

HISTOLOGY

EPITHELIAL TISSUES

Chapter 2

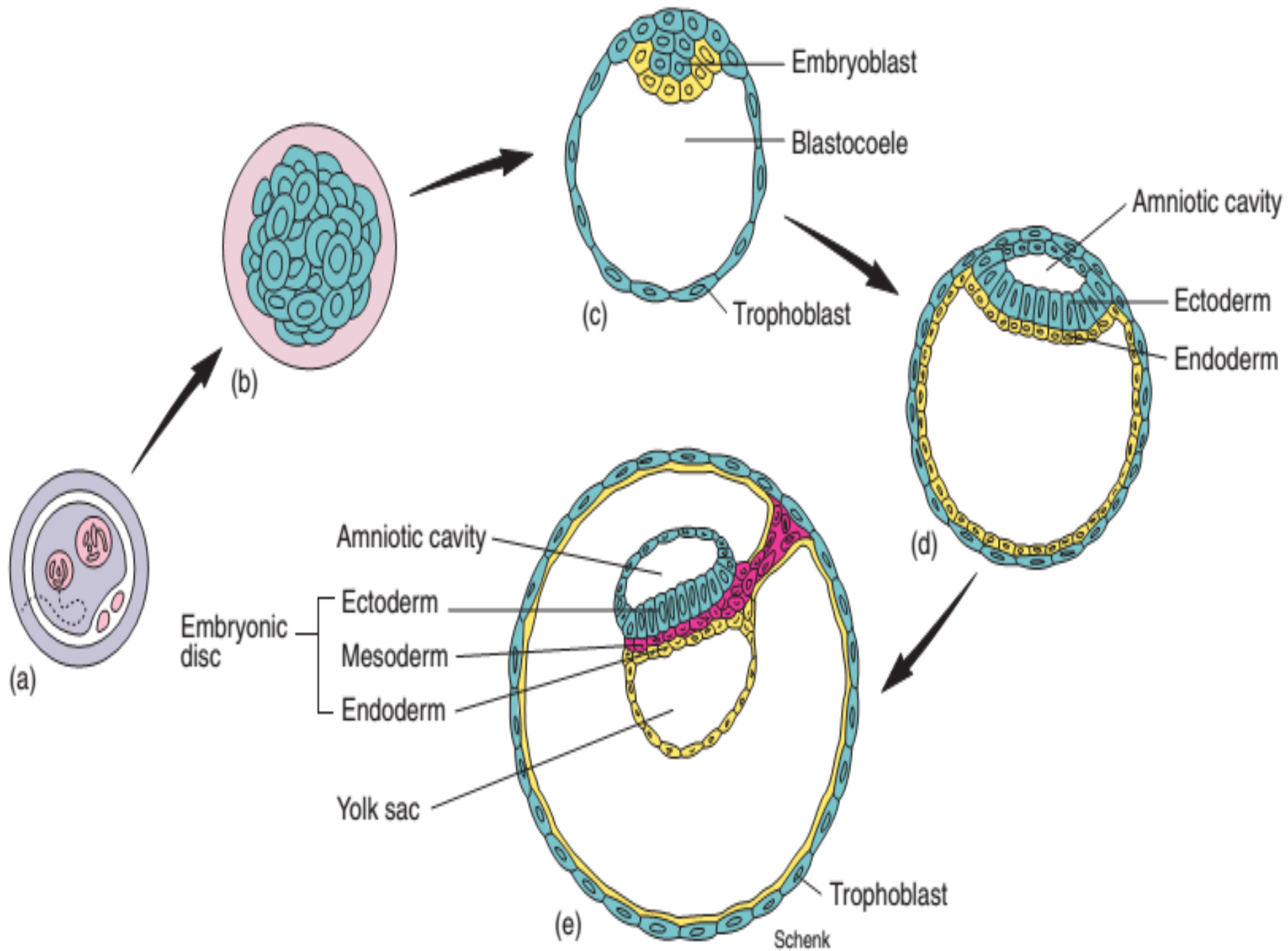
1st Prof. Anatomy

Arsalan

(Lecturer Department of Pharmacy University of Peshawar)

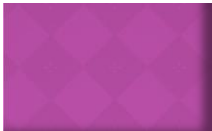
BODY TISSUES

- Tissue is an aggregation of similar cells and their products that perform same function.
- There are four principal types of tissues in the body:
 - **epithelial tissue:** covers body surfaces, lines body cavities and ducts and forms glands
 - **connective tissue:** binds, supports, and protects body parts
 - **muscle tissue:** produce body and organ movements
 - **nervous tissue:** initiates and transmits nerve impulses from one body part to another



**Table 4.1****Tissue Types**

Type	General Characteristics	General Functions	Primary Germ Layer Derivative	Example Subtypes and Their Locations
Epithelial tissue	Cellular, polar, attached, avascular, innervated, high regeneration capacity	Covers surfaces; lines insides of organs and body cavities	Ectoderm, mesoderm, endoderm	<i>Simple columnar epithelium</i> : Inner lining of digestive tract <i>Stratified squamous epithelium</i> : Epidermis of skin <i>Transitional epithelium</i> : Inner lining of urinary bladder
Connective tissue	Diverse types; all contain cells, protein fibers, and ground substance	Protects, binds together, and supports organs	Mesoderm	<i>Adipose connective tissue</i> : Fat <i>Dense regular connective tissue</i> : Ligaments and tendons <i>Dense irregular connective tissue</i> : Dermis of skin <i>Hyaline cartilage</i> : Articular cartilage in some joints <i>Fluid connective tissue</i> : Blood
Muscle tissue	Contractile; receives stimulation from nervous system and/or endocrine system	Facilitates movement of skeleton or organ walls	Mesoderm	<i>Skeletal muscle</i> : Muscles attached to bones <i>Cardiac muscle</i> : Muscle layer in heart <i>Smooth muscle</i> : Muscle layer in digestive tract
Nervous tissue	<i>Neurons</i> : Excitable, high metabolic rate, extreme longevity, nonmitotic <i>Glial cells</i> : Nonexcitable, mitotic	<i>Neurons</i> : Control activities, process information <i>Glial cells</i> : Support and protect neurons	Ectoderm	<i>Neurons</i> : Brain and spinal cord <i>Glial cells</i> : Brain and spinal cord



EPITHELIAL TISSUES

- Epithelial tissues cover body and organ surfaces, line body cavities and lumina and forms various glands
- Derived from endoderm, ectoderm, and mesoderm
- composed of one or more layers of closely packed cells
- Perform diverse functions of protection, absorption, excretion and secretion.

CHARACTERISTICS OF EPITHELIAL TISSUES

- ◉ **Highly cellular** with low extracellular matrix
- ◉ **Polar** - has an apical surface exposed to external environment or body cavity, basal layer attached to underlying connective tissue by basement membrane and lateral surfaces attached to each other by intercellular junctions
- ◉ **Innervated**
- ◉ **Avascular** - almost all epithelia are devoid of blood vessels, obtain nutrients by diffusion
- ◉ **High regeneration capacity**

Cardinal features of epithelium

- 1. Epithelial cells line surfaces.** Epithelia line and protect virtually all free surfaces in the human body except joint cavities and the anterior surface of the iris, which is a naked connective tissue domain.
 - a. The outer surface of the body is covered by the epithelial epidermis of skin. The hair follicles and glands in skin also have epithelial components.
 - b. Epithelium lines the digestive system and its diverticula, such as the respiratory system, liver, pancreas, and gallbladder.
 - c. The cardiovascular system is lined by an epithelium called **endothelium**.
 - d. Body cavities derived from the intraembryonic coelom (the pericardial cavity, thoracic cavity, and peritoneal cavity) are lined by an epithelium called **mesothelium**.
 - e. The urogenital system is lined by a layer of epithelial cells as well.
- 2. Epithelial cells have tight lateral adhesions.** An epithelium is one or more layers of cells that are tightly joined together. The adhesions hold the epithelial cells together into a coherent barrier tissue. The apical junctions between cells in many epithelia have a sealing and adhesive structure called the **junctional complex**, which isolates the internal milieu of the organism and tightly joins epithelial cells together.
- 3. Epithelial cells are polarized.** The epithelial apical surface typically faces a free surface of the body or the lumen of an organ or blood vessel and may be covered by microvilli or cilia. The basal surface rests on an extracellular layer of fibrils and glycoproteins called the **basement membrane**, or **basal lamina**, which is the boundary between the epithelium and the underlying connective tissue.
- 4. Epithelia are avascular.** In most organs, the connective tissue beneath or around the epithelium contains blood vessels and lymphatics, which nourish the epithelium by diffusion.

FUNCTIONS OF EPITHELIAL TISSUES

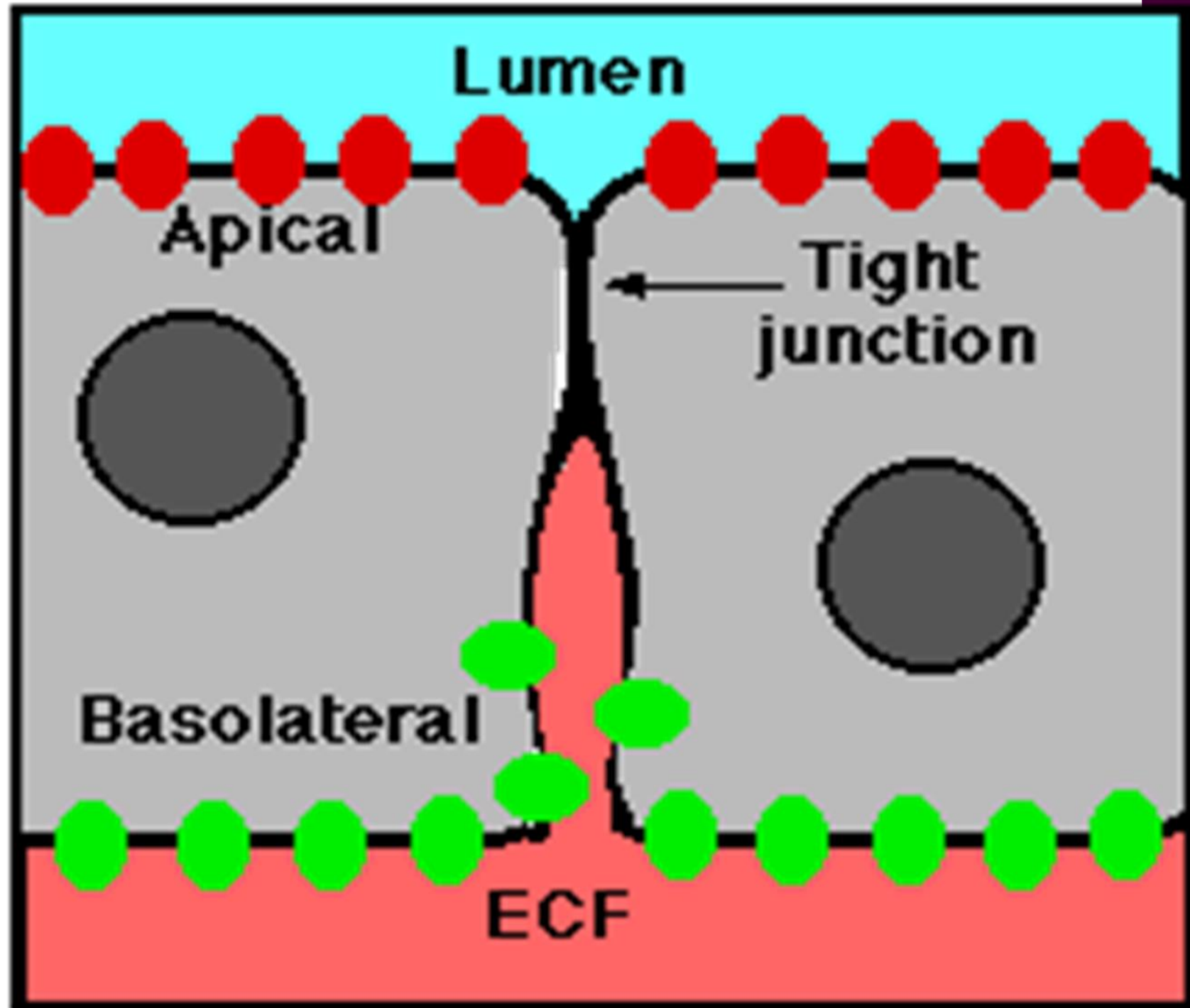
- ◉ **Protection:**
- ◉ **Selective permeability:** in GIT facilitate absorption, in kidney facilitate filtration, in lungs facilitate diffusion.
- ◉ **Secretions:** glandular epithelium form linings of various glands, involved in secretions.
- ◉ **Sensations:** contain some nerve endings to detect changes in the external environment at their surface

