Medical Biology

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Histology:

Histology: is the study of the tissues of the body.

Tissue: group of similar cells combined to perform a common function.

The human body is composed of only 4 basic types of tissue:

1. epithelial tissues.
2. connective tissues.
3. muscular tissues.
4. nervous tissues.

Epithelial Tissues:

Features of epithelium:

❋ Epithelium lines the surfaces of the body and is mainly located on the borders between the external and internal environments. Epithelium also lines all the internal body spaces that have a connection with the external environment at some stage.

❋ Epithelium plays an important role in homeostasis of the body and in maintaining the physiological parameters of the internal environment different from those outside the body.

❋ Epithelium is a tissue composed of cells, tightly-bound to each other, with no intercellular connective tissue. There are specializations of the cell membranes that play roles in maintaining the integrity of the tissue.

❋ Epithelium is an avascular tissue and has no integral blood supply.

❋ Epithelium develops in the embryo from all the three germ layers (Ectoderm, Mesoderm, Endoderm). For example, the epidermis of the skin is ectodermal in origin, the epithelium lining the serous cavities (peritoneum, pleura, pericardium) is derived from mesoderm (and is often referred to as mesothelium), whereas the epithelium lining most of the intestinal tract is endodermal.

Functions of epithelium:

1. Protection: Epithelial cells from the skin protect underlying tissue from mechanical injury, harmful chemicals, invading bacteria and from excessive loss of water.
2. Sensation: Specialized epithelial tissue containing sensory nerve endings is found in the skin, eyes, ears, nose and on the tongue.
3. Secretion: In glands, epithelial tissue is specialized to secrete specific chemical substances such as enzymes, hormones and lubricating fluids.
4. Absorption: Certain epithelial cells lining the small intestine absorb nutrients from the digestion of food.
5. Cellular transport: Transport of molecules across epithelial layers.

Polarity:

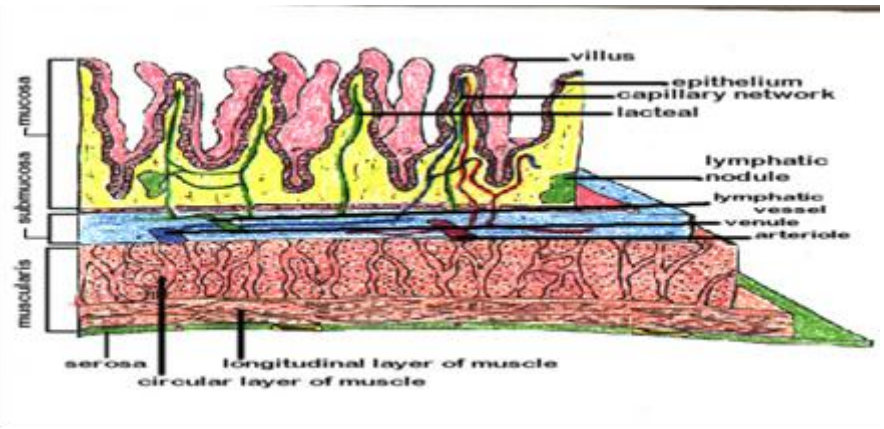
Epithelial cells are polarized cells and we can distinguish different areas of the cells (apical, basal, lateral) with specific structural modifications (unlike other tissues, where structural polarity is not found).

Apical modification of plasma membrane

Specific structures found on the apical surface (the free surface facing the lumen or external environment) include : microvilli, stereocilia, cilia or flagella.

micrvilli:

Finger like extensions of plasma membrane that are particularly abundant on the surface of the cells, involved in the absorption, such as the epithelial cells lining the intestine.



Stereocilia:

Specialized forms of microvilli. e.g. the stereocilia of auditory hair cells, are responsible for hearing by detecting sound vibration.

