Histology

Epithelium — Functions and Types of Epithelial Tissue

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The epithelial tissue is 1 of the 4 main types of tissue structures of the human body, along with muscle tissue, nerve tissue, and connective tissue. Tissues are cellular organizations with similar specializations. In addition to the systematic structure, it is important for every physician - not only for dermatologists - to know the distribution and function of all types of epithelial tissue in order to transfer this fundamental knowledge into the pathology.

Definition of the Epithelial Tissue

The epithelium is a complex of specialized cellular organizations arranged into sheets without significant intercellular substance. They always occupy boundary surfaces of the body, i.e. they are located on the skin surface or on the internal surface of hollow organs. From an embryological perspective, epithelial tissue derives from all 3 germ layers. Depending on their function, epithelial cells can be flat, cuboidal or cylindrical and are organized in either 1 or several layers. Epithelial cells connect to 2 different spaces and thus have an apical and a basal pole.
Apical is derived from the term apex which means peak. Basal, on the other hand, is derived from the base. In the medical nomenclature for hollow organs, the term luminal is often used to refer to the pole which faces the lumen. The pole oriented away from the lumen is called abluminal. The cell’s sidewalls are often structurally and functionally correspondent to the base and are referred to as the basolateral membrane. In other parts, epithelial tissues form the inner lining and external lining of body parts. To summarize, the apical pole faces the surface, while the basal pole is attached to the connective tissue located below the epithelium.

Types of epithelial tissue

There are 3 different types of epithelial tissue: *squamous, cuboidal, and columnar*. The differentiation and classification of the types of epithelial tissue are based on the shape of the cell (e.g., cuboidal), the arrangement (e.g., single-layered) and the cell surface (e.g., by kinocilia in the respiratory epithelium).
Functions of the epithelial tissue

General functions of the epithelial tissue include a **barrier (protection of tissues from radiation, desiccation, and invasion by pathogens and toxins)**, secretion (**substance release of hormones, sweat, mucus, and enzymes**) and absorption (**substance intake**). It contains no blood vessels and no nerve supply; the “cell nourishment” takes place between individual epithelial cells through the intercellular space.

Characteristics of the epithelial tissue

The epithelial tissue has a general characteristic that their cells are closely bound to each other through specialized structures such as tight junctions, desmosomes, interdigitations, gap junctions, and intercellular bridges. These gap junctions help in communication with 2 cells together by cementing each other. They constitute the linings of organs and body parts; they have 1 surface that is not attached to any cell, either exposed to the external environment or the lumen of an organ. They do not possess blood vessels and their nutrients requirement is fulfilled by connective tissue forming the basement membrane.

Basal Membrane

Epithelial cellular organizations are located on the basal membrane. The basal membrane is a thin extracellular matrix. It consists of the basal lamina, which is itself divided into the laminae rara externa and interna, the lamina densa, and the lamina fibroreticularis (except in renal corpuscles).

The function of the basal membrane is to stabilize the epithelial and endothelial cell layers. The attachment of cells is achieved with the help of syndecan or laminin and integrin. Microfilaments attach the lamina fibroreticularis to the perlecan in the lamina densa. Epithelial cells regenerate on the basal membrane.
Surface Epithelium

The surface epithelium primarily has barrier and transport functions. It is a mechanical and chemical barrier that prevents the uncontrolled substance exchange. It takes substances in (absorption) or releases them into the tissue (secretion).

Single-layered (Simple) Epithelium

The simple epithelial tissue is a closed network of flat epithelial cells. These are located on the basal membrane. It is composed of a single layer of cells that are specialized in diffusion, osmosis, filtration, secretion, and absorption. The simple epithelial tissue is found in the alveolar epithelium (pulmonary alveolus), the endothelium (lining of blood vessels and lymph vessels), and the mesothelium (lining of the body cavities). Medically, the simple epithelium is further divided into 2 types: simple cuboidal epithelium and simple columnar epithelium.

Simple cuboidal epithelium

The cells of the cuboidal epithelium are equally tall as they are wide and have a central round nucleus. The simple cuboidal epithelium is found, e.g., in kidney tubules and seminiferous tubules as well as in glandular excretory ducts and as retinal pigment epithelium and lens epithelium in the eye. They have large cytoplasmic content so, they perform important complex functions like absorption and secretion. They are found in exocrine glands, endocrine glands, and ducts of endocrine glands.
Simple columnar epithelium

Image: Electron microscopic image of human jejunum epithelium cells with densely packed microvilli.

