КАЗАНСКИЙ (ПРИВОЛЖСКИЙ) ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ
ИНСТИТУТ ФУНДАМЕНТАЛЬНОЙ МЕДИЦИНЫ И БИОЛОГИИ
Кафедра морфологии и общей патологии

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HISTOLOGY OF THE RESPIRATORY SYSTEM ORGANS

Teaching guide

Казань – 2023

УДК 611.018
ББК 28.706.93

Печатается по решению Учебно-методической комиссии
Института фундаментальной медицины и биологии КФУ
Протокол № 6 от 26 апреля 2023 г.

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Histology of respiratory system organs: teaching guide/ A.S. Pljushkina, D.I. Andreeva, A.P. Kiyasov, A. I. Bilyalov, K.N. Sultanova. – Kazan: Vestfalika, 2023. – 26 p.
Плюшкина А. С.
Histology of respiratory system organs: учебно-методическое пособие / А.С. Плюшкина, Д.И. Андреева, А.П. Киясов, А.И. Билялов, К.Н. Султанова. – Казань: Вестфалика, 2023.– 26 с.

Настоящее учебное издание адресовано студентам второго курса медицинских специальностей, обучающихся на английском языке, где представлен методический материал по теме «Гистология органов дыхательной системы». В учебно-методическом пособии излагаются фундаментальные представления о морфологии органов дыхательной системы, даны необходимые иллюстрации и подробные описания изучаемых гистологических препаратов, а также тестовые вопросы. Учебное издание составлено в соответствии с международной гистологической номенклатурой, содержит в себе фотографии и рисунки гистологических препаратов, сделанные авторами на кафедре морфологии и общей патологии Института фундаментальной медицины и биологии КФУ и подробное описание морфологического строения органов дыхательной системы, необходимые для сдачи модуля по этому разделу.

CONTENTS

1 OBJECTIVES

This section of histology addresses to the following questions:

• Three divisions of the respiratory system and their components

• Features of the right and left lungs

• The structure of the wall of the respiratory tube

• Differences in the wall structure of the respiratory tube in different parts of the respiratory tract

• The structure of the interalveolar septum

• The structure and functions of the blood- air barrier

• Effects of the sympathetic and parasympathetic system on the smooth muscles of the bronchi

• Structure, function and location of the pleura

The pictures were created with BioRender.com

2 GENERAL FEATURES OF THE RESPIRATORY SYSTEM

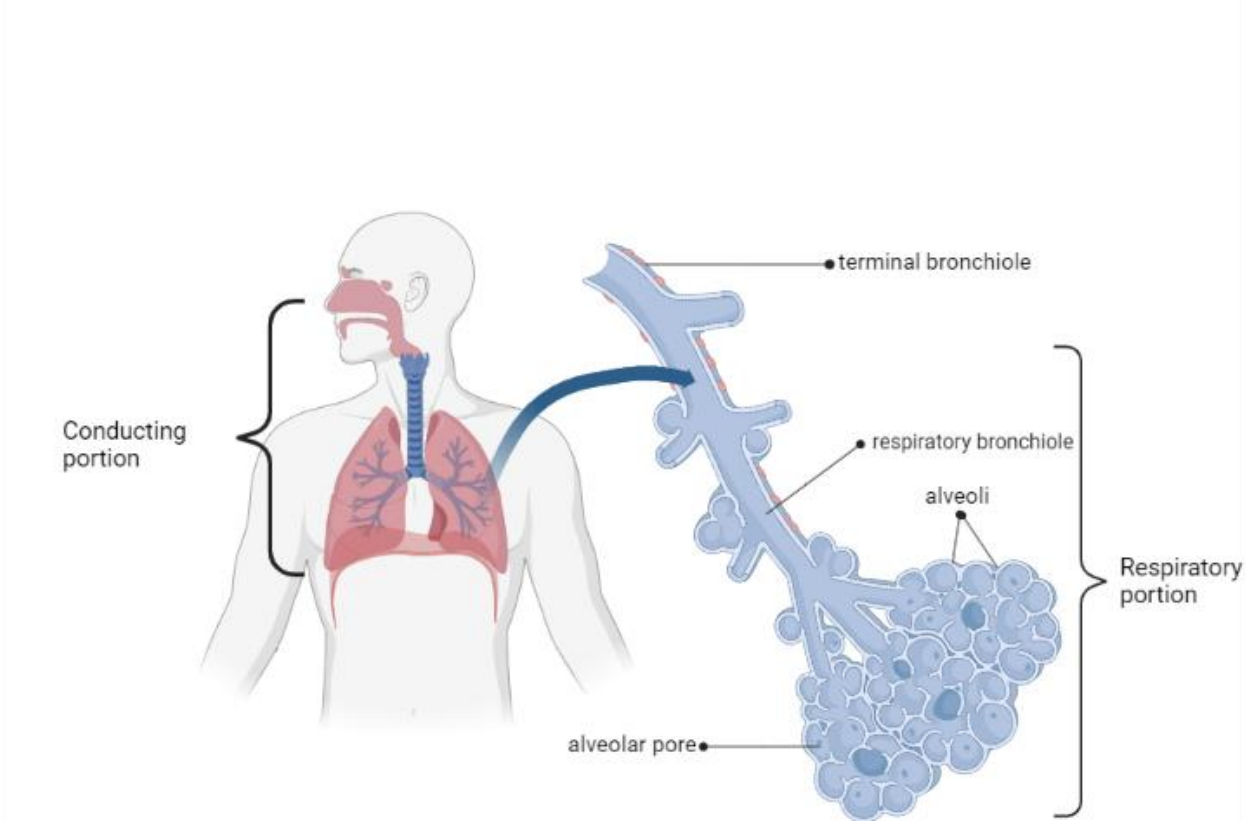
2.1. Organs of the respiratory system and their main functions

The respiratory system includes the lungs, airways (nasopharynx, larynx, trachea, bronchi) and associated structures. According to the specialization in gas exchange between the blood and air, including the uptake of oxygen and the release of carbon dioxide, the respiratory system can be functionally divided into three parts: **the conducting portion, the respiratory portion, and the ventilating mechanism**.

The ventilating mechanism stimulates air to move into the lungs (inhale) and out of the lungs (exhale). This part of the respiratory system includes diaphragm, thorax, intercostal muscles, abdominal muscles, and elastic connective tissue in the lungs. Inhalation is an active process and involves muscle contraction. During this process the intercostal muscles lift the ribs, while the diaphragm and abdominal muscles lower the floor of the thoracic cavity. As a result, the volume of the thoracic cavity increases, creating a vacuum and allowing air to go into the airways. Air, passing through the airways, expands their lumen, fills the lungs, the elastic connective tissue also stretches. Exhalation is a passive process: relaxation of the muscles leads to a retraction of elastic fibers, reducing the volume of the lungs and pushing out the air.

The conducting portion (the airways) (pic.1) is a system of tubes, the wall of which is designed in such a way as to conduct air to the place of gas exchange and back without falling under the pressure created by the ventilating mechanism. Air conditioning also takes place here: warming, cleaning, and moistening. The airways include the nasal cavity, nasopharynx, larynx, trachea, bronchi, bronchioles, and terminal bronchioles.

The respiratory portion is distinguished by alveoli, small bag-like structures, the thin wall of which provides gas exchange between air and blood. Alveoli form clusters in the terminal sections of the bronchial tree. The entrance to the alveoli opens on the walls of the respiratory bronchioles, alveolar ducts, atria, and alveolar sacs (like a hostel corridor, from which doors open to a large number of rooms).



