Epithelial Tissues

Epithelia separate the internal environment from the external environment by forming sheets of polarized cells held together by specialized junctional complexes and cell adhesion molecules. Epithelial cells participate in embryo morphogenesis and organ development in response to intrinsic and extrinsic signaling by tailoring cell proliferation, differentiation and cell death. We address the structural characteristics of epithelial cells within a biochemical and molecular framework as an introduction to the transition from a normal to a pathologic status.

General classification of epithelia

The epithelium is a tightly cohesive sheet of cells that covers or lines body surfaces (for example, skin, intestine, secretory ducts) and forms the functional units of secretory glands (for example, salivary glands, liver).

The traditional classification and nomenclature of different types of epithelia are based on two parameters:
1. The **shapes of individual cells.**
2. **The arrangement of the cells in one or more layers** .

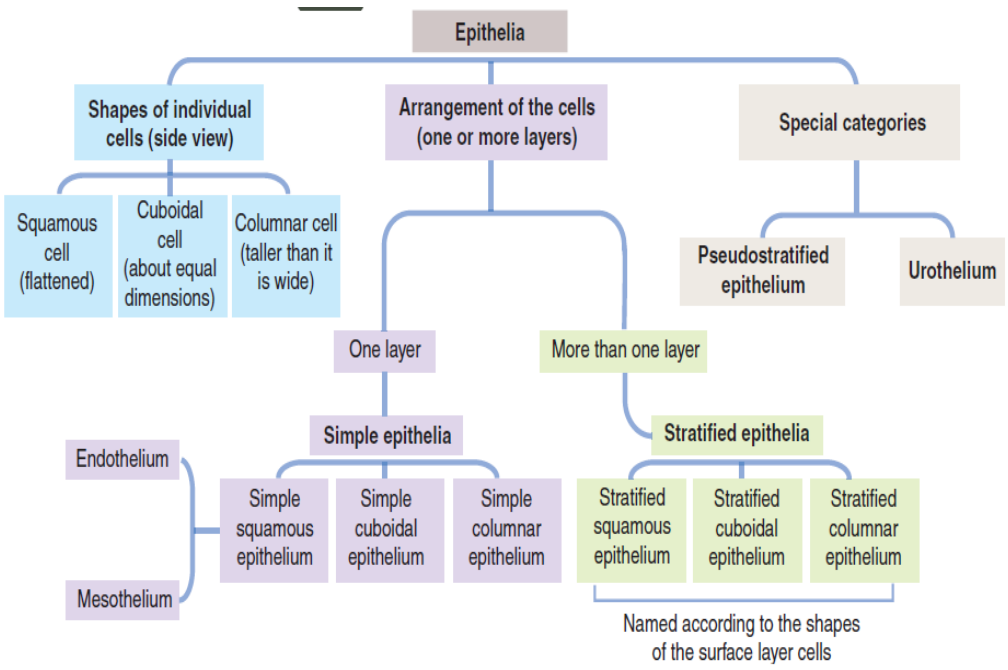
Individual epithelial cells can be flattened (**squamous cells**), have equal dimensions (**cuboidal cells**), and be taller than wider (**columnar cells**). According to the number of cell layers, an epithelium consisting of a **single cell layer** is classified as **simple epithelium. Simple epithelia**, in turn, are subdivided into **simple squamous epithelium**, **simple cuboidal epithelium**, and **simple columnar epithelium**, according to the shape of their cell components.

The specific name **endothelium** is used for the simple squamous epithelium lining the blood and lymphatic vessels. **Mesothelium** is the simple squamous epithelium lining all body cavities (peritoneum, pericardium, and pleura). **Stratified epithelia** are composed of **more than one cell layer**. Stratified epithelia are subclassified according to the shapes of the cells at the superficial or outer layer into **stratified squamous epithelium**, **stratified cuboidal epithelium**, and **stratified columnar epithelium**. Stratified squamous is the epithelium most frequently found and can be subdivided into **moderately keratinized (**also known as nonkeratinizing**)** or **highly keratinized** types .

The cells of the outer layer of a nonkeratinizing squamous epithelium **retain nuclei** (for example, esophagus and vagina). **Nuclei are absent in the outer layer of the highly keratinized stratified squamous epithelium** (for example, the epidermis of the skin). Stratified epithelia have **basal cells** aligned along the basal lamina. Basal cells are mitotically active and continuously replace the differentiating cells of the upper layers. Although rare, there are also **stratified cuboidal epithelia** (for example, in the ovarian follicles) and **stratified cuboidal epithelia** (for example, lining the intralobular ducts of salivary glands).

Two special categories are the **pseudostratified epithelium** and the **urothelium**. The pseudostratified epithelium consists of basal and columnar cells resting on the basal lamina. Only the columnar cells reach the luminal surface. Because the nuclei of the basal and columnar cells are seen at different levels,
one has the impression of a stratified epithelial organization.
Within this category are the **pseudostratified columnar ciliated epithelium** of the trachea and the **pseudostratified columnar epithelium with stereocilia** of the epididymis

The epithelium of the human urinary passages, also referred to as **urothelium**, has the characteristics of a pseudostratified epithelium: it consists of basal cells, intermediate cells and columnar dome-shaped cells, each extending thin cytoplasmic processes reaching the basal lamina . An important feature of this epithelium is its transitional height that varies with distention and contraction of the organ .



