meshwork of the reticular lamina contains type III collagen and is bound to the basal lamina by anchoring fibrils of type VII collagen, both of which are produced by cells of the connective tissue
- Besides acting as filters, functions of basement mem- branes include helping to provide structural support for epi- thelial cells and attach epithelia to underlying connective tissue. Basal lamina components help organize integrins and other proteins in the plasma membrane of epithelial cells, maintaining cell polarity and helping to localize endocytosis, signal transduction, and other activities. Basement membrane proteins also mediate many cell-to-cell interactions involving epithelia and mark routes for certain cell migrations along epi- thelia. Finally, the basement membrane also serves as a scaf- fold that allows rapid epithelial repair and regeneration.

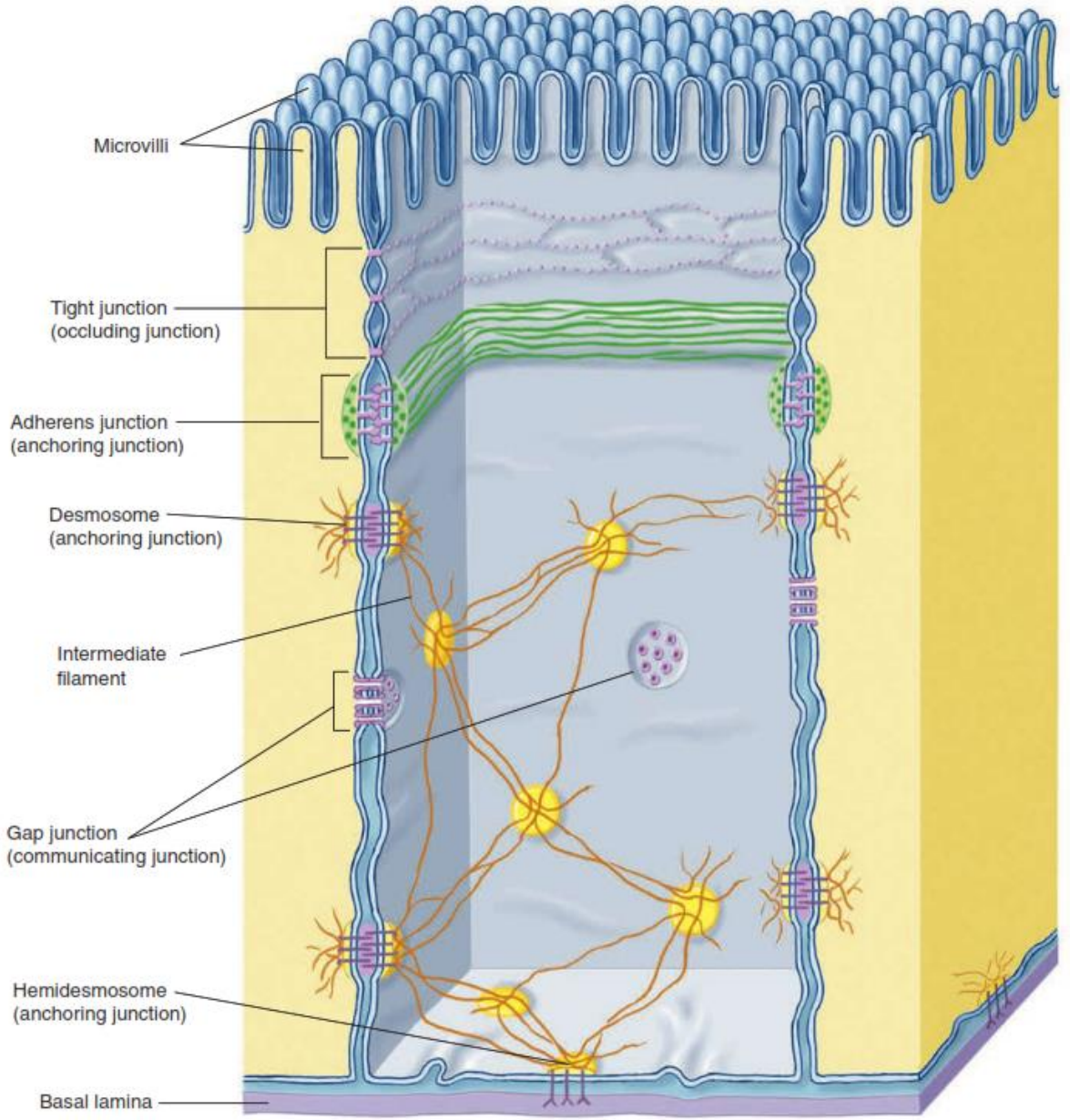
Intercellular Adhesion & Other Junctions

- Several membrane-associated structures provide adhesion and communication between cells. Some are present in other tissues but all are particularly numerous and prominent in epithelia.



Intercellular Adhesion & Other Junctions

- Lateral surfaces of epithelial cells have complexes of several specialized intercellular junctions with different functions:
- 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.

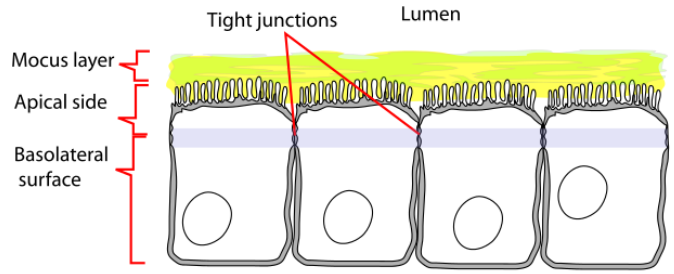


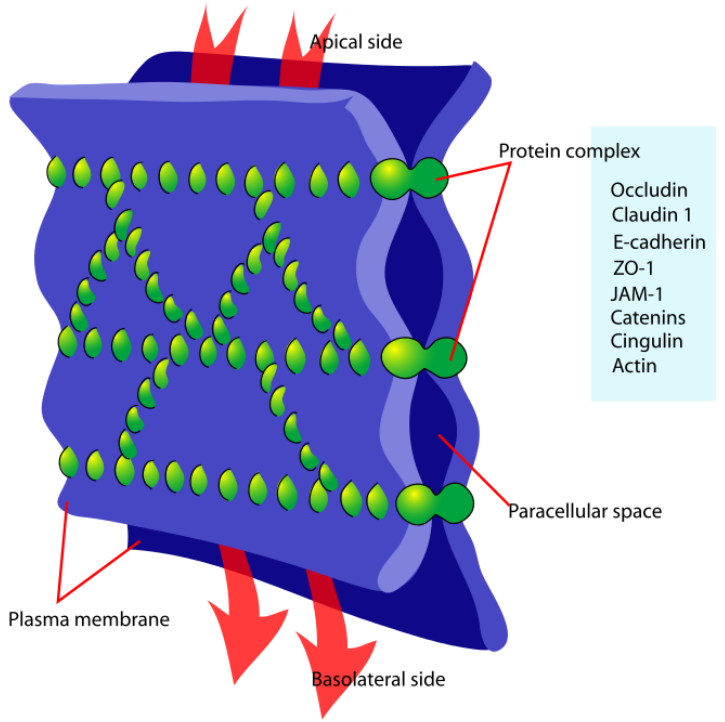
Intercellular Adhesion & Other Junctions

Junction	Tight Junction (Zonula Occludens)	Adherens 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

