The human organism contains different types of tissues, viz. muscle tissue, nervous tissue, connective tissue, and epithelial tissue. The epithelium forms the lining of the organs of the body, the vessels, cavities, and the skin. It is, therefore, the outermost layer that directly comes in contact with other chemical molecules. The epithelial cell membrane has been modified to perform its specific functions like absorption and secretion or act as a barrier.

Types of Epithelium

There are 3 basic types of epithelial cells. Each type is further categorized into simple type, if it is a single layer of cells, or stratified if arranged in multiple layers.

The squamous epithelium is made up of flattened cells. The simple squamous epithelium is present in areas of the body where diffusion, absorption or filtration takes place as the flattened structure of the cells decreases the diffusion pathway. The stratified squamous epithelium being multi-layered protects the organs from mechanical or chemical insult.

The cuboidal epithelium is made up of cuboid-shaped cells with a central nucleus. They are present in the areas of the body where the secretory function is required such as the pancreatic ducts. The columnar epithelium consists of elongated cells. These cells may have cilia present on their surface and form pseudo-stratified ciliated columnar epithelium. The cilia entrap particles and move them towards the external orifice, e.g., ciliated columnar epithelium in the airways.
Surfaces of Epithelial Cells

An epithelial cell typically has 4 surfaces:

- The apical surface, which faces the lumen. It is also known as the luminal border.
- The 2 lateral surfaces, through which 1 epithelial cell communicates with the epithelial cells on each side.
- The basolateral surface, which is opposite to the apical surface and faces the basement membrane.

Modification of Epithelial Cells

Cilia, villi, and microvilli

As mentioned above, the cilia are present on the columnar epithelium and produce to and from motion to entrap the particles and move them towards a specific direction parallel to the surface of the epithelium. They are, therefore, included in the primary defense of the body, in addition to other mechanical barriers. The villi and microvilli are present on the absorptive surfaces as they increase the surface area for absorption without increasing the size of the epithelium.
Channel proteins and carrier proteins

In order to move molecules from the lumen into the cells, from cells into the blood or vice versa, channel proteins and carrier proteins are present on the apical and basolateral surfaces of the epithelial cells.

The channel proteins allow small ions to move across the cell membrane. These are often gated to open and close in response to a certain stimulus.

Carrier proteins move large molecules across the cell membrane. In case the molecules are moved against the concentration gradient, these carrier proteins utilize an ATP molecule. They can carry 2 or more molecules at a time. When these molecules travel in the same direction, the action is called co-transport. When they move in opposite directions, it is termed as counter-transport.

Sodium-potassium (Na-K) pump

The Na-K pump is a carrier protein that moves 3 Na ions out and 2 K ions into the cell, against the concentration gradient. An ATP molecule is broken to give the energy required for the transport of ions.
Aquaporins

Aquaporins are specialized channel proteins present on the apical and basolateral surfaces of the epithelial cells. These are present in areas where excessive water reabsorption is required, e.g., the collecting duct of a nephron. Aquaporins allow the transcellular flow of water molecules.

Epithelial cell junctions

A cell junction is a multi-protein complex that provides contact between neighboring cells or between the cell and the extracellular matrix. There are 3 types of cell junctions present in an epithelial cell:

**Tight junctions:**

They act as a barrier to regulate the movement of molecules from one cell to another through extracellular spaces by diffusion or active transport. These are present on the lateral surfaces of the epithelial cells. They can be tighter with high electrical resistance or leakier with low electrical resistance.
**Gap junctions:**

These are also known as communicating junctions. They allow the cytoplasmic connection between 2 neighboring cells without the involvement of extracellular fluid. The connexin proteins form a cylindrical structure between the lateral surfaces of 2 adjacent epithelial cells. This cylindrical structure with pores is called the connexon. Its main role is to allow the free movement between the cells of ions and small molecules.

**Anchoring junctions:**

Anchoring junctions are made of anchoring proteins, which link the cytoskeleton of 1 cell to the cytoskeleton of another cell or to the extracellular matrix. The adhering junctions and desmosomes are present on the lateral surface of 2 epithelial cells, while the hemidesmosomes are present on the basolateral surfaces.

**Adhering junctions**

Adhering junctions consist of actin and cadherin protein filaments. Since actin is a contractile protein, the adhering junctions are also responsible for the change in the shape of sheets of the cells. These junctions are meant to hold epithelial cells together.

**Desmosomes** are made of intermediate filaments composed of keratin and desmin. Cadherin acts as a transmembrane linker. They are specialized to hold cells tightly together.

**Hemi-desmosomes** form a bridge between the epithelial cells and the extracellular matrix on the basolateral surface. They have intermediate filaments as the cytoskeletal anchor and integrin as the transmembrane linker.

Trans-Epithelial Transport

Transepithelial transport is the transport of a molecule from the lumen into the blood. In this case, the molecule, which needs to be absorbed, has to travel through more than 1 membrane surface.
Therefore, the transepithelial membrane potential difference is measured; it is the voltage across the epithelium and the sum of the membrane potentials for the outer and inner cell membranes.

It is also a useful diagnostic tool for the diagnosis of cystic fibrosis, in which the transepithelial membrane potential is more negative. In cystic fibrosis, the impaired cystic fibrosis transmembrane regulator (CFTR) causes the increased secretion of chloride (Cl) ions into the lumen and the increased reabsorption of Na ions into the epithelial cells. This results in thick mucus secretions.

References


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