STRUCTURE

- Epithelium rests on connective tissue.
- Between the epithelium and connective tissue is present the basement membrane which is extracellular matrix made up of protein fibers and carbohydrates.
- Basement membrane attach epithelium to connective tissue and also regulate movement of material between epithelium and connective tissue
- Epithelial cells are bound together by specialized connections in the plasma membranes called intercellular junctions .
There are four types of junctions:
 - Tight junctions,
 - Adhering junctions,
 - Desmosomes
 - Gap junctions

Tight Junctions

- Present on apical surface and completely attaches each cell to its neighbors.
- Formed by fusion of plasma membrane proteins among neighboring cells so the apical surfaces of the cells are tightly connected.
- As a result intercellular space is sealed off
- The tight junction forces almost all materials to move through, rather than between, the epithelial cells in order to cross the epithelium



ADHERING JUNCTIONS

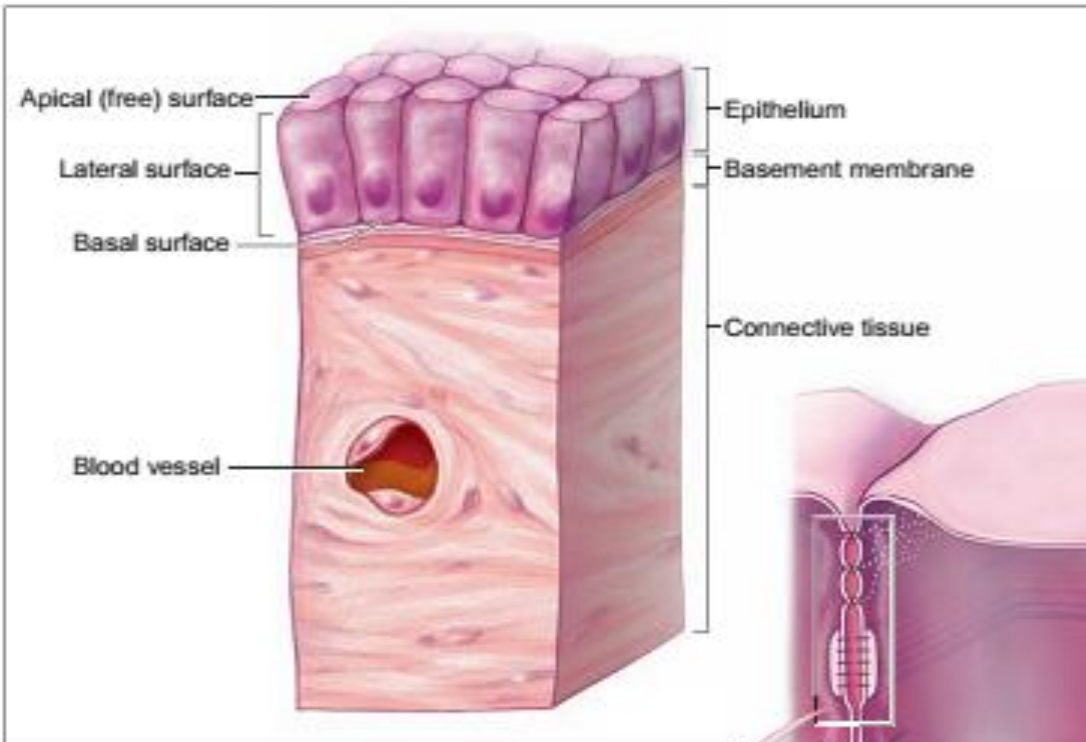
- ◉ Made up of dense layer of proteins on the inside of the plasma membrane
- ◉ Transmembrane proteins called cadherin join the cells together.
- ◉ Cadherin are inserted into the protein plaque on in adjacent cells and they join together in the intercellular space.
- ◉ Adherens junctions help epithelial surfaces resist separation during various contractile activities.
- ◉ Allows passage of material between adjacent cells through lateral surfaces.

DESMOSOMES

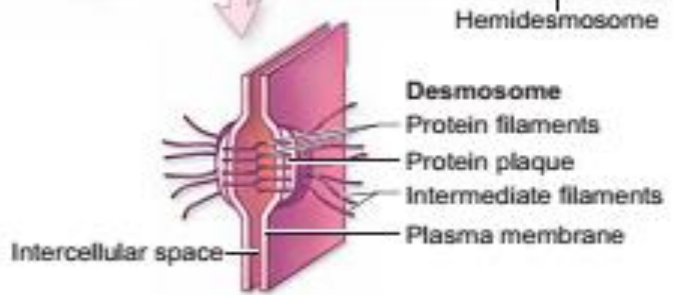
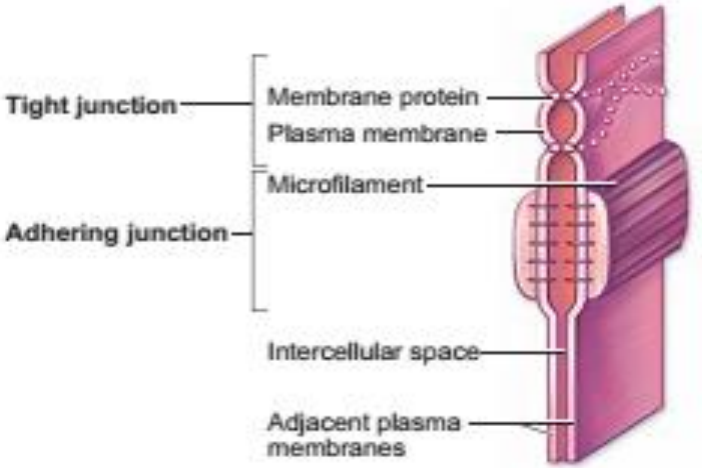
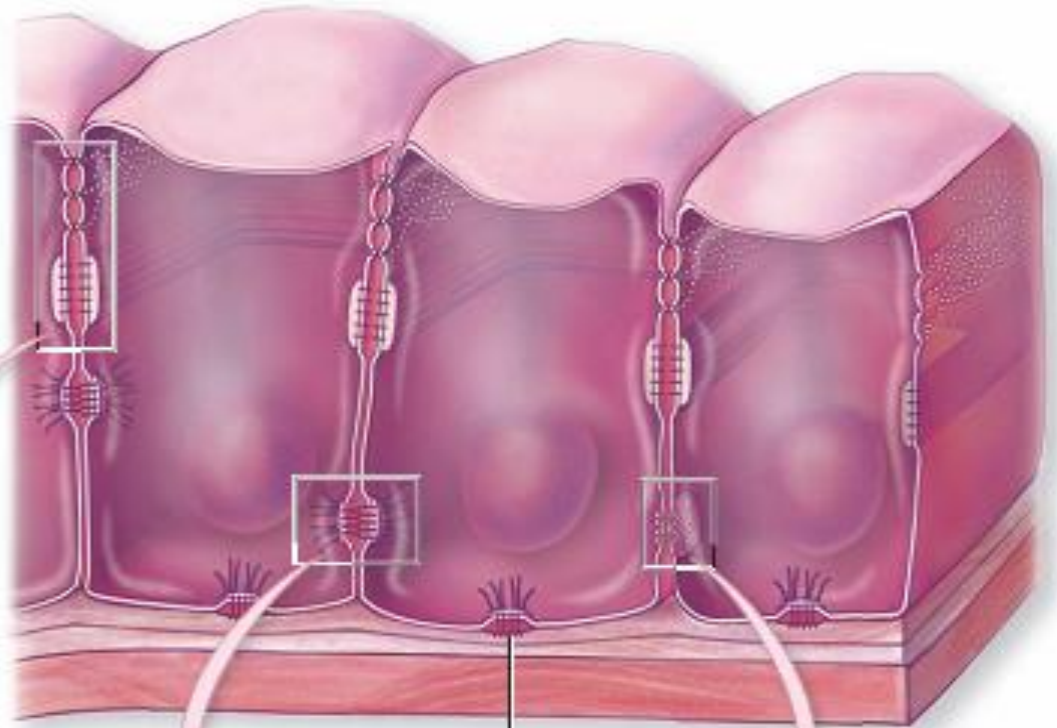
- Made up of protein plaque and transmembrane protein that extend into the intercellular space between adjacent cell membranes and attach cells to one another
- The protein plaque is attached to elements of the cytoskeleton known as intermediate filaments.
- The intermediate filaments extend from desmosomes on one side of the cell across the cytosol to desmosomes on the opposite side of the cell.
- Desmosomes provide mechanical support at potential stress points and do not completely encircle the cell.
- Present mainly in epidermis

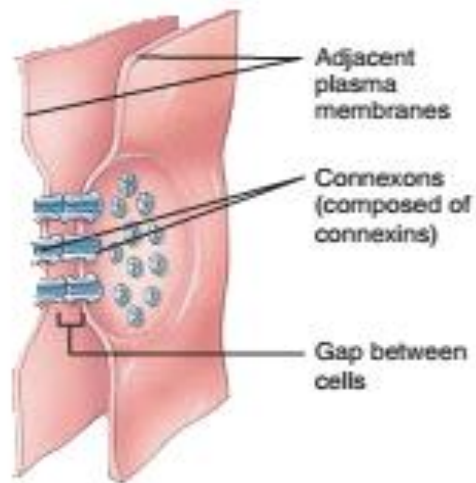
GAP JUNCTION

- ◉ Gap junctions are made up of tiny fluid filled tunnels called connexons.
- ◉ Each connexon consists of six transmembrane proteins called connexin , arranged in a circular fashion to form a tiny, fluid-filled tunnel or pore
- ◉ At gap junction the cell membranes of adjacent cells are separated by small intercellular space, as against other types of junctions where the membranes are fused.
- ◉ Through the gap junctions ions and small molecules can diffuse from the cytosol of one cell to another, but the passage of large molecules is prevented.

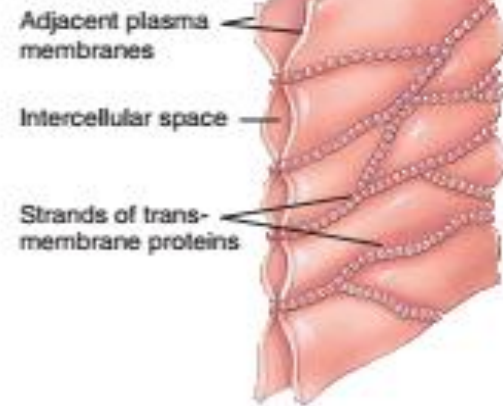
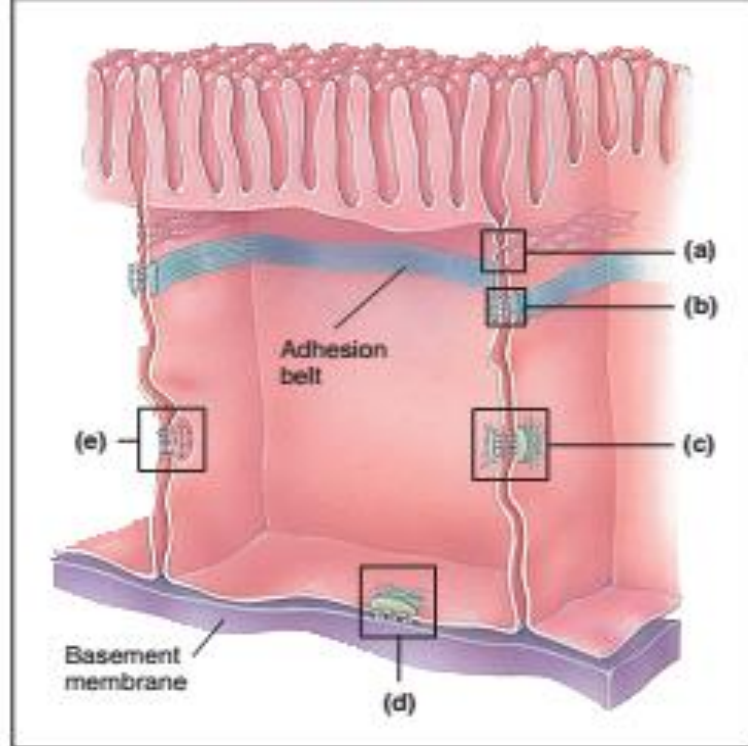