Intercellular Adhesion & Other Junctions

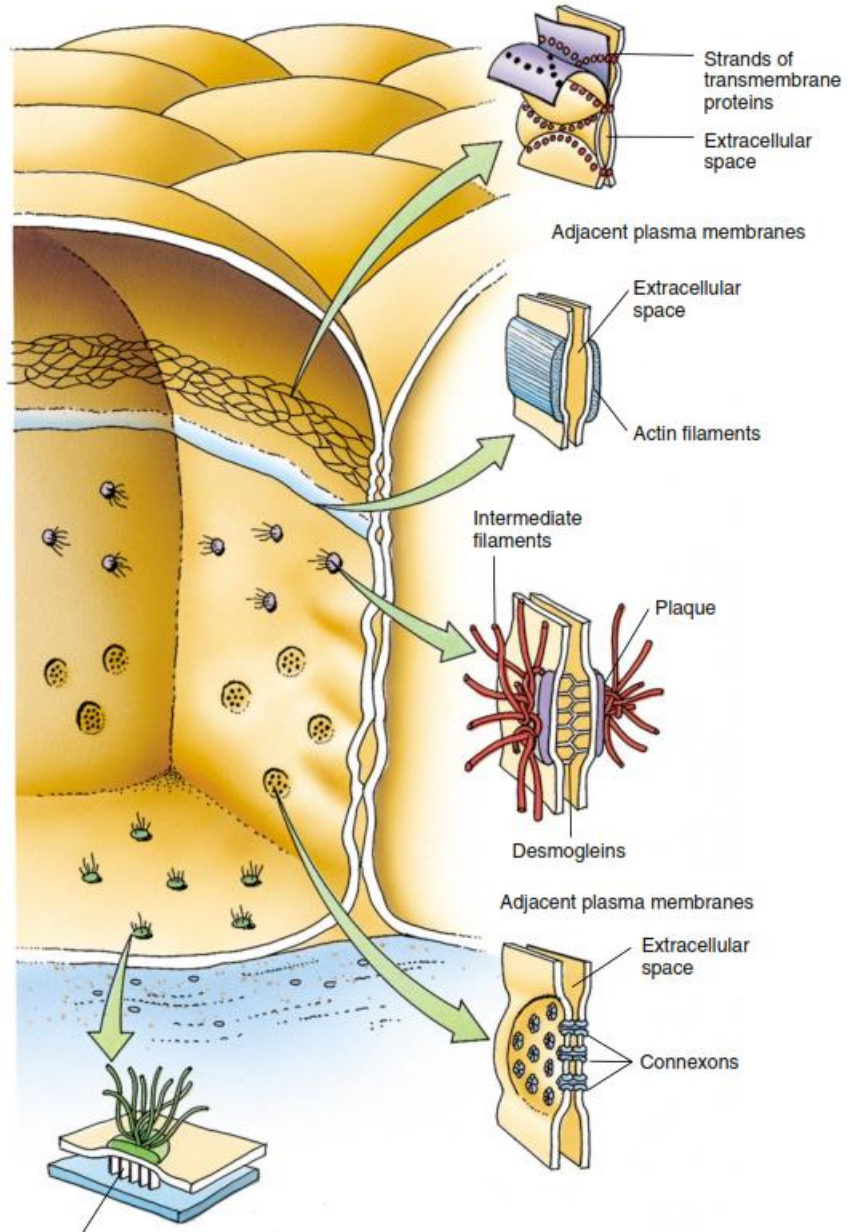
- Tight junctions, also called zonulae occludens, are the most apical of the junctions. The term “zonula” indicates that the junction forms a band completely encircling each cell. In TEM the adjacent membranes at these junctions appear fused or very tightly apposed. The seal between the two cell membranes is due to tight interactions between the transmembrane proteins: claudin and occludin.





Intercellular Adhesion & Other Junctions

- Tight junctions, also known as occluding junctions or zonulae occludentes (singular, zonula occludens)
- The intercellular seal of tight junctions ensures that molecules crossing an epithelium in either direction do so by going through the cells (a transcellular path) rather than between them (the paracellular pathway).



Intercellular Adhesion & Other Junctions

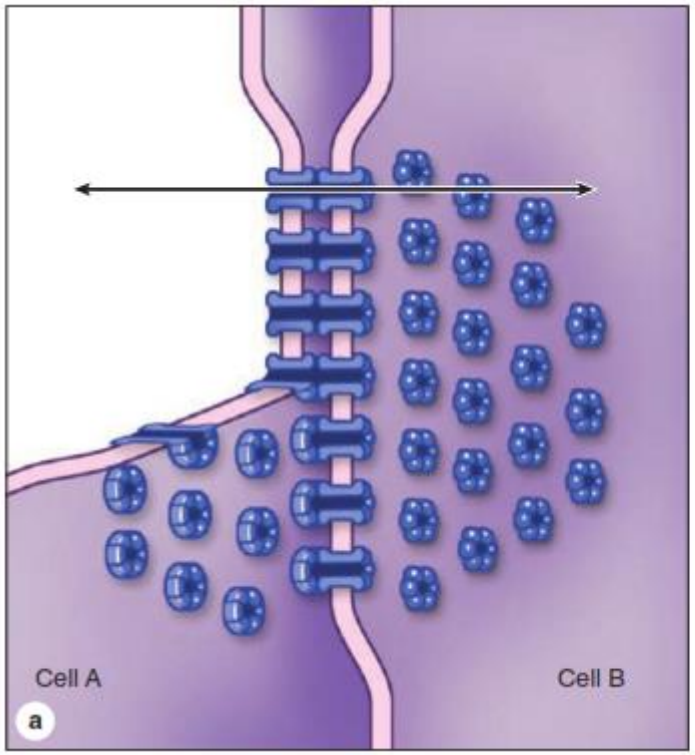
- The second type of junction is the adherens junction or zonula adherens, which also encircles the epithelial cell, usually immediately below the tight junction. This is an adherent junction, firmly anchoring a cell to its neighbors. Cell adhesion is mediated by cadherins, transmembrane glycoproteins 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.

Intercellular Adhesion & Other Junctions

- Another anchoring junction is the desmosome (Gr., desmos, binding and soma, body) or macula adherens (L. macula, spot).
- Desmosomes are disc-shaped structures at the sur- face of one cell that are matched with identical structures at an adjacent cell surface (Figures 4–4 and 4–5). Desmosomes contain larger members of the cadherin family called desmogleins and desmocollins. The cytoplasmic ends of these clustered transmembrane proteins bind plakoglobins, catenin-like proteins that link to larger proteins called desmoplakins in an electron-dense plaque. Desmoplakins in turn bind intermediate filament proteins rather than actins.

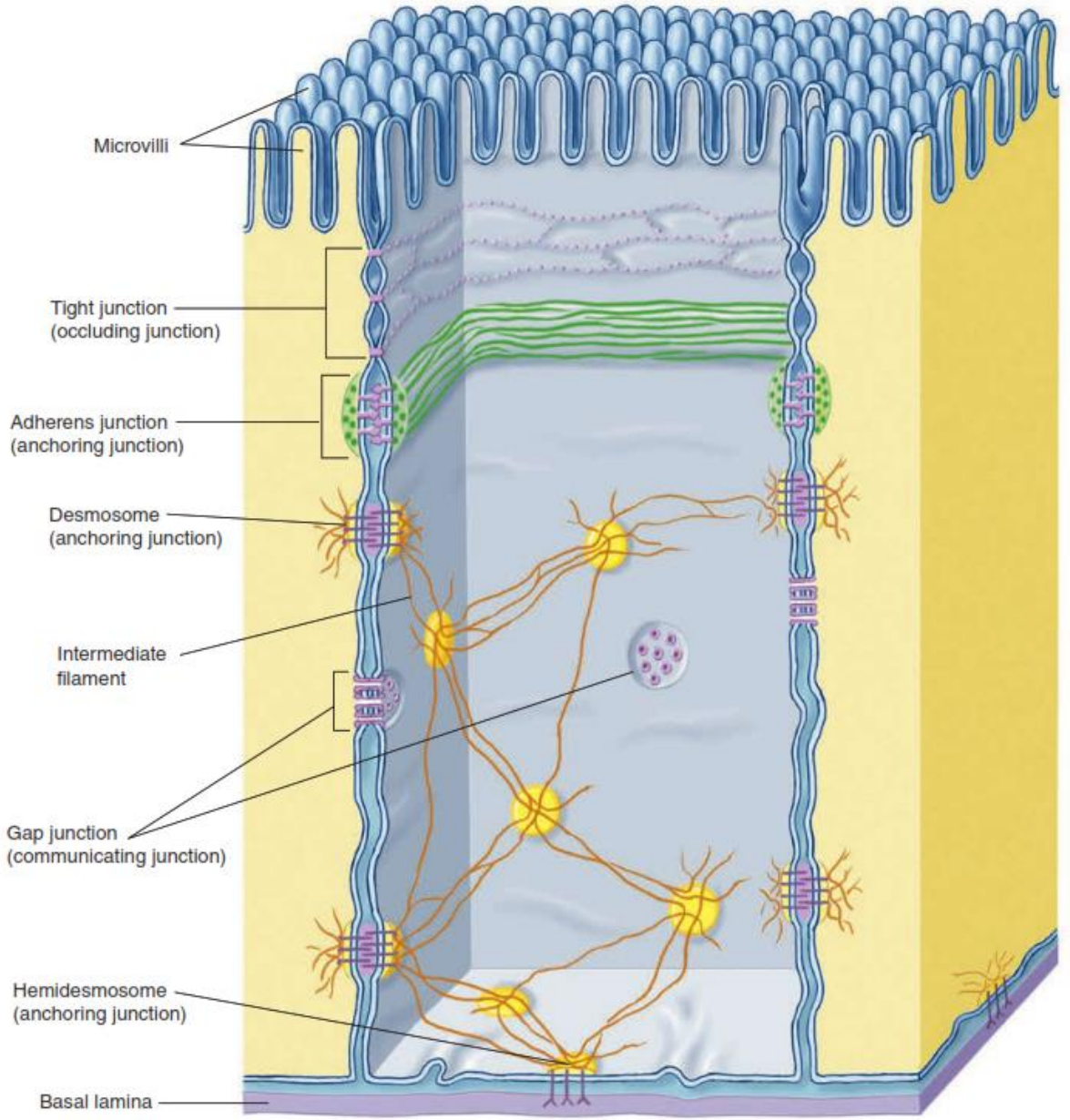
Intercellular Adhesion & Other Junctions

