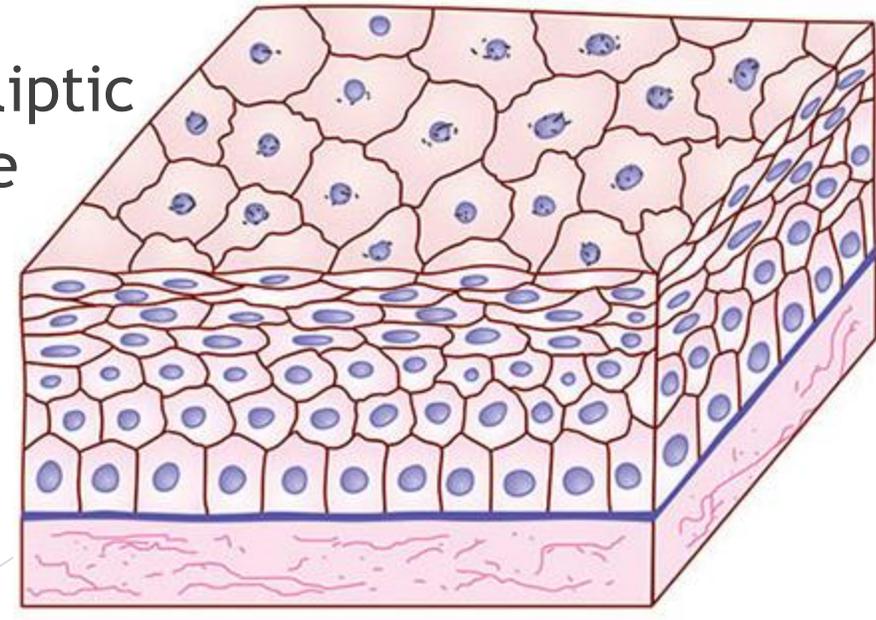


Epithelial Tissue-2

Hanan Jafar. BDS.MSc.PhD

Introduction

- ▶ 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.
- ▶ Epithelial cell nuclei vary in shape and may be elliptic (oval), spherical, or flattened, with nuclear shape corresponding roughly to cell shape.



Epithelial Nuclei

- ▶ Because the lipid-rich membranes of epithelial cells are frequently indistinguishable by light microscopy, the number and shape of their stained nuclei are important indicators of cell shape and density.
- ▶ The nuclei also allow one to determine the number of cell layers in an epithelium, a primary morphologic criterion for classifying epithelia.
- ▶ Columnar cells generally have elongated nuclei, squamous cells have flattened nuclei, and cuboidal or pyramidal cells have more spherical nuclei

Types of Epithelia

- ▶ Epithelia can be divided into two main groups: **covering (or lining) epithelia** and **secretory (glandular) epithelia**.
- ▶ This is an arbitrary functional division for there are lining epithelia in which all the cells also secrete (eg, the lining of the stomach) or in which glandular cells are distributed among the lining cells (eg, mucous cells in the small intestine or trachea).

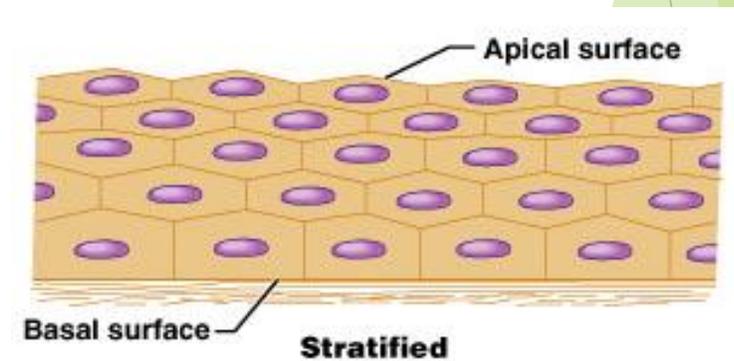
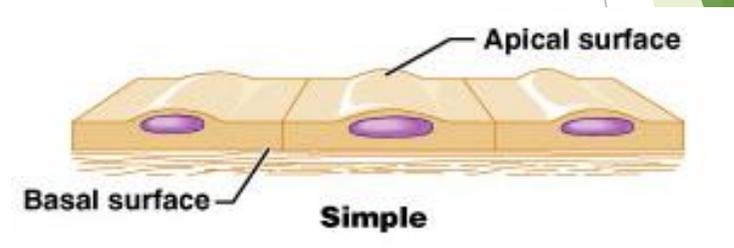
Covering or Lining Epithelia

- ▶ Cells of covering epithelia are organized into one or more layers that cover the surface or line the cavities of an organ.
- ▶ Such epithelia are classified according to the number of cell layers and the cell morphology in the outer layer

Classifications & Naming of Epithelia

- ▶ According to number of layers
 - ▶ Simple – one layer of cells

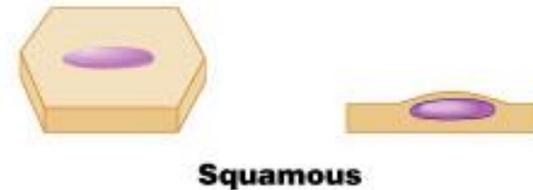
- ▶ Stratified – more than one layer of cells



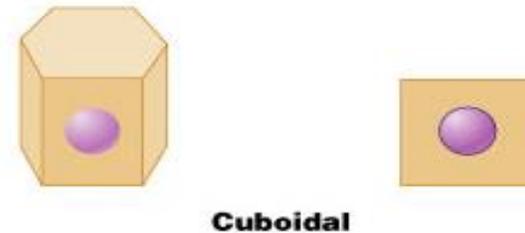
Classification & Naming of Epithelia

▶ According to shape of cells (in stratified epithelia, shape of most apical layer)

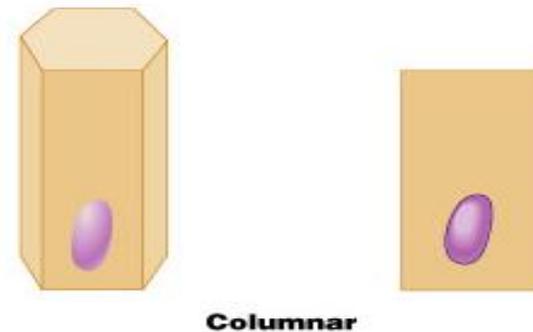
▶ Squamous – cells wider than tall (plate or “scale” like)



▶ Cuboidal – cells are as wide as tall, as in cubes



▶ Columnar – cells are taller than they are wide, like columns



Naming Epithelia

- ▶ Naming the epithelia includes both the layers (first) and the shape of the cells (second)
 - ▶ i.e. stratified cuboidal epithelium
- ▶ The name may also include any accessory structures
 - ▶ Keratin
 - ▶ Goblet cells
 - ▶ Cilia
- ▶ Special epithelial tissues (don't follow naming convention)
 - ▶ Pseudostratified
 - ▶ Transitional

Epithelium

Simple

- Squamous
- Cuboidal
- Columnar
- Pseudostratified

Stratified

- Squamous
- Cuboidal
- Transitional
- Columnar

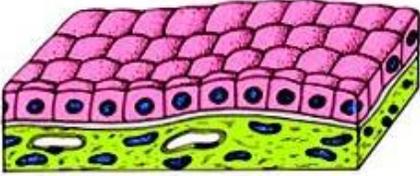
- keratinized
- nonkeratinized

Types of epithelium

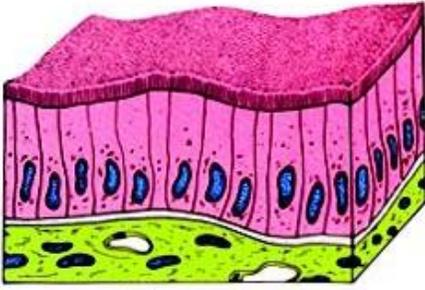
(SIMPLE)



Squamous

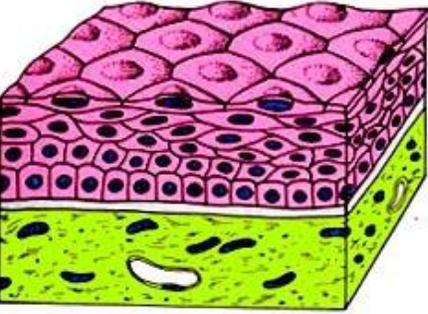


Cuboidal

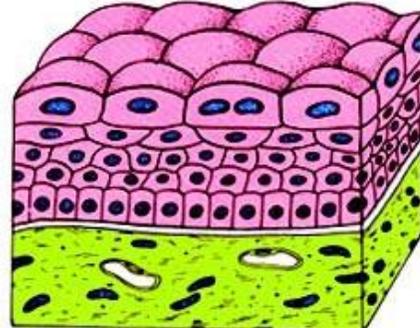


Columnar

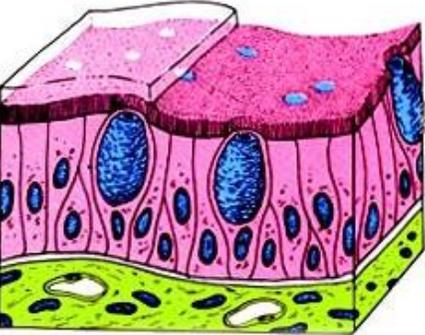
(STRATIFIED)



Squamous



Transitional



Pseudostratified

TABLE 4-3

Common types of covering epithelia.

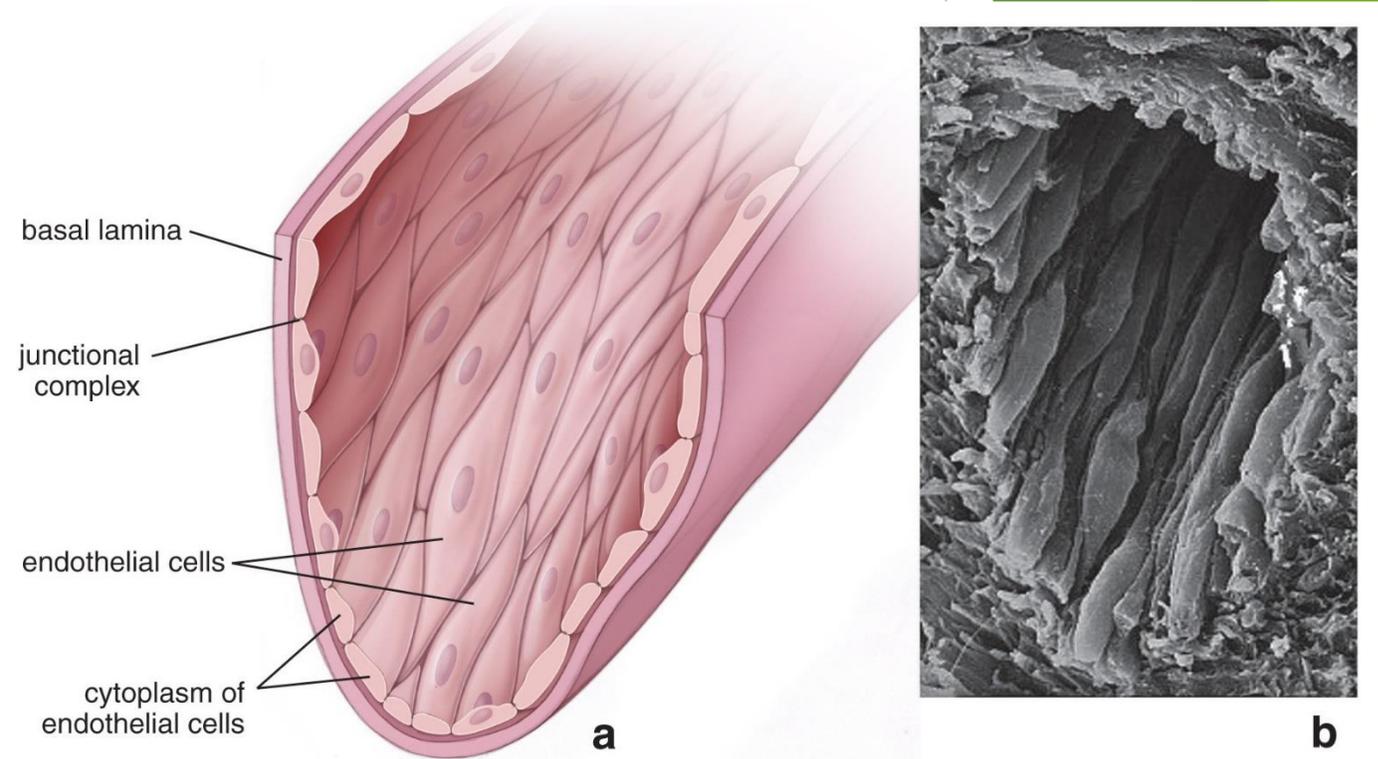
Major Feature	Cell Form	Examples of Distribution	Main Function
Simple (one layer of cells)	Squamous	Lining of vessels (endothelium); Serous lining of cavities: pericardium, pleura, peritoneum (mesothelium)	Facilitates the movement of the viscera (mesothelium), active transport by pinocytosis (mesothelium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

Simple Squamous Epithelium

- ▶ **Locations:**
 - ▶ Vascular system (endothelium)
 - ▶ Body cavities (mesothelium)
 - ▶ Bowman's capsule (kidney)
 - ▶ Lung alveoli
- ▶ **Major function:**
 - ▶ Exchange

