Histology

Epithelium – Functions and Types of Epithelial Tissue

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The epithelial tissue is one of the four 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 and general information on the epithelium

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 three germ layers. Depending on their function, epithelial cells can be flat,
cuboidal or cylindrical and are organized in either one or several layers. Epithelial cells connect to two different spaces and thus have an **apical and a basal pole**.

Apical derives from the term apex which means peak. Basal, on the other hand, derives from 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 side walls are often structurally and functionally correspondent to the base and are referred to as **basolateral membrane**. To summarize, the apical pole faces the surface, while the basal pole is attached to the connective tissue located below the epithelium.

The differentiation and classification of the types of epithelial tissue is 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).

General functions of epithelial tissue include **barrier** (protection), **secretion** (substance release) and **absorption** (substance intake). It contains no blood vessels; the “cell nourishment” takes place between individual epithelial cells through the intercellular space.

**Types of Epithelium**

<table>
<thead>
<tr>
<th>Simple squamous</th>
<th>Simple cuboidal</th>
<th>Simple columnar</th>
<th>Transitional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratified squamous</td>
<td>Stratified cuboidal</td>
<td>Pseudostratified columnar</td>
<td></td>
</tr>
</tbody>
</table>

**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 et 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

![Image: “Schematische Darstellung des Endothels mit Astrozyten in der Blut-Hirn-Schranke” by Kuebi (added translation). License: CC BY 3.0]

The simple epithelial tissue is a **closed network of flat epithelial cells**. These are located on the basal membrane. 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 two 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.

Simple columnar epithelium
The simple columnar epithelium consists of **longitudinal-oval** cells with a uniform nucleus 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, for example, in the stomach, intestines, gallbladder, fallopian tubes and uterus.

### Stratified epithelium

The classification of stratified epithelium is based on the **cell shape of the superficial layer**. If, for example, the superficial layer consists of flat cells, it is part of a stratified squamous epithelium. The stratified epithelium is classified into three 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 four sections:

- **Stratum basale**: Prismatic dark-colored cells with 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).
Stratified, keratinized squamous epithelium

The outermost cell layers of the epithelium consist of flattened cells with no nuclei, converting into scales. They are called stratum corneum, and their purpose is to mechanically protect underlying tissue from dehydration. The stratified, keratinized squamous epithelium is divided into five sections:

- Stratum basale
- Stratum spinosum
- Stratum granulosum: Flattened cells with keratohyalin granules
- Stratum lucidum: Conversion area
- Stratum corneum

The above structure shows the typical skin epithelium (epidermis).

Transitional epithelium (urothelium)
The urothelium consists of a **basal layer**, several **intermediate cells layers** and an **umbrella cell layer**. Umbrella cells (**superficial cells**) are large and often have two 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 one layer of cells. 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).

### Video about epithelial tissue

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### Overview of the epithelium

<table>
<thead>
<tr>
<th>Cells</th>
<th>Location</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<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>---------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</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>
<tr>
<td>Simple columnar epithelium</td>
<td>Ciliated epithelium in the bronchi, fallopian tubes and uterus; smooth (non-ciliated) epithelium in digestive tract and urinary bladder</td>
<td>Absorbs; secretes mucous 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 mucous, which is moved by ciliated epithelium</td>
</tr>
<tr>
<td>Pseudostratified squamous epithelium</td>
<td>Lines the esophagus, mouth and vagina</td>
<td>Protects against abrasion</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 have specialized in producing substances and releasing them in the organism (secretion). The elaboration and release is carried out by **external stimuli** or **constitutively**. 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.

<table>
<thead>
<tr>
<th><strong>Pseudostratified cuboidal epithelium</strong></th>
<th>Sweat glands, salivary glands, mammary glands</th>
<th>Protects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pseudostratified columnar epithelium</strong></td>
<td>Male urethra, some glandular ducts</td>
<td>Secretes and protects</td>
</tr>
<tr>
<td><strong>Transitional epithelium</strong></td>
<td>Lines urinary bladder, urethra and ureters</td>
<td>Allows the urinary tracts to stretch</td>
</tr>
</tbody>
</table>

Images: “Summary of Epithelial Tissue Cells” by Phil Schatz. License: [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)
**Exocrine glands**

Exocrine glands secrete their products **through a duct onto the inner or outer surface of the body**. Examples are salivary glands, sweat glands and mammary glands of the breast.

**Endocrine glands**

Endocrine glands release their **incretions directly into the blood** stream and therefore have no excretory duct. Incretions are mostly hormones. Examples of endocrine glands are the thyroid gland, as well as testicules 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
Special epithelial pathologies

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

Papillomas
Papillomas are **benign epithelial tumors**. 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 an **edema**. This edema is an intercellular accumulation of fluid which 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 urine or urine sediment samples, it should be assumed that a **urinary tract infection** has taken place. Its causes 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.
Frequent exam questions on epithelium

The answers can be found below the reference list.

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

A. From an embryological perspective, epithelial tissue is derived from all three 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, 2B, 3C

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