- Gap junctions mediate intercellular communication rather than adhesion or occlusion between cells.
- The transmembrane gap junction proteins, connexins, form hexameric complexes called connexons, each of which has a central hydrophilic pore about 1.5 nm in diameter. When two cells attach, connexins in the adjacent cell membranes move laterally and align to produce connexons between the two cells.
- Gap junctions permit intercellular exchange of molecules with small (<1.5 nm) diameters.



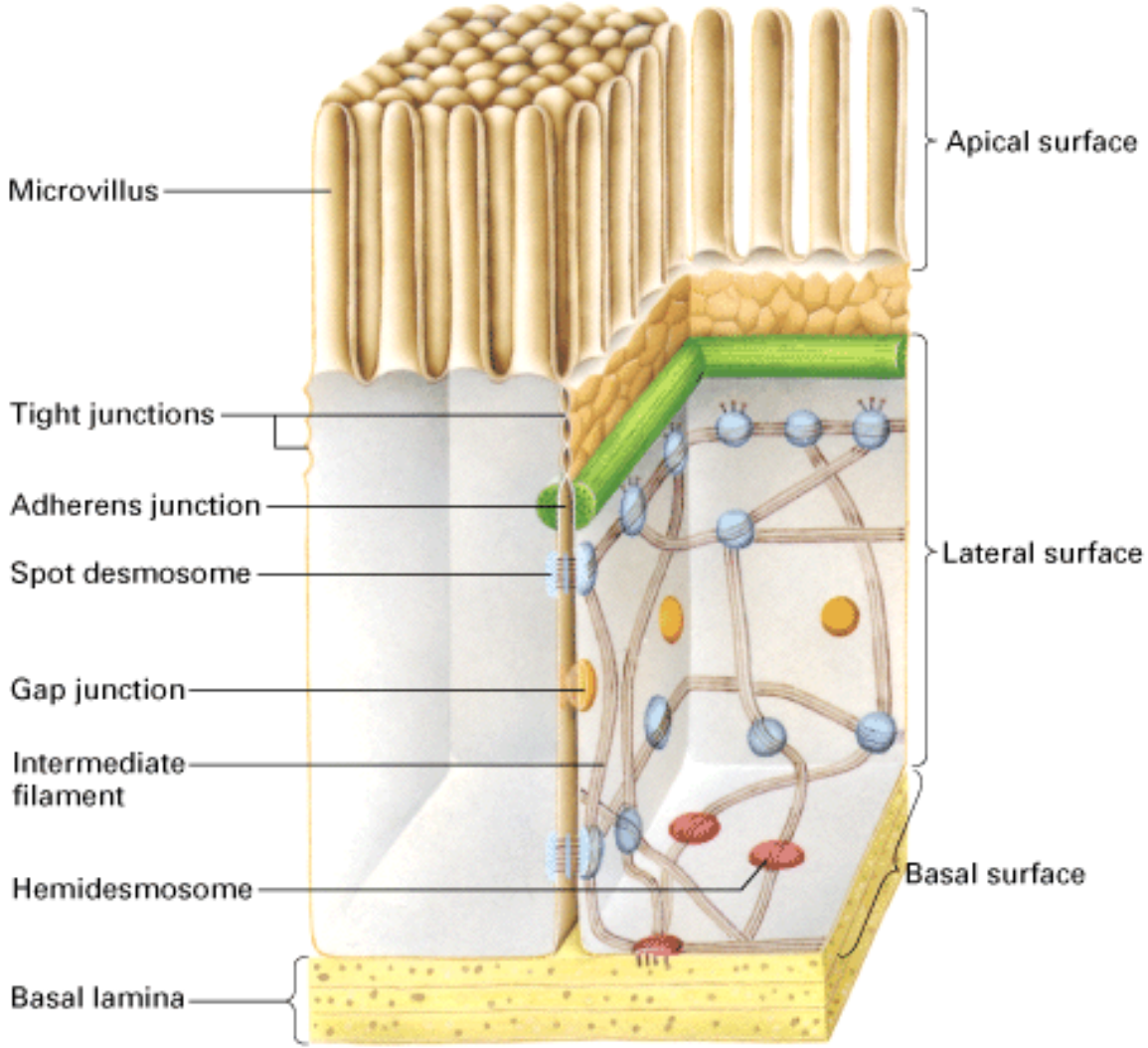
Intercellular Adhesion & Other Junctions

- On the basal epithelial surface, cells attach to the basal lamina by anchoring junctions called hemidesmo-somes (Gr. hemi, half + desmos + soma).
- These adhesive structures resemble a half-desmosome ultrastructurally, but unlike desmosomes the clustered 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.



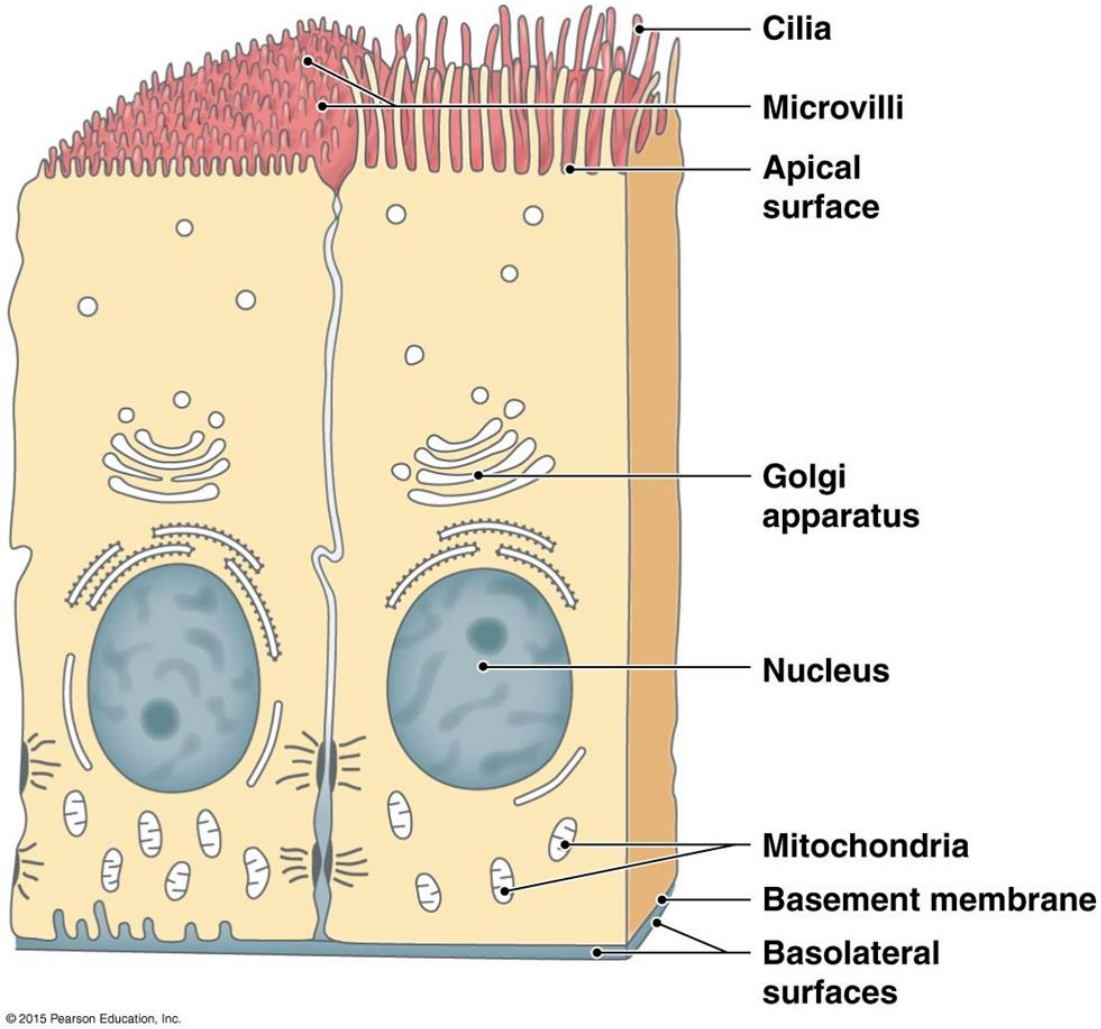
SPECIALIZATIONS OF THE APICAL CELL SURFACE

- The apical ends of many columnar and cuboidal epithelial cells have specialized structures projecting from the cells. These function either to increase the apical surface area for better absorption or to move substances along the epithelial surface.