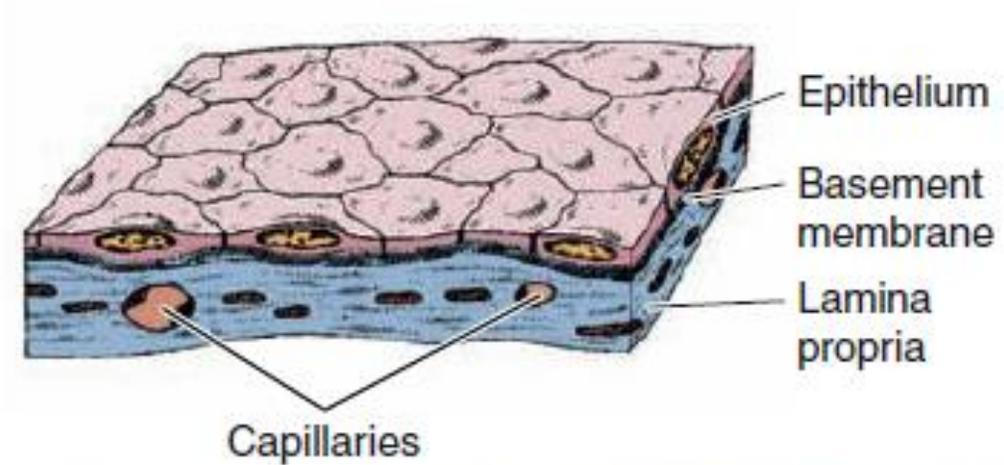
Endothelium

- ▶ *Endothelium* is the simple squamous epithelium that lines the lumen of the cardiovascular system