(a) Epithelium-connective tissue junction

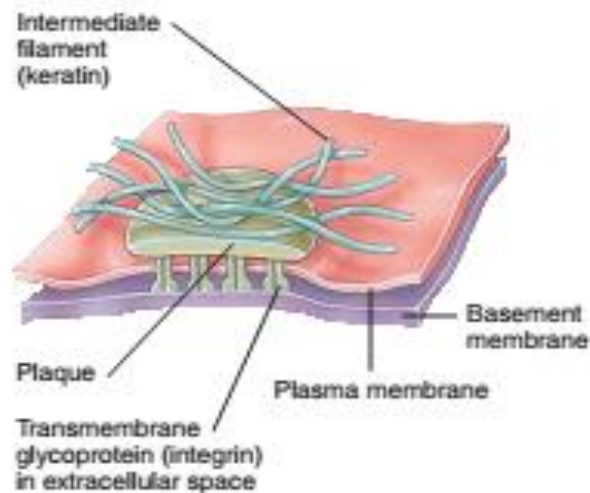




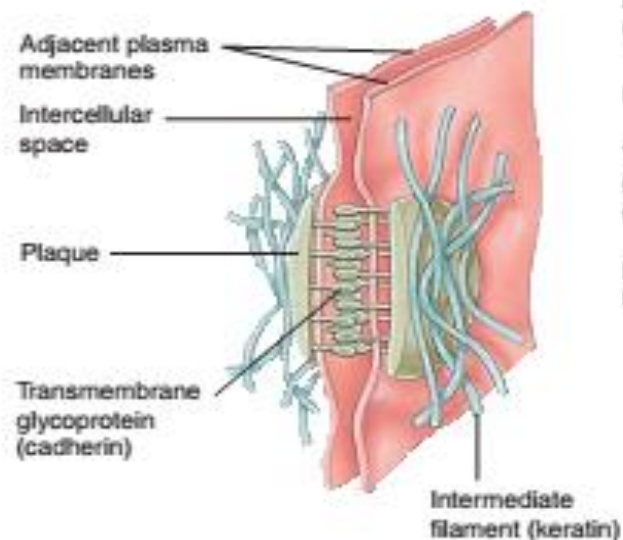
(e) Gap junction



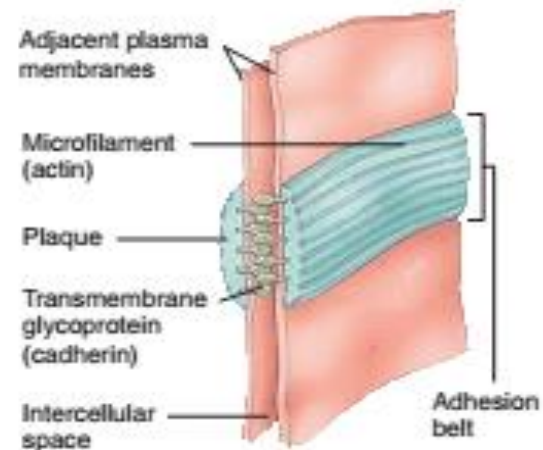
(a) Tight junctions



(d) Hemidesmosome

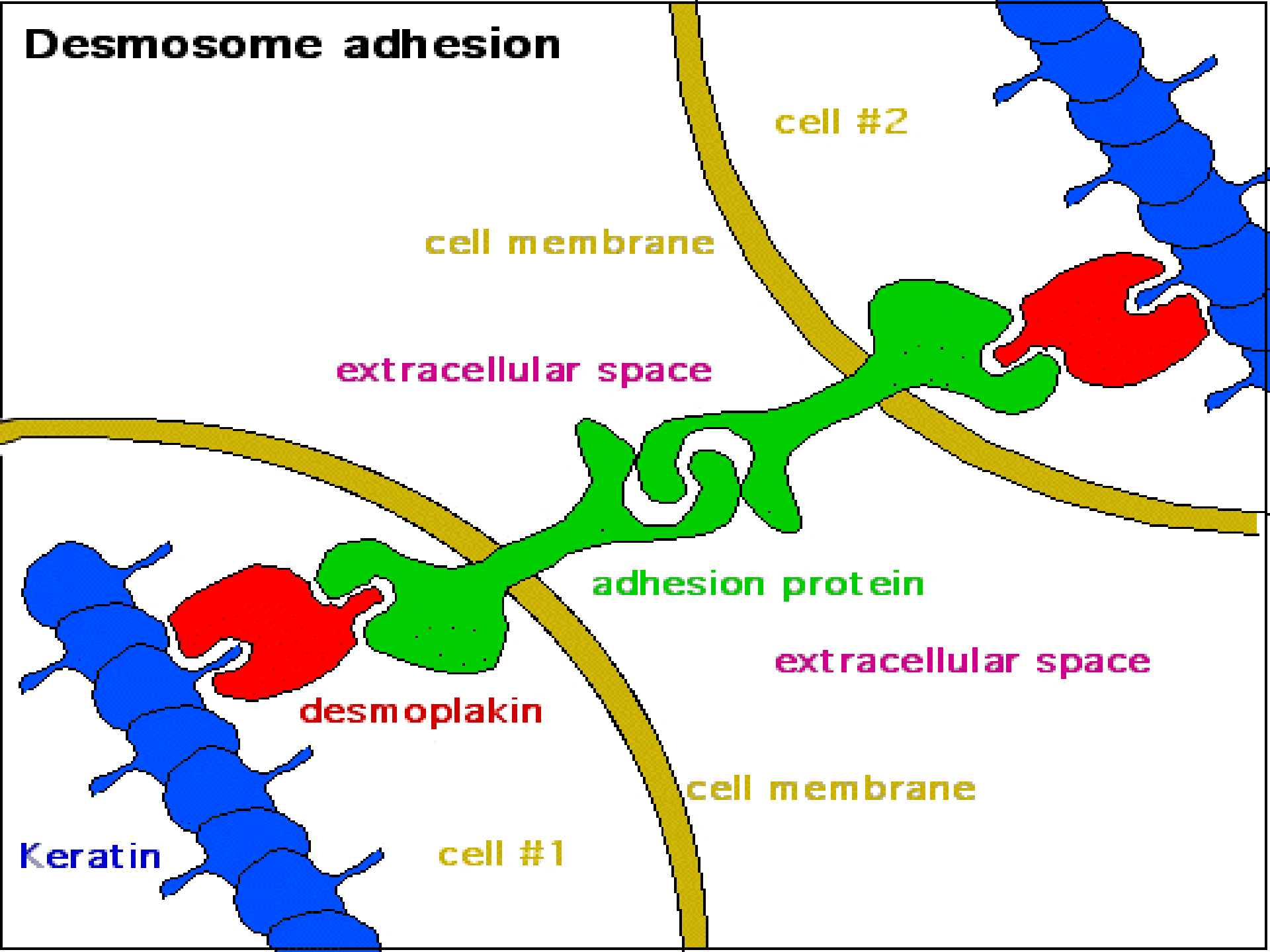


(c) Desmosome



(b) Adherens junction

Desmosome adhesion



CLASSIFICATION OF EPITHELIAL CELLS

- Classified on the basis of
 - Number of cells layers
 - Shape
- On the basis of **number of cells layer** there are three types of epithelial tissues
- **Simple epithelia:** single layer of cells that functions in diffusion, osmosis, filtration, secretion, or absorption
- **Stratified epithelia:** consists of two or more layers of cells that protect underlying tissues
- **Pseudo stratified epithelia:** appears to have multiple layers of cells because the cell nuclei lie at different levels
 - ✓ not all cells reach the apical surface but all cells rests of basement membrane.
 - ✓ Cells that do extend to the apical surface may contain cilia; others secrete mucus

Classification on basis of shape

Squamous epithelium are thin, which allows for the rapid passage of substances through them.

Cuboidal epithelium are as tall as they are wide and are shaped like cubes or hexagons.

- ◉ They may have microvilli at their apical surface and function in either secretion or absorption.

Columnar epithelium are much taller than they are wide, like columns, and protect underlying tissues.

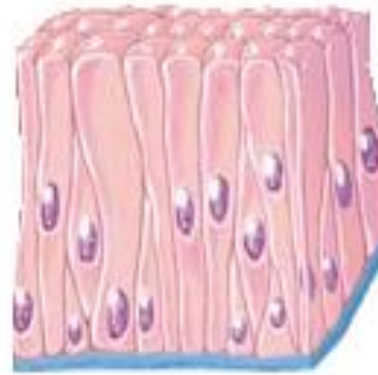
- ◉ Their apical surfaces may have cilia or microvilli, and they often are specialized for secretion and absorption.

Transitional epithelium change shape, from squamous to cuboidal and back, as organs stretch to a larger size and then collapse to a smaller size.

Arrangement of layers



Simple



Pseudostratified



Stratified

Basement membrane

Cell shape



Squamous



Cuboidal



Columnar

Basement membrane

Combining these two characteristic following types of epithelial tissues are present in body

I. Simple epithelium

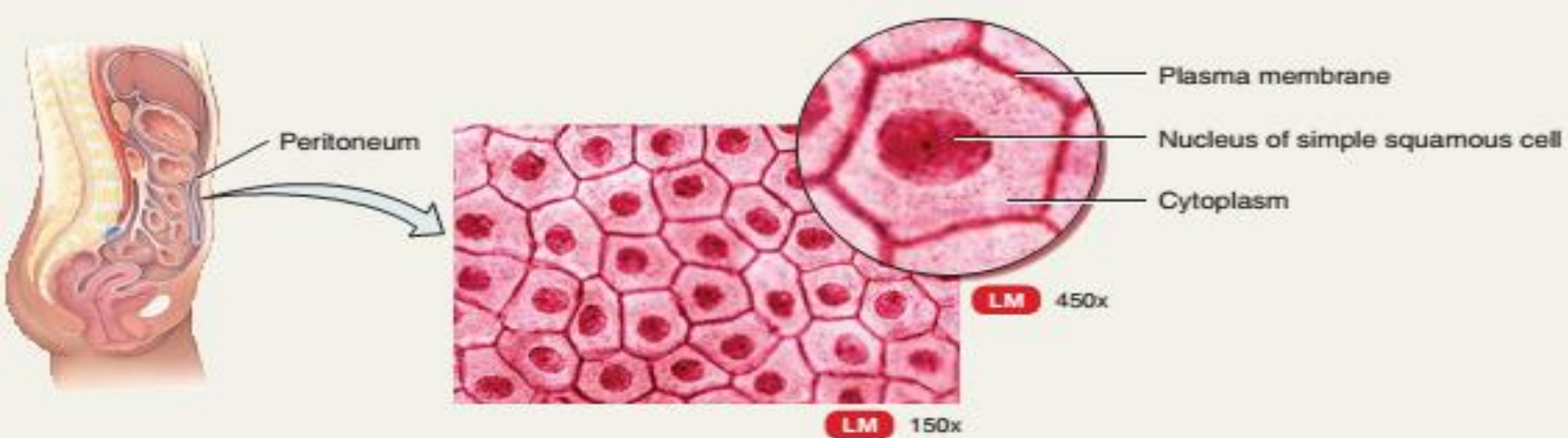
- A. Simple squamous epithelium
- B. Simple cuboidal epithelium
- C. Simple columnar epithelium (nonciliated and ciliated)
- D. Pseudostratified columnar epithelium (nonciliated and ciliated)