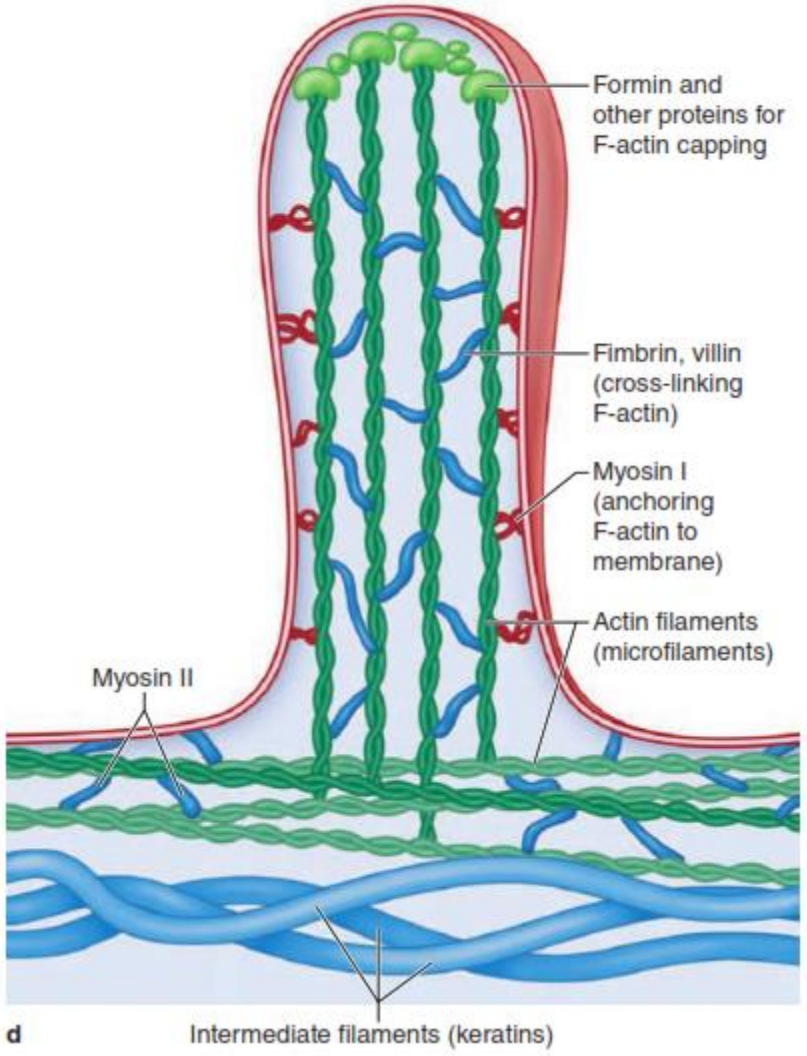
Microvilli

- Many cells have cytoplasmic projections best seen with the electron microscope. Such extensions usually reflect the movements and activity of actin filaments and are both temporary and variable in their length, shape, and number. However, in epithelia specialized for absorption the apical cell surfaces are often filled with an array of projecting microvilli (L. villus, tuft), usually of uniform length. In cells such as those lining the small intestine, densely packed microvilli are visible as a brush or striated border projecting into the lumen



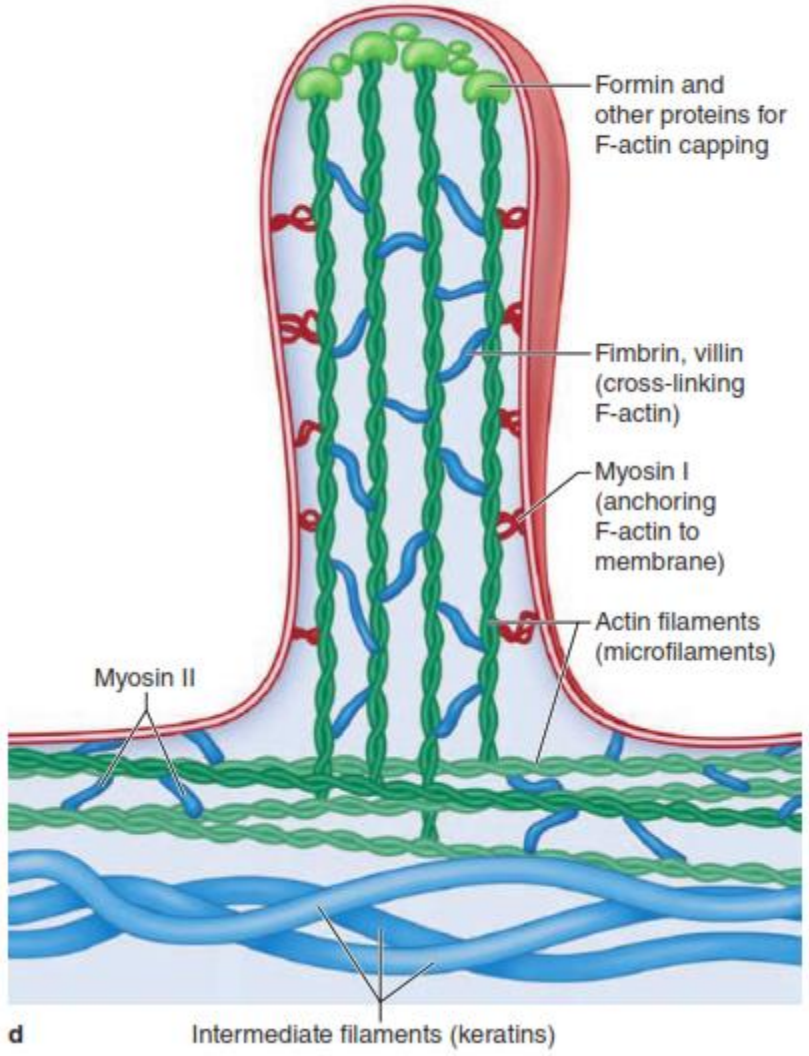
Microvilli

- The average microvillus is about 1 µm long and 0.1 µm wide, but with hundreds or thousands present on the end of each absorptive cell, the total surface area can be increased by 20- or 30-fold.
- The thick glycocalyx covering microvilli of the intestinal brush border includes membrane-bound proteins and enzymes for digestion of certain macromolecules.