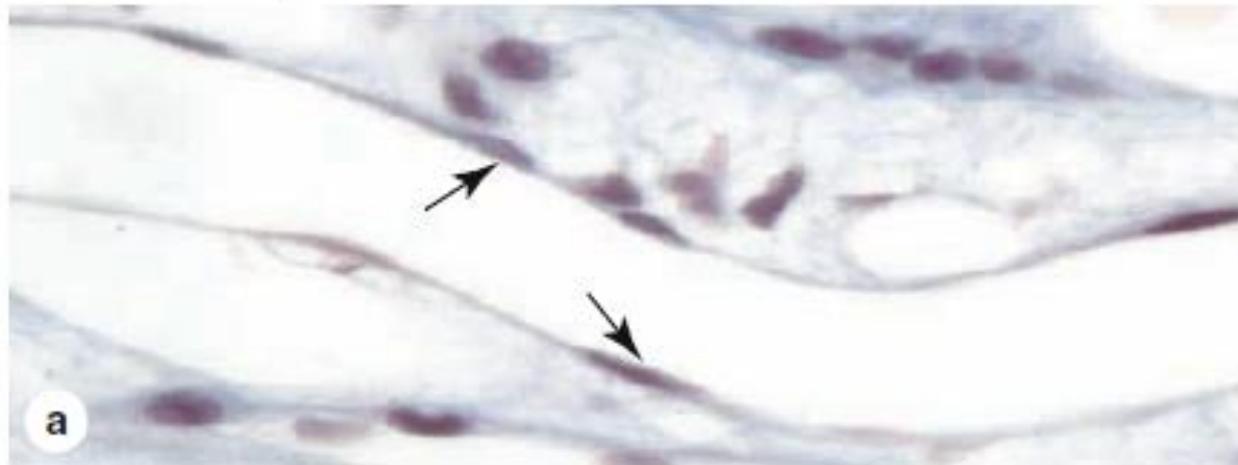


Simple squamous epithelium

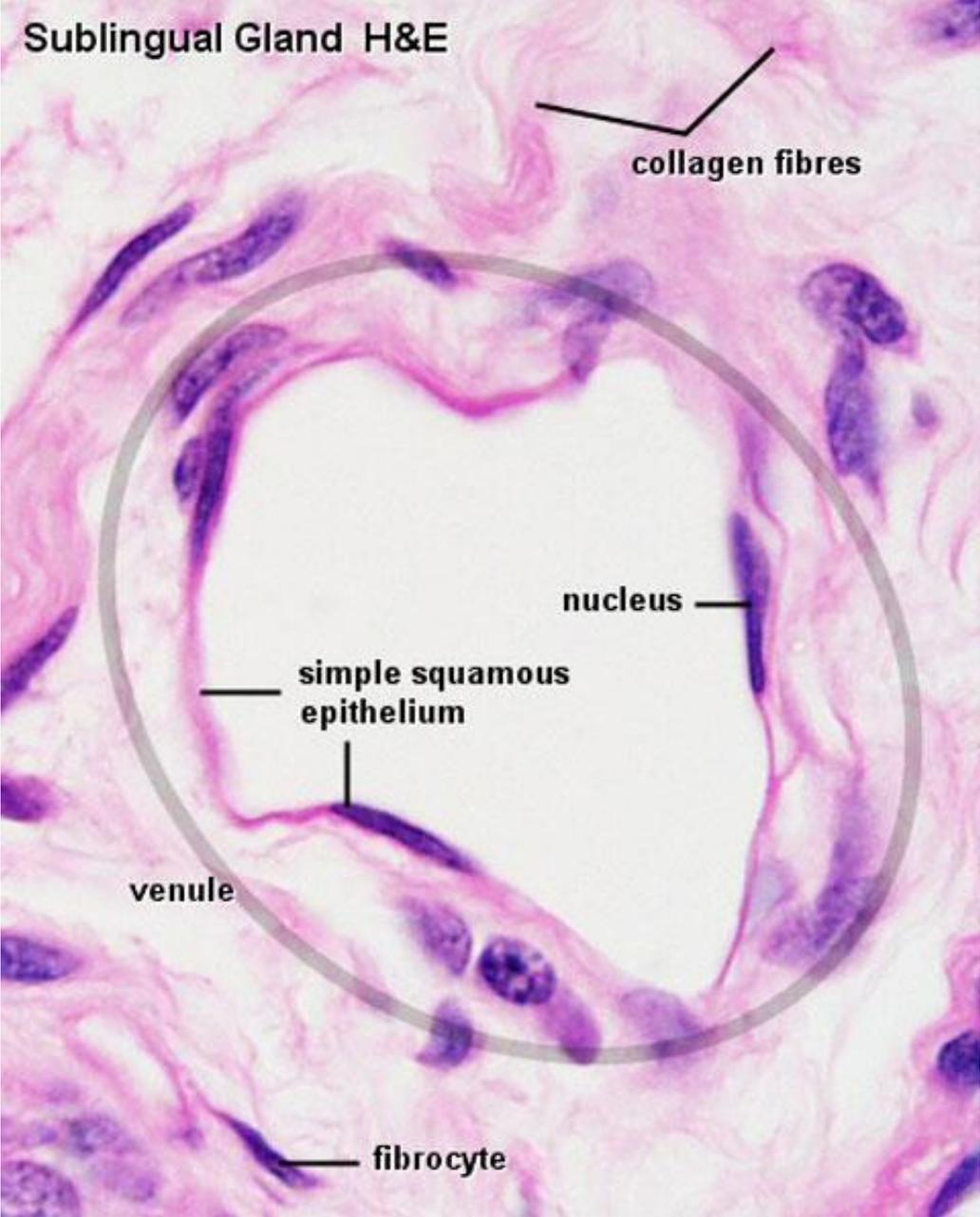
► Endothelium



Longitudinal section

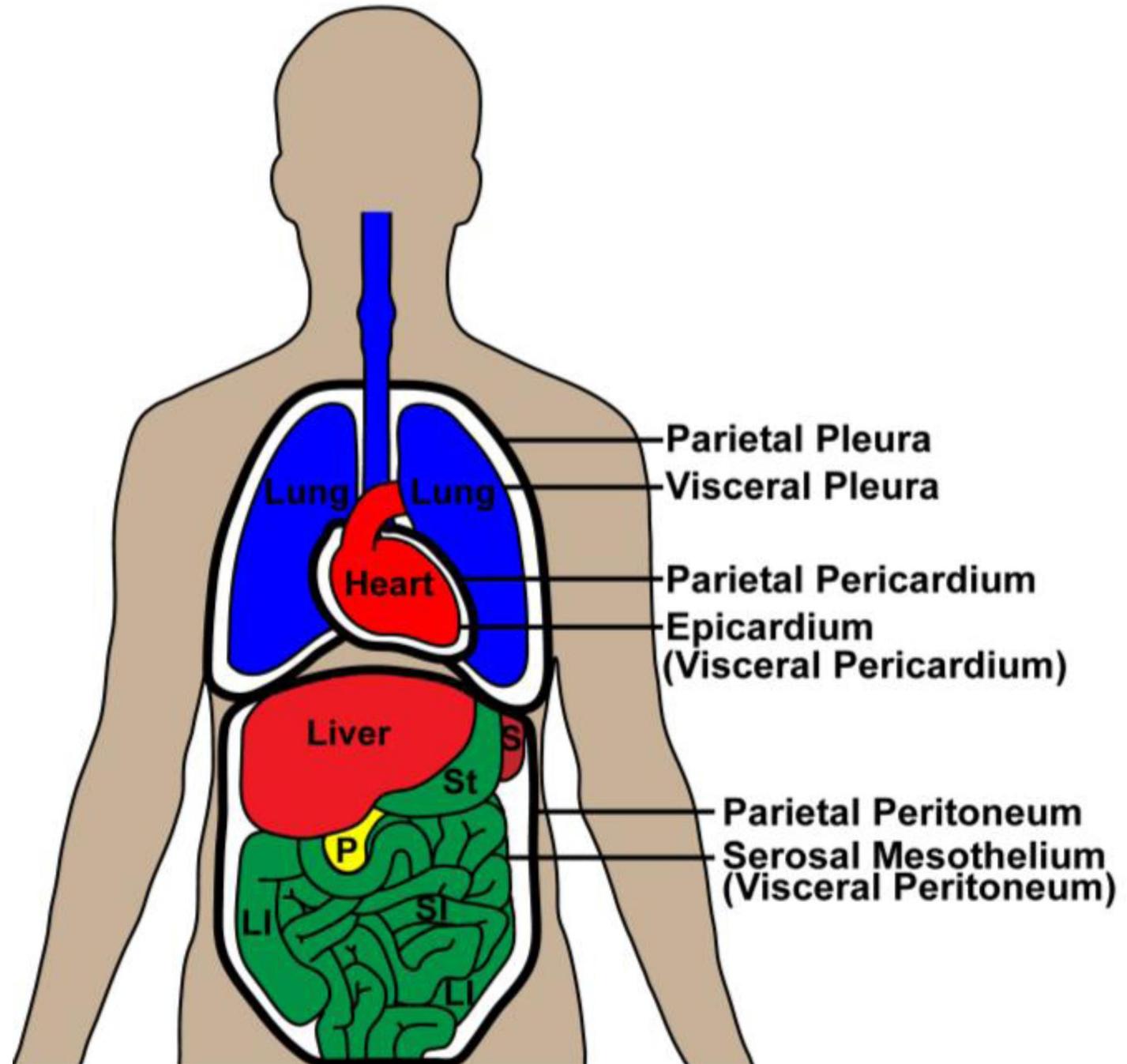


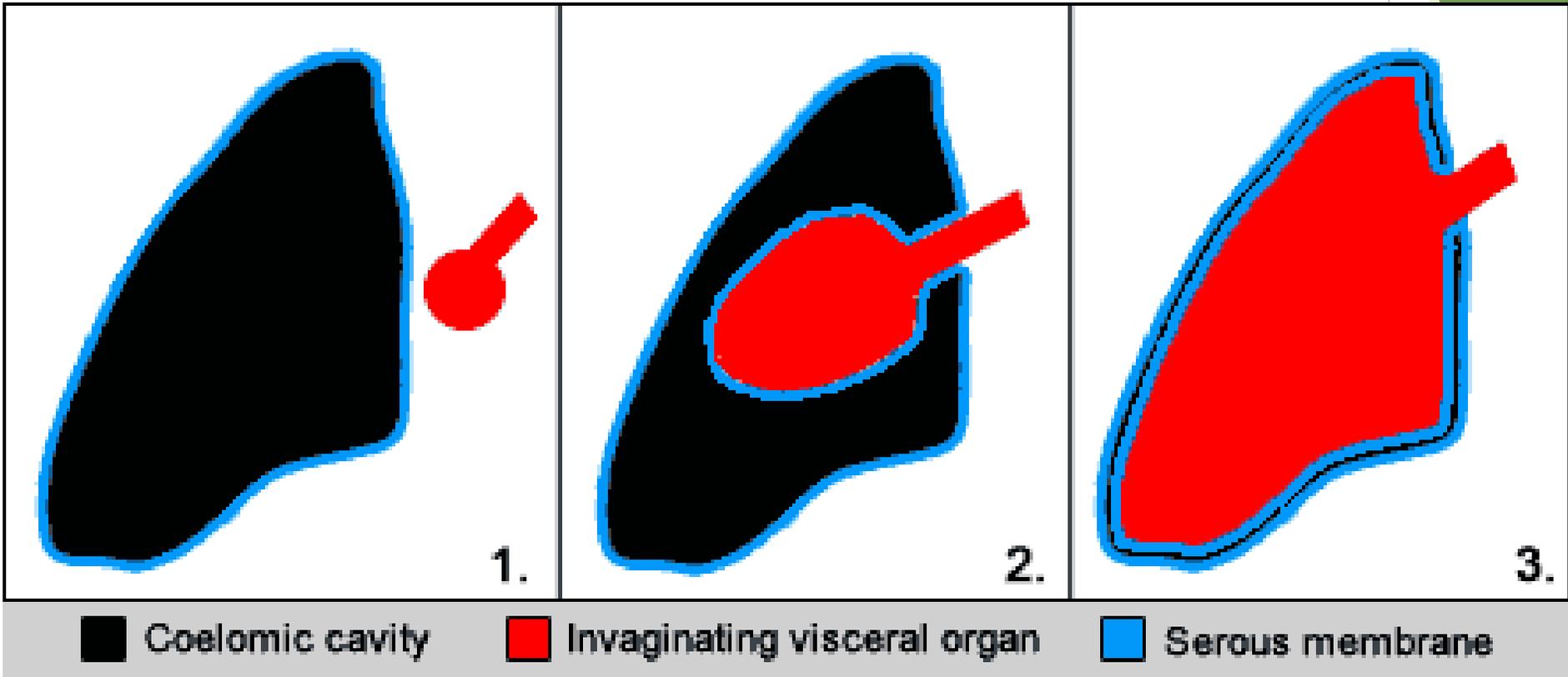
Cross section



Mesothelium

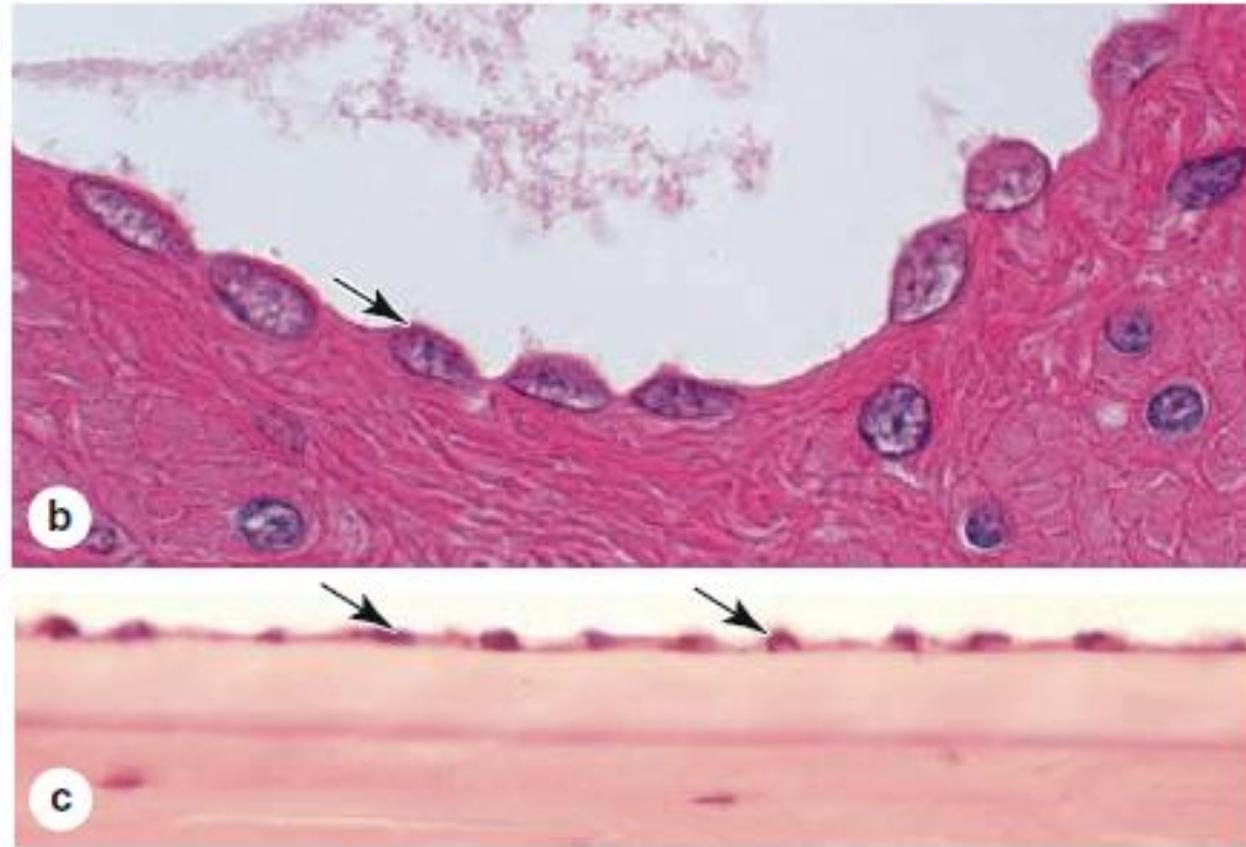
- ▶ *Mesothelium* is the simple squamous epithelium that lines serous cavities (peritoneal, pleural, and pericardial cavities) and covers many of the organs in these cavities





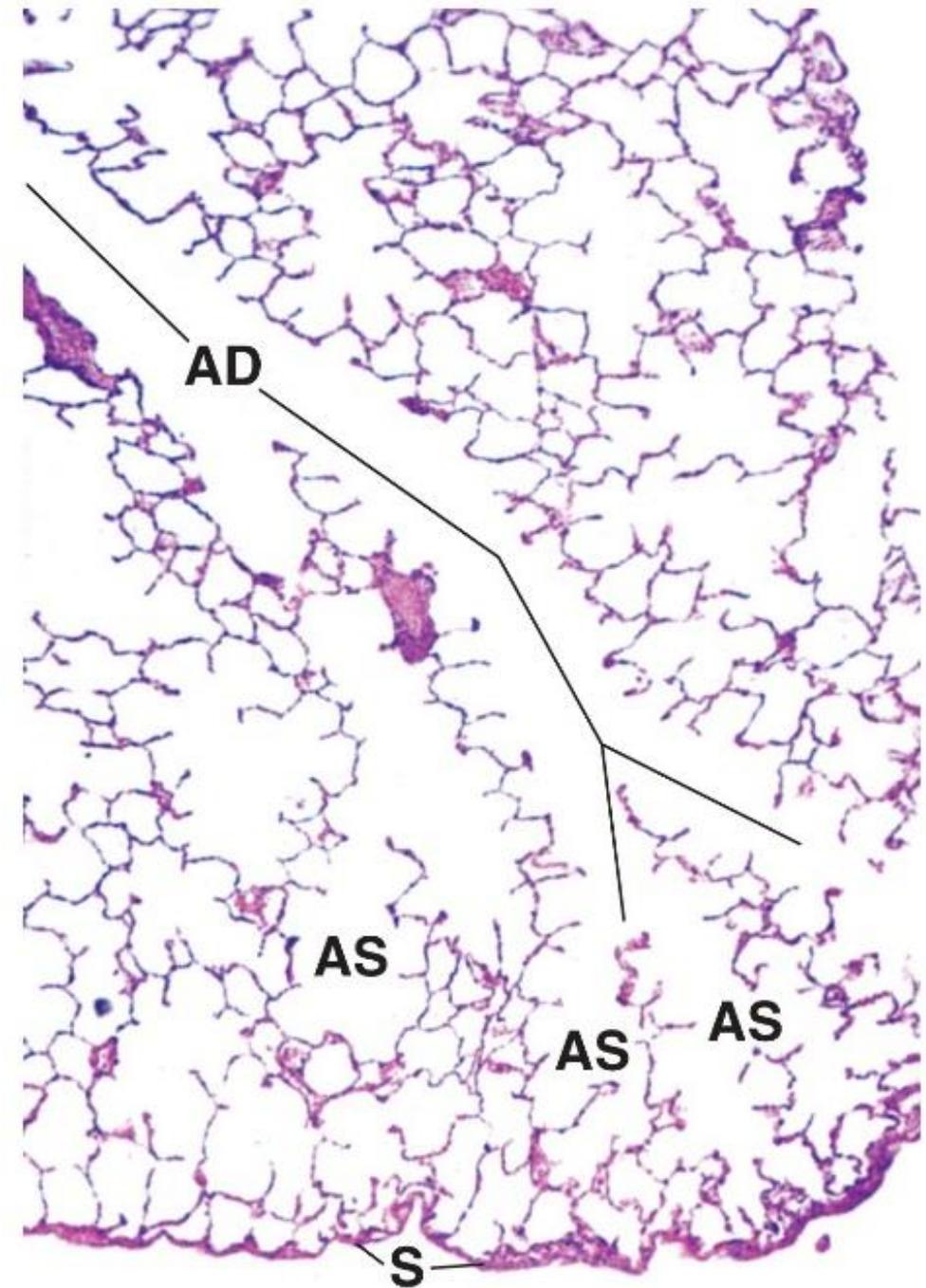
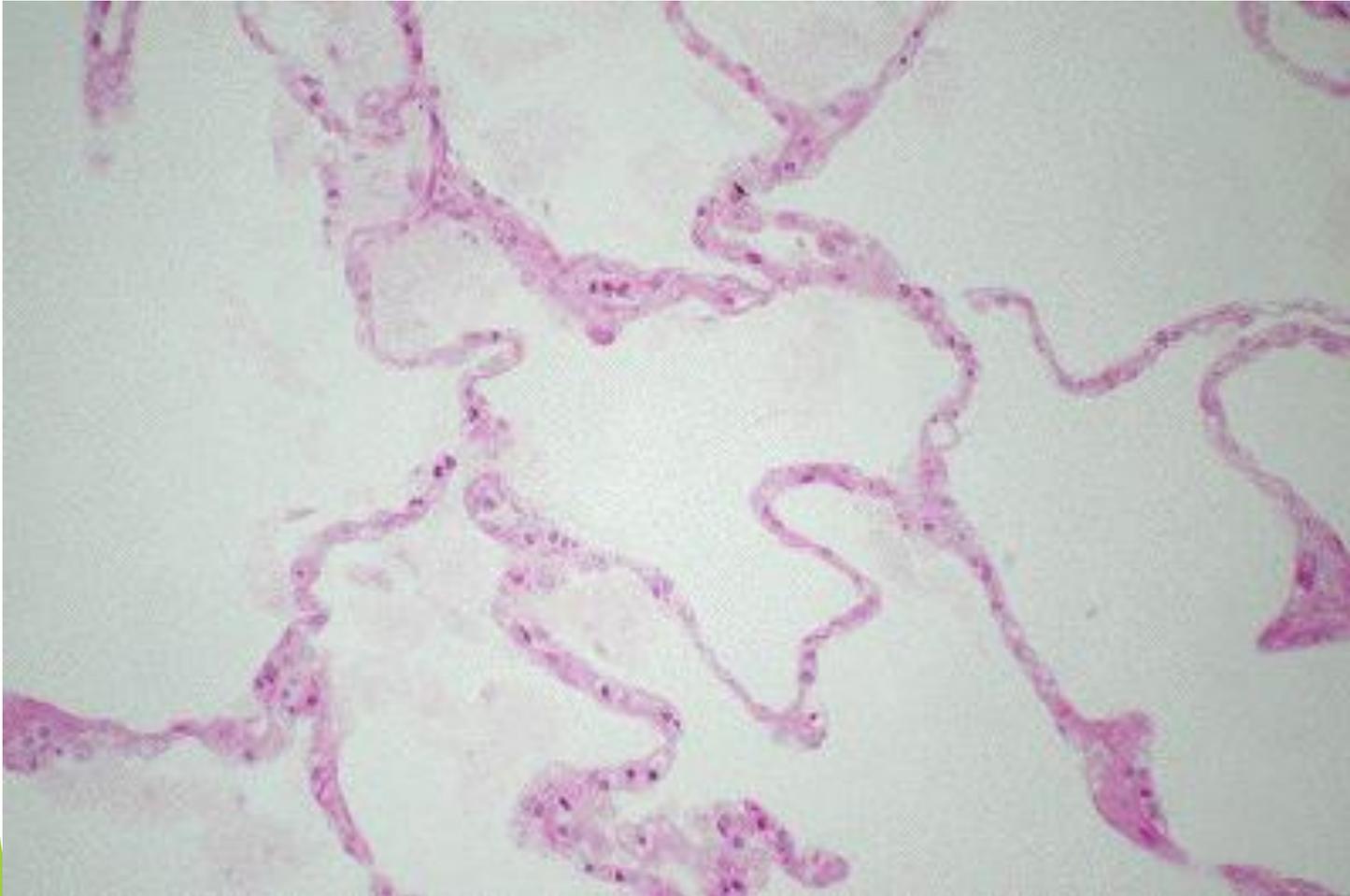
Simple squamous epithelium