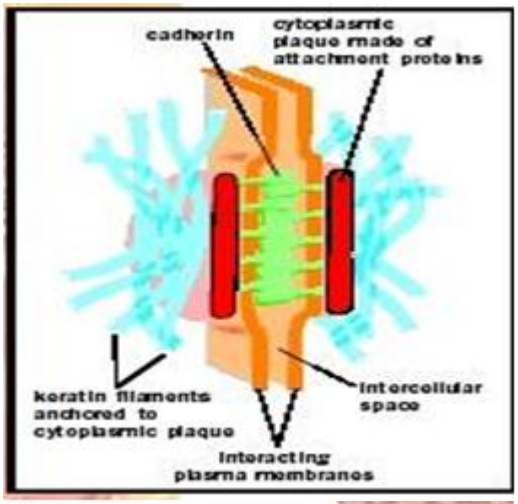
The lateral surfaces (between adjacent epithelial cells) typically have "junctional complexes" including :

- tight junctions.
- adhering junctions (desmosomes).
- communicating junctions (gap junctions or nexuses).

Lateral modification of plasma membrane

The lateral parts of the cell membrane can show several specialization that form "intercellular junctions", functions of these junctions:

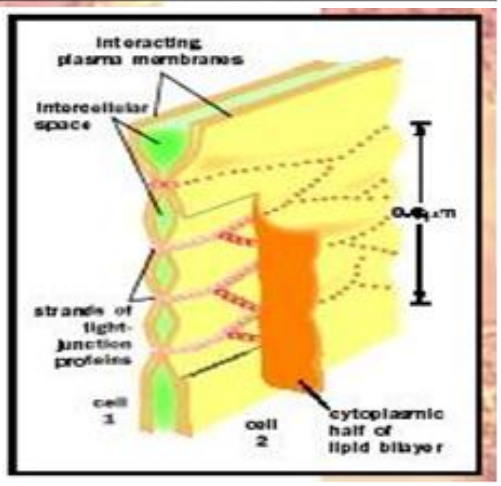
1. they are the sites of adhesion between adjacent cell.
2. they prevent the flow of materials through the intercellular compartment.
3. they help in the intercellular communication.



There are **three** types of junctions:

1. adhesion junctions (desmosomes):

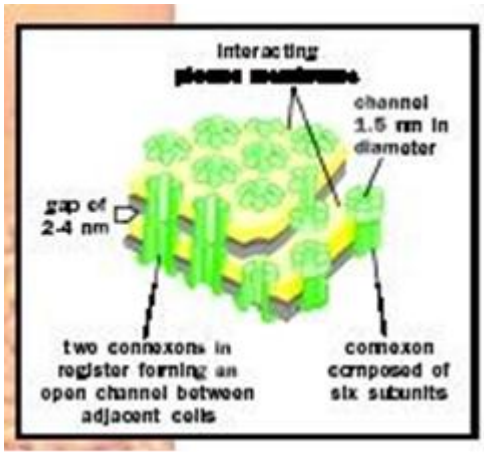
- in this type, the internal cytoplasmic plaques firmly attached to the cytoskeleton within each cell, are joined by intercellular filaments.
- In some organs like the heart, stomach and bladder, where tissues get stretched, adhesion junctions hold the cell together.



2. tight junctions:

- adjacent cells are even more closely joined by tight junctions in which plasma membrane proteins actually attach to each other producing a zipper like fastening.

- These junctions between cells form an impermeable barrier and prevent the flow of materials in intercellular spaces. e.g. in the kidneys the urine stays within kidney tubules because the cells are joined by tight junction.



3. gap junctions:

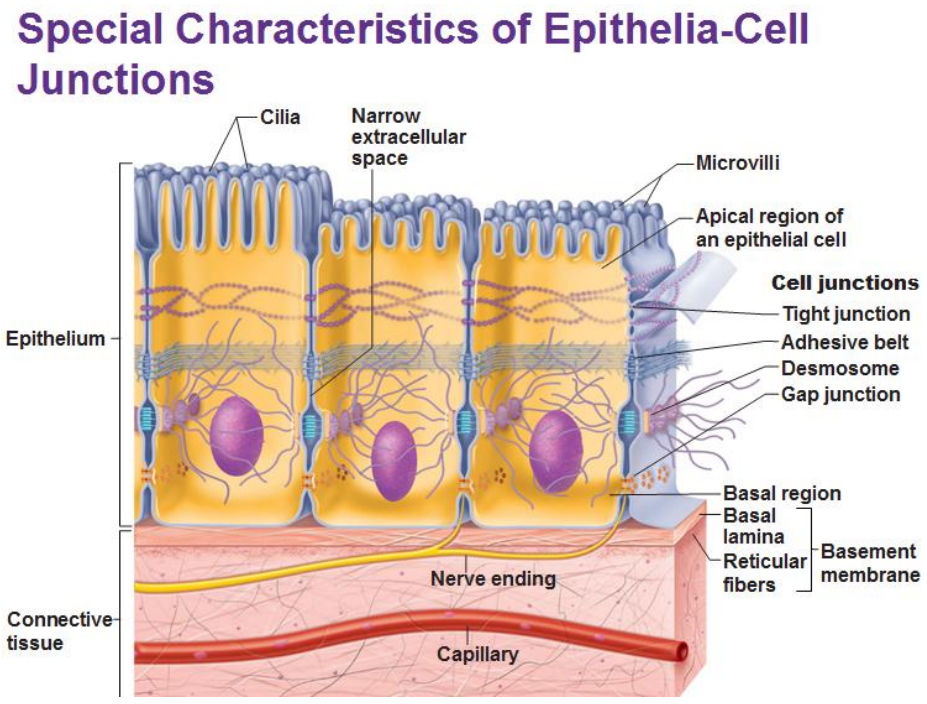
- it allows cells to communicate, and is formed when two identical plasma membrane channels join.
- The channel of each cell is lined by six plasma membrane proteins.
- Functions of gap junctions are:

1. it lends strength to the cells.
2. it allows small molecules and ions to pass between them.

Gap junctions are important in heart muscle and smooth muscle because they permit a flow of ions that is required for the cells to contract.

Basal modification of plasma membrane

Epithelial cells are separated from the underlying connective tissue by a basal lamina. The plasmalemma at the base of epithelial cells, especially those with metabolic function (ion-transporting epithelia) may be modified by having marked invaginations to increase the surface area.



Basal lamina:

All epithelial cells have at their basal surface a sheet like extracellular structure called the basal lamina, separating them from the underlying connective tissue (*lamina propria*). The basal laminae, are visible only by transmission electron microscopy, where are formed from an electron-dense layer (20-100 nm thick) composed of:

1. lamina lucidae: which appear to be transparent.
2. lamina densa: a delicate network of fine fibrils.

Basal laminae are composed mainly of type IV collagen and a glycoprotein, called laminin.

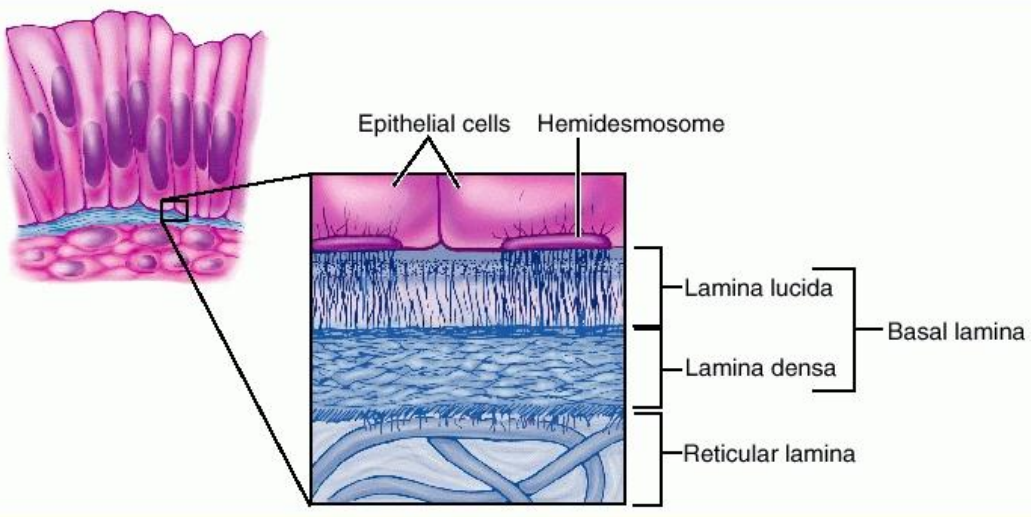
Basal laminae are not exclusive features of epithelia, but are also found associated with some other cell types.

Basal lamina is sometimes attached to the underlying connective tissue by anchoring fibrils of unknown composition.

In some instance, reticular fibers are closely associated with the basal lamina forming a layer termed the reticular lamina, the reticular fibers are produced by connective tissue cells and it is responsible for affixing the lamina densa to the underlying connective tissue thus the epithelial sheath is bound to the underlying connective tissue.