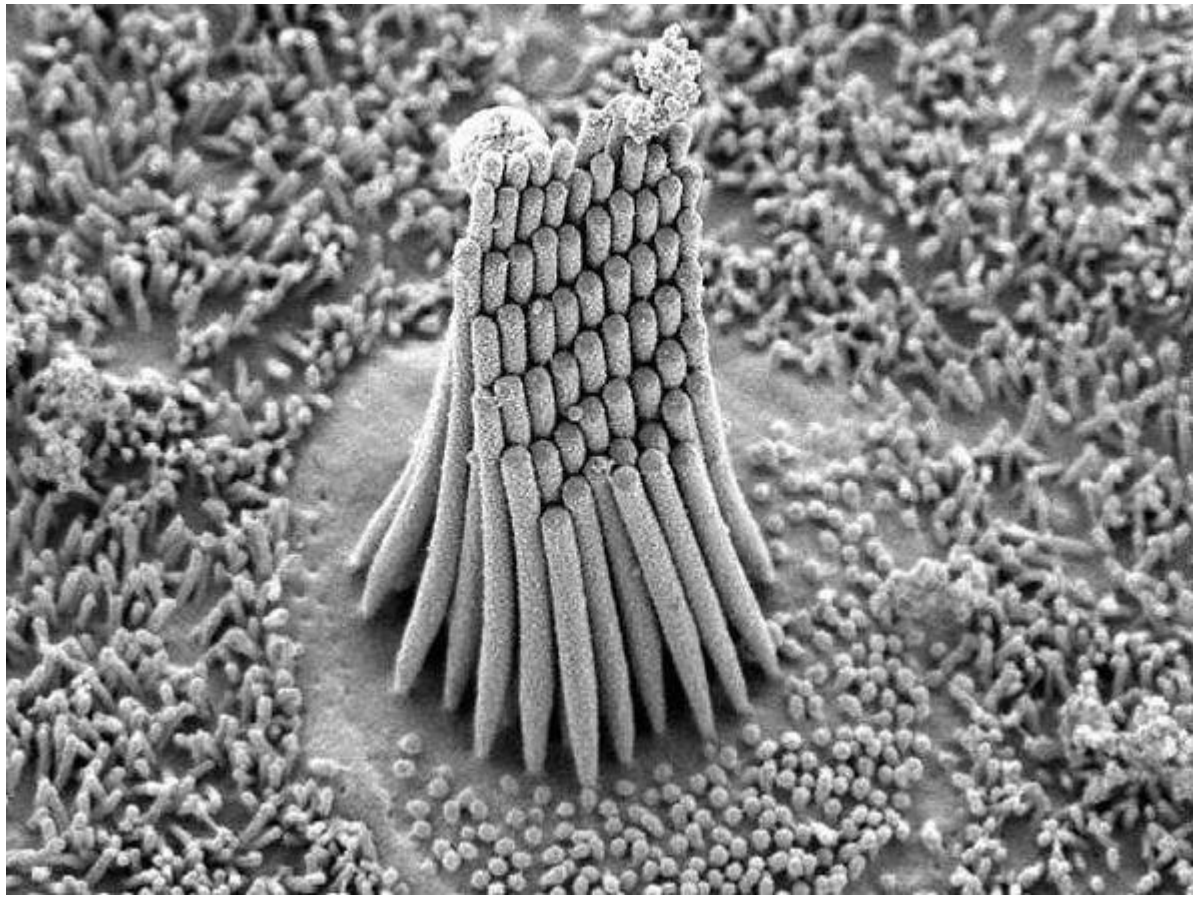
Microvilli

- Each microvillus contains bundled actin filaments capped and bound to the surrounding plasma membrane by actin-binding proteins.
- Although microvilli are relatively stable, the microfilament arrays are dynamic and undergo various myosin-based movements, which help maintain optimal conditions for absorption via numerous channels, receptors, and other proteins in the plasmalemma.
- The actin filaments insert into the terminal web of cortical microfilaments at the base of the microvilli.



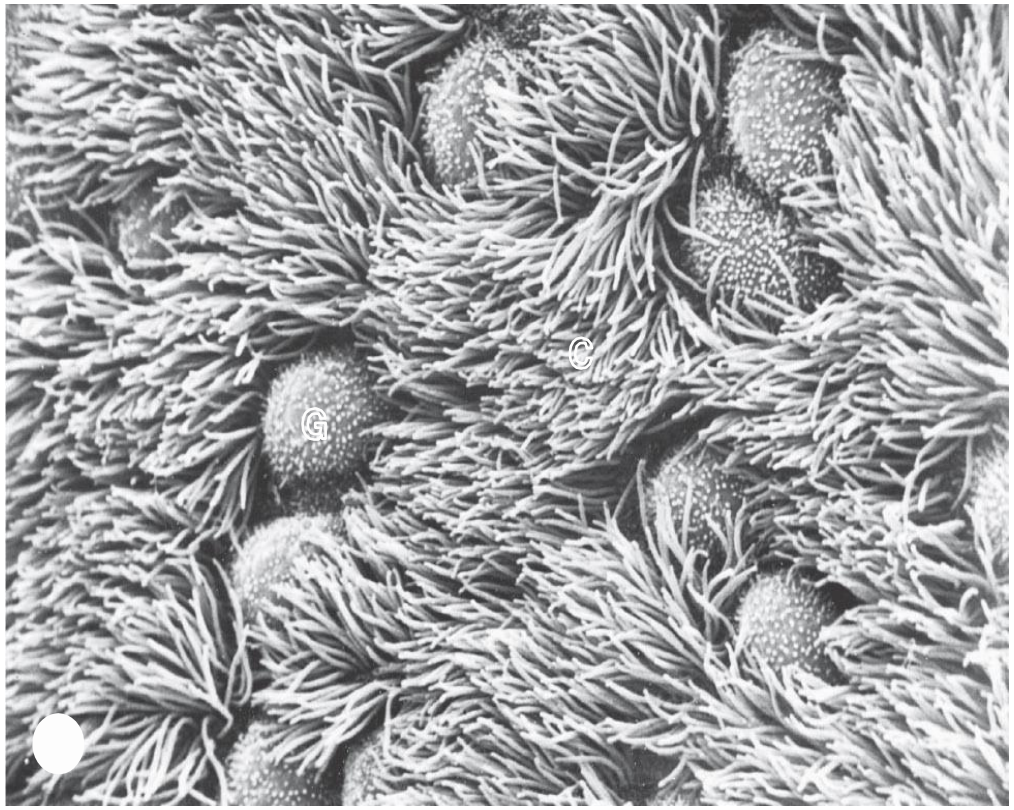
Stereocilia

- Stereocilia are a much less common type of apical process, best seen on the absorptive epithelial cells lining the male reproductive system. Like microvilli, stereocilia increase the cells' surface area, facilitating absorption.
- More specialized stereocilia with a motion-detecting function are important components of inner ear sensory cells.
- Stereocilia resemble microvilli in containing arrays of microfilaments and actin-binding proteins, with similar diameters, and with similar connections to the cell's terminal web.
- However, stereocilia are typically much longer and less motile than microvilli, and may show branching distally.