The simple columnar epithelium consists of longitudinal-oval cells with a uniform nucleus, aligned in a row mostly located at the base of the cell. Their apical surface is often covered with microvilli to facilitate a strong absorption. This epithelium type can be found in high secretory areas and absorptive areas, e.g., in the stomach, intestines, gallbladder, fallopian tubes, and uterus.

Stratified epithelium

The classification of the stratified epithelium is based on the cell shape of the superficial layer. If, e.g., the superficial layer consists of flat cells, it is part of stratified squamous epithelium. They are multilayered found in parts where protection from mechanical or chemical abuse is essential. The stratified epithelium is classified into 3 different forms.

Stratified, non-keratinized squamous epithelium

The cell shape of the stratified, non-keratinized squamous epithelium changes from the basal toward the free surface and is divided into 4 sections:

- Stratum basale: prismatic dark-colored cells with a round nucleus
- Stratum parabasale: polygonal dark-colored cells arranged in stratified tissue
- Stratum spinosum: polyhedral, polygonal cells connected by desmosomes
- Stratum superficiale: flattened cells degraded and desquamated in the outermost layers

This type of epithelium is found in the mucosa of the oral cavity and esophagus, as well as the vagina, and in the eye (corneal epithelium).
The outermost cell layers of the epithelium consist of flattened cells with no nuclei and cytoplasm, converting into scales. They are called the stratum corneum, and their purpose is to mechanically protect underlying tissue from dehydration.

**The stratified, keratinized squamous epithelium is divided into 5 sections:**

- Stratum basale
- Stratum spinosum
- Stratum granulosum: flattened cells with keratohyalin granules
- Stratum lucidum: conversion area
- Stratum corneum

The above structure shows an example of the typical skin epithelium—the epidermis. It is the outermost layer of the 3 layers that make up the skin; the inner layers are the dermis and hypodermis.

**Transitional epithelium (urothelium)**
The urothelium consists of a basal layer, several intermediate cell layers, and an umbrella cell layer. Umbrella cells (superficial cells) are large and often have 2 nuclei. The crusta, a very dense network of cytoplasm, is located beneath its apical membrane. The plasma membrane consists predominantly of rigid plaques containing uroplakin (transmembrane proteins). Transitional epithelium is primarily found in the efferent urinary tract, i.e. in the renal pelvis, ureter, urinary bladder, and the initial part of the urethra.

Pseudostratified Epithelium

The important characteristic of this epithelium type is that their cells do touch the basal membrane, but not all of them reach the free surface. The cells that reach the free surface belong to the columnar type. The cells that do not reach the free surface rest on the basal lamina and have a round nucleus. The term pseudostratified is derived from the appearance of this epithelium. Because the cell nuclei appear at different heights, it conveys the erroneous impression that there is more than 1 layer of cells. The non-ciliated pseudostratified epithelium is found, e.g., in the epidydimal duct and vas deferens, and ciliated pseudostratified epithelium with kinocilium is found in the respiratory tract (nasal cavity and bronchi).

Overview of the Epithelium

<table>
<thead>
<tr>
<th>Cells</th>
<th>Location</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple squamous epithelium</td>
<td>Air sacs of lungs; lining of the heart; blood vessels and lymphatic vessels</td>
<td>Allows materials to pass through by diffusion and filtration; secretes lubricating substance</td>
</tr>
<tr>
<td>Simple cuboidal epithelium</td>
<td>In ducts and secretory portions of glands; in kidney tubules</td>
<td>Secretes and absorbs</td>
</tr>
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<tr>
<td>Simple columnar epithelium</td>
<td>Ciliated epithelium in the bronchi, fallopian tubes, and uterus; smooth (non-ciliated) epithelium in the digestive tract and urinary bladder</td>
<td>Absorbs; secretes mucus and enzymes</td>
</tr>
<tr>
<td>Pseudostratified epithelium</td>
<td>Ciliated epithelium lines the trachea and a large part of the upper digestive tract</td>
<td>Secretes mucus, which is moved by ciliated epithelium</td>
</tr>
<tr>
<td>Stratified squamous epithelium</td>
<td>Lines the esophagus, mouth, and vagina</td>
<td>Protects against abrasion</td>
</tr>
<tr>
<td>Stratified cuboidal epithelium</td>
<td>Sweat glands, salivary glands, and mammary glands</td>
<td>Protects</td>
</tr>
<tr>
<td>Stratified columnar epithelium</td>
<td>Male urethra, some glandular ducts</td>
<td>Secretes and protects</td>
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<tr>
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<td>-----------------------</td>
</tr>
<tr>
<td>Transitional epithelium</td>
<td>Lines urinary bladder, urethra, and ureters</td>
<td>Allows the urinary tracts to stretch</td>
</tr>
</tbody>
</table>

**Glandular Epithelium**

Associations of particularly differentiated and specialized epithelial cells are called glandular epithelium and consequently located in the glandular tissue. They are specialized in producing substances such as enzymes, hormones, sweat, oil, mucus, etc. and releasing them in the organism (secretion). The elaboration and release are carried out by external stimuli or constitutively into ducts on the surface or into the blood. Based on the specialization of the glandular epithelium, we distinguish between exocrine and endocrine glands. The classification is based, among other factors, on the number and location of secreting cells and the type of secretion.
Exocrine glands

Exocrine glands secrete their products through a duct onto the inner or outer surface of the body. They have their own ducts and extensive blood supply and are in control of hormones and nerves. Examples are salivary glands, sweat glands, tear glands, and mammary glands of the breast.

Endocrine glands

Endocrine glands release their incretions directly into the bloodstream and therefore have no excretory duct. Incretions are mostly hormones. Examples of endocrine glands are the thyroid gland, as well as the testicles and ovaries.

Pancreas: special form of glandular tissue

The pancreas has the particular anatomical and physiological characteristic of having both types of glands. Its exocrine portion passes digestive enzymes through the pancreatic duct into the duodenum, while the endocrine portion (islets of Langerhans)
produces the hormones insulin and glucagon and releases them into the body.

**Special Epithelial Pathologies**

In addition to the physiology and histology, a physician should know, understand and treat the pathology of the epithelium. Below you will see some examples of specific disease types and their symptoms.

**Mechanical damage**

In simple wounds, like cuts and scrapes, the healing process is done by the proliferation and spread of epithelial cells in 24 hours. Deep burns (3rd degree) are largely corrected by epithelial regrowth.

**Papillomas**
Papillomas are **benign epithelial tumors**. They grow in the stratified squamous epithelium. The most frequent form is the wart (basal cell papilloma), a proliferation of epithelial cells from the stratum basale of the skin. The result is a compact organized epithelial node that can keratinize.

**Adenomas**

Like the papillomas, adenomas are also **benign epithelial tumors that can grow in glands**. Adenomas can develop into malignant tumors, the so-called adenocarcinomas.

**Allergic contact dermatitis**

When in contact with a specific allergen, the skin epithelium is loosened up like a sponge by the formation of edema. This edema is an intercellular accumulation of fluid that can also converge into bubbles. Typical allergens that cause such eczema are, e.g., animal hair (epithelium allergy).

**Epithelium in urine or urine sediment**

If an unusually high concentration of epithelial cells is found in the urine or urine sediment samples, it should be assumed that a urinary tract infection has taken place. It gives rise to the need to be clarified by further analysis.

**Ichthyosis**

**Ichthyosis** refers to various forms of mostly **genetically determined skin keratinization**. Patients suffer from large scaly hyperkeratosis of the skin with impaired desquamation.
Review Questions

The answers can be found below the references.

1. **Which of the following statements about the epithelial tissue is not correct?**

   A. From an embryological perspective, epithelial tissue is derived from all 3 germ layers.
   B. Epithelial tissue has no significant intercellular substance.
   C. Epithelial tissue is found on the skin surface or on the internal surface of hollow organs.
   D. Epithelial tissue is supplied in intercellular spaces and through blood vessels.
   E. Epithelial cells have an apical and a basal pole.

2. **How many types of single-layered (simple) epithelium are there?**

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

3. **Which of the following is not a part of the basal lamina of the basal membrane?**
A. Lamina rara externa  
B. Lamina densa  
C. Lamina propria  
D. Lamina fibroreticularis  
E. Lamina rara interna

References


Correct answers: 1 D, 2C, 3C

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