Basement membrane:

Is formed by the combination of a basal lamina and a reticular lamina and therefore, it is thicker. It is stained well by special histochemical stains and so it is seen by the light microscope.



Functions of basal lamina:

1. it is considered as a molecular filter and as a flexible, firm support for the overlying epithelium.
2. provide a selective barrier between connective tissue and other cells.
3. the presence of the basal lamina around a muscle cell is necessary for the establishment of new neuromuscular junctions.
4. the ability to influence cell polarity.
5. regulate cell proliferation and differentiation by binding with growth factors.
6. influence cell metabolism.

Epithelia are avascular. Blood vessels of the underlying connective tissue (*lamina propria*) supply the necessary nutrients and metabolites, which are transported to and from the epithelial cells by diffusion.

In the contact area between epithelial cells and the basal lamina, there is hemidesmosomes, these structures resemble a half desmosmes and bind the cell to the basal lamina.

Classification of epithelia:

Epithelia are divided into main groups according to their structure and function:

- ❖ covering epithelium.
- ❖ glandular epithelium.

Covering epithelia are tissues in which the cells are organized in layer that cover the external surface or line the cavities of the body. They can be divided into two groups depending on the number of layers of which it is composes. Epithelial tissue which is only one cell thick is known as **simple epithelium**. If it is two or more cells thick , it is known as **stratified epithelium**.

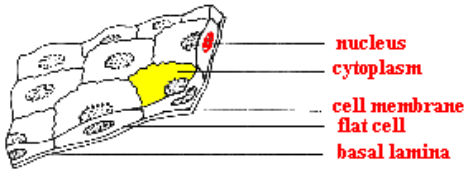
Covering epithelium:

Simple epithelia:

Simple epithelium can be subdivided according to the shape and function of its cells:

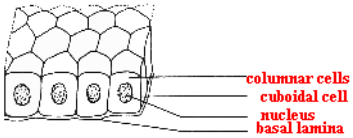
- **Simple squamous epithelium:**

Squamous cells have the appearance of thin, flat plates. Squamous cells tend to have horizontal flattened nuclei because of the thin flattened form of the cell. They form the lining of cavities such as blood vessels (endothelium), and parietal wall of Bowmanns capsule in kidney glomeruli, also line the serous cavities of the body (peritoneum, pleura, pericardium) which known as Mesothelia.



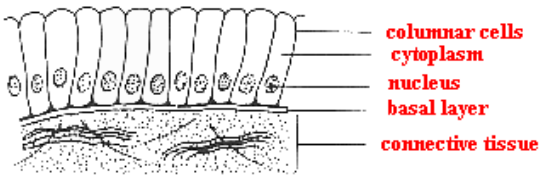
- **Simple Cuboidal Epithelium:**

Cuboidal cells are roughly square or cuboidal in shape. Each cell has a spherical nucleus in the centre. Cuboidal epithelium line many small ducts in the body. Examples include the urinary ducts of the kidney, the bile ductules of the liver, or the cells lining thyroid follicles.

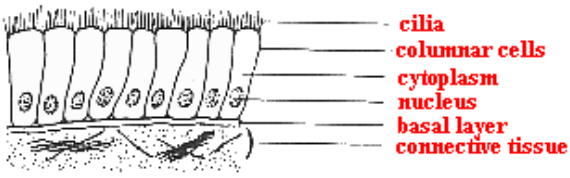


- **Simple Columnar Epithelium:**

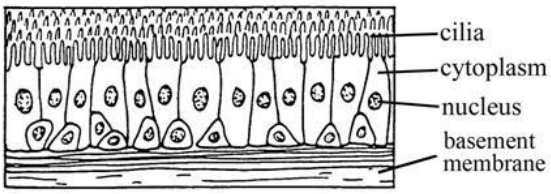
Columnar epithelial cells are elongated and rectangular-shaped. The nuclei are elongated and are usually located near the base of the cells. It either striated or non striated. *Non striated columnar epithelium* forms the lining of the stomach and gall bladder, the larger ducts near the urinary papilla of the renal pyramids.



Striated epithelium (or called simple columner with striated border or with brush border) is usually found in the small intestine (jujenum), there is goblet cells between the columnar cells in the jujenum and the microvilli is called brush border.