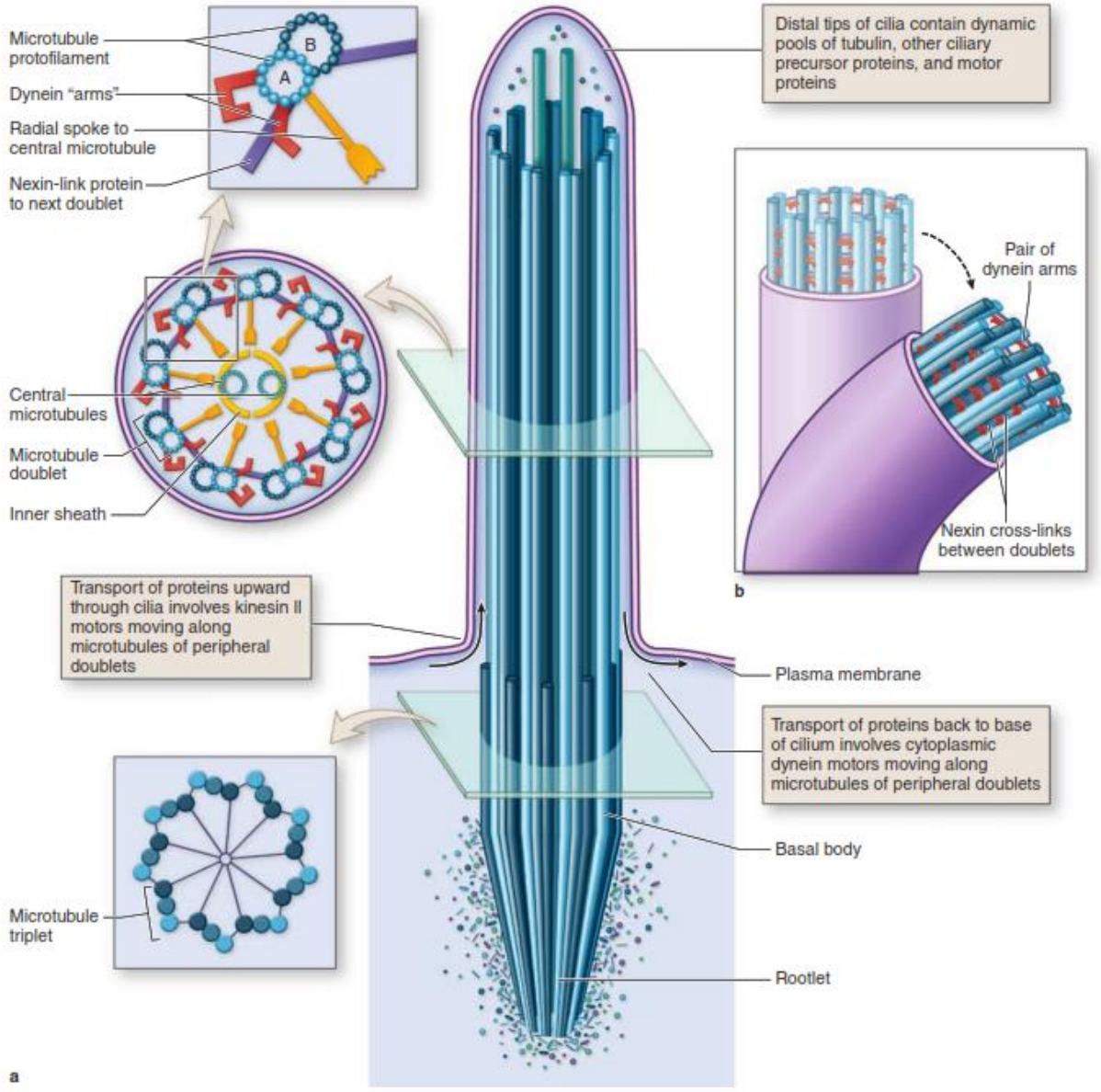
Cilia

- Cilia are long, highly motile apical structures, larger than microvilli, and containing internal arrays of microtubules not microfilament



Cilia

- Cilia are long, highly motile apical structures, larger than microvilli, and containing internal arrays of microtubules not microfilament
- each cilium has a core structure consisting of nine peripheral microtubule doublets (in which a few tubulin protofilaments are shared) arrayed around two central microtubules.
- This 9 + 2 assembly of microtubules is called an axoneme.



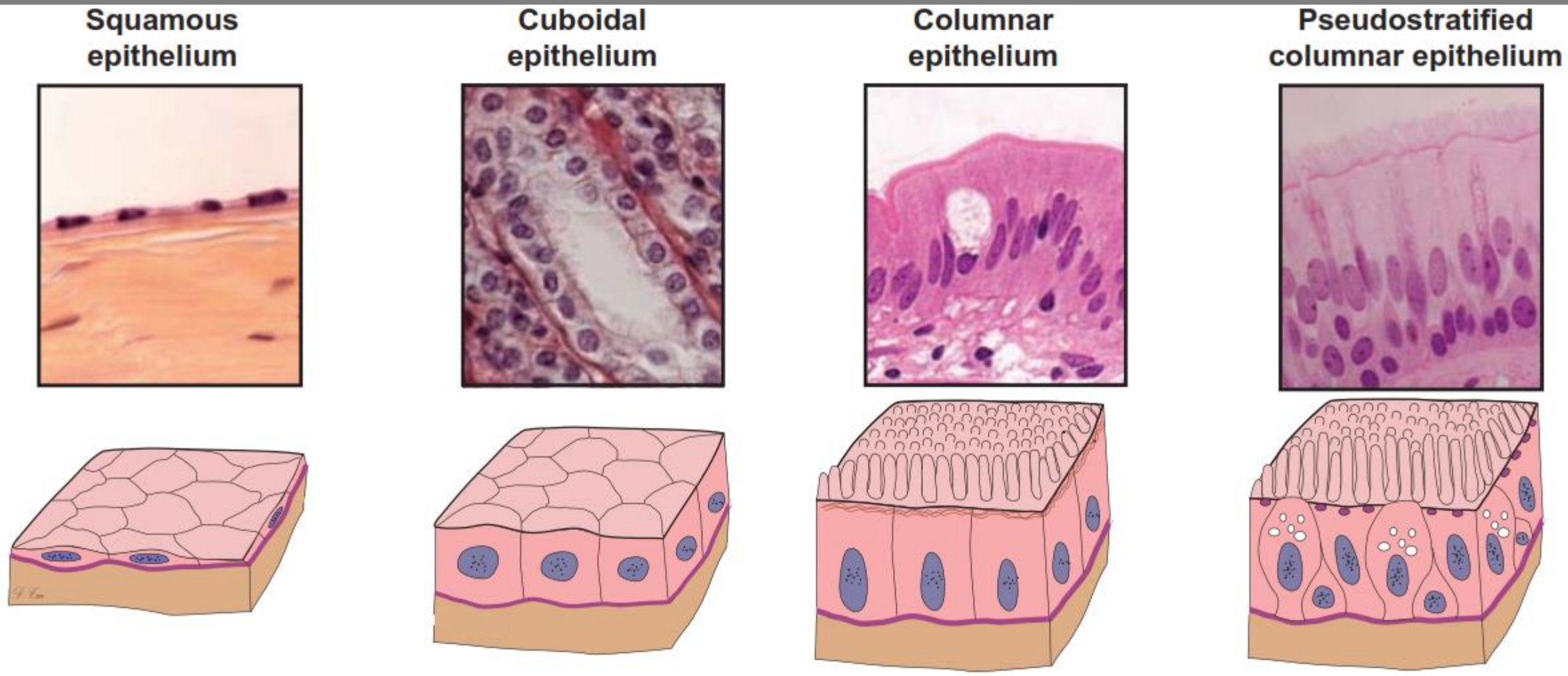
TYPES OF EPITHELIA

- Epithelia can be divided into two main groups:
- covering (or lining) epithelia and
- secretory (glandular) epithelia.

TYPES OF EPITHELIA

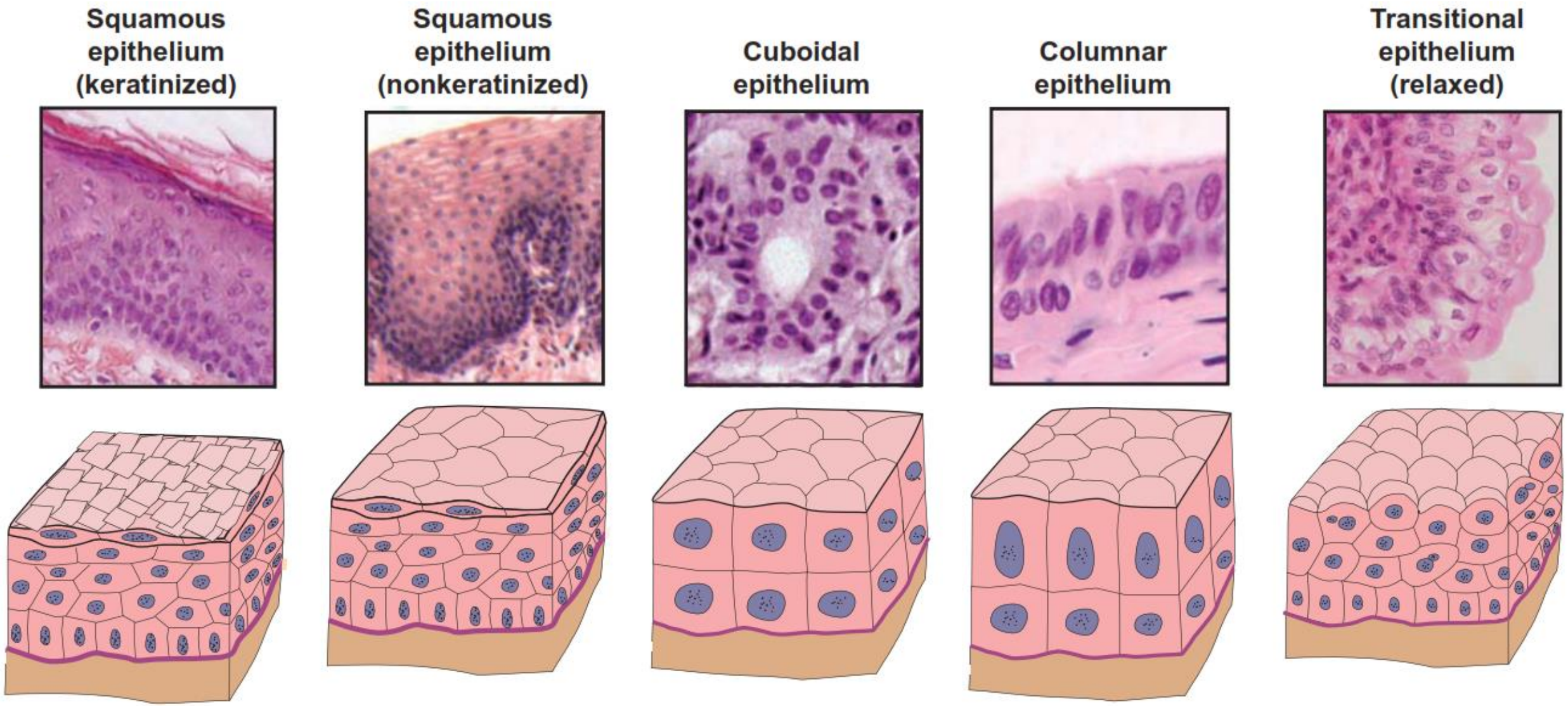
Major Feature	Cell Form	Examples of Distribution	Main Function
Simple (one layer of cells)	Squamous	Lining of vessels (endothelium); Serous lining of cavities: pericardium, pleura, peritoneum (mesothelium)	Facilitates the movement of the viscera (mesothelium), active transport by pinocytosis (mesothelium 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