Main characteristics of epithelia:

• Epithelia line and cover all body surfaces except the articular cartilage, the enamel of the tooth, and the anterior surface of the iris.
• The basic functions of epithelia are **protection** (skin), **absorption** (small and large intestine), **transport of material** at the surface (mediated by cilia), **secretion** (glands), **excretion** (tubules of the kidneys), **gas exchange** (lung alveolus), and **gliding between surfaces** (mesothelium).

• Most epithelial cells renew continuously by mitosis.
• Epithelia lack a direct blood and lymphatic supply. Nutrients are delivered by diffusion.

• Epithelial cells have almost no free intercellular substances (in contrast to connective tissue).

• The cohesive nature of an epithelium is maintained by **cell adhesion molecules** and **junctional complexes**.

• Epithelia are anchored to a **basal lamina**. The basal lamina and connective tissue components cooperate to form the **basement membrane**.

• Epithelia have structural and functional **polarity**.

Epithelial cell polarity

An important aspect of an epithelium is its **polarity**.
Polarity is essential to carry out specific functions of the various organ systems. Polarity is determined by the distribution of proteins and lipids and the rearrangement of the cytoskeleton. Most epithelial cells lining surfaces and cavities and have three **geometric** domains :

1. The **apical (uppermost) domain** is exposed to the lumen or external environment and displays **apical differentiations**.

2. The l**ateral domain** faces neighboring epithelial cells linked to each other by **cell adhesion molecules** and **junctional complexes**.

3. The **basal domain** is associated with a **basal lamina** that separates the epithelium from underlying connective tissue, representing the internal environment. The basal lamina, of epithelial cell origin, is reinforced by components of the connective tissue.

For example, the apical domain has structures important for the **protection** of the epithelial surface (such as **cilia** in the respiratory tract) or for the **absorption** of substances (such as **microvilli** in the intestinal epithelium). In contrast, the basolateral domain facilitates directional or vectorial transport
functions prevented from trespassing the sealing junctions.

Apical differentiations

The **apical domain** of some epithelial cells can display
three types of differentiation:
1. **Cilia.**
2. **Microvilli.**
3. **Stereocilia.**

*CILIA :There are two types of **cilia** (singular, **cilium**): **multiple motile cilia** and a **single** or a **primary non-motile cilium**.

Multiple motile cilia function to **coordinate fluid or cargo flow on the surface of an epithelium.** The trachea and the oviduct are lined by **ciliated epithelial cells**. In these epithelia, ciliary activity is important for the local defense of the respiratory system and for the transport of the fertilized egg tothe uterine cavity.

Some cells have a **single** or **primary non-motile cilium** . its act as a sensory antenna for the cell, receiving signals from other cells or fluids nearby.

- In the kidney, for example, cilia bend with urine flow and send a signal to alert the cells that there is a flow of urine.
- In the eye, non-motile cilia are found inside the light-sensitive cells (photoreceptors) of the retina. These cilia act like microscopic train-tracks, and allow the transport of vital molecules from one end of the photoreceptor to the other. The importance of a single cilium emerges from rare recessive human disorders known as **ciliopathies** caused by structural or functional abnormalities of cilia.

***MCROVILLI:** (singular, **microvillus**) are finger-like cell projections of the apical epithelial cell surface containing a core of cross-linked microfilaments. The intestinal epithelium and portions of the nephron in the kidney are lined by epithelial cells with microvilli forming a **brush**

border. In general, a brush border indicates the **absorptive** function of the cell.

***STEROCILIA**(stereovilli) (singular, **stereocilium**) are long and **branching** finger-like projections of the apical epithelial cell surface. Similar to microvilli,Stereocilia/stereovilli are typical of the epithelial lining of the epididymis and contribute to the process of sperm maturation occurring in this organ.

Cell junctions

cell junctions are necessary for providing stronger stability. In addition, the movement of solutes, ions, and water through an epithelial layer occurs **across** and **between** individual cell components.
Cell junctions are **symmetrical** structures formed between two adjacent cells. There are three major classes of cell junctions:

1. Tight junctions.
2. Anchoring junctions.
3. Gap or **communicating junctions.**

*Tight junctions

Tight junctions (also called **occluding junctions**) have two major functions:

1. They determine **epithelial cell polarity** by separating the apical domain from the basolateral domain and preventing the free diffusion of lipids and proteins between them.

2. They prevent the free passage of substances across an epithelial cell layer (**paracellular pathway barrier**).

Anchoring junctions

Anchoring junctions are found below the tight junctions, usually near the apical surface of an epithelium.
There are three classes of **anchoring junctions** Cell adhesion molecules
1. The **zonula adherens** or **belt desmosome** Similar to the tight junctions, the **zonula adherens**
is a **beltlike junction**.

2. The **macula adherens** or **spot desmosome** (also called **desmosome**) is a **spotlike** junction associated with **keratin intermediate filaments.**

3. The **hemidesmosome** are **asymmetrical** structures anchoring the basal domain of an epithelial cell to the underlying basal lamina

*Gap junctions or communicating junctions **are symmetrical communicating junctions** formed by integral membrane proteins called **connexins**.

Basement membrane

The basement membrane consists of two components

1. The **basal lamina**, a sheet like extracellular matrix in direct contact with epithelial cell surfaces. The basal lamina results from the self-assembly of laminin molecules with type IV collagen, and proteoglycans.

2. A **reticular lamina**, formed by type III collagen fibers, supports the basal lamina and is continuous with the connective tissue.

The basal and reticular laminae can be distinguished by electron microscopy. Under the light microscope, the combined basal and reticular laminae receive the name of basement membrane, which can be recognized by the **periodic acid–Schiff** (**PAS**) stain.