► Mesothelium



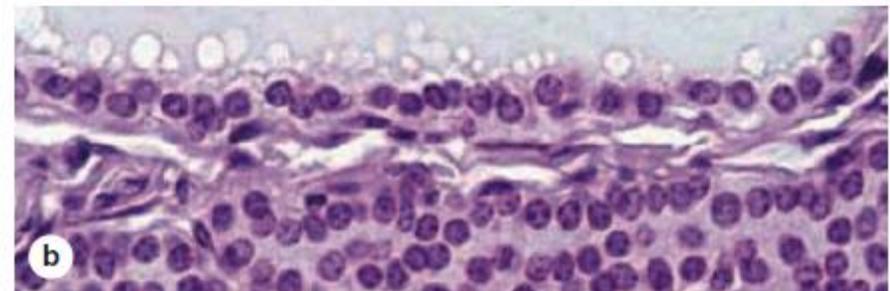
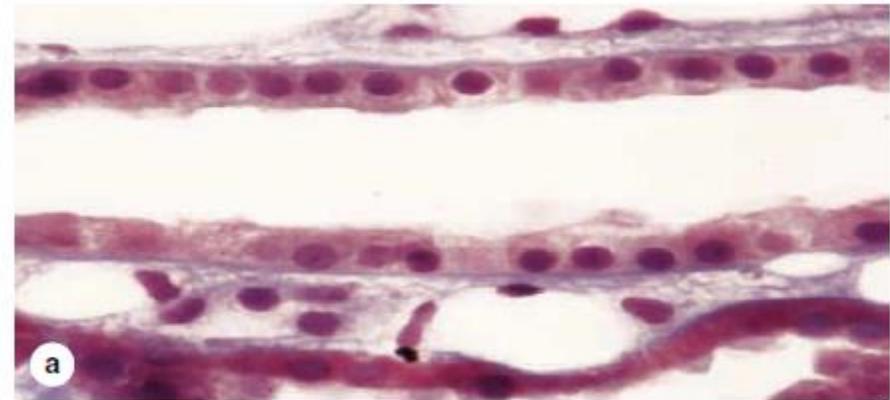
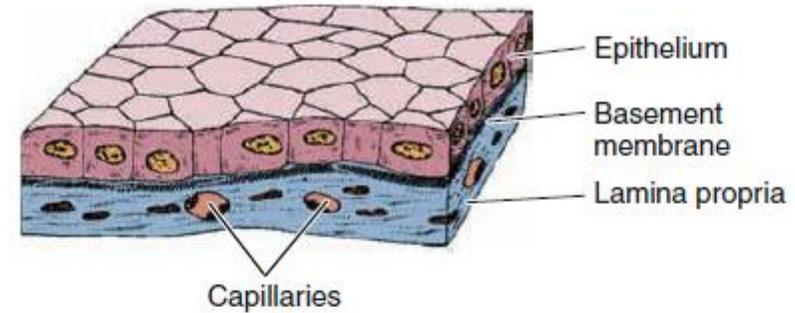
Simple squamous epithelium

► Alveoli

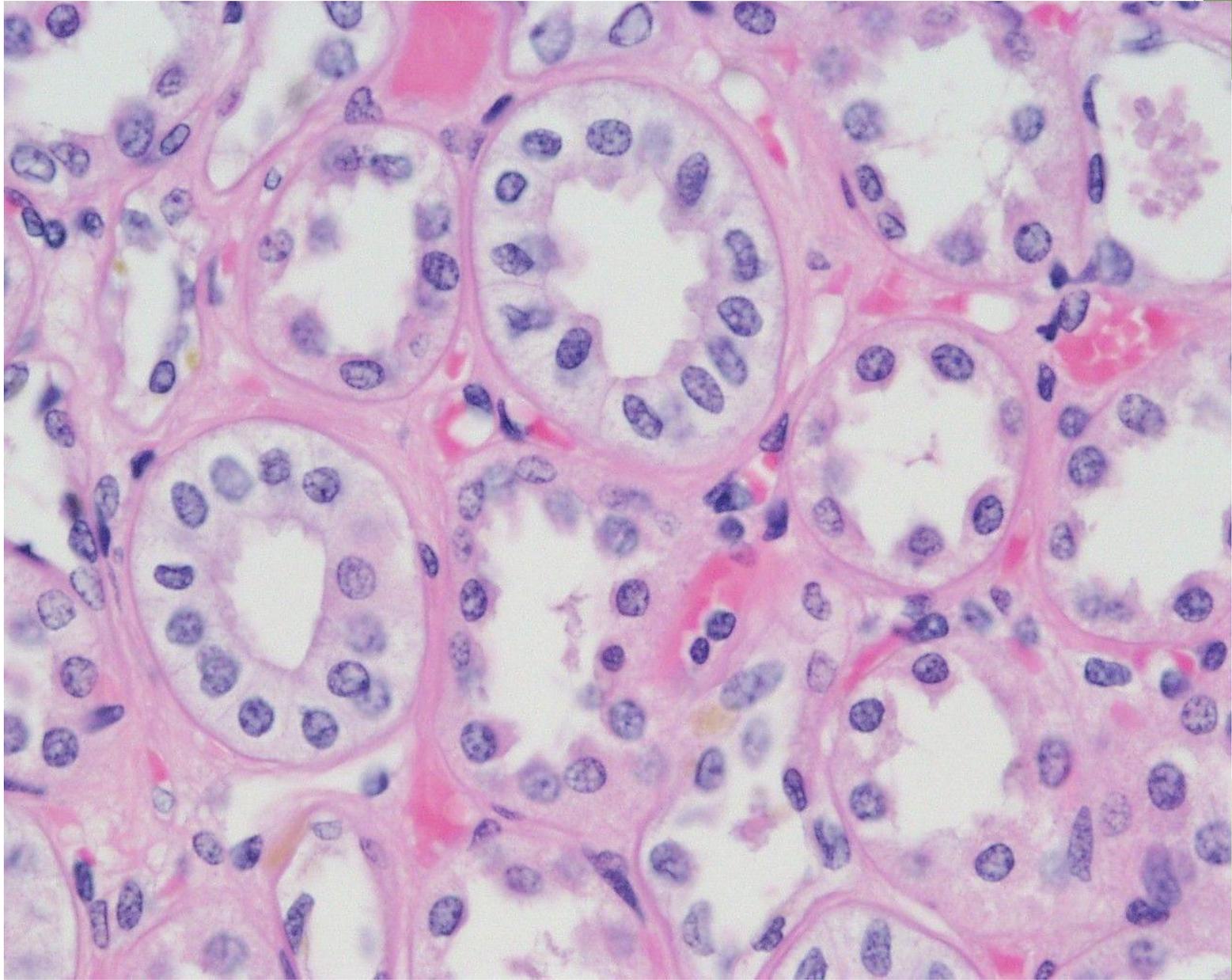


Simple cuboidal

- ▶ Nuclei are rounded
- ▶ Mainly found in small ducts of glands
- ▶ Found covering the ovaries
- ▶ Found in kidney tubules
- ▶ Functions in covering and secretions



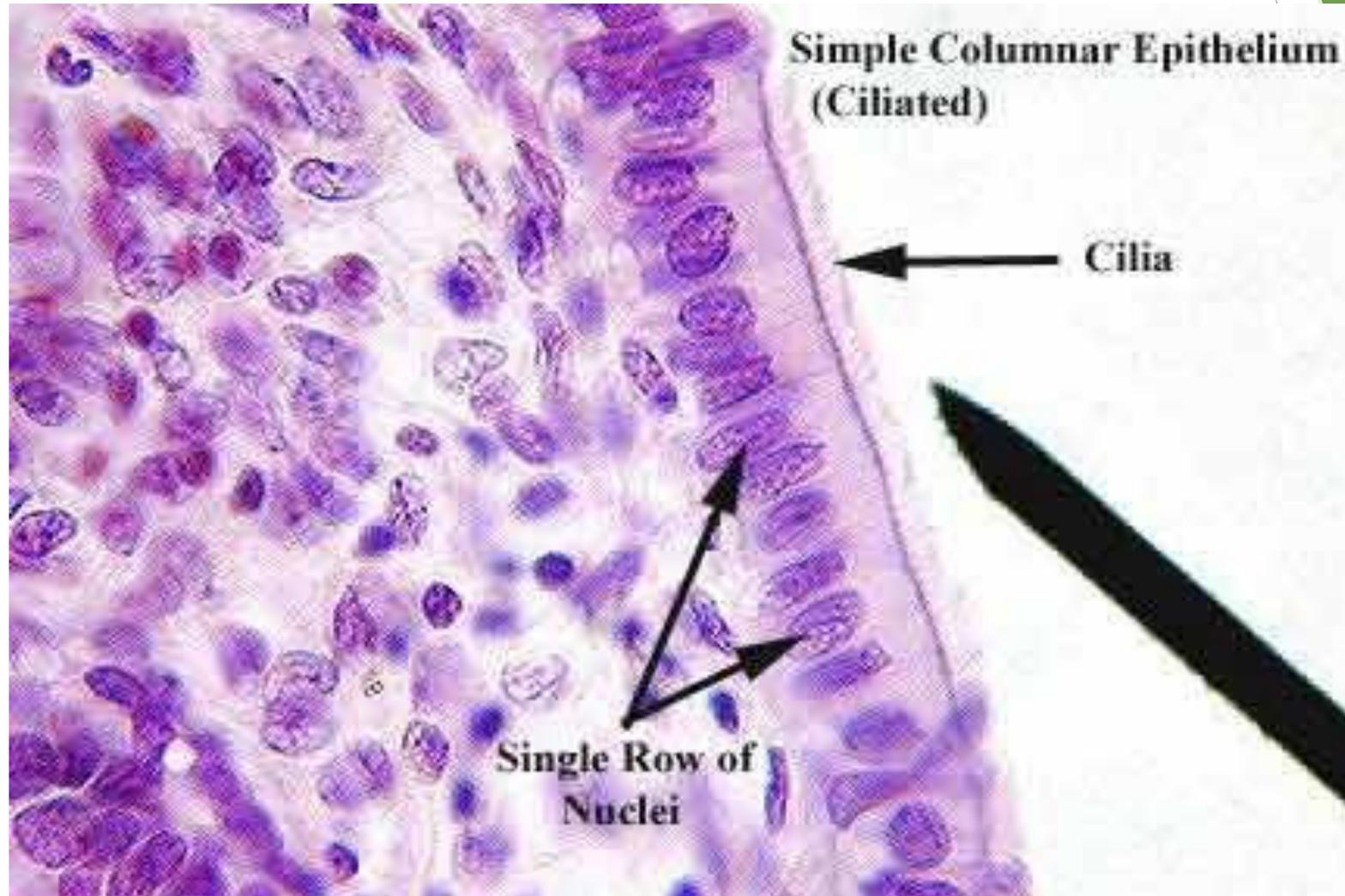




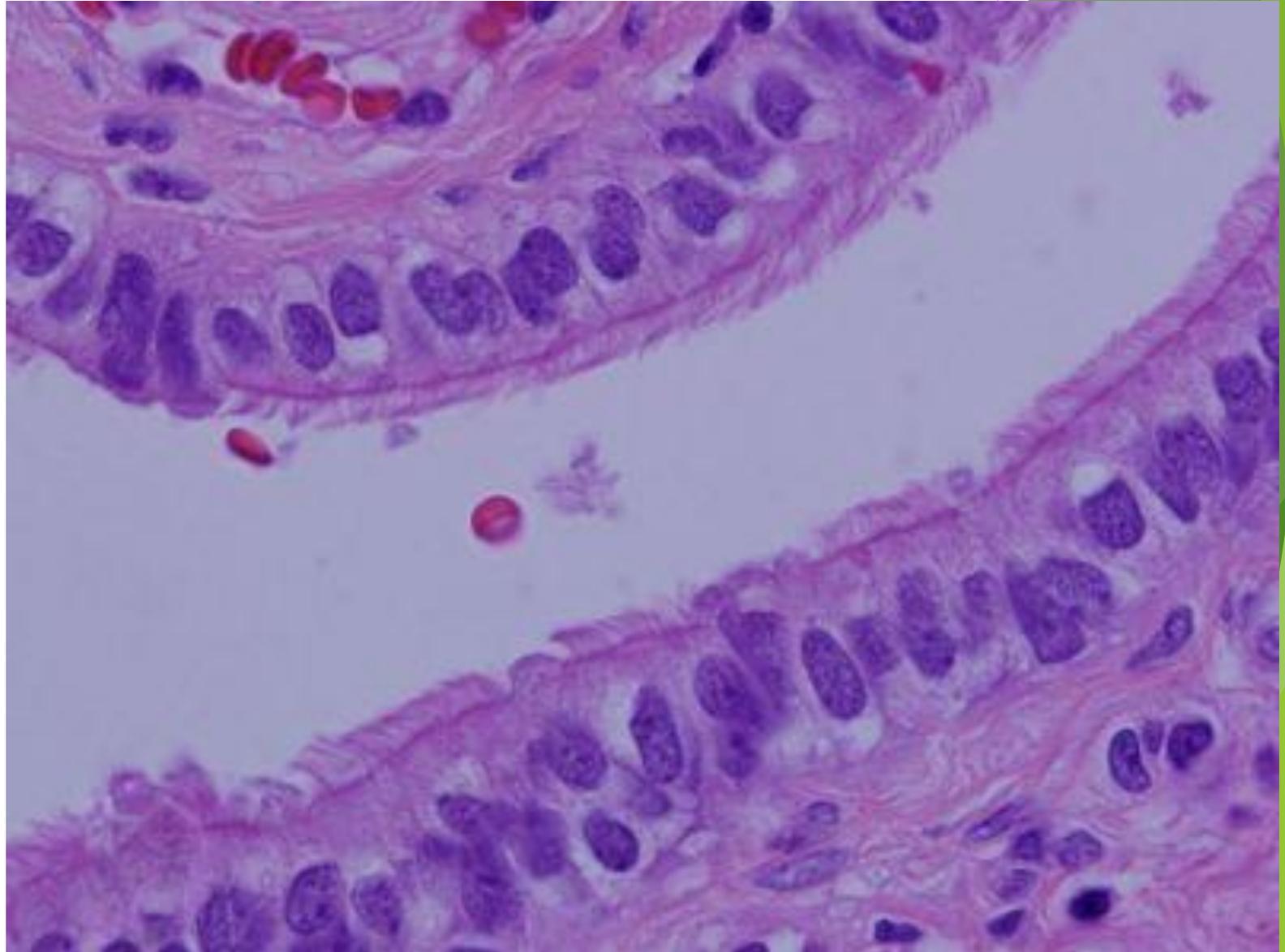
Simple columnar

- ▶ Main function is absorption
- ▶ Also functions in protection and secretion
- ▶ Nuclei are elongated
- ▶ Ciliated simple columnar is found in the fallopian tube (oviduct)
- ▶ Simple columnar epithelium with microvilli and goblet cells (mucous-secreting cells) is found lining the intestines