TYPES OF EPITHELIA



Simple epithelia (one layer of epithelial cells)

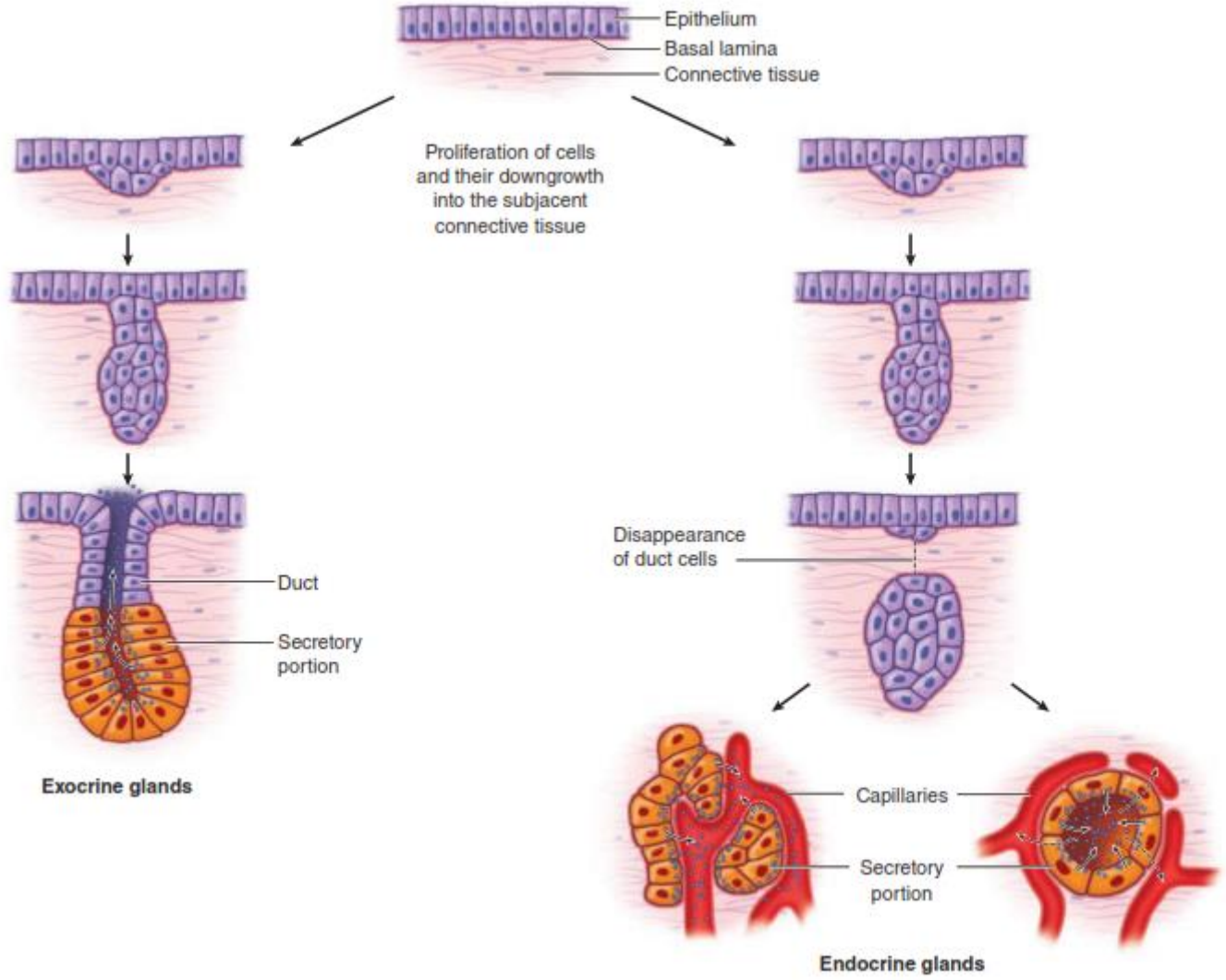
Epithelial tissue



Stratified epithelia (two or more layers of epithelial cells)

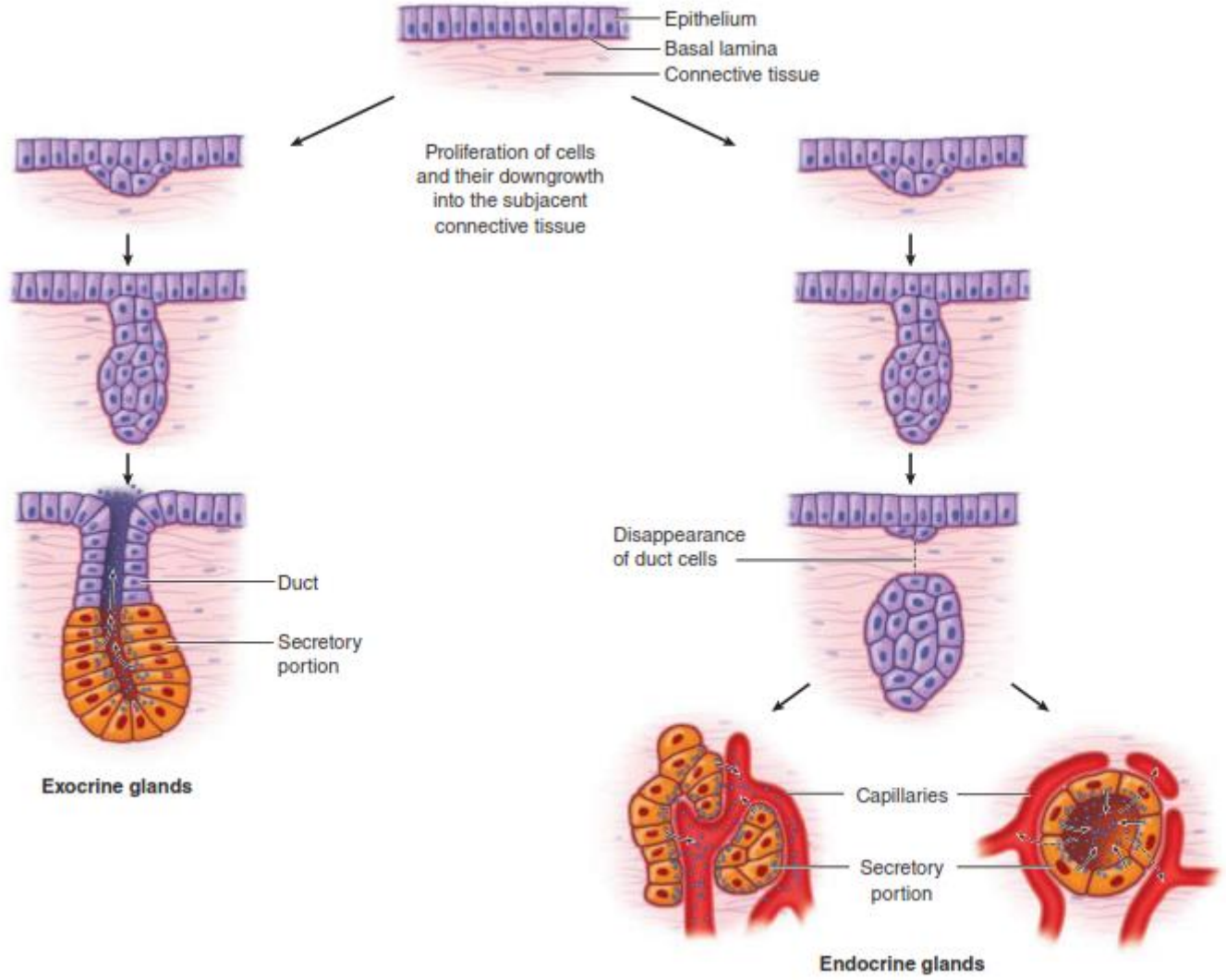
Secretory Epithelia & Glands

- Epithelial cells that function mainly to produce and secrete various macromolecules may occur in epithelia with other major functions or comprise specialized organs called glands
- Glands develop from covering epithelia in the fetus by cell proliferation and growth into the underlying connective tissue, followed by further differentiation