- **Pseudo stratified epithelium:**



Consists of a single layer of cells in which all cells attach to the basement membrane but not all cells reach the surface. It consist of different cell shapes (fusiform, columnar, and basal cells), the nuclei of these cells located at different levels so giving the tissue this pseudo stratified pattern.

It either *ciliated* or *non ciliated*. It is lining the passage of the respiratory system (e.g. treachea) which is the ciliated form. The non ciliated form present in ducts of parotid glands, lining of vas deferens of male reproductive system.

Stratified epithelium:

The stratified epithelial tissue is made of more than one layer of cells and classified according to the cell shape of its superficial layer to

1. squamous 2. cuboidal 3. columnar 4. transitional.

These typically are at sites needing a more defensive, rather than a metabolic function.

1. stratified squamous epithelial tissue:

Composed of many layers of cells, the basal layer composed of columnar or cuboidal cells, the middle cell layers composed of polygonal cells, and the superficial layer is squamous cells.

There are 2 types of stratified squamous epithelium:

- ❖ stratified squamous non- keratinized type:

It lines the moist cavities of the mouth, esophagus, vagina and anal canal. This exhibit live superficial cells contain nuclei.

- ❖ stratified squamous keratinized type:

It lines the dry areas like the skin and contains non- living cells rich with keratin intermediate filament and containing no nucleus.

2. stratified cuboidal epithelium:

Consist of 2 layers of cuboidal cells, the nuclei are large and central, is found in large excretory ducts of sweat and salivary glands.

3. stratified columnar epithelium:

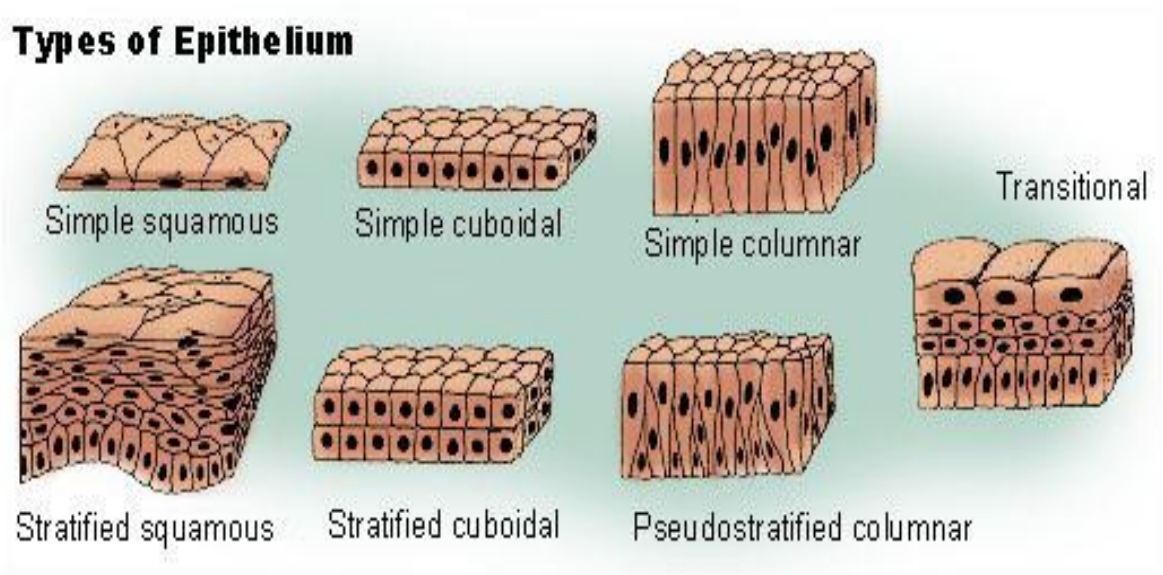
It is present only in small areas in the human body such as the largest ducts of exocrine glands and male urethra. The superficial cells are columnar and below there are polygonal cells and the basal cells either cuboidal or columnar.

4. transitional epithelium:

Is found exclusively in the excretory passages of the urinary system. It lines the urinary bladder, the ureter, and the upper part of the urethra. The basal layer cells are small polygonal or short columnar. The middle layer cells are pyramidal, while the superficial layer cells are large, with umbrella shaped or dome like cells, and sometimes are binucleated.