II. Stratified epithelium

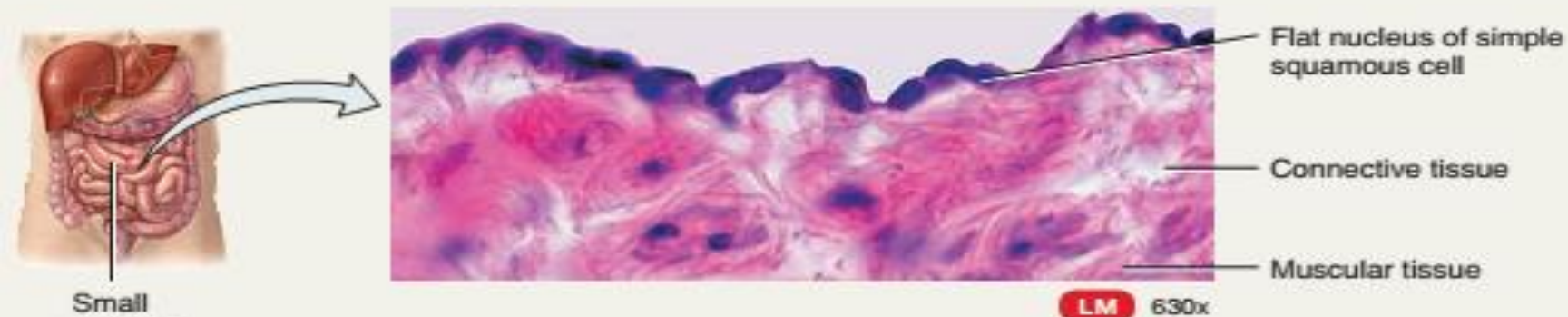
- A. Stratified squamous epithelium (keratinized, when surface cells are dead and become hardened, and nonkeratinized, when surface cells remain alive)
- B. Stratified cuboidal epithelium
- C. Stratified columnar epithelium
- D. Transitional epithelium

SIMPLE SQUAMOUS EPITHELIUM

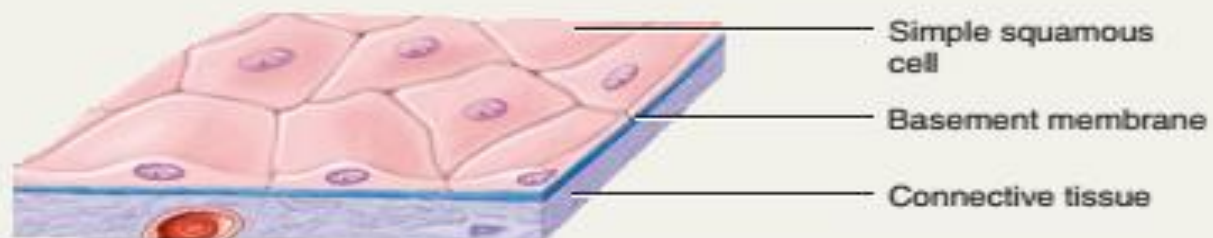
- ◉ Single layer of flat cells that resembles a tiled floor when viewed from apical surface.
- ◉ Has centrally located nucleus
- ◉ Present at sites of filtration, diffusion or at site of secretion of serous membrane.
- ◉ lines the cardiovascular and lymphatic system - **endothelium**. prevent abnormal blood clotting because of smooth surface and in capillaries it facilitates exchange of fluid
- ◉ forms the epithelial layer of serous membranes - **mesothelium** - reduce friction
- ◉ Found in Bowman's capsule of kidney, inner surface of ear drum and air sacs of lungs - diffusion and filtration



Surface view of simple squamous epithelium of mesothelial lining of peritoneum



Sectional view of simple squamous epithelium (mesothelium) of peritoneum of small intestine



SIMPLE CUBOIDAL EPITHELIUM

- ◉ Single layer of cube-shaped cells.
- ◉ Has round, centrally located nucleus.
- ◉ Its main functions are secretion and absorption.
- ◉ It has abundance of organelles to facilitate active transport
- ◉ frequently found in glands, such as salivary glands, the thyroid gland, and the pancreas, where its function is secretion.
- ◉ Simple cuboidal epithelium also covers the ovaries and lines most of the kidney tubules. In one part of the kidney tubule, it absorbs substances from the tubule, and in another part it secretes substances into the tubule.



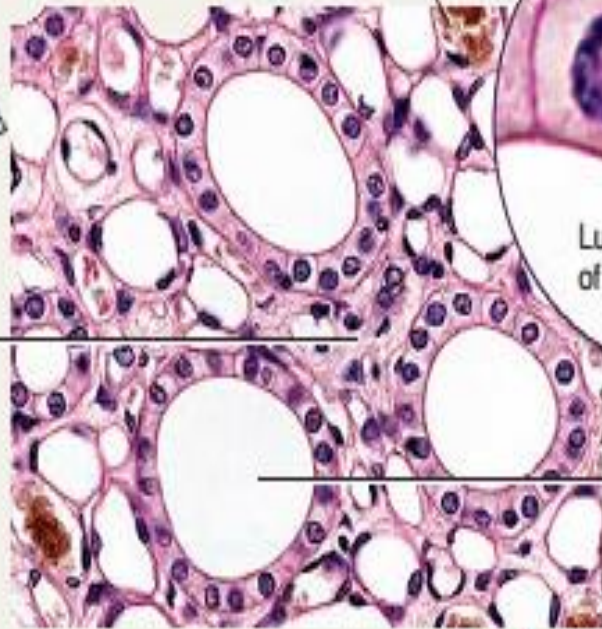
Kidney

Blood capillary with red blood cells

Connective tissue

Nucleus of simple cuboidal cell

Connective tissue

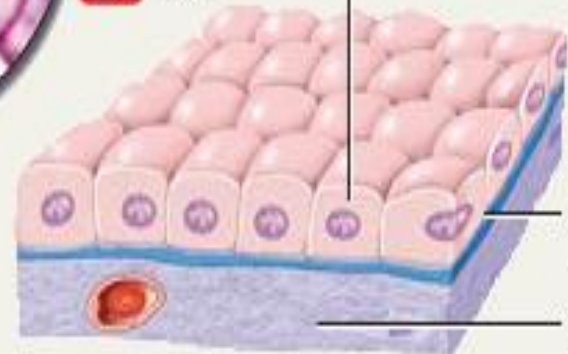


Lumen of tubule

LM 500x

Lumen of tubule

Simple cuboidal cell



Basement membrane

Connective tissue

LM 100x

Simple cuboidal epithelium

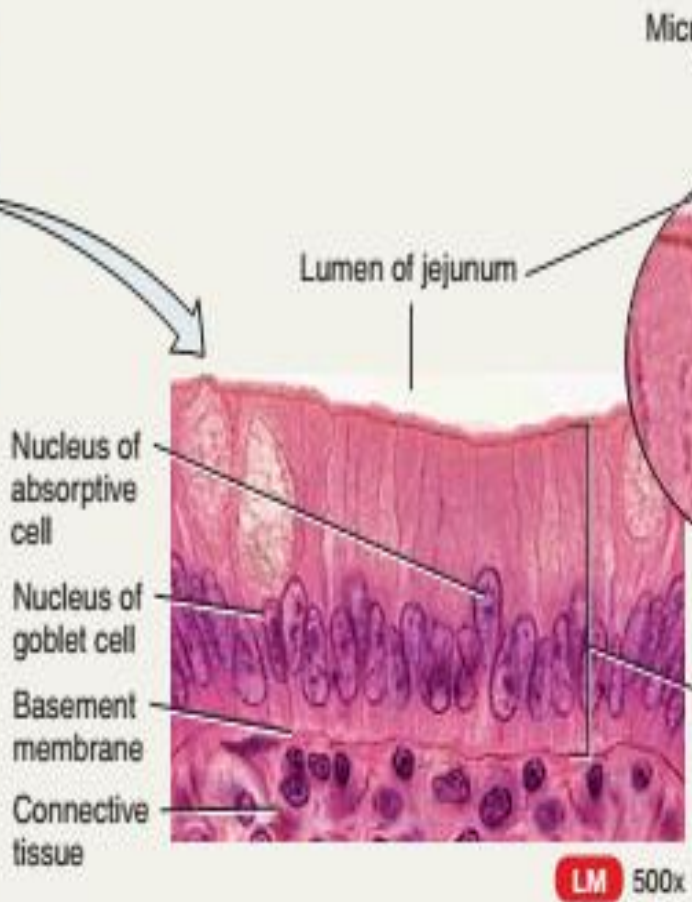
Sectional view of simple cuboidal epithelium of urinary tubules

NONCILATED SIMPLE COLUMNAR EPITHELIUM

- ◉ Single layer of non-ciliated column like cells with oval nuclei near base of cells
- ◉ More tall than wide
- ◉ Some of them are goblet cells - modified columnar epithelial cells that secrete mucus at their apical surfaces. Before release, mucus accumulates in upper portion of cell, causing it to bulge and making the whole cell resemble a goblet or wine glass.
- ◉ Also has microvilli to increase surface area for absorption
- ◉ **Function** :larger columnar cells contain more organelles and are capable of higher level of secretion and absorption. secretes mucous which lubricates linings of digestive tract, which helps prevent destruction of stomach lining by acidic gastric juice secreted by stomach.
- ◉ Lines gastrointestinal tract (from stomach to anus), ducts of many glands, gallbladder

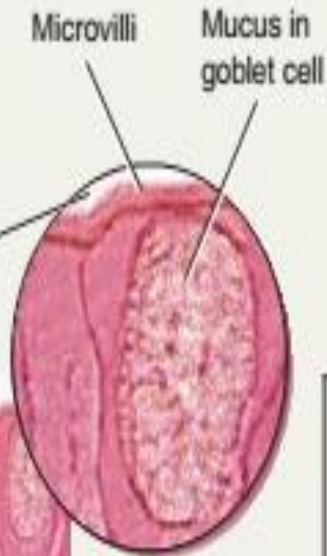


Small intestine

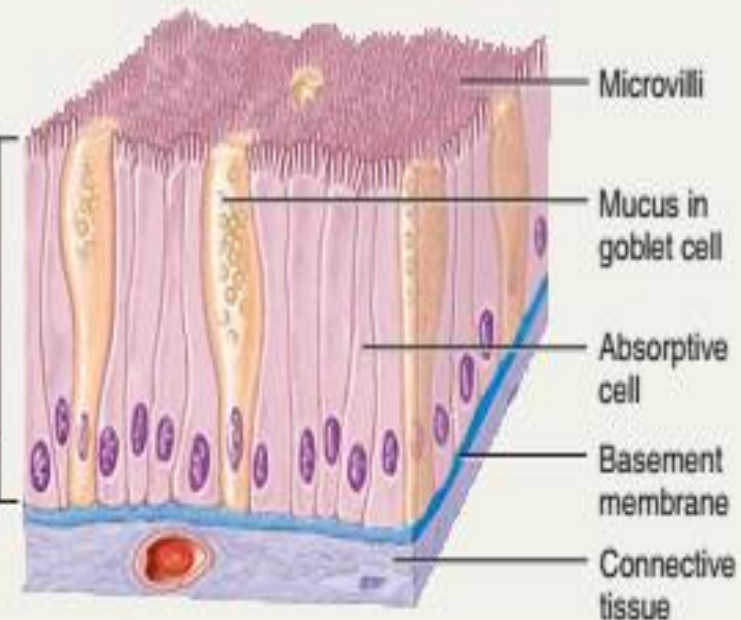


LM 500x

Sectional view of nonciliated simple columnar epithelium of lining of jejunum of small intestine



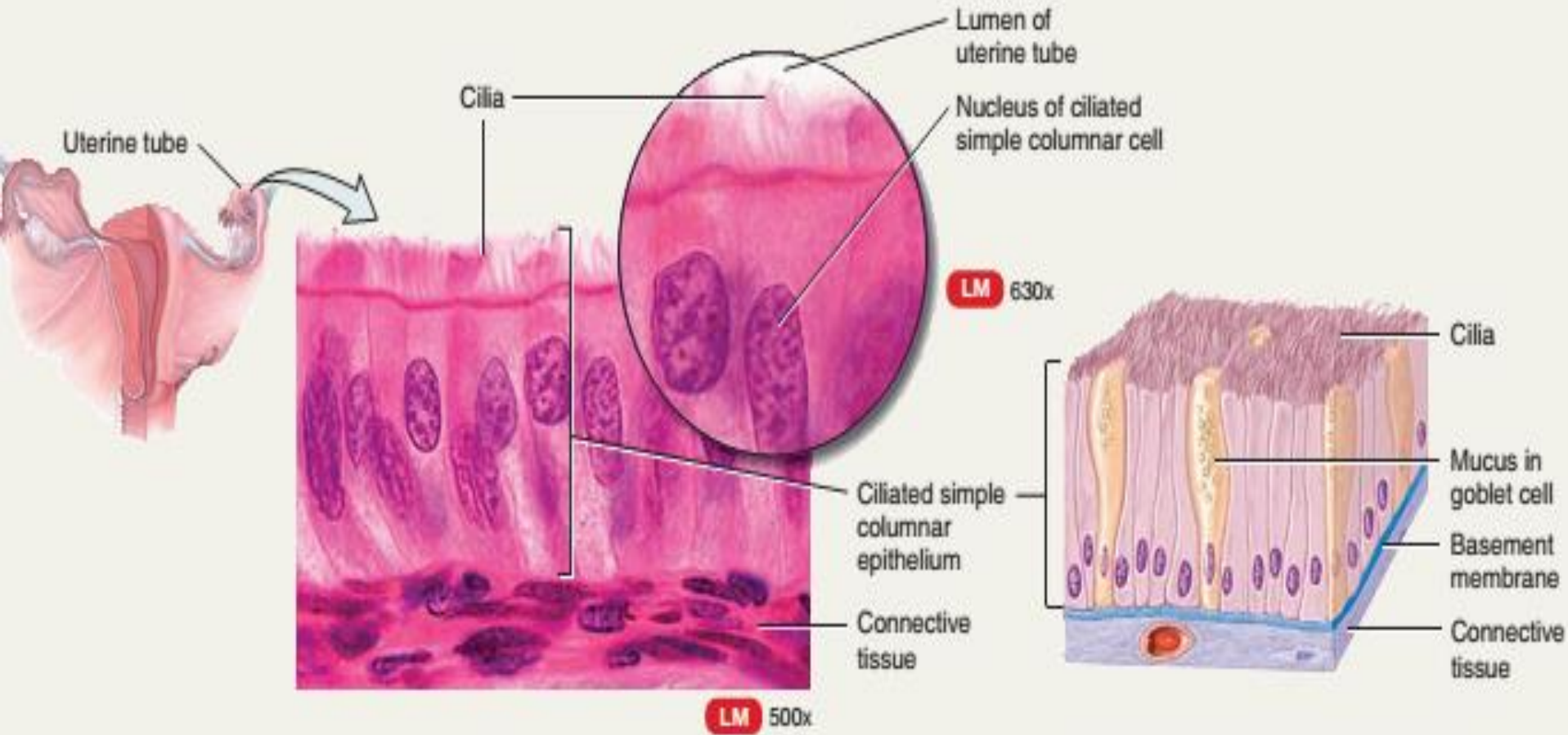
LM 1500x



Nonciliated simple columnar epithelium

CILIATED SIMPLE COLUMNAR EPITHELIUM

- ◉ Single layer of ciliated column like cells with oval nuclei near base of cells
- ◉ Some of the cells are goblet cells
- ◉ Located in bronchioles of respiratory tract, uterine tubes, uterus, central canal of spinal cord and ventricles of brain
- ◉ Their unique function is because of cilia which beat and move mucus, foreign particles and other secretions for clearance and swallowing.

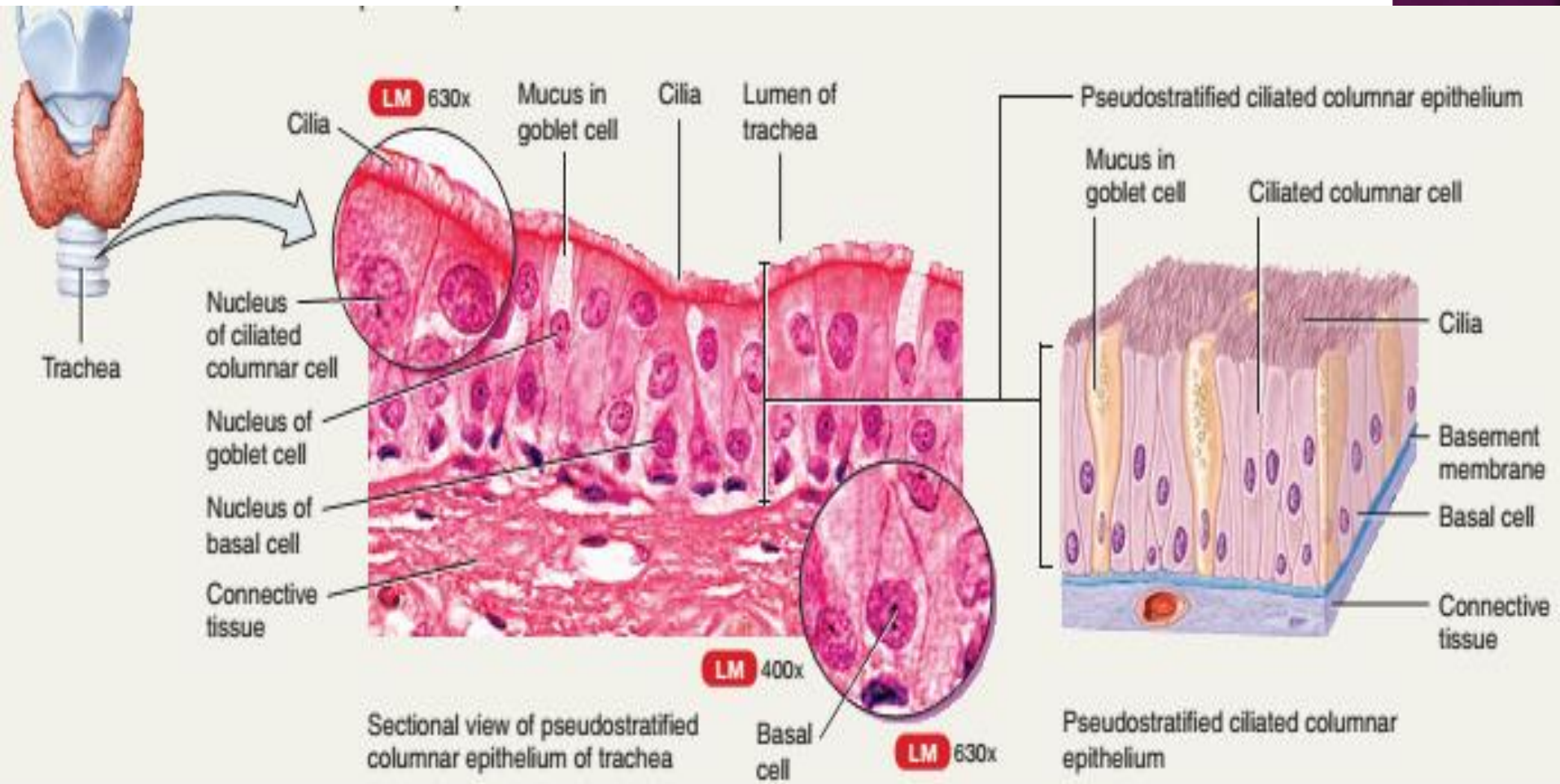


Sectional view of ciliated simple columnar epithelium of uterine tube

Ciliated simple columnar epithelium

PSEUDOSTRATIFIED COLUMNAR EPITHELIUM

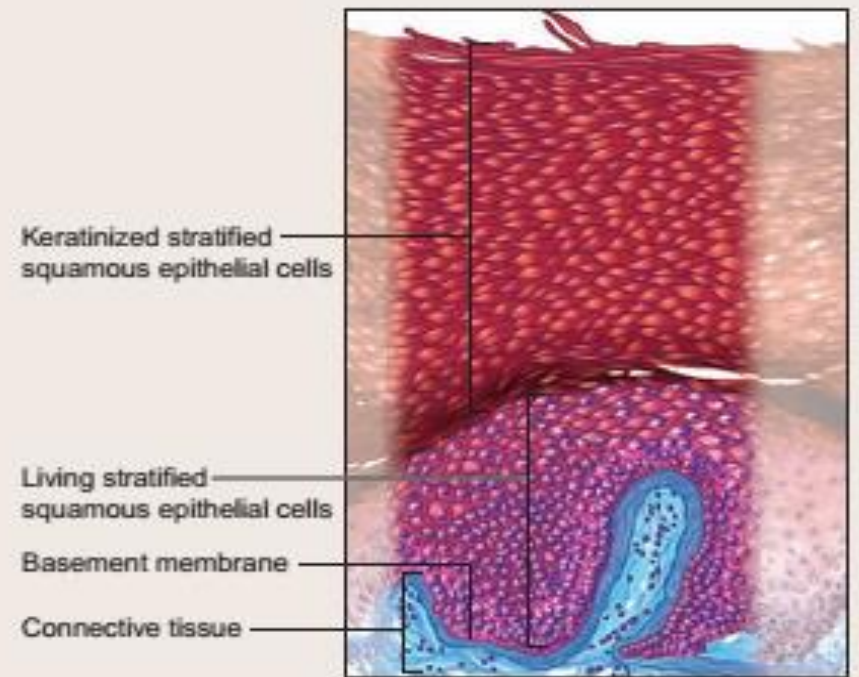
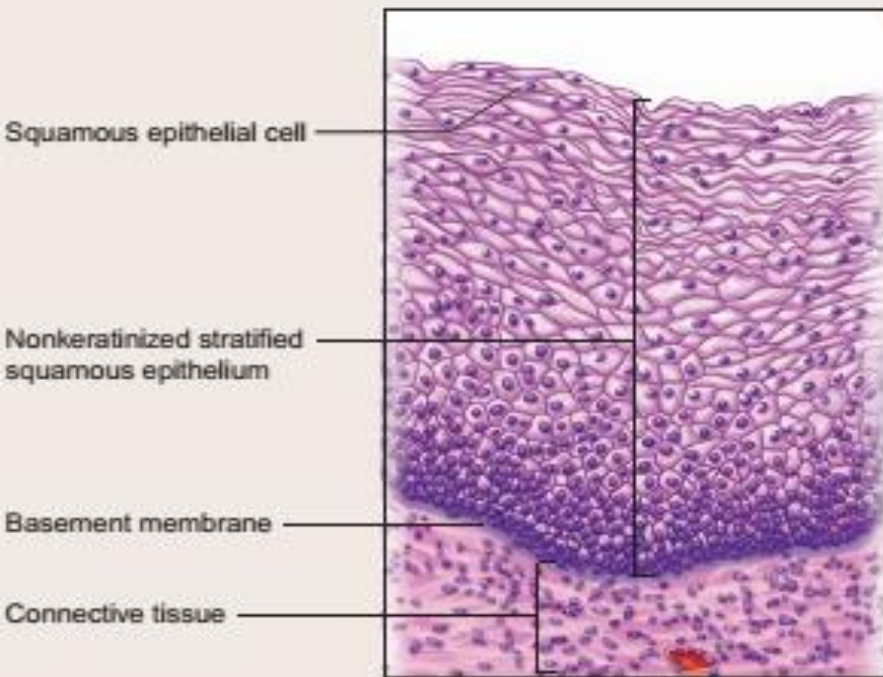
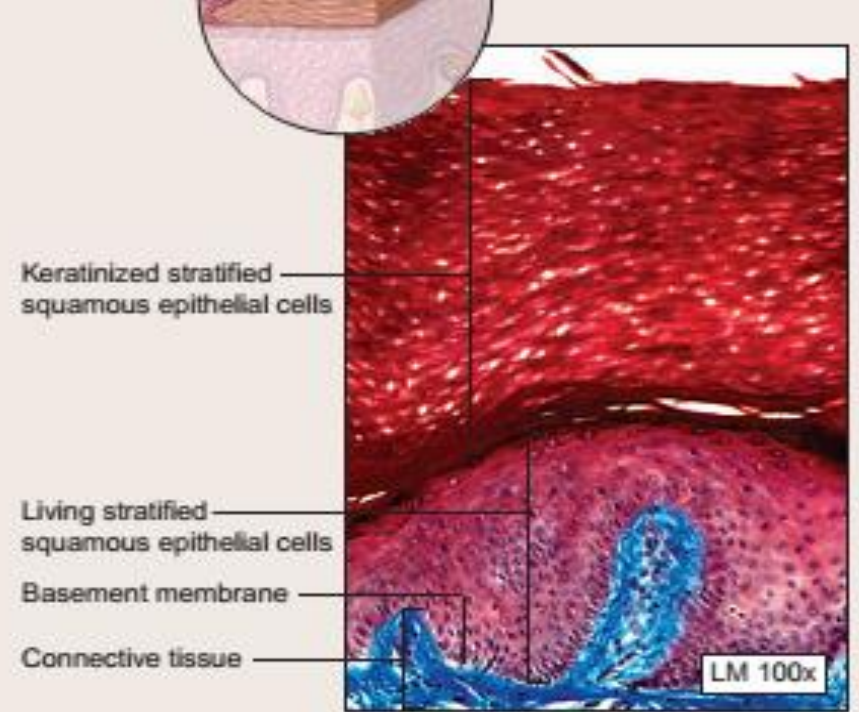
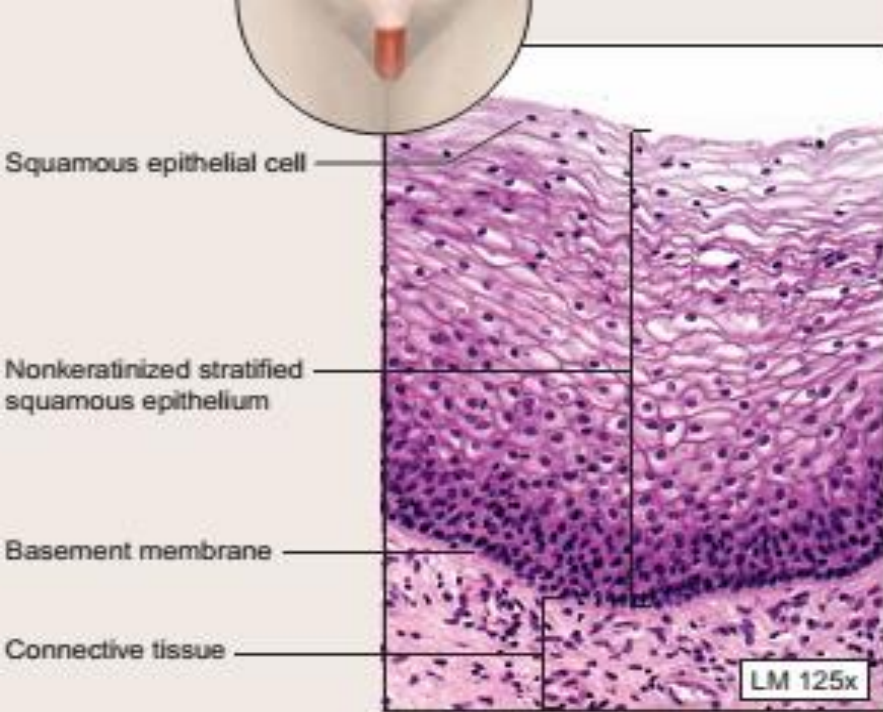
- ◉ Appears to have several layers because cell nuclei are at various levels.
- ◉ All cells are attached to basement membrane in a single layer, but some cells do not extend to apical surface
- ◉ When viewed from side, these features give false impression of a multilayered tissue
- ◉ May be ciliated or non ciliated. The ciliated has cilia and goblet cells while non ciliated do not have these features.
- ◉ Ciliated variety secretes mucus that traps foreign particles, and cilia sweep away mucus for elimination from body; nonciliated variety functions in absorption and protection.
- ◉ Ciliated variety lines airways of most of upper respiratory tract; nonciliated variety lines larger ducts of many glands, epididymis, and part of male urethra



STRATIFIED SQUAMOUS EPITHELIUM

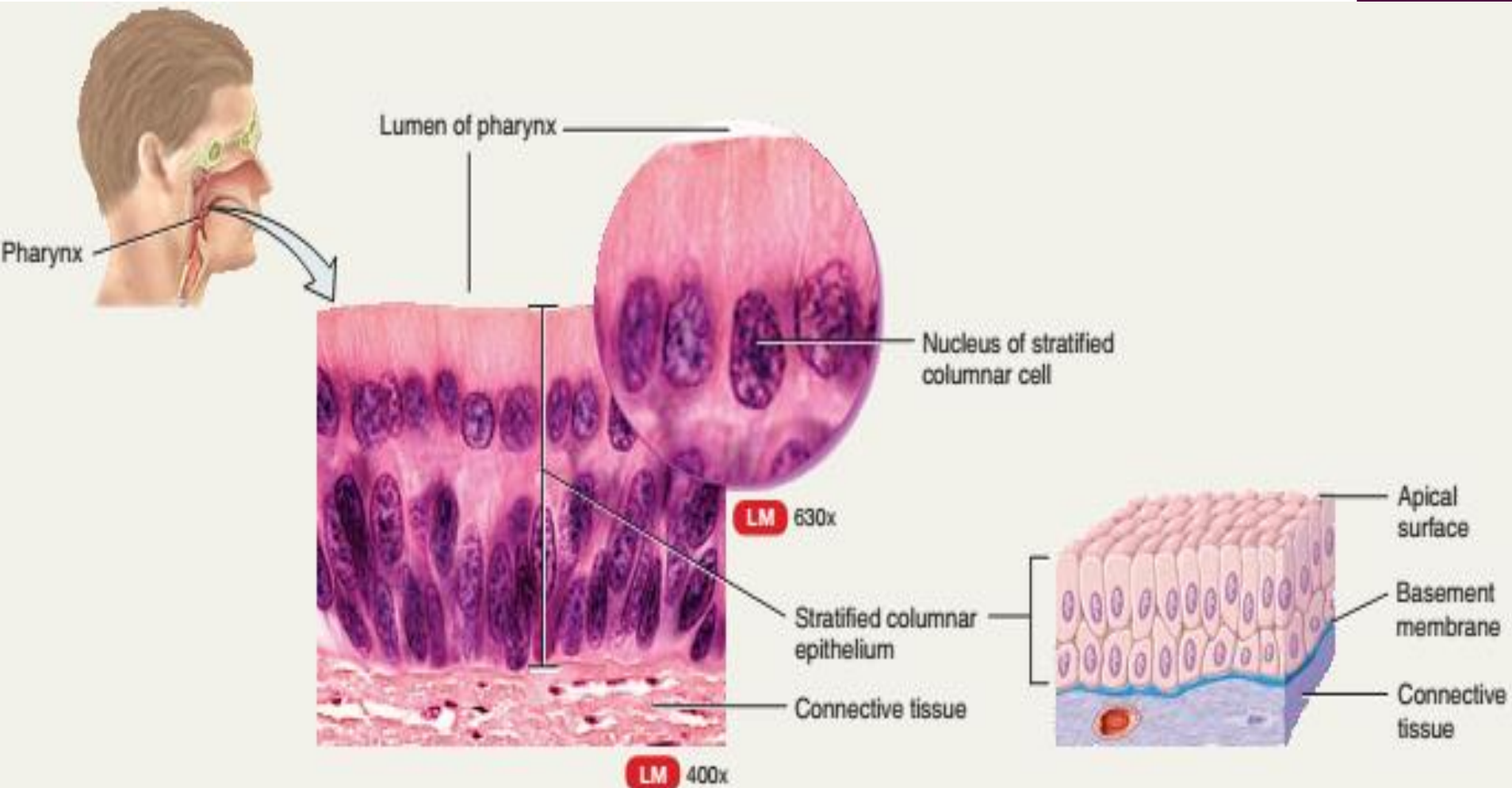
- ◉ Stratified squamous epithelium has multiple cell layers, and only the deepest layer of cells is in direct contact with the basement membrane
- ◉ The cells in the basal layers have a varied shape often described as polyhedral, the superficial cells at the apical surface display a flattened, squamous shape.
- ◉ Adapted to protect underlying tissues from damage due to activities that are abrasive and cause friction
- ◉ Stem cells in the basal layer continuously divide to produce cells that gradually moves toward the surface to replace the cells lost during protective activities.
- ◉ As the cells moves upwards towards apical surface they move away from blood supply in connective tissue and become dehydrated, metabolically less active, cytoplasm shrinks and protein accumulates in cell. Ultimately they may die or loose cell junction and are sloughed off.

- ◉ Stratified squamous epithelium is of two types.
Keratinized and non keratinized
- ◉ In **keratinized stratified squamous epithelium**, the apical surface is composed of layers of cells that are dead. These cells lack nuclei and all organelles and are filled with tough, protective keratin. The superficial cells lack nuclei when they are viewed under the microscope. The cells gradually accumulate keratin as they move towards the apical surface.
- ◉ The epidermis (outer layer) of the skin consists of keratinized stratified squamous epithelium
- ◉ In **non-Keratinized squamous epithelium** the apical cells are alive and are kept moist with secretions. Nucleus can be visualized in cells present on apical surface.
- ◉ Nonkeratinized stratified squamous epithelium lines the oral cavity (mouth), part of the pharynx (throat), the esophagus, the vagina, and the anus.



STRATIFIED COLUMNAR EPITHELIUM

- Basal layers usually consist of shortened, irregularly shaped cells, apical layer has columnar cells
- Uncommon. Present in parts of urethra; large excretory ducts of some glands, such as esophageal glands; small areas in anal mucous membrane; part of conjunctiva of eye
- Function in protection and secretion

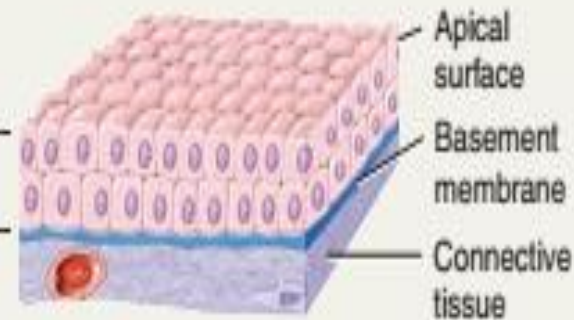
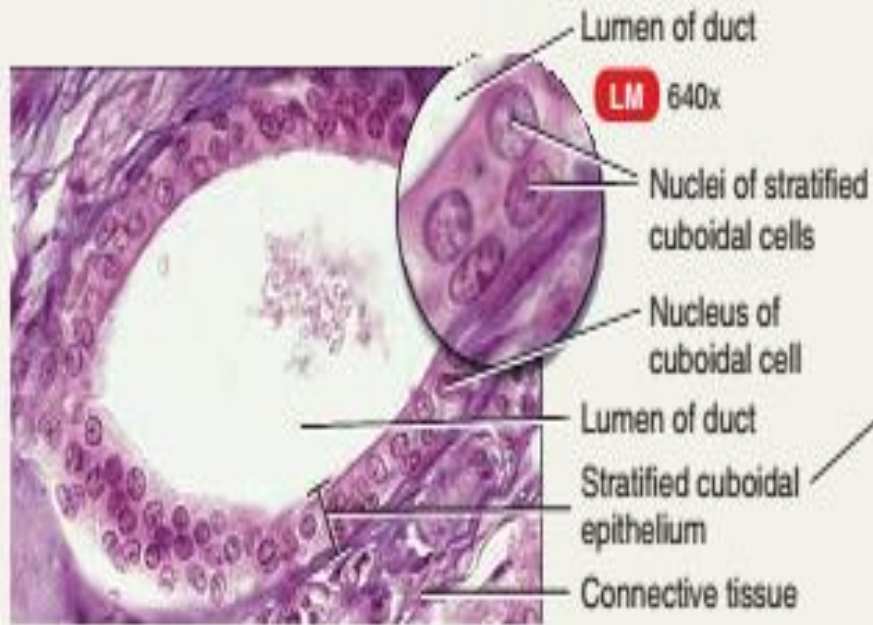


Sectional view of stratified columnar epithelium of lining of pharynx

Stratified columnar epithelium

STRATIFIED CUBOIDAL EPITHELIUM

- Two or more layers of cells; cells in apical layer are cube-shaped
- Rarely found . Present in ducts of adult sweat glands and esophageal glands, part of male urethra
- Protection, limited secretion



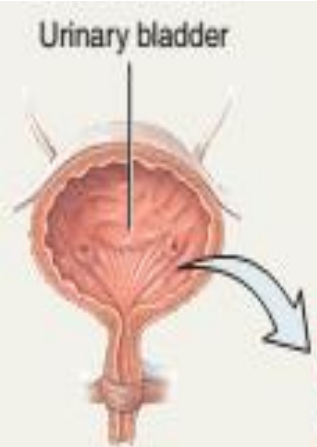
Stratified cuboidal epithelium

LM 380x

Sectional view of stratified cuboidal epithelium of the duct of an esophageal gland

TRANSITIONAL EPITHELIUM

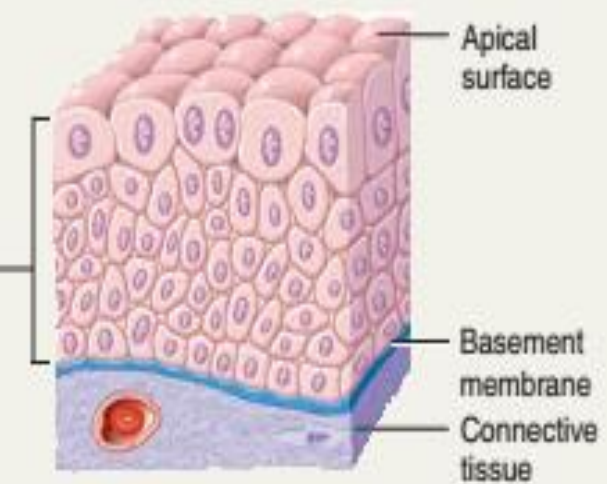
- ◉ Transitional epithelium varies in appearance, depending on whether it is in a relaxed or a stretched state
- ◉ In a relaxed state, the basal cells appear almost cuboidal, and the apical cells are large and rounded. During stretching, the apical cells continue to flatten, becoming almost squamous.
- ◉ Transitional epithelium is found only in the urinary system, particularly lining the cavity of the urinary bladder and lining the lumina of the ureters. This tissue is specialized to permit distension (stretching) of the urinary bladder as it fills with urine.



LM 400x



LM 630x



Relaxed transitional epithelium

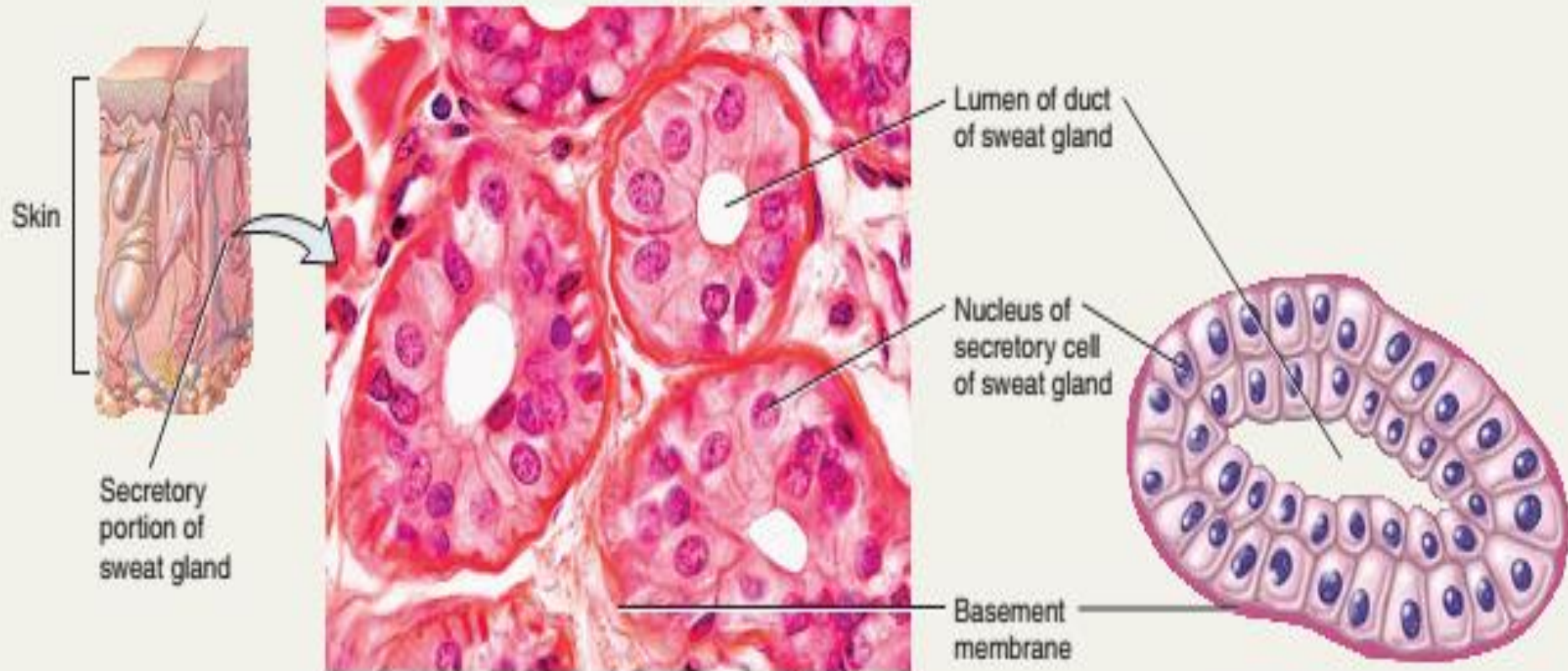
Type	Structure and Function	Location
Simple squamous epithelium	Single layer of flattened cells; diffusion and filtration	Forming capillary walls; lining air sacs (alveoli) of lungs; covering visceral organs; lining body cavities
Simple cuboidal epithelium	Single layer of cube-shaped cells; excretion, secretion, or absorption	Covering surface of ovaries; lining kidney tubules, salivary ducts, and pancreatic ducts
Simple columnar epithelium	Single layer of nonciliated column-shaped cells; protection, secretion and absorption	Lining digestive tract, gall bladder, and excretory ducts of some glands
Simple ciliated columnar epithelium	Single layer of ciliated column-shaped cells; transport role through ciliary motion	Lining uterine (fallopian) tubes and limited areas of respiratory tract
Pseudo-stratified ciliated columnar epithelium	Single layer of ciliated, irregularly shaped cells; protection, secretion, ciliary motion	Lining respiratory passageways and auditory tubes
Stratified squamous epithelium keratinized	Multilayered, contains keratin, outer layers flattened and dead; protection	Epidermis of the skin
Stratified squamous epithelium (non-keratinized)	Multilayered, lacks keratin, outer layers moistened and alive; protection and pliability	Linings of oral and nasal cavities, esophagus, vagina, and anal canal
Stratified cuboidal epithelium	Usually two layers of cube-shaped cells; strengthening of luminal walls	Ducts of larger sweat glands, salivary glands, and pancreas
Transitional epithelium	Numerous layers of rounded nonkeratinized cells; distension	Lining urinary bladder and portions of ureters and urethra

GLANDULAR EPITHELIUM

- ◉ A **gland** is a single cell or a mass of epithelial cells adapted for secretion.
- ◉ Glands are composed predominantly of epithelial tissue with supporting connective tissue
- ◉ Embryological development is from tiny invaginations (infoldings) or evaginations (outfoldings) of membranous epithelia.
- ◉ There are two types of glands depending on how the cells release the substances they produce:
 - ❖ **Exocrine glands**
 - ❖ **Endocrine glands**

EXOCRINE GLANDS

- ◉ Exocrine glands have ducts (tubes) to take the secretion away from the gland to the site of its function.
- ◉ secrete their products into ducts that empty onto the surface of covering and lining epithelium such as the skin surface or the lumen of a hollow organ
- ◉ Salivary glands, for example, secrete saliva that is carried by ducts to the oral cavity. Sweat glands secrete sweat that is transported by ducts to the skin surface.
- ◉ Exocrine glands within the skin include oil (sebaceous) glands, sweat glands, and mammary glands. Exocrine glands within the digestive system include the salivary and pancreatic glands



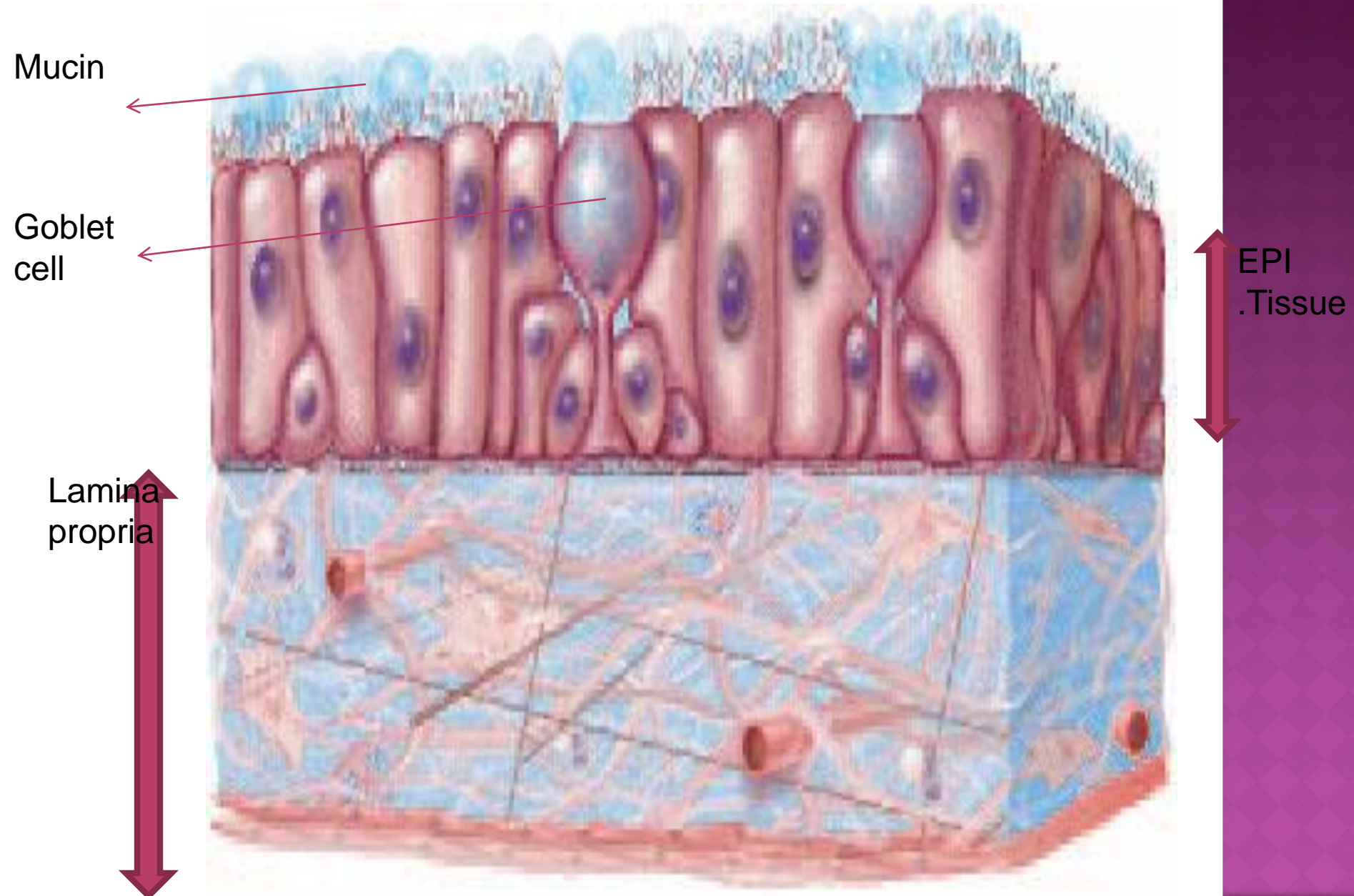
LM 400x

Sectional view of the secretory portion of an exocrine gland (eccrine sweat gland)

CLASSIFICATION OF EXOCRINE GLANDS

- On the basis of their structures exocrine glands are classified as
 - ❖ Unicellular glands: Unicellular glands are single-celled glands, such as *goblet cells* . *That* occur within most epithelial tissues. Goblet cells are found in the epithelial linings of the respiratory and digestive systems
 - ❖ Multicellular glands: As the name implies, the glands composed of both secretory cells and cells that form the walls of the ducts

STRUCTURE OF GOBLET CELL



◉ Multicellular glands are further classified on basis of three criteria:

(1) Structure of Ducts:

(2) Shape of the secretory portion:

(3) Method of release of product

◉ **Classification based on Structure of Ducts**

❖ **Simple:** If the duct of the gland does not branch, it is a simple gland

❖ **Compound:** If the duct branches, it is a compound gland.

Classification based on shape of Secretory portion

A: Tubular Gland:

if the secretory portion resembles a tube then this will be called as Tubular gland.

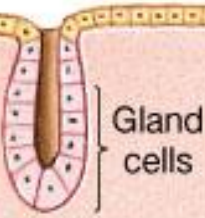
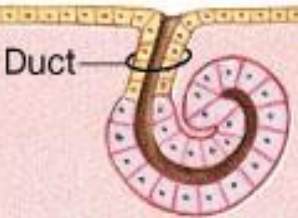



B: Acinar glands:

In this case the secretory portion resembles a flask or a dilated Sac and the Sac will be called as Acinus or Alveolus.


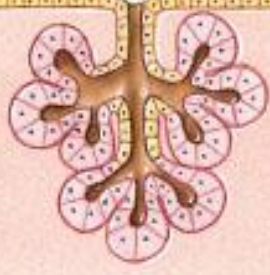
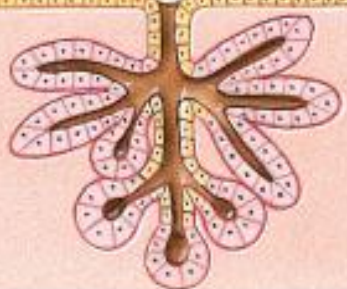
C: Tubuloacinar glands:

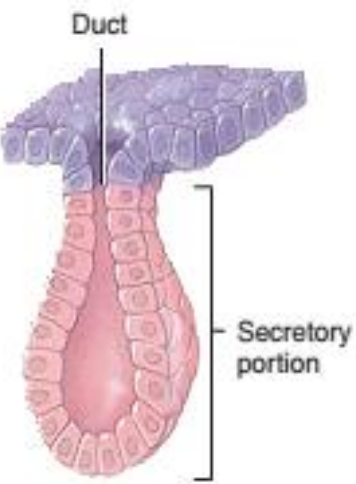
Multicellular glands with a secretory portion that resembles both a tube and a flask are termed as *tubuloacinar glands*.

SIMPLE GLANDS

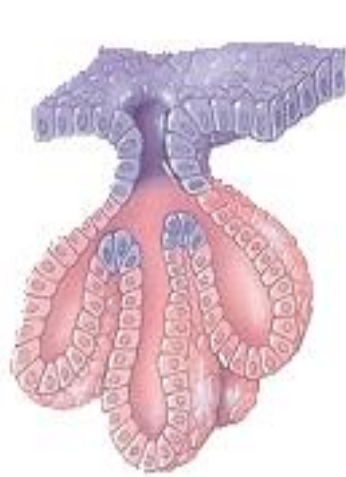
 <p style="text-align: right;">Gland cells</p>	 <p>Duct</p>			
<p style="text-align: center;">SIMPLE TUBULAR</p> <p><i>Examples:</i> Intestinal glands (crypts of Lieberkühn)</p>	<p style="text-align: center;">SIMPLE COILED TUBULAR</p> <p><i>Examples:</i> Merocrine sweat glands</p>	<p style="text-align: center;">SIMPLE BRANCHED TUBULAR</p> <p><i>Examples:</i> Gastric glands Mucous glands of esophagus, tongue, duodenum</p>	<p style="text-align: center;">SIMPLE ALVEOLAR (ACINAR)</p> <p><i>Examples:</i> Not found in adult; a stage in development of simple branched glands</p>	<p style="text-align: center;">SIMPLE BRANCHED ALVEOLAR</p> <p><i>Examples:</i> Sebaceous (oil) glands</p>

COMPOUND GLANDS

		
<p style="text-align: center;">COMPOUND TUBULAR</p> <p><i>Examples:</i> Mucous glands (in mouth) Bulbourethral glands (in male reproductive system) Testes (seminiferous tubules)</p>	<p style="text-align: center;">COMPOUND ALVEOLAR (ACINAR)</p> <p><i>Examples:</i> Mammary glands</p>	<p style="text-align: center;">COMPOUND TUBULOALVEOLAR</p> <p><i>Examples:</i> Salivary glands Glands of respiratory passages Pancreas</p>



Simple tubular



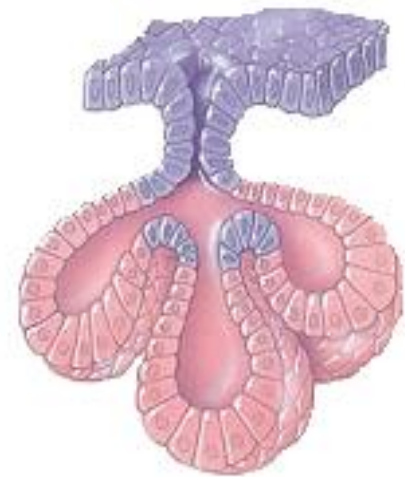
Simple branched tubular



Simple coiled tubular



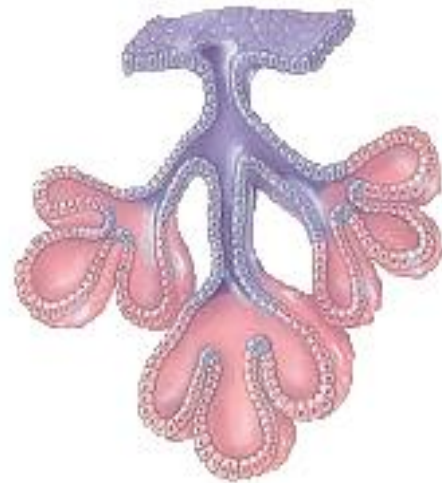
Simple acinar



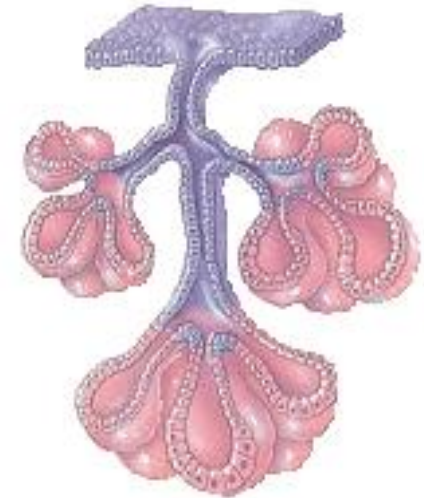
Simple branched acinar



Compound tubular



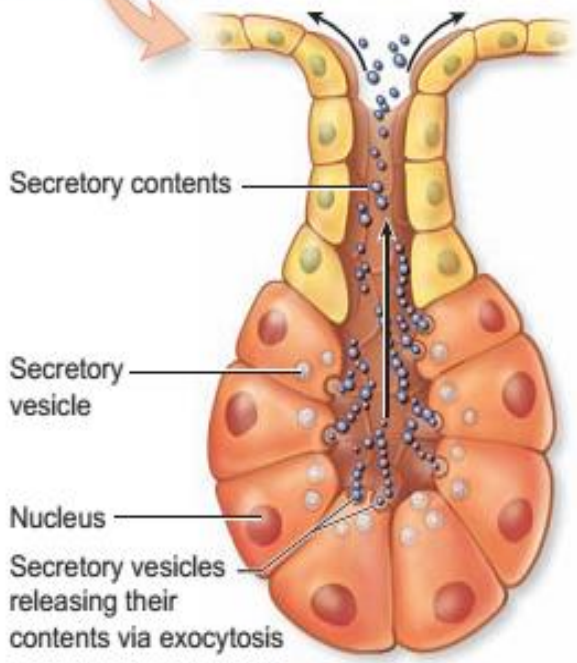
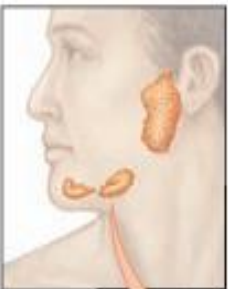
Compound acinar



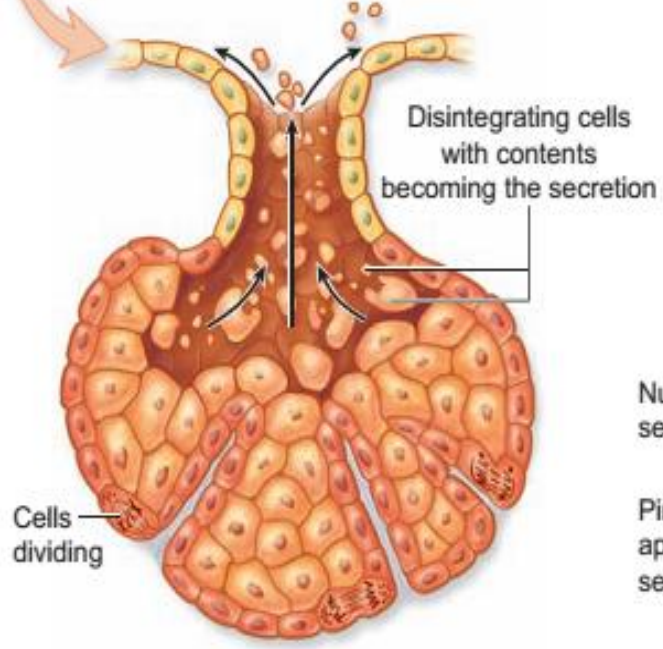
Compound tubuloacinar

Classification based on mode of release

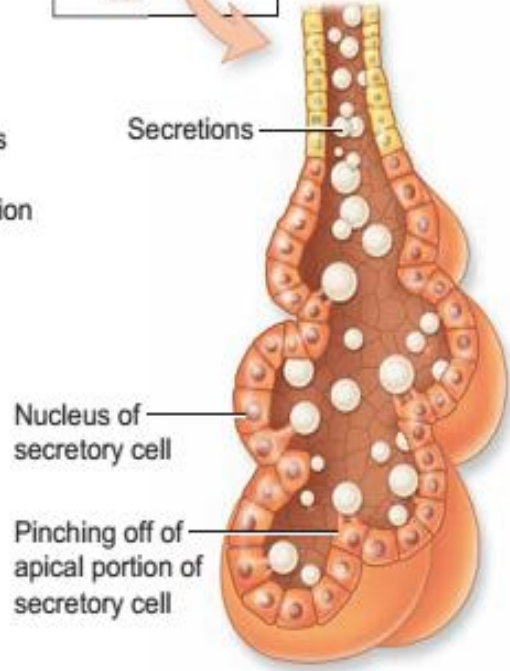
- ◉ **Merocrine gland :**
- ◉ synthesize their secretions on ribosomes attached to rough ER; process and package them at the Golgi complex; and release them from the cell in secretory vesicles via exocytosis
- ◉ Examples include *tear* glands, pancreas, gastric glands.



(a) Merocrine gland



(b) Holocrine gland



(c) Apocrine gland

Apocrine glands:

- accumulate their secretory product at the apical surface of the secreting cell. Then, that portion of the cell pinches off by exocytosis from the rest of the cell to release the secretion. The remaining part of the cell repairs itself and repeats the process
- Examples are Mammary glands and some **sweat** gland. Provides nourishment to infant and regulate body temperature.

Holocrine gland

- ◉ accumulate a secretory product in their cytosol. As the secretory cell matures, it ruptures and becomes the secretory product.
- ◉ Because the cell ruptures in this mode of secretion, the secretion contains large amounts of lipids from the plasma membrane and intracellular membranes.
- ◉ The sloughed off cell is replaced by a new cell.
- ◉ Example is sebaceous gland which release thick secretion to prevent skin from drying.

CLASSIFICATION BASED ON NATURE OF SECRETION

Glands are classified not only by their structure but also by nature of their secretions.

- ◉ **Serous glands** produce relatively thin, watery fluids such as perspiration, milk, tears, and digestive juices.
- ◉ **Mucous glands**, found in the tongue and roof of the mouth among other places, secrete a glycoprotein called *mucin*. After it is secreted, mucin absorbs water and forms the sticky product *mucus*.
- ◉ **Mixed glands**, such as the two pairs of salivary glands, contain both serous and mucous cells and produce a mixture of the two types of secretions.
- ◉ **Cytogenic glands** release whole cells. The only examples of these are the testes and ovaries, which produce sperm and egg cells.

ENDOCRINE GLANDS

- ⦿ **Endocrine glands** - called “ductless glands” discharge their secretions into the intracellular fluid, where it diffuses into the blood stream. These secretions are hormones, or chemical messengers, which regulate many bodily functions.

References

- ❑ Human anatomy, “Chap.4 Histology” Kent M Van dee Graff
- ❑ Human Anatomy, “Tissue level of organization” Michael McKinley.
- ❑ Anatomy and Physiology “Histology” Seely Stephen and Tate
- ❑ Histology and Cell biology by Kurt .E. Johnson