Picture 1- Schematic diagram of the respiratory system

2.2. Wall structure

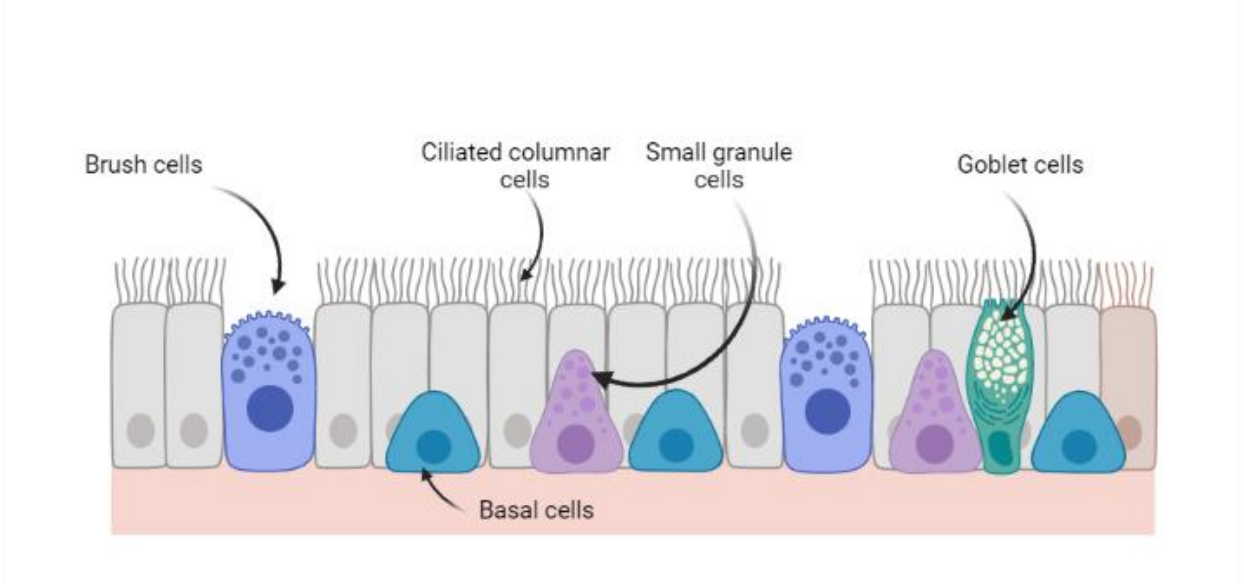
The walls of the organs of the respiratory system consist of several layers: 1) **respiratory mucosa** (endodermal epithelium and lamina propria with mucous glands), 2) **fibromusculocartilagineous layer** containing mostly hyaline cartilage that prevents the walls from falling off, and muscle tissue that regulates the diameter of the lumen, and 3) **adventitial layer** containing collagen and elastic fibers. All layers of the wall, except for the epithelium, develop from the lateral mesoderm (splanchnomesoderm).

1. Respiratory mucosa is composed of respiratory epithelium and lamina propria.

Respiratory epithelium (pic. 2)- pseudostratified columnar ciliated epithelium with goblet cells. It lines most of the airways. As the airways branch and the bronchial diameter decreases, the height of the epithelial cells decreases, the number of goblet cells decreases, and then the number of cilia also decreases.

Types of epithelial cells.

- **Ciliated columnar cells** predominate in the respiratory epithelium. Each cell has about 300 mobile cilia on the apical surface, associated with basal bodies in the apical part of the cytoplasm (remember how cilia are arranged).
- **Goblet cells** are the next numerous types of epithelial cells. They produce a mucous secret that covers the epithelium, removes bacteria and foreign particles from the inhaled air. The movement of the columnar cell cilia removes this mucus from the airways in the opposite direction to the inhaled air, to the oral cavity.
- **Brush cells** are columnar, but lack of cilia and often have microvilli on the apical surface. Among them, two types of cells are distinguished: some are immature cells, which can give rise to ciliated or goblet cells; the others have nerve endings on their basal surface and are able to perform a receptor function.
- **Small granule cells**, resembling basal cells, but contain numerous cytoplasmic granules. They are endocrine cells of the diffuse neuroendocrine system (DNES). **Basal cells** are small round cells that are located on the basal plate and do not reach the apical surface. They may be stem cells that give rise to other cell types of respiratory epithelia.



Picture 2- Respiratory epithelium

As you remember from the epithelium tissues classes, the epithelium can undergo ***metaplasia*** *in response to a change in the microenvironment. Thus, in the respiratory epithelium of smokers, more goblet cells appear in response to higher levels of inhaled air pollution, while the number of ciliated cells decreases under the influence of carbon monoxide. These changes can lead to impaired patency of the small airways but are reversible.*

The lamina propria consists of loose connective tissue, contains mucous glands in the upper airways (from the nasal cavity to the bronchi). The content of elastic fibers increases towards the alveoli.

2. Fibromusculocartilagineous layer. The skeletal connective tissue (cartilage and bone tissue) that provides the framework for the airways is present in the nasal cavity and only cartilage tissue in the larynx, trachea and bronchi. As the diameter of the bronchi decreases, the amount of the cartilage tissue gradually decreases, and the cartilage completely disappears at the level of the bronchioles.

Smooth muscle tissue appears at the level of the trachea, where it connects the ends of the C-shaped cartilages. The wall of the bronchi is surrounded in a spiral by many layers of smooth muscle cells. The thickness of the muscle layer gradually decreases, disappearing at the level of the alveolar ducts.

3.Adventitia is composed of loose connective tissue.

3 CONDUCTING PORTION

3.1 Nasal cavity

The nasal septum divides the nasal cavity into two chambers. The nasal cavity includes **the vestibule** and **the nasal cavity proper**, which differ in the location, size and structure of the walls.

A. The vestibule is a smaller but wider part of the nasal cavity, located anteriorly, just behind the nostrils. Its framework is made by cartilage. The vestibule is lined by stratified squamous keratinized epithelium as a continuation of the epidermis covering the external nose. In the initial region of the vestibule there are sebaceous and sweat glands, as well as short thick hair, vibrissae, which filter large particles from the inhaled air. Posteriorly, the epithelium changes to stratified squamous non-keratinized, and when moving into the nasal cavity proper, to the respiratory epithelium.

B. The nasal cavity proper is the larger, narrower, posterior portion of the nasal cavity. It is lined by respiratory epithelium, in its underlying lamina propria there

are mucous glands and venous plexuses. Venous plexuses ("swelling bodies"), located in the mucosa of both halves of the nasal cavity, are filled with blood alternately every 20-30 minutes. This restricts the flow of air in one of the halves of the nasal cavity, thereby controlling the drying of the mucosa. The arterial plexuses of the wall of the nasal cavity consist of vascular arcades, through which blood flows from back to front, that is, opposite to the flow of inhaled air, additionally warming it. The framework of nasal cavity proper is made by bone tissue.

The medial wall of the nasal cavity proper is formed by bony and cartilaginous septum (the nasal septum). The lateral walls are thrown into folds by the presence of three shelf-like, bony projections called conchae. They increase surface area and cause turbulence in airflow to allow more efficient conditioning of inspired air.

The upper wall of the nasal cavity and the superior conchae are lined by specialized **olfactory epithelium** (pic.3). The olfactory epithelium, like the respiratory epithelium, is also pseudostratified, but it lacks goblet cells and contains very different cell types.

The olfactory epithelium consists of three cell types:

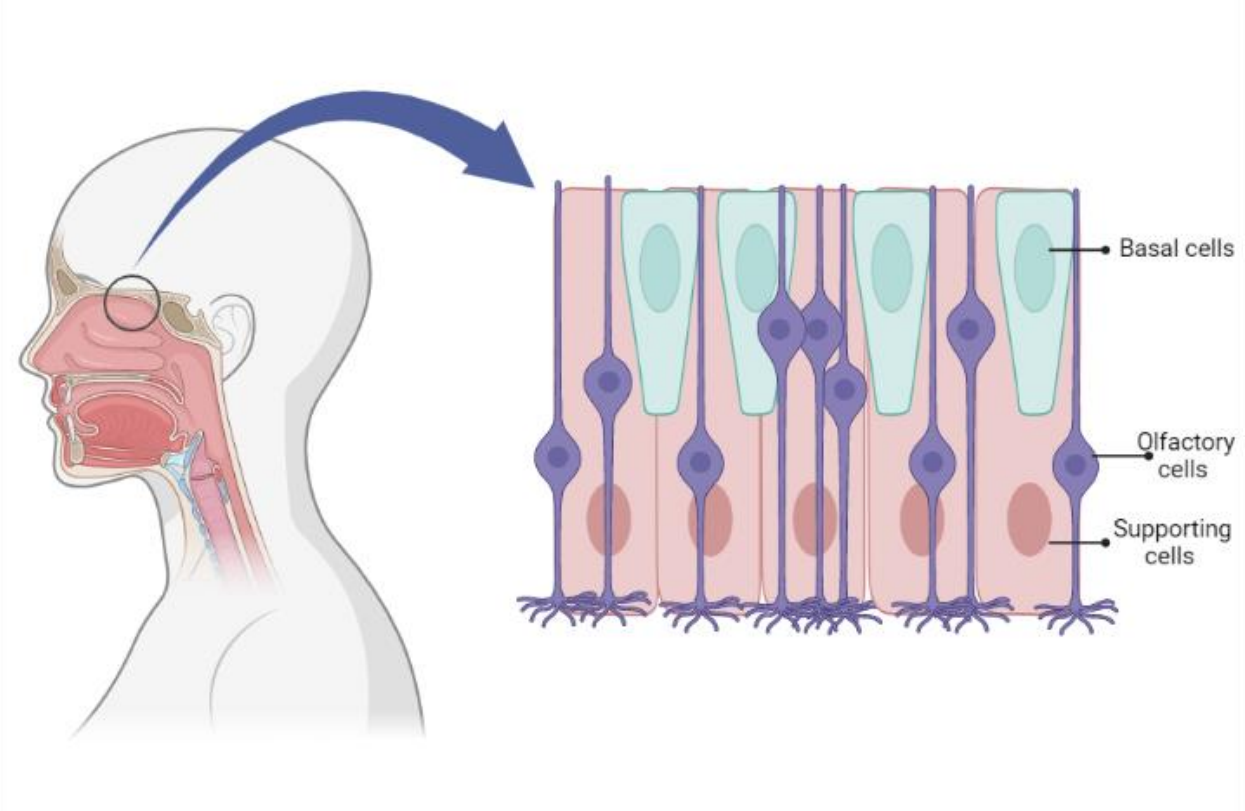
a. Olfactory cells are bipolar neurons that develop from the embryonic neuroectoderm. Their large round pale nucleus forms the middle layer of nuclei in the epithelium. From the top of the cells, 6-20 long nonmotile cilia are projected into the nasal cavity, which increase the receptor surface. The action of a chemical on the cilium receptors forms a potential. The base of each cell continues into an axon, which penetrates the basal lamina and joins similar axons to form bundles of nerve fibers, which transport the impulse to the brain.