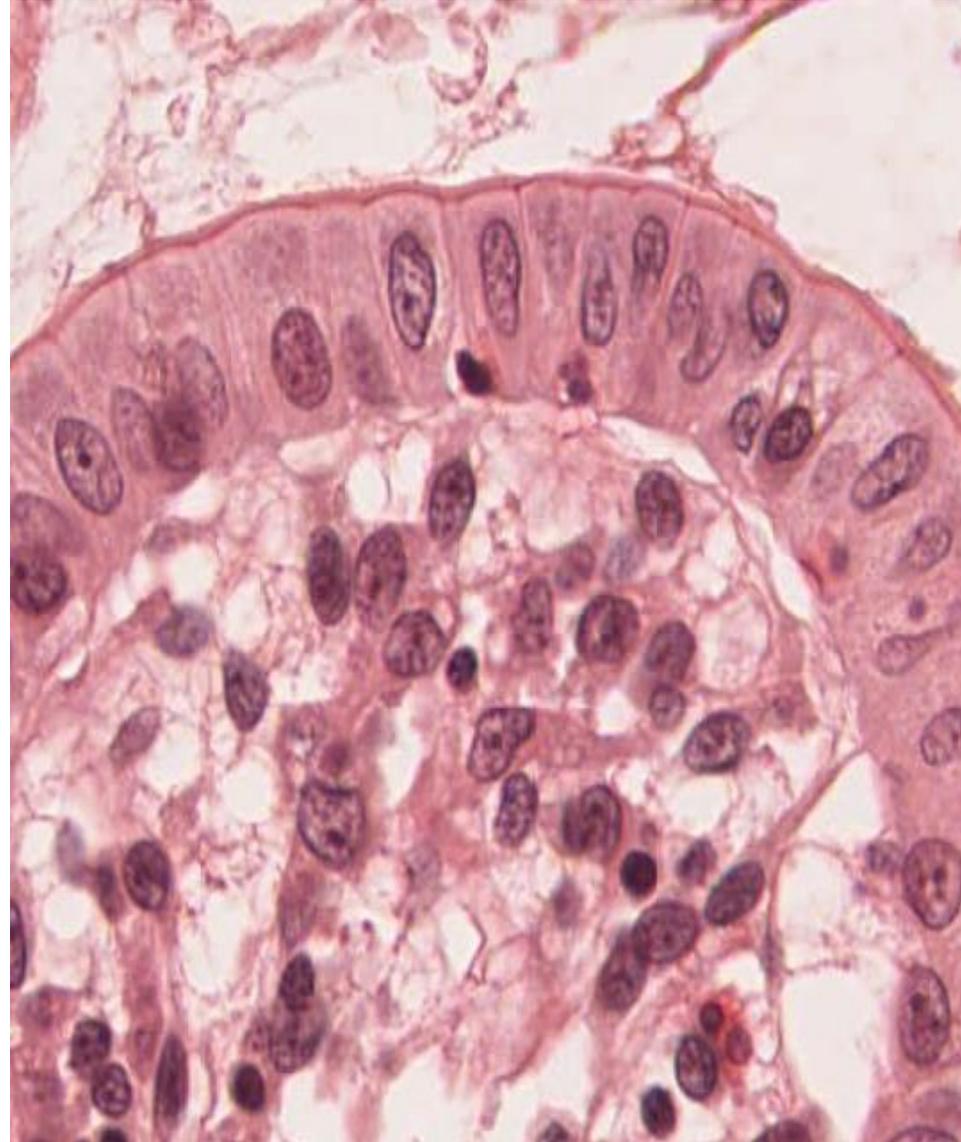
Simple columnar epithelium ciliated



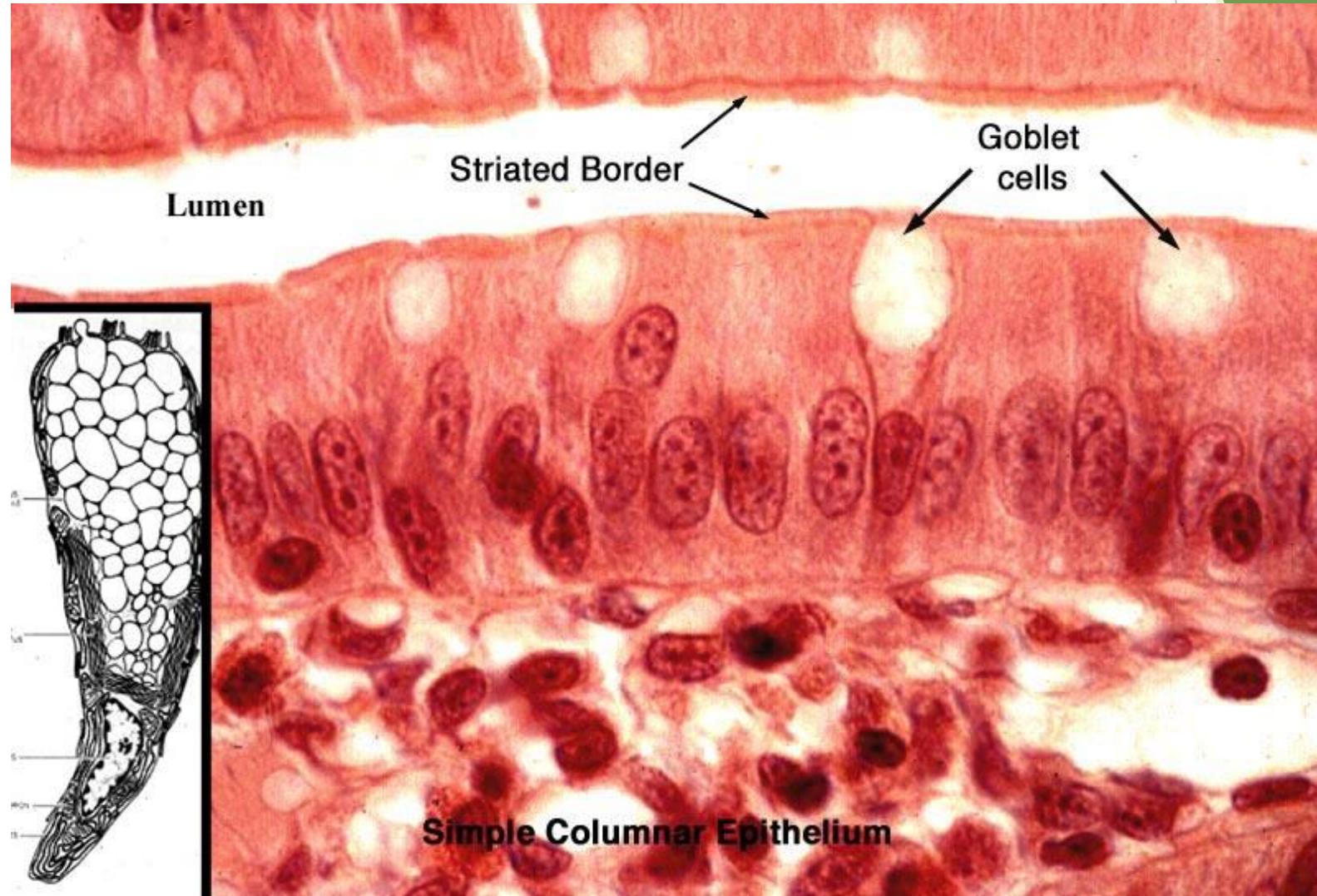
Simple columnar epithelium ciliated



Simple columnar epithelium with microvilli



Simple columnar epithelium with microvilli and goblet cells



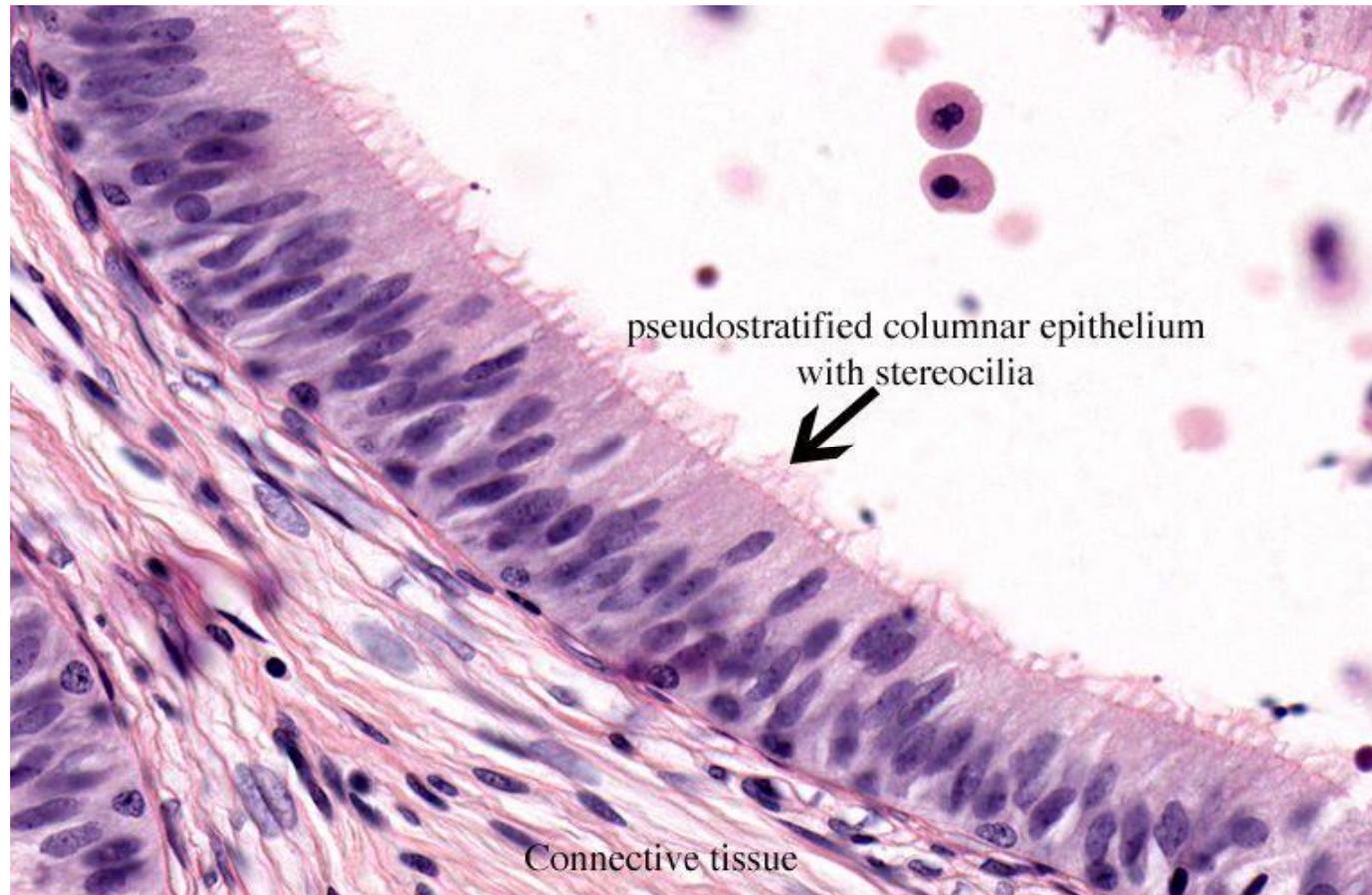
Pseudostratified columnar epithelium

- ▶ In this epithelium, tall irregular cells all are attached to the basement membrane but their nuclei are at different levels and not all cells extend to the free surface, giving a stratified appearance.
- ▶ A good example of pseudostratified columnar epithelium is that lining the upper respiratory tract, where the cells are also heavily ciliated.