Secretory Epithelia & Glands

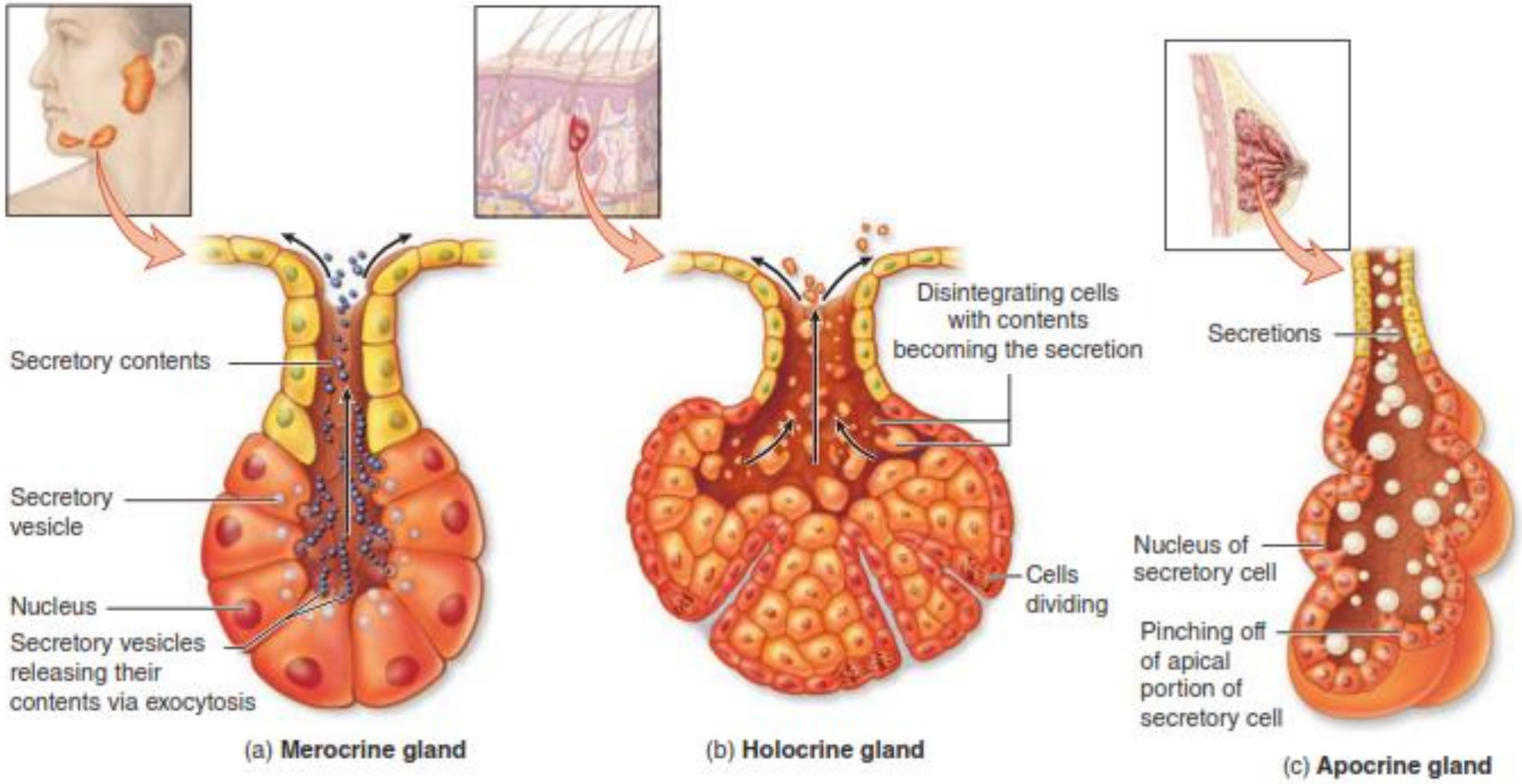
- Exocrine glands remain connected with the surface epithelium, the connection forming the tubular ducts lined with epithelium that deliver the secreted material where it is used.
- Endocrine glands lose the connection to their original epithelium and therefore lack ducts.



Secretory Epithelia & Glands

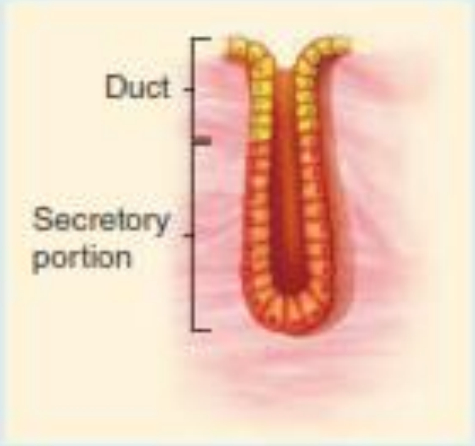
- Three basic mechanisms for releasing the product are commonly used by cells specialized for secretion:
- Merocrine secretion: This is the most common method of protein or glycoprotein secretion and involves typical exocytosis from membrane-bound vesicles or secretory granules.
- Holocrine secretion: Here cells accumulate product continuously as they enlarge and undergo terminal differentiation, culminating in complete cell disruption that releases the product and cell debris into the gland's lumen. This is best seen in the sebaceous glands producing lipid- rich material in skin
- Apocrine secretion: Here product accumulates at the cells' apical ends, portions of which are then pinched off to release the product surrounded by a small amount of cytoplasm and cell membrane.

Secretory Epithelia & Glands



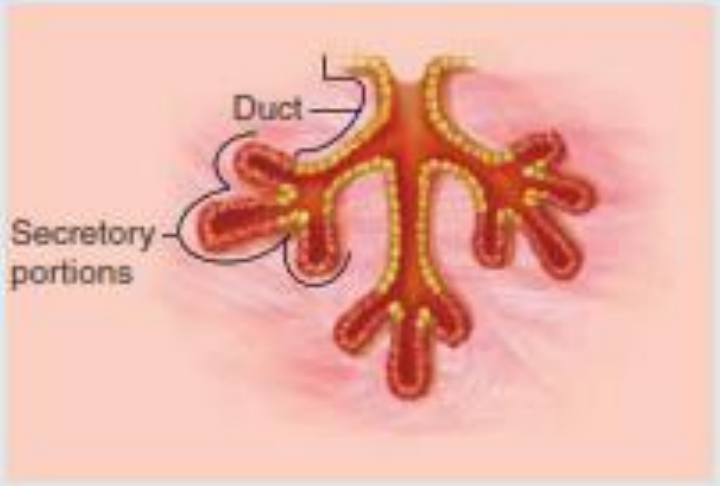
Secretory Epithelia & Glands

SIMPLE Glands **(Ducts Do Not Branch)**

Class	Simple Tubular	Branched Tubular	Coiled Tubular	Acinar (or Alveolar)	Branched Acinar
					
Features	Elongated secretory portion; duct usually short or absent	Several long secretory parts joining to drain into 1 duct	Secretory portion is very long and coiled	Rounded, saclike secretory portion	Multiple saclike secretory parts entering the same duct
Examples	Mucous glands of colon; intestinal glands or crypts (of Lieberkühn)	Glands in the uterus and stomach	Sweat glands	Small mucous glands along the urethra	Sebaceous glands of the skin

Secretory Epithelia & Glands

COMPOUND Glands **(Ducts from Several Secretory Units Converge into Larger Ducts)**

Class	Tubular	Acinar (Alveolar)	Tubuloacinar
			
Features	Several elongated coiled secretory units and their ducts converge to form larger ducts	Several saclike secretory units with small ducts converge at a larger duct	Ducts of both tubular and acinar secretory units converge at larger ducts
Examples	Submucosal mucous glands (of Brunner) in the duodenum	Exocrine pancreas	Salivary glands