b. Supporting cells are a cylindrical shape cells with an extension at the apical pole, covered with microvilli. The cells contain an endoplasmic reticulum, lysosomes, lipid droplets, and a red-brown pigment that helps distinguish the olfactory epithelium from the respiratory epithelium. Their pale nuclei occupy the superficial third of olfactory epithelium. Supporting cells are believed to provide physical support, nourishment and electrical insulation for the olfactory cells.

c. Basal cells are small conical cells at the base of the olfactory epithelium. Cell nuclei occupy the basal third of olfactory epithelium. The basal cells have considerable proliferative capacity and can replace both supporting and olfactory cells.

The olfactory epithelium is underlined by lamina propria which is composed of richly vascularized connective tissue. It contains Bowman glands (olfactory glands), which produce a serous secret with IgA, lysozyme and odorant binding

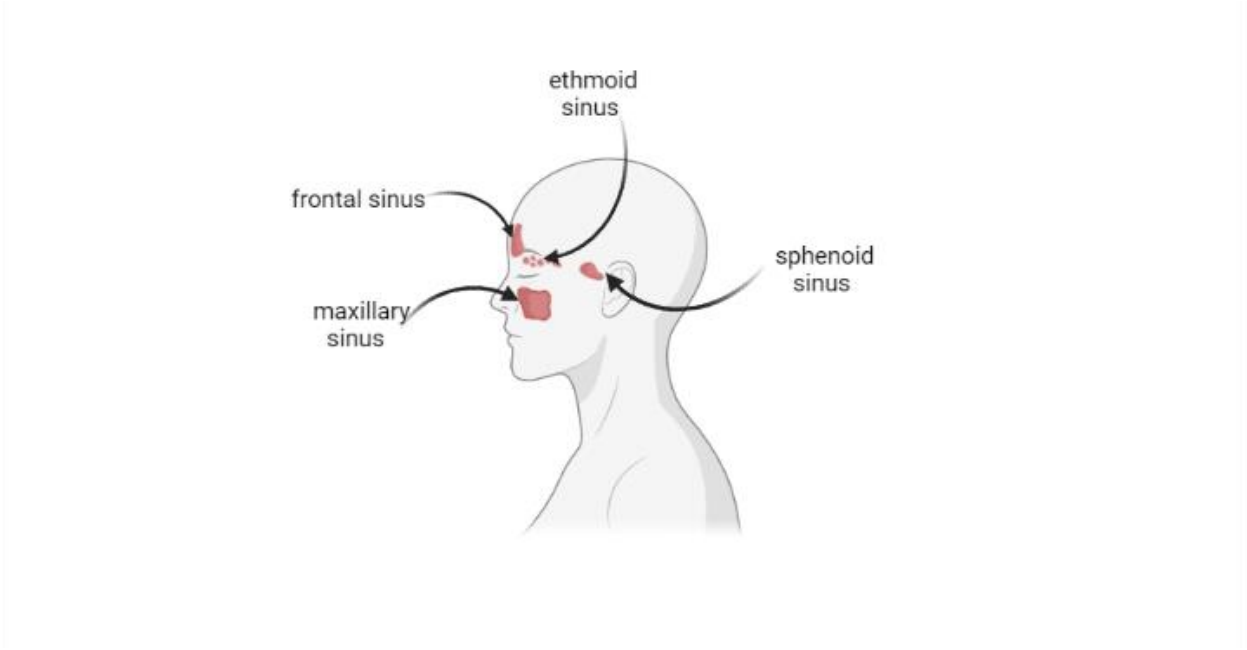
protein, a molecule that prevents the odorant from leaving the region of the olfactory epithelium, thus enhancing the individual´s ability to detect odors.



Picture 3 - Schematic diagram of the olfactory epithelium

3.2 Paranasal sinuses

Air cavities in the frontal, maxillary, ethmoid and sphenoid bones, are known as paranasal sinuses, which communicate with the nasal cavity (pic. 4). They are lined by a thin respiratory epithelium with a small number of goblet cells. The submucosa contains a few mucous glands and fuses with the periosteum. The paranasal sinuses lighten the weight of the bones of the skull, are involved in warming and moistening the inhaled air, and serve as resonators for voice formation.



Picture 4 - Paranasal sinuses

3.3 Nasopharynx

The walls of nasopharynx are made by bone and skeletal muscle tissue, lined with respiratory epithelium. The pharyngeal tonsil, an unencapsulated patch of lymphoid tissue, is located in the posterior aspect of the nasopharynx.

3.4 Larynx

The larynx is a symmetrical tube located in the neck between the base of the oropharynx and trachea. During swallowing, the entrance to the larynx is closed by the epiglottis. The skeleton of the larynx is formed by several cartilages and skeletal muscles. The larynx also performs the function of voice formation.

The wall of the larynx is made by hyaline and elastic cartilages, which are connected to each other by ligaments, and their movements with respect to one another are controlled by skeletal muscles.

A. Epiglottis: is made by elastic cartilage. Its upper surface is covered by stratified squamous nonkeratinized epithelium, the lower surface is covered by respiratory epithelium. The lamina propria contains a small number of mucous glands. During swallowing, the root of the tongue presses on the epiglottis, which closes the entrance to the larynx and directs food into the esophagus. After the swallowing the elastic cartilage returns to its original position, opening the airways.

B. Laryngeal cartilages. Several cartilages surround the lumen of the larynx, serve as its skeleton and attachment point for skeletal muscles. The larger unpaired thyroid and cricoid cartilages, as well as most of the paired arytenoid cartilages, are

hyaline, while the smaller paired cuneiform and corniculate cartilages and the tips of the arytenoids - are elastic.

B. Vocal apparatus. The expanded part of the larynx under the epiglottis, surrounded by the thyroid cartilage, contains two pairs of symmetrical mucosal folds. **False vocal folds** (the vestibular folds) are at the top, covered by ciliated epithelium and contain glands whose ducts open into the space separating them from the **true vocal folds** (ventricle of the larynx). The true vocal folds are covered by stratified squamous nonkeratinized epithelium. Each true vocal fold contains a **vocal ligament** - a bundle of elastic fibers that run front to back, and a bundle of skeletal muscle fibers - **the vocalis muscle**. The vocal folds vibrate under the influence of inhaled air. The vocalis and cricothyroid muscles regulate the tension of the folds, the other muscles of the larynx control the width of its lumen. Thus, the muscles of the larynx regulate the pitch (frequency) and other characteristics of the sounds produced by the vibrating vocal folds.

3.5 Trachea

The trachea is a 10 cm long tube that connects the larynx and the primary bronchi. The trachea has three layers: mucosa, submucosa and adventitia. The wall of the trachea is reinforced by 10-12 hyaline cartilage rings (C-rings). The open end of these rings faces posteriorly and are connected to each other by smooth muscle.

The mucosa is composed of respiratory epithelium and lamina propria. Lamina propria is composed of loose connective tissue and contains lymphoid nodules, mucous and seromucous glands.

The submucosa is composed of dense irregular connective tissue housing numerous mucous and seromucous glands.

3.6 Bronchial tree

The bronchial tree begins at the bifurcation of the trachea, as the right and left primary bronchi (pic. 5). The bronchial tree branches within the lung, while as the caliber of the bronchi decreases, changes occur in the structure of their wall (pic. 6).

A. The right and left primary bronchi enter the right and left lungs. The structure of the primary bronchi resembles the structure of the trachea, but the cartilaginous rings are completely closed, and the spiral bundles of smooth muscle fibers completely surround the lumen. The right bronchus is more vertical than the left. Therefore, foreign particles that have entered the respiratory tract are likely to be on the right side.

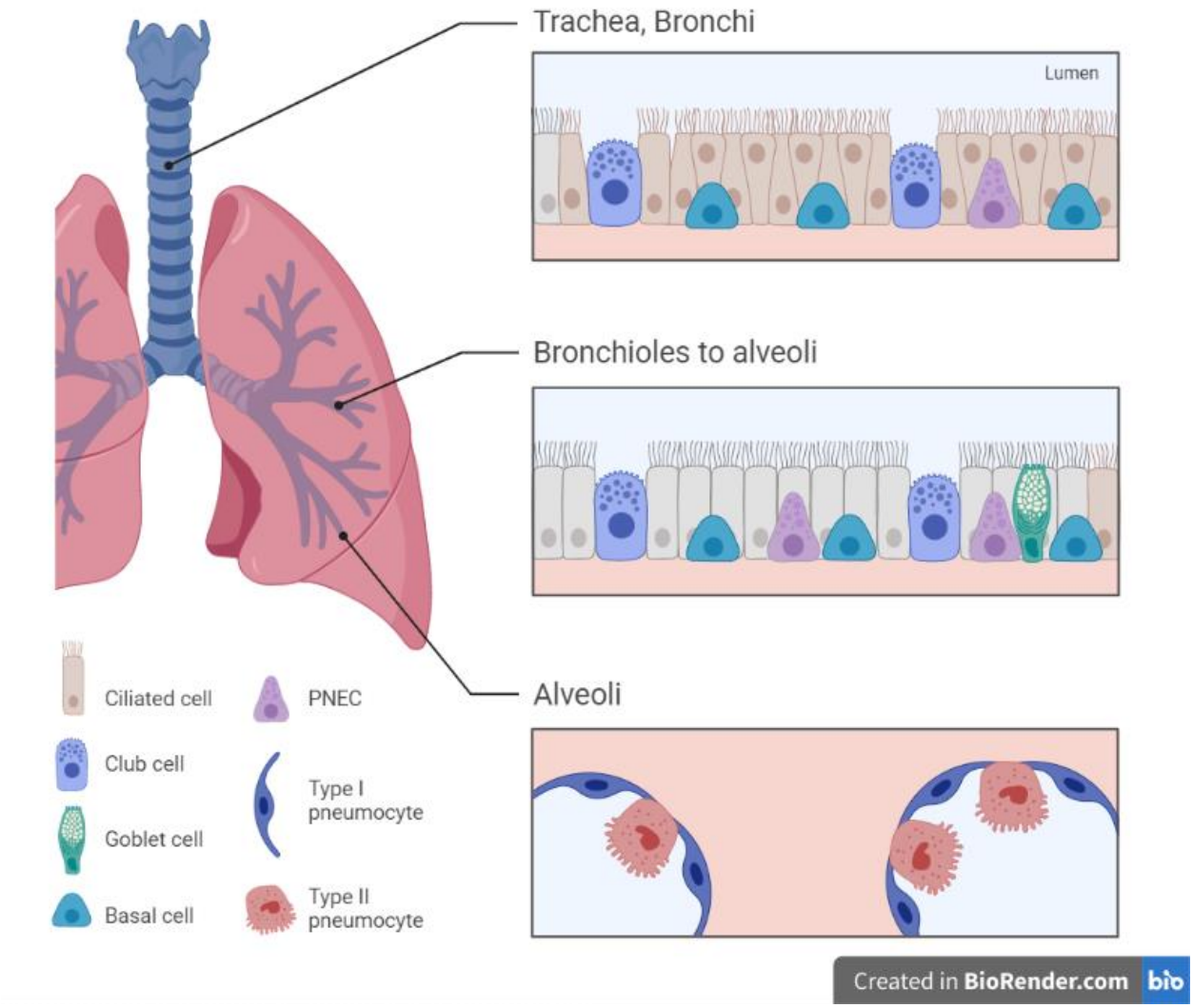
B. Lobar (secondary) bronchi are branches of the primary bronchi, each of them corresponds to a lobe of the lung. Since there are three lobes in the right lung and

two in the left, the right primary bronchus is divided into three lobar bronchus, and the left one into two. In structure, the lobar bronchi are like the primary bronchi, but the cartilaginous tissue does not form a ring, but is present in the form of islets.

B. Segmental (tertiary) bronchi are continuations of the lobar bronchi, each corresponding to a bronchopulmonary segment. Even though each lung consists of 10 segments, a different number of lobar bronchi leads to different branching of the segmental bronchi in the right and left lungs. The left lung often has only 8 or 9 segmental bronchi. The structure of the segmental bronchi corresponds to the structure of the lobar bronchi, despite their smaller diameter. Segmental bronchi can divide several times with the formation of bronchi of an even smaller caliber.

D. Bronchioles are branches of the smallest bronchi and differ from them in the absence of cartilage and glands in their wall. Larger bronchioles are lined with typical ciliated epithelium, with branching the number of layers and height of epithelial cells decreases. As a result, the smaller bronchioles are lined with a single layer of columnar or cuboidal ciliated epithelium. Each bronchiole gives rise to 5-7 terminal bronchioles.

E. Terminal bronchioles are the smallest components of the airways, lined with a single layer of columnar or cuboidal ciliated epithelium, goblet cells are practically absent. The elimination of goblet cells before the cilia in the lower parts of the bronchial tree is important in preventing individuals from drowning in their own mucus. In the epithelium of the terminal bronchioles, dome-shaped **Clara cells (club cells)** are present, which cytoplasm contains glycogen granules, a developed Golgi complex, and mitochondria. The main function of Clara cells is to protect the epithelium of the bronchioles by lining it with their secretory product, known as Clara Cell Secretory Protein (CCSP) and a substance like one of the components of lung surfactant that reduces the surface tension of bronchioles and facilitates the maintenance of their patency. Clara cells are also responsible for reducing the toxicity of inhaled harmful substances through the cytochrome P450 found in the smooth ER of these cells. Clara cells can also act as stem cells, differentiating into ciliated epithelial cells to regenerate bronchiole epithelium. Each terminal bronchiole can branch to form two or more **respiratory bronchioles** or open directly into **the alveolar duct**.



Picture 5 - Respiratory epithelium on different levels of bronchial tree

4 RESPIRATORY PORTIONS

4.1. Respiratory bronchioles

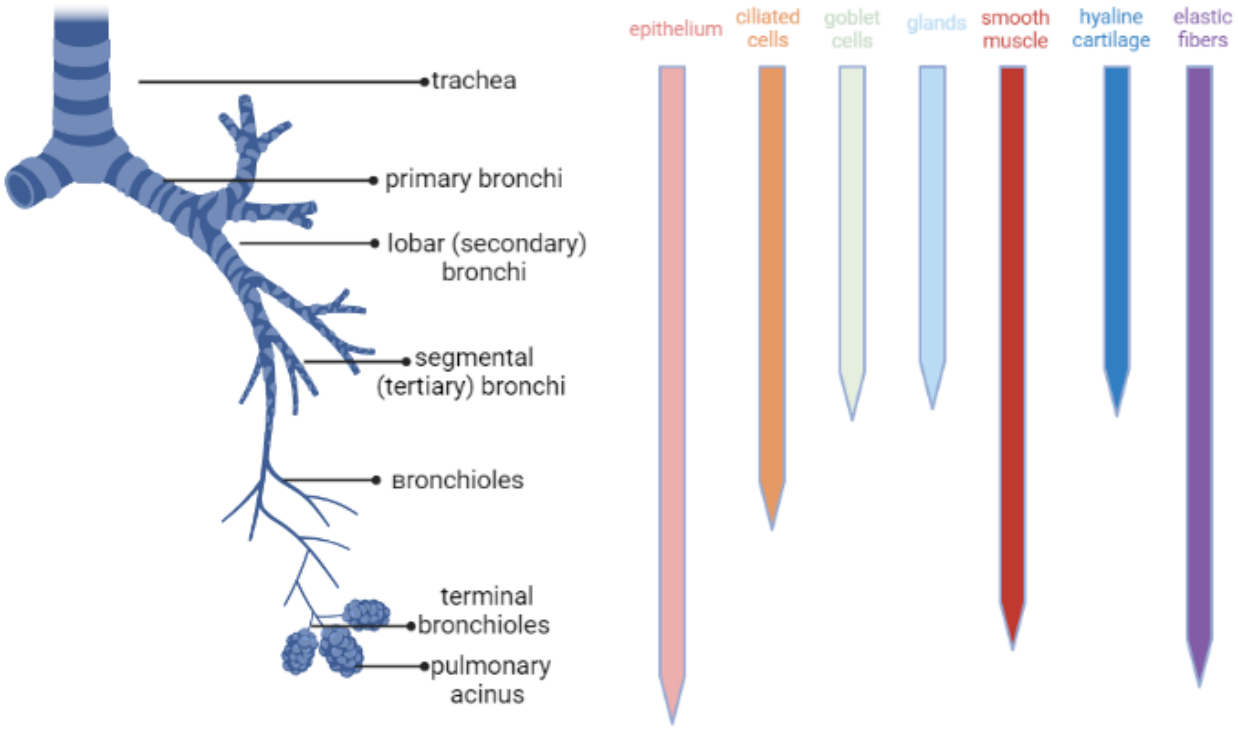
Respiratory bronchioles are the beginning of the respiratory portion of the respiratory system. The branches of one respiratory bronchiole make up the **pulmonary acinus** (alveolar tree). The cuboidal epithelium lining them resembles the epithelium of the terminal bronchioles, but it is constantly interrupted by thin-walled sac-like structures - **alveoli**. The number of alveoli increases towards the distal respiratory bronchioles. As the number of alveoli increases, cilia gradually disappear in the epithelium of the respiratory bronchioles. Goblet cells are absent.

4.2. Alveolar ducts

Alveolar ducts are distal continuation of respiratory bronchioles. The alveoli are located so close to each other that it seems as if the wall of the alveolar passages consists only of them. The wall of the alveolar ducts looks like small "buttons" protruding between the alveoli. "Buttons" consist of smooth muscle cells covered with a single layer of cuboidal epithelium without cilia. Thus, the alveolar duct looks like a long corridor with so many rooms (alveoli) opening from it that it seems that the corridor has no walls.

4.3. Atria and alveolar sacs.

The atria are the final division of the alveolar passages. Their structure can be compared to a corridor (alveolar duct) leading to a foyer (atrium). From the foyer you can get into small rooms (alveoli), as well as one or two short, blindly ending corridors (alveolar sacs). These short corridors also lead to rooms (alveoli). In other words, the difference between atria and alveolar sacs is that atria can communicate with alveolar ducts, alveoli and alveolar sacs, while alveolar sacs can only communicate with alveoli and atria. All these structures can be perfectly seen on longitudinal sections of the respiratory section. However, it is very difficult to make such sections in practice, usually the section runs across or diagonally across different parts of the respiratory tract. In this case, only the openings of the alveoli are visible, it is difficult to distinguish between alveolar sacs and atria. In this case, the size of the “button” protruding into the lumen can serve as a differential criterion. There are no smooth muscle cells in the wall of the alveolar sacs, which means that the size of the “button” will be smaller than in the atria or alveolar duct.



Picture 6 – Schematic diagram of bronchial tree

4.4. Alveoli

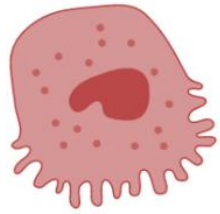
Alveoli are the hallmark of the respiratory portion. The alveoli are small sacs (approximately 200 μm in diameter) that open into the respiratory bronchioles, alveolar ducts, atria and alveolar sacs. The alveoli are separated from each other by thin interalveolar septa.

1.Interalveolar septa play an important role in gas exchange, the main function of the respiratory portion. The septa consist of two layers of simple squamous epithelium and an interstitium between them. The interstitium consists of continuous capillaries, elastic and collagen fibers, ground substance, fibroblasts, mast cells, macrophages, leukocytes and interstitial cells that can contract in response to the release of histamine and epinephrine. These elastic fibers are an important component of the ventilating mechanism. Gas exchange occurs between the air in the alveoli and the blood in the capillaries of the interstitium.
2. Alveolar pores. Each alveolar septum has one or more pores, the diameter of which varies from 10 to 15 μm. They connect adjacent alveoli, equalize pressure and provide collateral air circulation. The pores allow the maximum use of available alveoli in case of some small airways are blocked.
Alveolar cell types

1. Type I cells (also are called type I alveolar cells, type I pneumocytes, or squamous alveolar cells) are squamous epithelial cells lining approximately 97% of the alveolar surface.

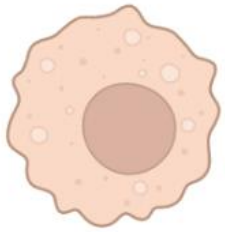
They are very thin (about 25 nm) gas-permeable component of the blood-air barrier. Organelles (Golgi complex, endoplasmic reticulum, mitochondria) are located around the nucleus. Thus, most of the cytoplasm is free of organelles, except for the abundant small pinocytotic vesicles that are involved in the turnover of pulmonary surfactant and the removal of foreign particles from the alveolar surface. Type I cells are connected to each other by desmosomes and tight junctions, thus preventing the seepage of extracellular fluid into the alveolar lumen.

2. Type II cells (also known as type II alveolar cells, type II pneumocytes, great alveolar cells, alveolar septal cells) line the remaining 3% of the alveolar surface. They are dispersed among type I cells and form occluding junctions with them.



Type II cells are almost cuboidal shape cells with a round nucleus and are usually located in regions where adjacent alveoli are separated from each other by a septum. Electron micrographs display numerous mitochondria, well-developed Golgi complex. The most distinguishing feature is the presence of large (0.2 μm) lamellar bodies that contain pulmonary surfactant, the secretory product of these cells. Pulmonary surfactant is composed of phospholipids, glycosaminoglycans, and proteins.

3. Alveolar macrophages (dust cells)- representatives of the system of mononuclear macrophages.



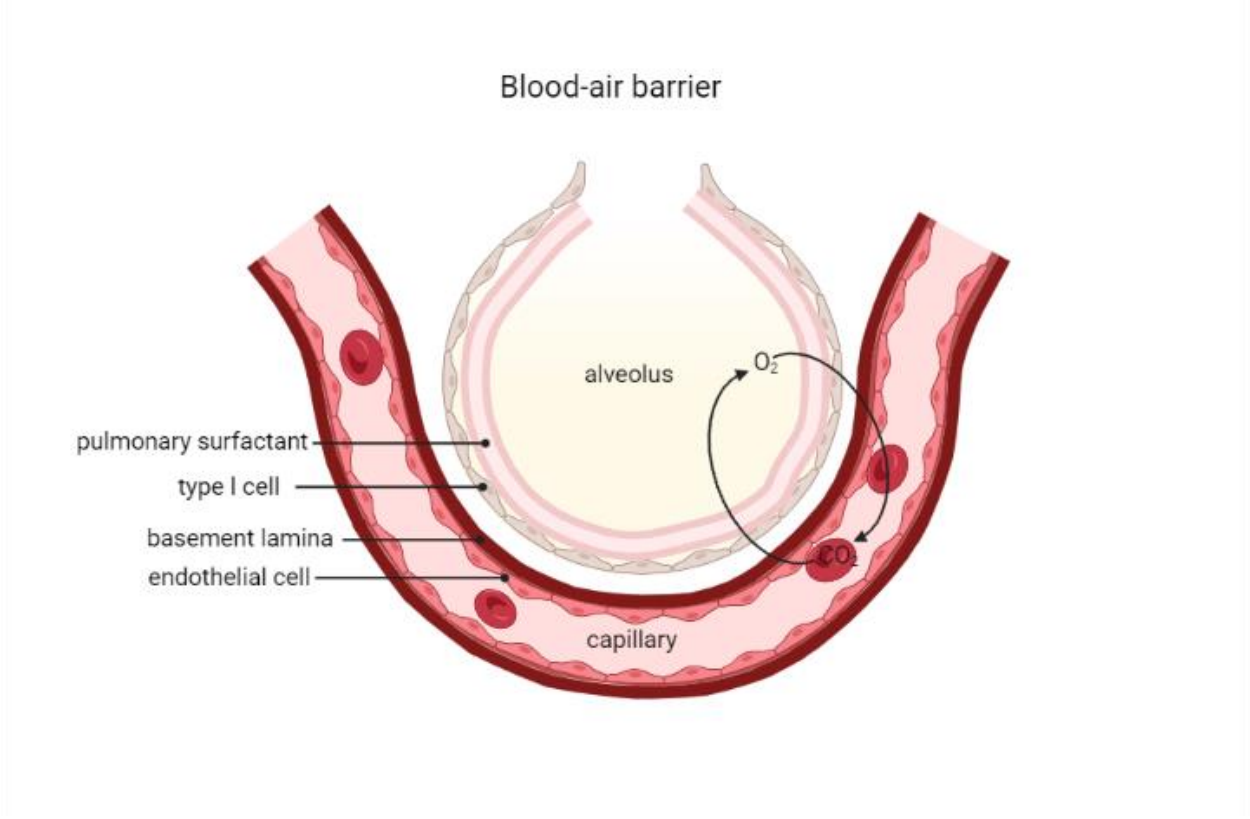
These large cells can be found both on the inner surface of the alveoli and in the interstium. Alveolar macrophages phagocytose foreign particles, such as dust, other inhaled particles, and microorganisms, and thus maintain a sterile environment within the lungs. They also assist type II cells in the uptake of surfactant.

4.5. Blood-air barrier

Blood-air barrier includes structures through which the exchange of oxygen and CO2 takes place. The thickness of the alveolar barrier varies from 0.1 to 0.5 μm and consists of four layers (pic. 7):

1) a film of pulmonary surfactant on the alveolar surface,

2) the cytoplasm of squamous epithelial cells (type I cells),
3) a fused basal membrane of type I cells and capillary endothelial cells,
4) the cytoplasm of endothelial cells lining the interstitial capillaries.



Picture 7 – Blood-air barrier

4.6. Pulmonary surfactant

Pulmonary surfactant is synthesized and secreted by type II cells on the alveolar surface, is removed from the surface by alveolar macrophages and by type I and type II cells. Its composition and continuous turnover allow it to perform two major functions. The pulmonary surfactant reduces the surface tension of the alveoli and has some antibacterial effect. This substance forms a thin two-layer film on the alveolar surface. One layer is represented by an aqueous basal layer (hypophase), composed mainly of protein, and a layer of phospholipids (mainly dipalmitoyl lecithin), whose fatty acid tails extend into the lumen. By reducing surface tension, the surfactant prevents collapse of the alveoli during expiration, which means that it facilitates the process of breathing. At the time of the next breath, thanks to the surfactant, no effort is required to re-straighten the alveoli. Since surfactant begins to be synthesized in the last weeks of fetal development, premature infants often suffer respiratory distress syndrome due to its deficiency. Glucocorticoids (hormones of the adrenal cortex) stimulate the secretion of surfactant, and therefore improve the infant’s condition and increase their chances for survival.

4.7. Regeneration

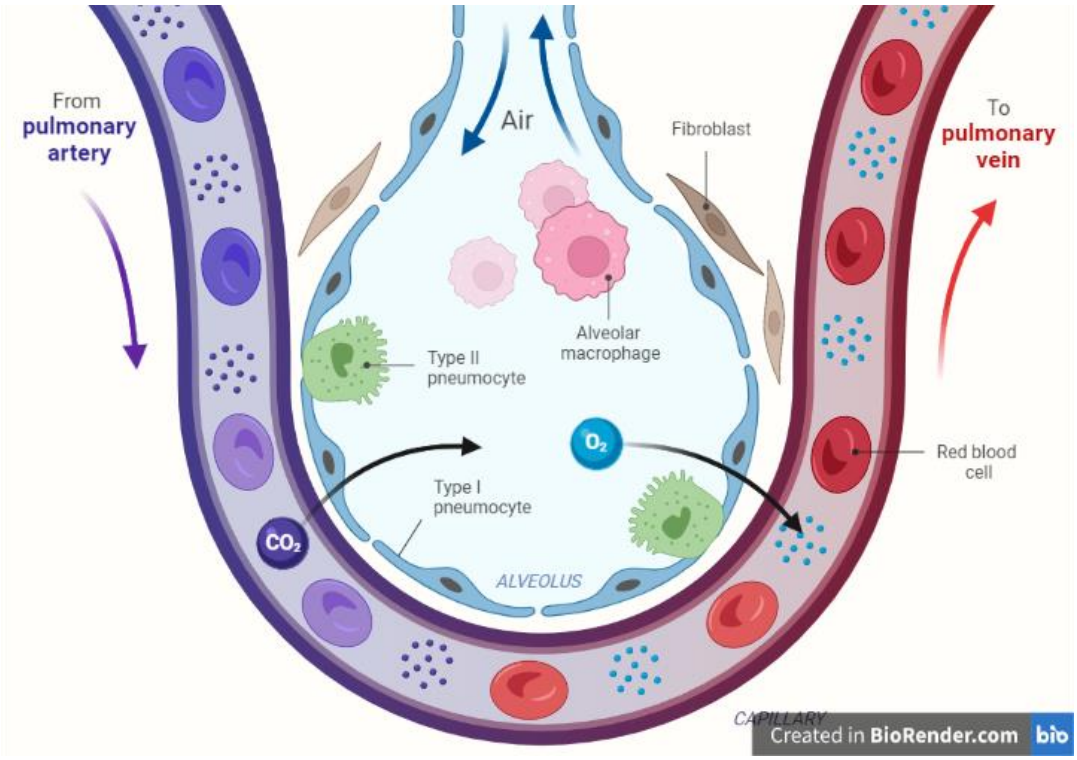
Regeneration of the alveolar epithelium is provided by type II cells, which give rise to both type I and type II cells.

5. PULMONARY CIRCULATION

5.1. Blood supply

The lungs have a dual blood supply: functional (pulmonary) and systemic (nutrient) circulation.

1. **Functional circulation** is provided by the pulmonary arteries and veins. The pulmonary trunk is a large elastic vessel that originates from the right ventricle of the heart. Then the pulmonary trunk is divided into right and left pulmonary arteries which penetrate the lungs. The pulmonary arteries divide dichotomously and repeat the branching of the bronchial tree. Arteries are divided into arterioles, then break up into capillaries that wrap around the alveoli. They carry oxygen-poor blood for oxygenation and here that gas exchange occurs. The blood in the capillaries becomes oxygenated and drains into the venules, then into the veins of increasing diameter (pic. 8). Then the blood drains into the pulmonary veins (2 in each lung), which carry arterial blood to the left side of the heart and then to the aorta. Large pulmonary veins accompany the bronchi, smaller branches are distributed in the connective tissue septa, separating the bronchopulmonary segments.



Picture 8 - Schematic diagram of alveolar gas exchange

2. Systemic circulation is provided by bronchial arteries and veins. The bronchial arteries are typical muscular arteries and arise from the thoracic aorta, sometimes from the intercostal arteries. They are always smaller than the accompanying arteries. The bronchial arteries penetrate the hilum of the lung, repeat the branching of the bronchial tree, and anastomose with the branches of the arteries in the respiratory portion. The branches of the bronchial arteries carry oxygen-rich blood to the capillaries of the bronchi, bronchioles, interstitium and pleura. Blood is collected in the submucosal venous plexus of the bronchi, and then drains into the bronchial veins. Bronchial veins are typical small-caliber veins that carry blood from the submucosal venous plexus and accompany the bronchial tree. The branches accompanying the larger bronchi drain into the unpaired, semi-unpaired or posterior intercostal veins. Many small bronchial veins drain into the pulmonary veins.

The bronchial and pulmonary arteries form the anastomoses between the systemic and pulmonary circulations. These anastomoses are located mainly in the respiratory bronchioles and under the pleura. The blood flow in bronchopulmonary anastomoses is directed from the systemic to the pulmonary circulation.

5.2. Lymphatic drainage

The lung has a dual-lymph drainage. Lymphatic vessels are divided into superficial and deep network, both draining into the lymph nodes near the hilum. Vessels of the deep network have few valves and accompany the bronchial tree or pulmonary veins in the connective tissue. Vessels of the superficial network have many valves and are located in the visceral pleura. Lymphatic vessels are absent from the interalveolar septa; here, the capillary network is responsible for draining excess interstitial fluid.

6. INNERVATION

Autonomic motor and general sensitivity nerves penetrate the pulmonary root and accompany the blood vessels and the bronchial tree. Sensory nerves are responsible for the poorly localized pain sensations, react to substances that irritate the airways, and are involved in the cough reflex. Parasympathetic fibers (from the vagus nerve) increase the secretion of mucosal glands and cause bronchial constriction, while sympathetic fibers cause bronchial dilation.

Sympathomimetic drugs, such as albuterol, are used during asthma attacks to stimulate bronchodilatation and suppress the secretory activity of epithelial cells.

7. PLEURA

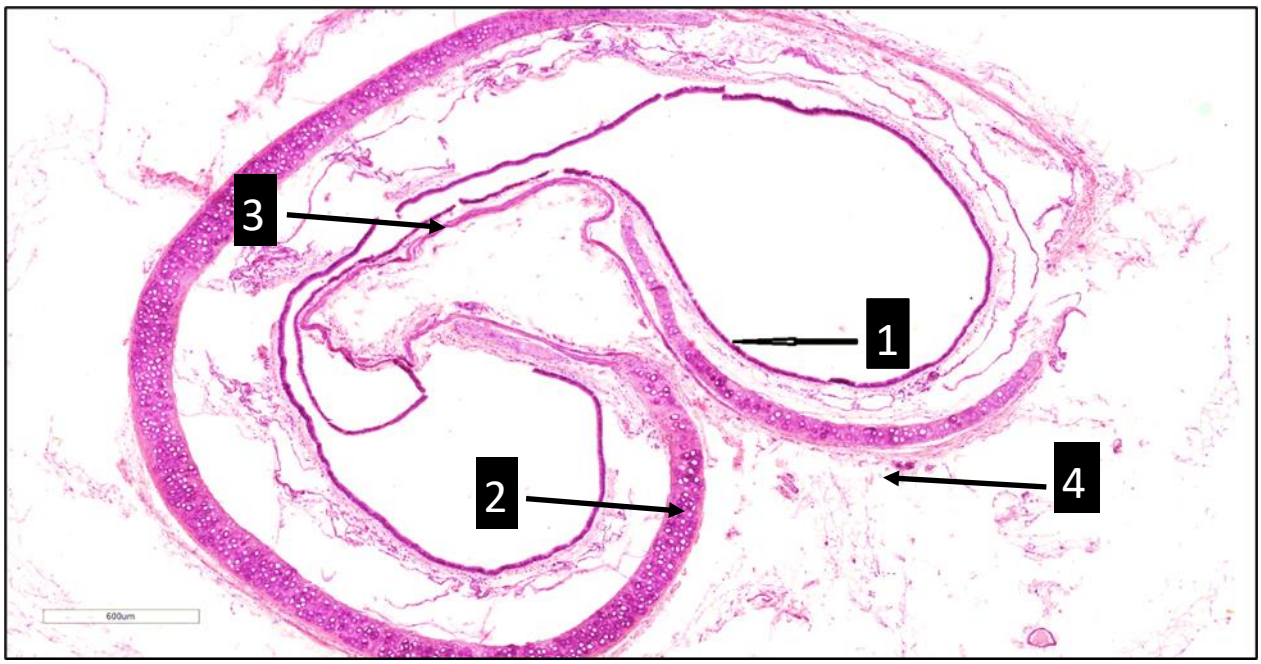
The serous membrane has two layers, one covers the lung (**visceral pleura**), the other lines the inner wall of the thoracic cavity (**parietal pleura**). Just like the peritoneum and pericardium, the pleura is composed of mesothelium and loose connective tissue.

The narrow pleural cavity, lined with mesothelium, is located between the parietal and visceral pleura. Normally, the pleural cavity contains a small amount of serous fluid (produced by the serous membranes), which, together with the mesothelium, reduces friction between the surface of the lungs and the walls of the thoracic cavity during breathing. In some diseases or injuries, excess fluid accumulates in the pleural cavity (hydrothorax), or air enters (pneumothorax), which increases its volume and limits respiratory movements. Small amounts of fluid or air can be sucked in on their own, otherwise medical intervention is needed to prevent collapse of the lung.

8. HISTOLOGYCAL SLIDES

8.1. Slide № 1 (Trachea)

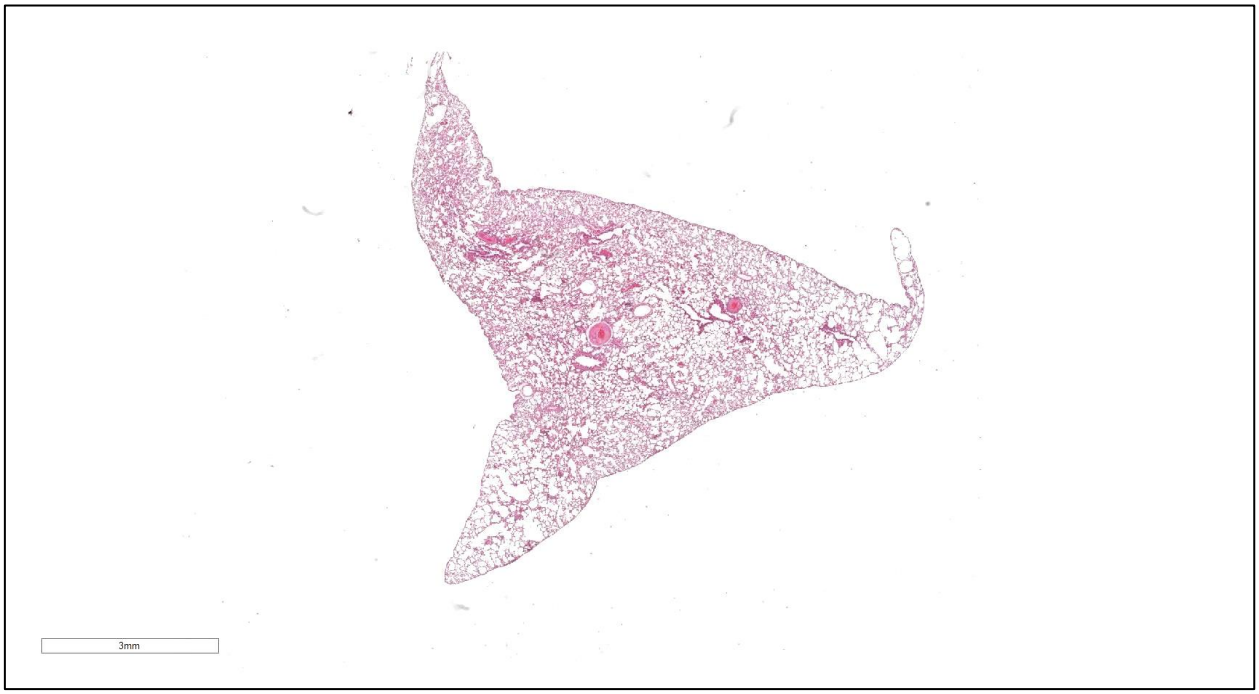
The Slide № 1 is a cross section of the trachea. The wall of the trachea is made by three layers: mucosa, fibromusculocartilagineous layer and adventitia. The mucosa is composed of respiratory epithelium and lamina propria. Lamina propria is formed by loose connective tissue and contains lymphoid nodules and glands. Fibromusculocartilagineous layer contains C-shaped hyaline cartilage in the anterior portion of the organ and smooth muscle tissue in its posterior portion. Adventitia is made by loose connective tissue.



Slide 1- Trachea. 1- respiratory epithelium, 2- hyaline cartilage, 3- smooth muscle, 4- adventitia. Hematoxylin and eosin

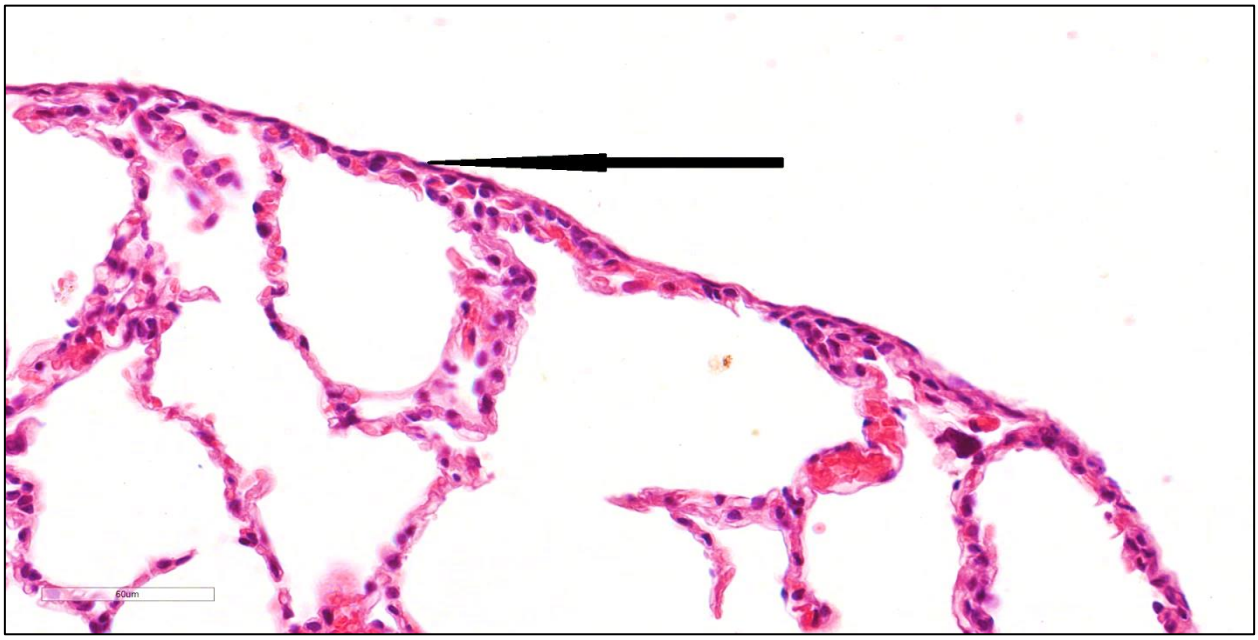
8.2. Slide № 2 (Lung)

The Slide № 2 is a section of the lung covered with pleura. The pleura is a serous membrane composed of mesothelium and underlying loose connective tissue.



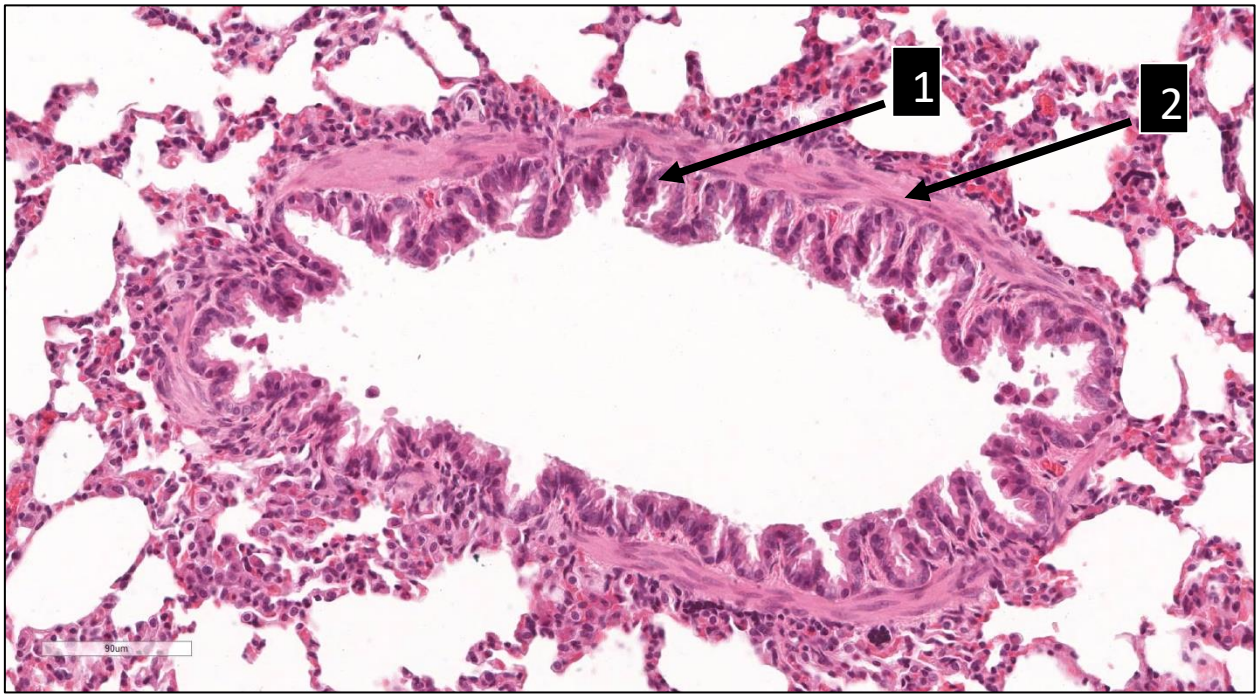
Slide. 2 A. Lung. Hematoxylin and eosin

On high magnification the mesothelium is identified as a simple squamous epithelium (Slide. 2 B) lying on the basement membrane. Epithelial cells are tightly adjacent to each other, there is no intercellular matrix between them.



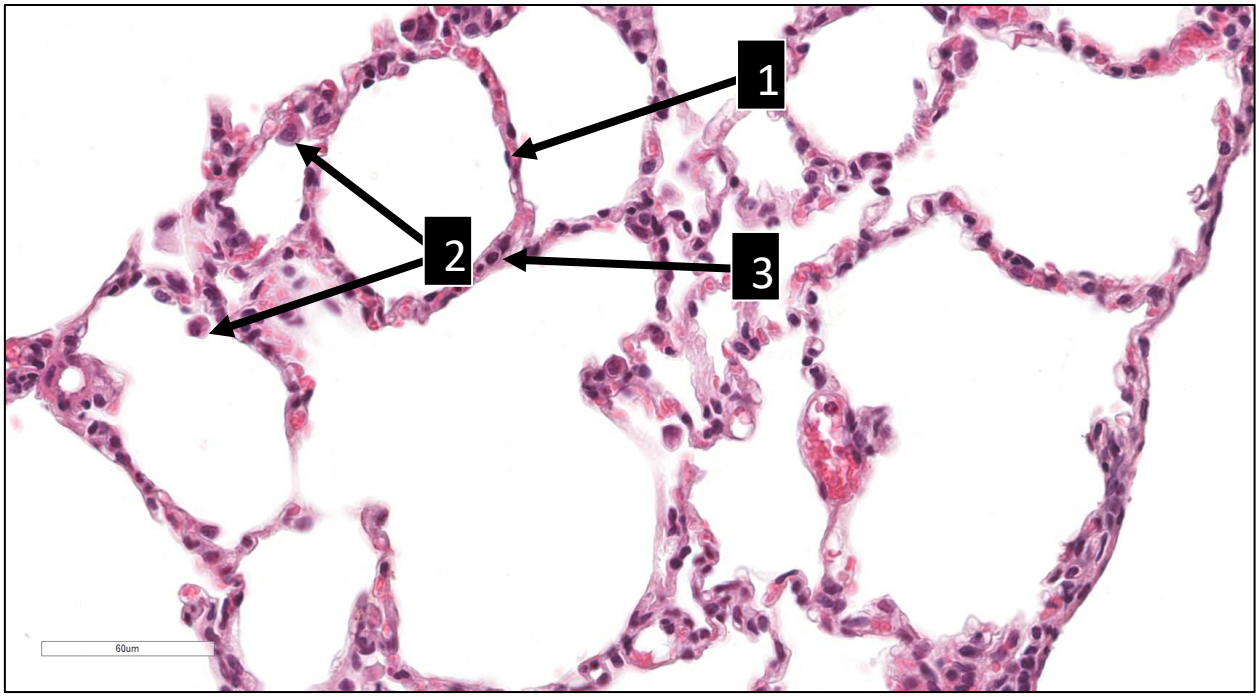
Slide. 2 B. Pleura, lung. The arrow indicates the mesothelium (simple squamous epithelium). Hematoxylin and eosin

The bronchiole is also visible on this slide. Its wall is made by simple cuboidal epithelium and smooth muscle tissue.



Slide. 2 C. Bronchiole. 1- simple cuboidal epithelium, 2- smooth muscle tissue. Hematoxylin and eosin

On the high magnification of the lung the alveoli are identified. Their wall is made of type I cells, which form the blood-air barrier, and type II cells - cuboidal shaped cells with the round nucleus. On the slide the alveolar macrophages are visible in the lumen of the alveoli.



Slide. 2 D. Alveoli. 1- type I cell; 2- alveolar macrophages;3 - type II cell. Hematoxylin and eosin

9. MULTIPLE-CHOICE QUESTIONS

1. Respiratory epithelium:
   a. Is a simple squamous epithelium
   b. Is a stratifired squamous epithelium
   c. Lines the alveolar ducts
   d. Lines the alveolar sacs
   e. Lines the bronchi
2. Alveolar macrophages are located within:
   a. Respiratory alveoli
   b. Interalveolar septa
   c. The cartilage of the bronchi
   d. A and B
   e. A, B and C
3. The presence of which of the following characterize the respiratory bronchiole:
   a. Alveolus
   b. Cartilage
   c. Epithelium
   d. Lamina propria
   e. Smooth muscle
4. Clara cells in the bronchioles secrete:
   a. A serous product
   b. A mucous product
   c. Glycosaminoglycans
   d. Histamine
   e. Surfactant
5. The wall of the bronchiole has no:
   a. Cartilage
   b. Cilia
   c. Epithelial lining
   d. Lamina propria
   e. Smooth muscle
6. Which cell type forms most of the respiratory surfaces of the lung?
   a. olfactory cell
   b. alveolar type I cell
   c. macrophage
   d. alveolar type II cell

7. Which part of the conductive portion of the respiratory system is characterized by the presence of smooth muscle and a ciliated simple columnar epithelium and the absence of cartilage and glands?

a. respiratory bronchiole
b. bronchiole
c. alveolar duct
d. alveolus

8. All the following show a decrease in amount from trachea to alveoli EXCEPT:

a. Cilia
b. Goblet cells
c. Cartilage
d. Elastic fibers
e. Smooth muscle

9. Pulmonary surfactant:

a. Has a bactericidal effect
b. Consists primarily of phospholipid
c. Is secreted by type II cells
d. Reduces surface tension and helps prevent alveolar collapse
e. All the above

10. First part of respiratory portion of respiratory tract:

a. Larynx
b. Trachea
c. Bronchi
d. Bronchioles
e. Respiratory bronchioles
f. Alveolar ducts

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