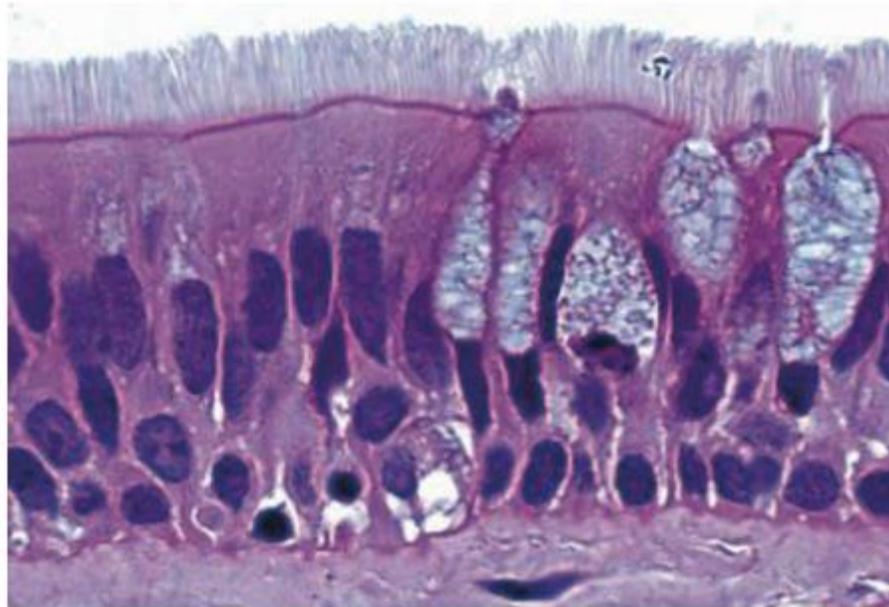
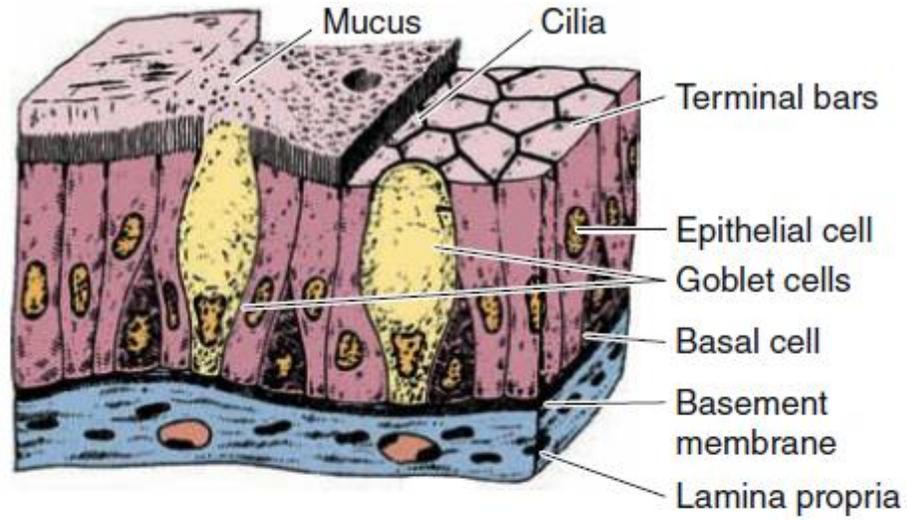
Pseudostratified epithelium

- ▶ Nuclei appear as if they were many layers
- ▶ In fact all cells reach basement membrane
- ▶ Found in male reproductive system
- ▶ Might have goblet cells (mucous-secreting cells)
- ▶ A special type “Ciliated pseudostratified columnar epithelium with goblet cells” is found lining some parts of the respiratory system and is called respiratory epithelium

Pseudostratified columnar epithelium with stereocilia



Ciliated pseudostratified columnar epithelium with goblet cells (Respiratory)



Stratified Epithelia

- ▶ Contain two or more layers of cells
- ▶ Regenerate from below (mitosis is limited to the basal layer)
- ▶ Major role is protection
- ▶ Are named according to the shape of cells at apical layer

Stratified Squamous Epithelium

▶ Specific types

- ▶ Keratinized – contain the protective protein keratin

 - ▶ Surface cells are dead and full of keratin

- ▶ Non-keratinized – forms moist lining of body openings

▶ Function

- ▶ Protects underlying tissues in areas subject to abrasion

▶ Location

- ▶ Keratinized – forms epidermis

- ▶ Non-keratinized – forms lining of oral cavity (mouth), esophagus, and vagina

Stratified Squamous Keratinized Epithelium

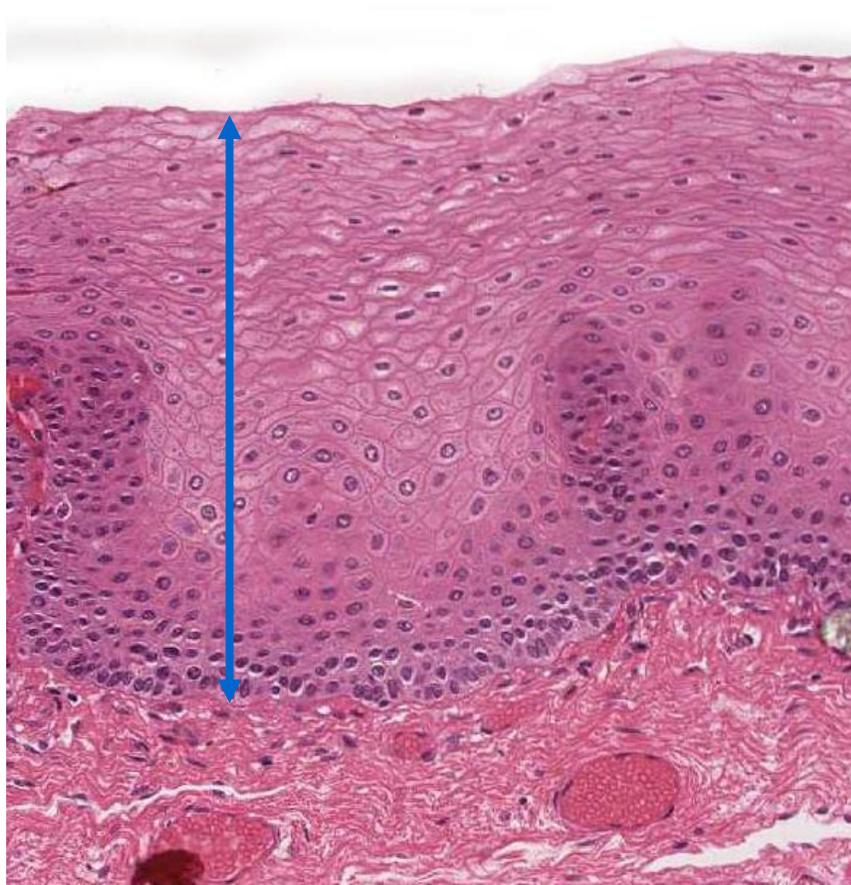
- ▶ The very thin surface cells of stratified squamous epithelia can be “keratinized” (packed with keratin filaments) or “nonkeratinized” (with relatively sparse keratin).
- ▶ **Stratified squamous keratinized epithelium** is found mainly in the epidermis of skin, where it helps prevent dehydration from the tissue.
- ▶ Its cells form many layers, with the less differentiated cuboidal cells near the basement membrane.
- ▶ These cells have many desmosomes and become more irregular in shape and then flatten as they accumulate keratin in the process of **keratinization** and are moved progressively toward the skin surface, where they become thin, metabolically inactive packets (squames) of keratin lacking nuclei.
- ▶ This surface layer of cells helps protect against water loss across this epithelium

Stratified Squamous Non-Keratinized Epithelium

- ▶ **Stratified squamous nonkeratinized epithelium** lines moist internal cavities (eg, mouth, esophagus, and vagina) where water loss is not a problem.
- ▶ Here the flattened cells of the surface layer retain their nuclei and most metabolic functions.

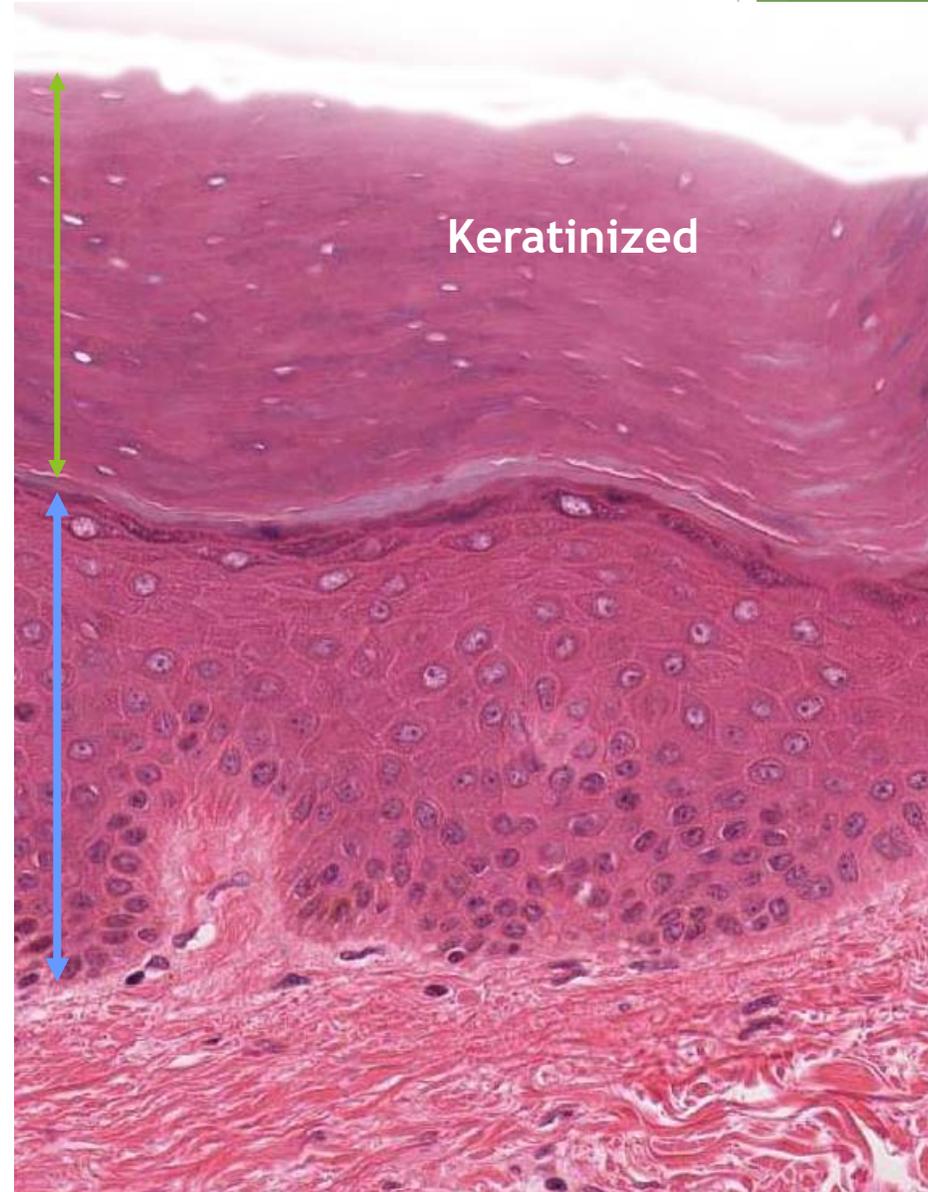
Stratified Squamous Epithelium

Non-keratinized



Lines esophagus, oral cavity, vagina...

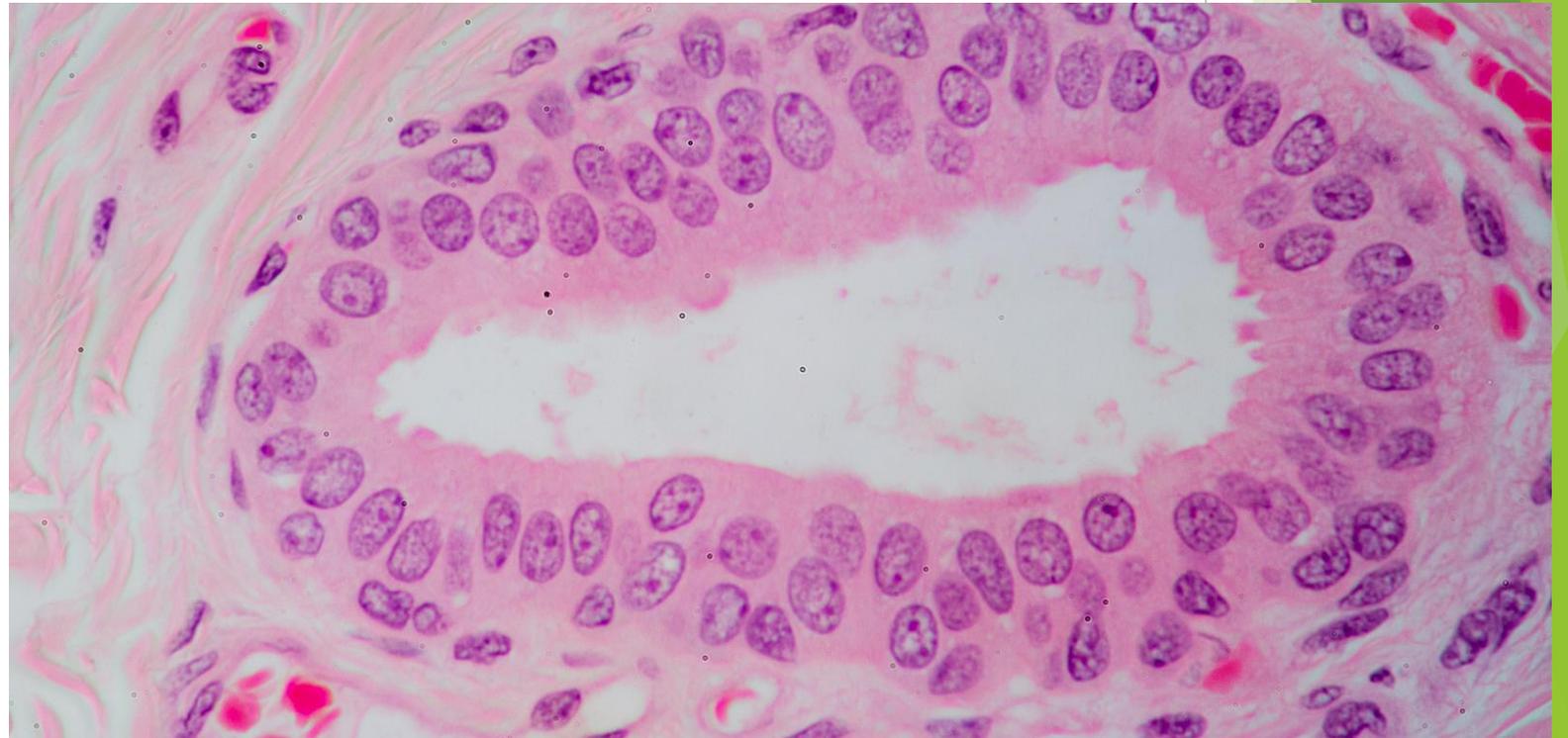
Keratinized



Lines thick and thin skin

Stratified cuboidal

- ▶ Two layers only
- ▶ Found lining larger ducts of glands

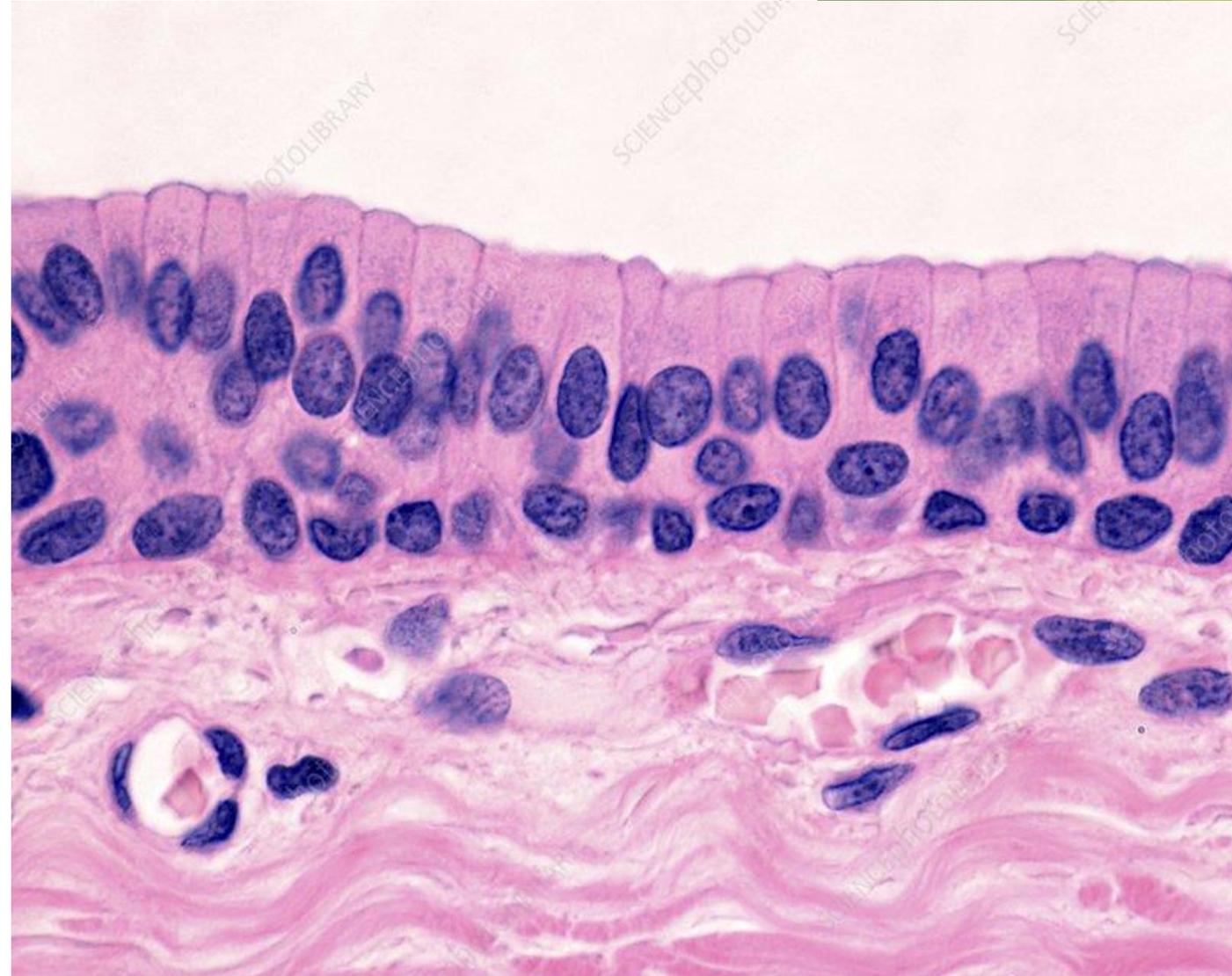


Stratified cuboidal and stratified columnar epithelia

- ▶ **Stratified cuboidal and stratified columnar epithelia** are both relatively rare.
- ▶ Stratified cuboidal epithelium occurs in the excretory ducts of salivary and sweat glands.
- ▶ Stratified columnar epithelium is seen in the conjunctiva lining the eyelids, where it is both protective and mucus secreting.

Stratified columnar epithelium

- ▶ Two layers only; basal cuboidal and apical columnar
- ▶ Very rare type
- ▶ Found in conjunctiva of eye



Transitional epithelium (Urothelium)

- ▶ Unique **transitional epithelium** or **urothelium** lines much of the urinary tract, extending from the kidneys to the proximal part of the urethra, and is characterized by a superficial layer of large, dome-like cells sometimes called umbrella cells.
- ▶ These cells are specialized to protect underlying tissues from the hypertonic and potentially cytotoxic effects of urine.
- ▶ Importantly, unique morphological features of the cells allow *distension* of transitional epithelium as the urinary bladder fills

Transitional epithelium (Urothelium)

▶ Description

- ▶ Basal cells usually cuboidal or columnar
- ▶ Superficial cells dome-shaped (un-stretched) or flattened (stretched)
- ▶ Some cells have two nuclei (bi-nucleated)

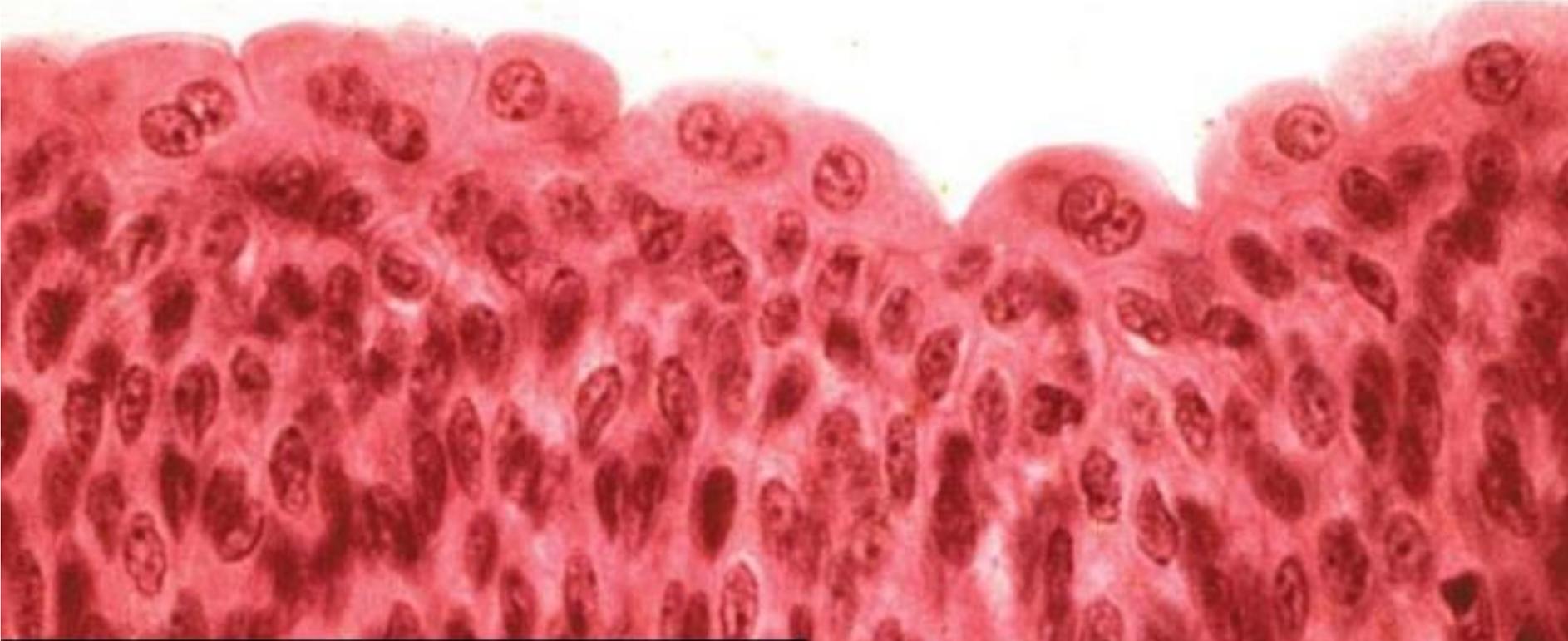
▶ Function

- ▶ Stretches to permit distension of urinary bladder

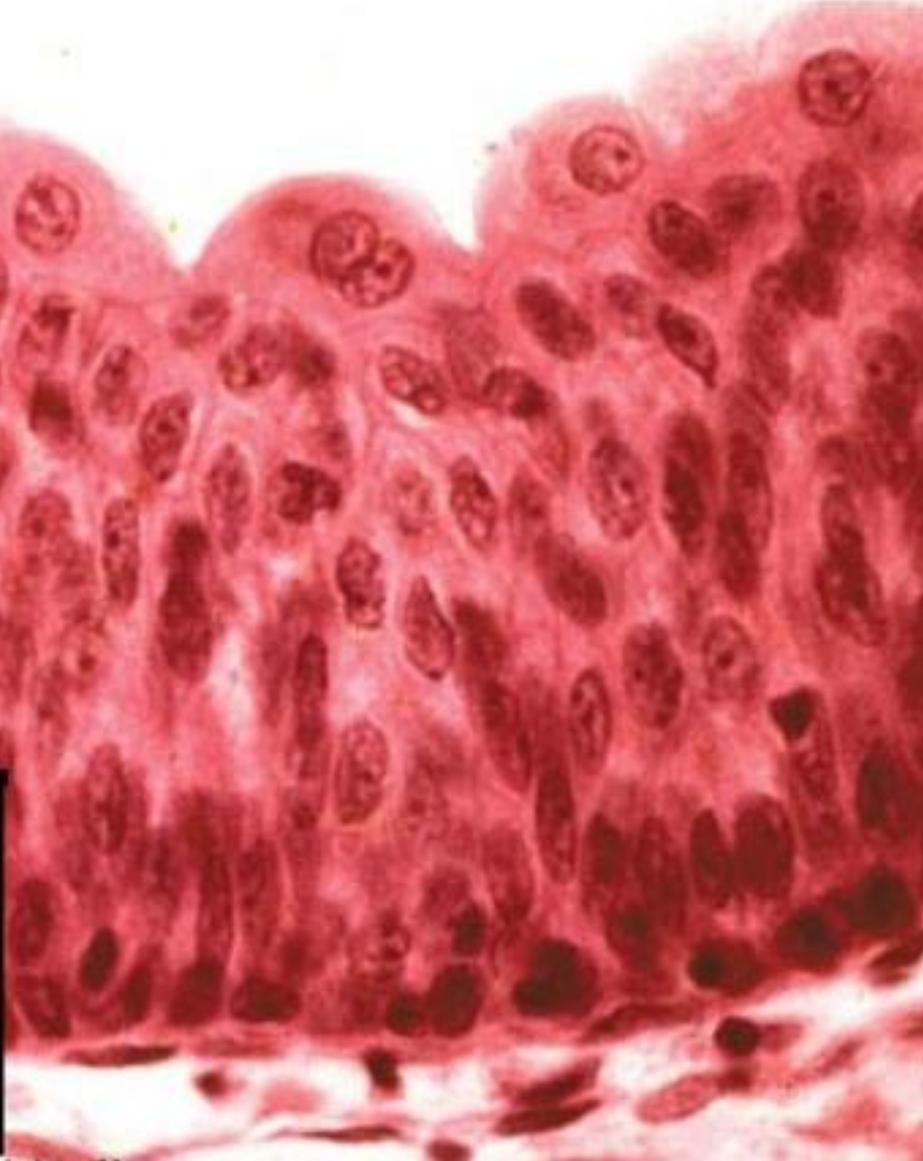
▶ Location

- ▶ Lines ureters, urinary bladder and part of urethra (found in urinary system only)

Un-stretched



Stretched



Medical Applications

- ▶ In individuals with chronic vitamin A deficiency, epithelial tissues of the type found in the bronchi and urinary bladder may gradually be replaced by stratified squamous epithelium.
- ▶ In **chronic bronchitis**, common among habitual smokers, the number of goblet cells in the lining of airways in the lungs often increases greatly. This leads to excessive mucus production in areas where there are too few ciliated cells for its rapid removal and contributes to obstruction of the airways. The ciliated pseudostratified epithelium lining the bronchi of smokers can also be transformed into stratified squamous epithelium by metaplasia.

Transport across epithelia

- ▶ Many cells have the ability to actively transport certain ions **against** concentration and electrical potential gradients. An important example is the extrusion of Na^+ from cells by the transmembrane protein $\text{Na}^+/\text{K}^+-\text{ATPase}$, also called the Na^+/K^+ pump, which allows cells to maintain the required low intracellular sodium concentration

Transcellular transport

- ▶ Some epithelial cells specialize in the transfer of ions (by ion pumps) and water (via the membrane channels called aquaporins) in either direction across the epithelium, the process known as **transcellular transport**.
- ▶ Apical tight junctions prevent paracellular diffusion or backflow *between* the cells.
- ▶ Epithelia of kidney tubules are key sites for ion and water transport

Transcytosis

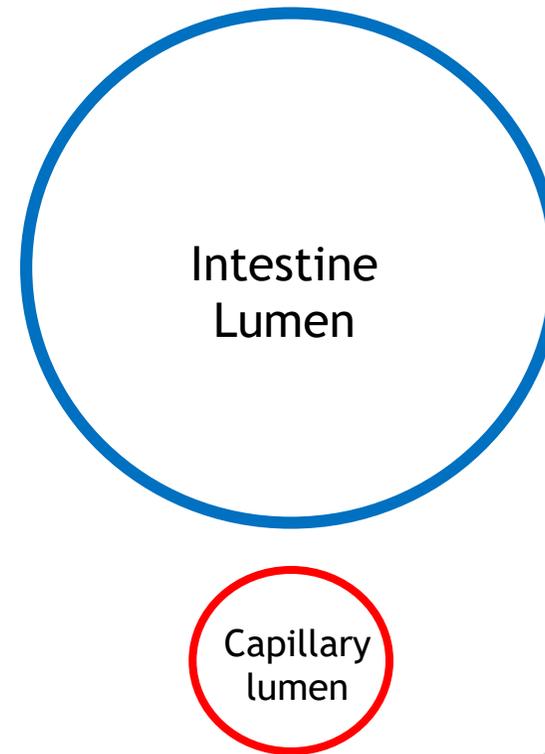
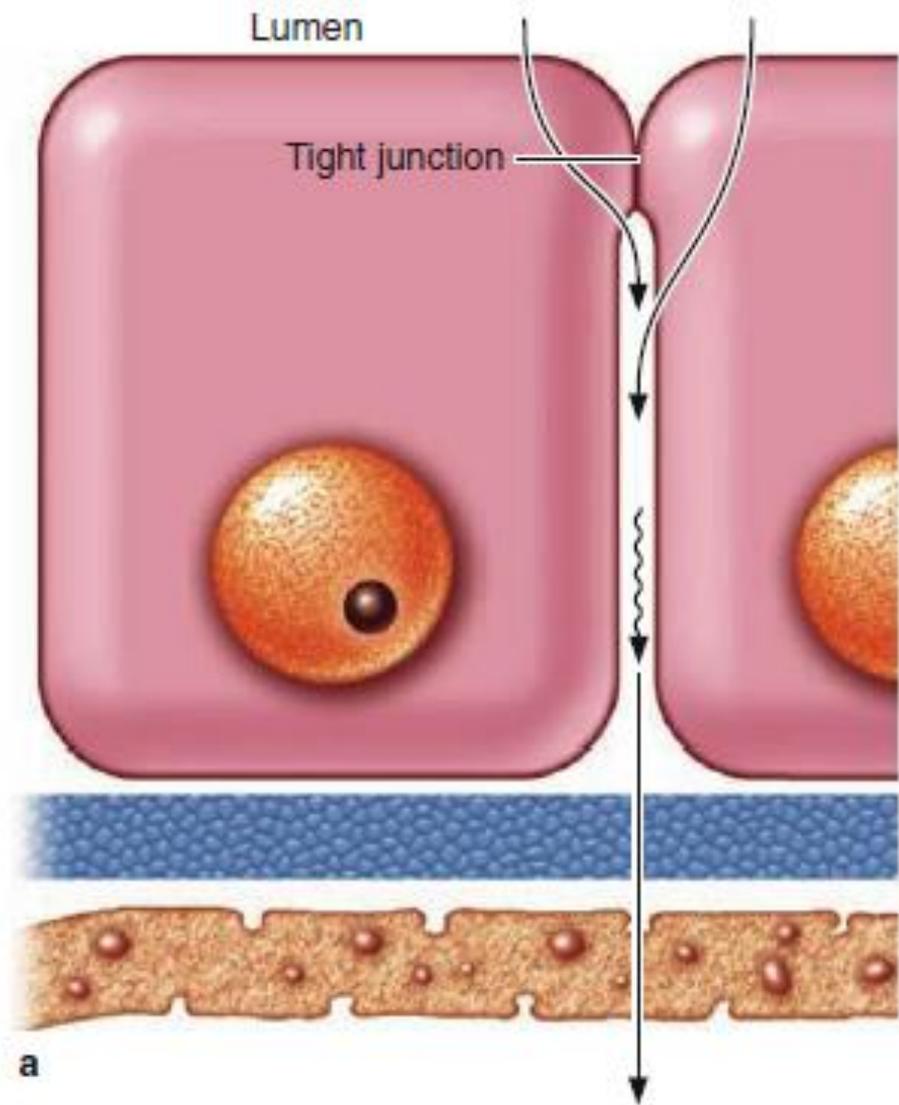
- ▶ All cells can also internalize extracellular molecules and fluid using endocytosis and formation of cytoplasmic, membrane-bound vesicles.
- ▶ This activity is clearly observed in the simple squamous epithelial cells lining blood and lymphatic capillaries (endothelia) or body cavities (mesothelia).
- ▶ These thin cells have few organelles other than the abundant pinocytotic vesicles, which cross the thin cells in both directions and release their contents on the opposite side by exocytosis.
- ▶ This process of **transcytosis** also occurs between the apical and basolateral membranes domains in cells of simple cuboidal and columnar epithelia and is important in many physiologic processes.

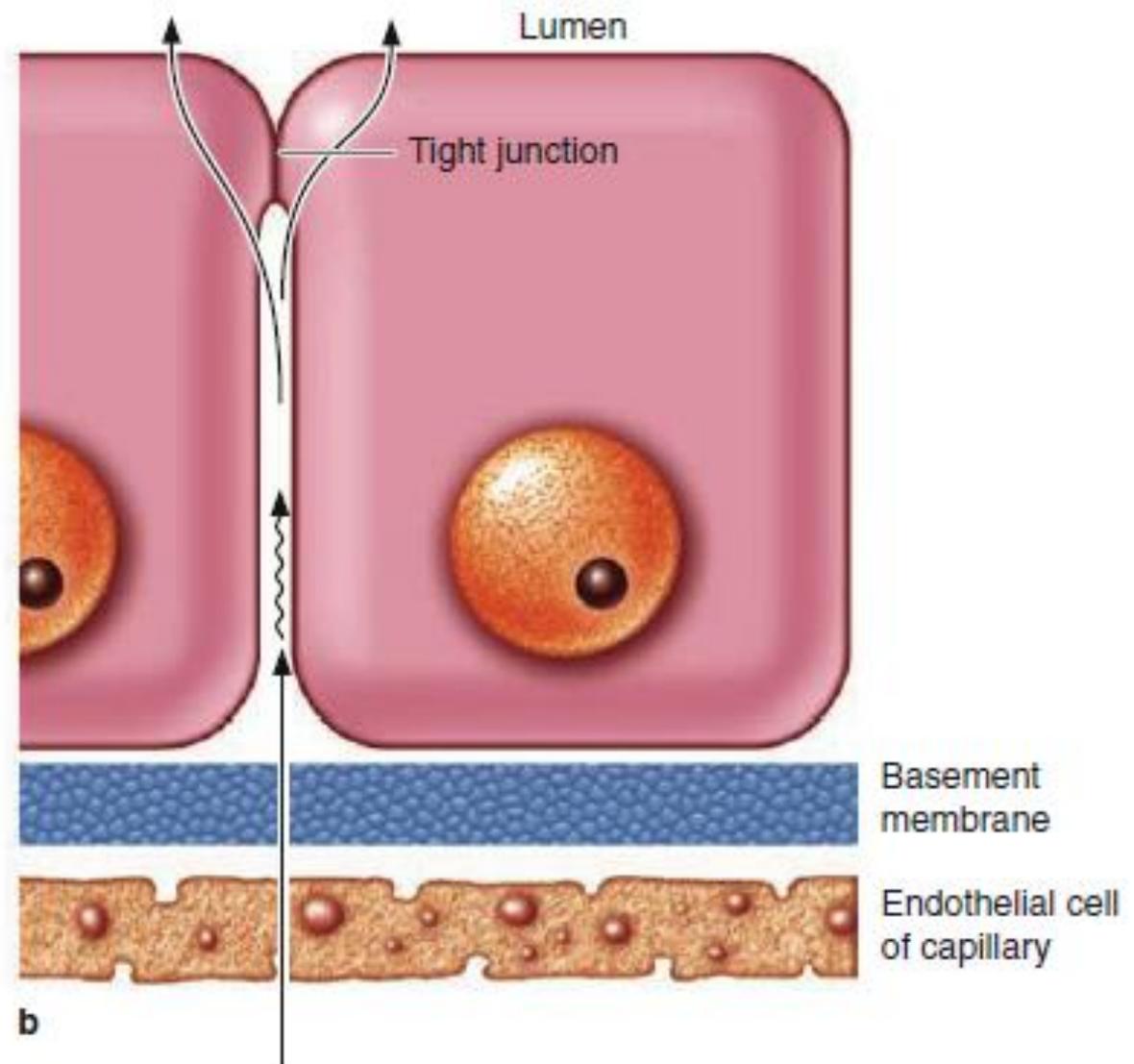
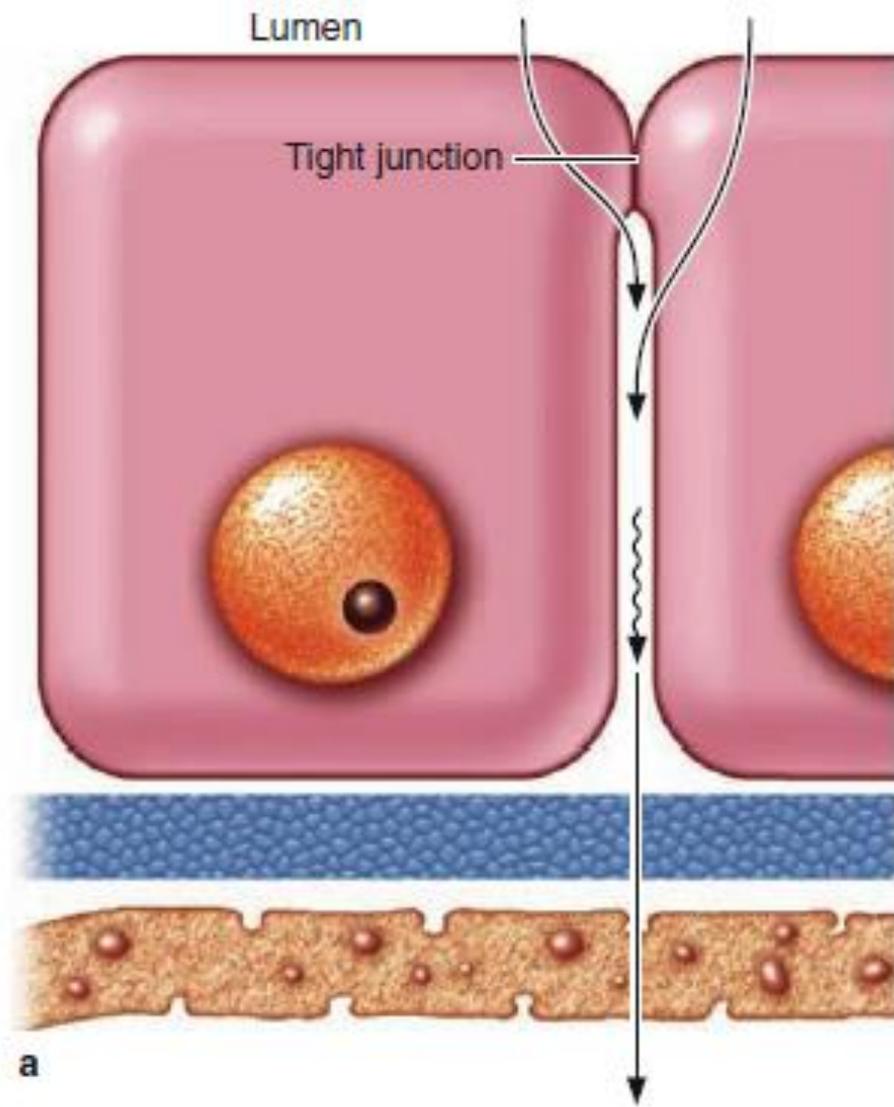
Absorption and Secretion

- ▶ Ion and water transport across epithelia can occur in either direction, depending on the organ involved.

(a) Absorption is the process of transport from an organ or duct's lumen to capillaries near the epithelial basement membrane and involves movement from the apical to the basolateral cell membrane domains. Absorption occurs for example in the epithelium of the gallbladder and intestine where it serves to concentrate bile or obtain water and ions from digested material.

(b) Secretion involves transport in the other direction from the capillaries into a lumen, as in many glands and the choroid plexus. Secretion by epithelial cells removes water from the neighboring interstitial fluid or plasma and releases it as part of the specialized aqueous fluids in such organs.





Renewal of Epithelial Cells

- ▶ Epithelial tissues are relatively labile structures whose cells are renewed continuously by mitotic activity and stem cell populations.
- ▶ The rate of renewal varies widely; it can be fast in tissues such as the intestinal epithelium, which is replaced every week, or slow, as in the large glands.
- ▶ In stratified epithelial tissues, stem cells and mitosis occur only within the basal layer in contact with the basal lamina.
- ▶ In some functionally complex epithelia, stem cells are located only in restricted niches some distance from the transit amplifying cells and differentiating cells.
- ▶ For example, the epithelium lining the small intestine is derived completely from stem cells found in the simple glands between the intestinal villi.
- ▶ In the epidermis, many stem cells are located at a characteristic position along the wall of hair follicles.

Medical Application

- ▶ Under certain abnormal conditions, one type of epithelial tissue may undergo transformation into another type in another reversible process called **metaplasia**.
- ▶ In heavy cigarette smokers, the ciliated pseudostratified epithelium lining the bronchi can be transformed into stratified squamous epithelium.
- ▶ Some epithelial cells are prone to abnormal growth or dysplasia, which can progress to precancerous growth called **neoplasia**.
- ▶ Early neoplastic growth is often reversible and does not always result in cancer.