This type of tissue has the ability to rearrange the no. of the cell layers, depending on whether it is in a distended or contracted state.

e.g. in the contracted bladder, the epithelium consists of 5-6 layers and the cells are dome shaped while in distended bladder, the tissue is made up of 2-3 layers, the superficial layer is composed of large squamous cells, but only the basal one is composed of cuboidal cells.

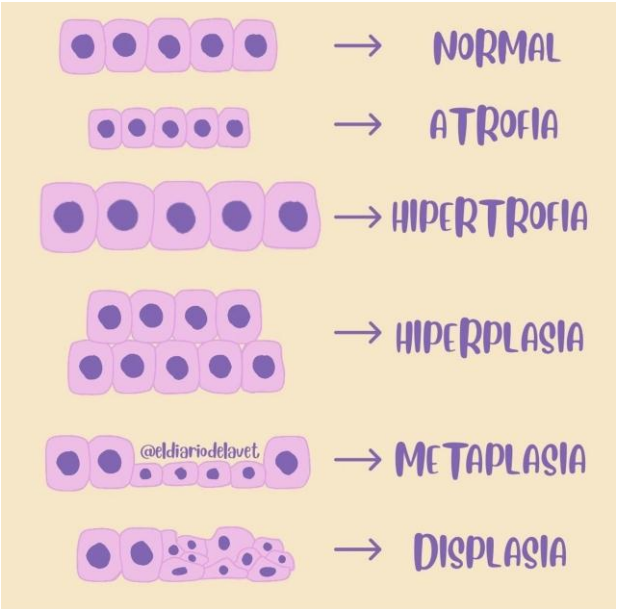


Clinical Correlation:

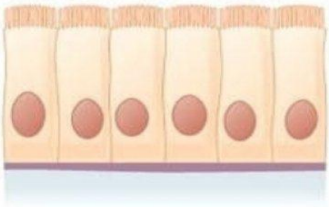
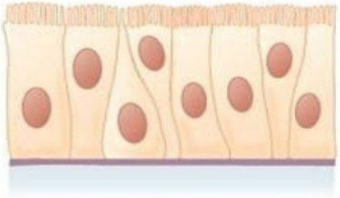
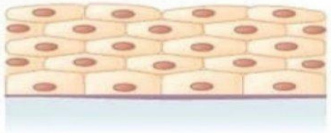
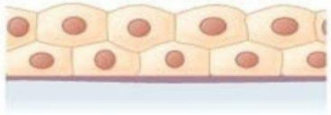
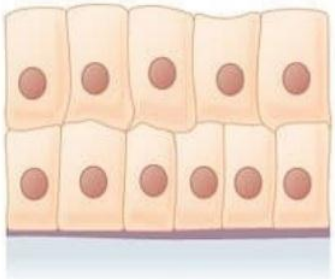
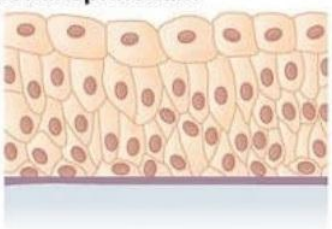
Epithelial Metaplasia

Epithelial metaplasia is a reversible conversion of one mature epithelial cell type to another mature epithelial cell type. Metaplasia is generally an adaptive response to stress, chronic inflammation, or other abnormal stimuli. The original cells are substituted by cells that are better suited to the new environment and more resistant to the effects of abnormal stimuli. The most common epithelial metaplasia is columnar-to-squamous and occurs in the glandular epithelium, where the columnar cells become replaced by the stratified squamous epithelium. For example, squamous metaplasia frequently occurs in the pseudostratified respiratory epithelium of the trachea and bronchi in response to prolonged exposure to cigarette smoke.

Metaplasia is usually a reversible phenomenon, and if the stimulus that caused metaplasia is removed, tissues return to their normal pattern of differentiation. If abnormal stimuli persist for a long time, squamous metaplastic cells may transform into squamous cell carcinoma. Cancers of the lung often originate from squamous metaplastic epithelium. Squamous columnar epithelium may give rise to glandular adenocarcinomas.



When metaplasia is diagnosed, all efforts should be directed toward removing the pathogenic stimulus i.e., cessation of smoking and monitoring the metaplastic site to ensure that cancerous changes do not begin to develop.

Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch