Histology Department

(1st week/Lecture 7)

By

Prof. Dr. Sohair A Eltony

Histology Department, Faculty of Medicine, Assiut University

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Histology of the Respiratory tract

Respiratory portion

Learning objectives

After this lecture, students should be able to:

1- Discriminate the histological structure of the respiratory bronchioles, alveolar ducts and alveolar sacs and discriminate the type of their lining epithelium.

2- List the components of the interalveolar septum.

3- Describe the histological structure of the alveolar epithelial cells (type I & type II) and their functions.

4- List the components of the blood air barrier.

5- Correlate the histological structure and function of the alveolar macrophages with clinical data.

6- Identify the type and function of pleural epithelium.

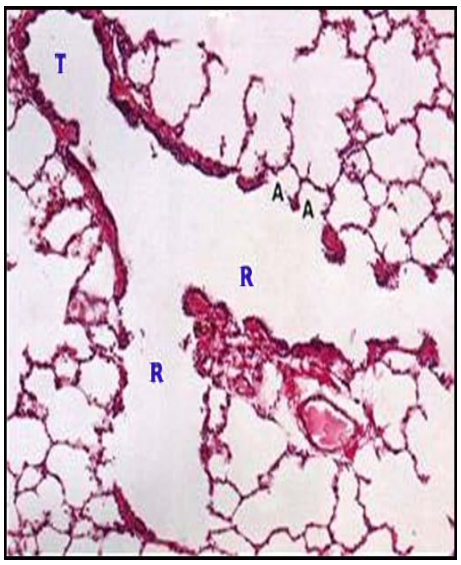
7- Know the structural unit of the lung (pulmonary) lobule) and pulmonary vascular supply.

8- List the pulmonary defense mechanisms and the types of hypersensitivity reactions (immunology).

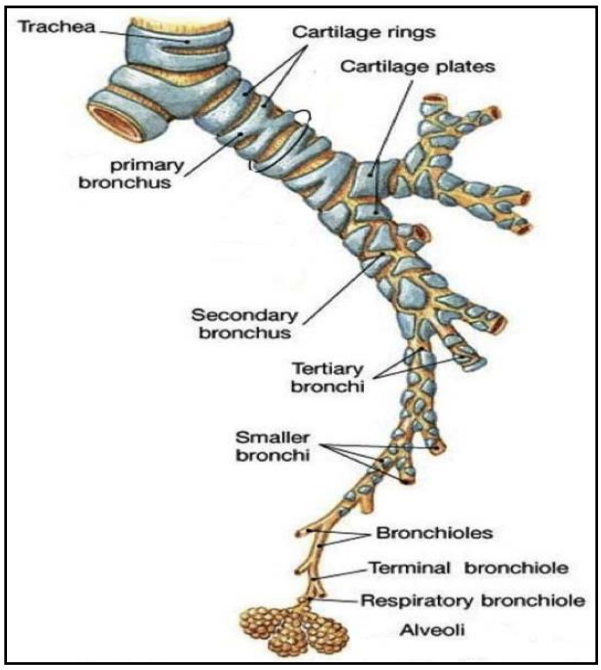
The respiratory portion of the respiratory tract is composed of respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli.

Respiratory bronchioles

- The bifurcation of the terminal bronchioles give rise to the respiratory bronchioles.
- The respiratory bronchioles characterized by the presence of sporadic alveoli.
- The respiratory bronchiolar epithelium resembles that of the terminal bronchioles (simple cuboidal ciliated epithelium with Clara cells).

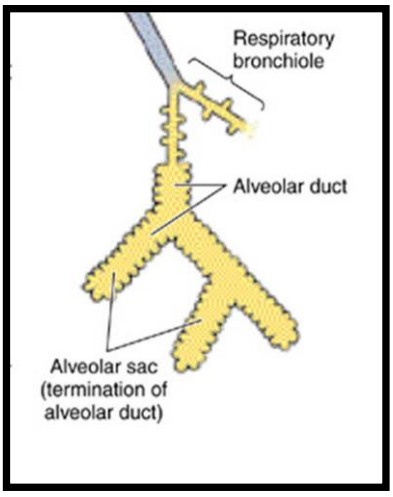


T: terminal bronchiole.
R: respiratory bronchiole.
A: alveoli.



Alveolar ducts and sacs

- The respiratory bronchioles terminate in alveolar ducts whereas alveoli become more numerous and closer together. The alveolar ducts are lined with extremely attenuated squamous cells.
- The alveolar duct ends in a pouch of clusters of alveoli called **"alveolar sac".**



Alveoli

- Are air sacs that form the major compartment specialized for gas exchange. There are approximately 300 million alveoli in the two lungs.

- Adjacent alveoli are separated by a thin **"interalveolar septum"** consisting of connective tissue matrix notably elastic and reticular fibers, and dense network of pulmonary capillaries. Macrophages can also be found within the septum.

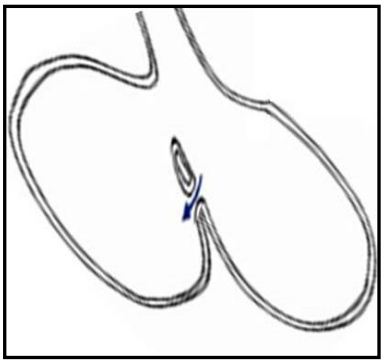
☻ Elastic fibers in the interalveolar septum enables alveoli to expand with inspiration and contract passively with expiration.

– What is the relevance of this fact to emphysema?

☻ Emphysema is a condition characterized by decreased elasticity of lung tissue and therefore do not recoil so strongly.

- Pulmonary capillary endothelial cells are joined by tight junctions to form a continuous endothelium without fenestrations.

- **Pores of Kohn** in the septum connect the adjacent alveolar spaces, allow passage of air between alveoli to equalize pressure, and give an alternative route for movement of gases between alveoli during local bronchiolar obstruction.



- The alveoli are lined by **alveolar epithelium (pneumocytes)**. **There are 2 types of alveolar cells:**

  Type I alveolar cells comprise about 95% of the alveolar epithelial surface and are characteristically squamous. Type I cells are one component of the blood air barrier that provide minimum thickness for gas exchange.

  Type II alveolar cells are rounded and account for the remaining 5% of alveolar surface area. They secrete pulmonary surfactant which lines alveoli, reducing surface tension, maintaining their stability and minimizing work required to inflate the lungs. Surfactant is stored in the whorled cytoplasmic **lamellar bodies** of type II alveolar

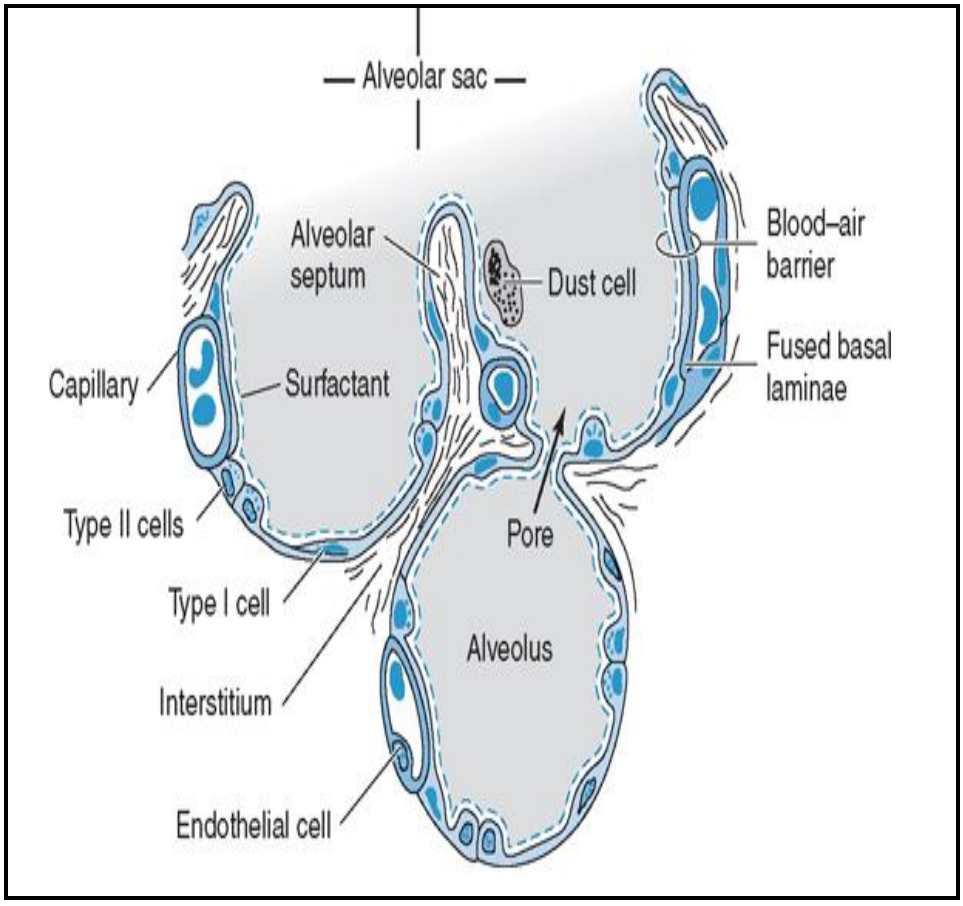
cells. Type II cells are also a stem cell population and can divide and differentiate into type I cells if the alveolar epithelium is damaged.

(Structure of type II alveolar cell, see the practical book)

☻ **Infant respiratory distress syndrome**, the leading cause of death in premature babies, is due to incomplete differentiation of type II alveolar cells and a resulting deficit of surfactant and difficulty in expanding the alveoli in breathing.

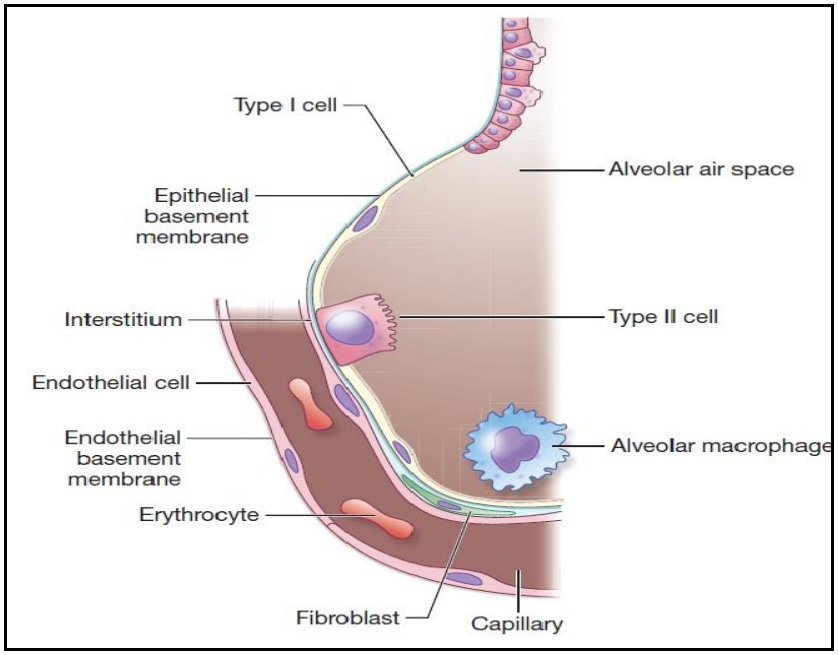
- Air in the alveoli is separated from capillary blood by components referred as the **"blood–air barrier**". This comprises a layer of surfactant, type I alveolar epithelial cells, the fused basal laminae of the epithelial layer and capillary endothelial cells, and the endothelial cells themselves.

  (Structure of the blood air barrier, see the practical book)



Alveolar macrophages

- **Alveolar macrophages** move on the surfactant layer to **phagocytose** microorganisms and particles and secrete cytokines. These cells also assist in surfactant turnover.



- **Alveolar macrophages** engulf debris (hence the name **"dust cells"**) and phagocytize RBCs that leak into alveoli in case of **congestive heart failure** (hence the name **"heart failure cells"**).

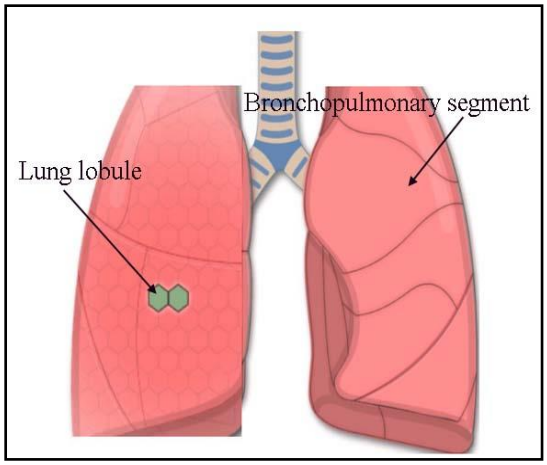
Pleura

- The lungs are surrounded by a **mesothelium (simple squamous epithelium).** The **visceral pleura** adheres to the lungs. The **parietal pleura** lines the thoracic cavity.

- This epithelium **secretes serous fluid** which lubricates the potential space (pleural cavity) between these pleurae facilitating the smooth sliding of one surface over the other during respiratory movements.

☻ **Pleural effusion:** In some disease states, fluid accumulates in the pleural cavity produces shortness of breath.

Pulmonary lobule & Pulmonary vascular supply



- The lung lobes are subdivided into several functional **bronchopulmonary segments**, each supplied by its own artery and tertiary bronchus.

- **Pulmonary arteries** transport relatively deoxygenated blood from the right ventricle to the lungs. The **bronchial arteries** supply the bronchi and pulmonary connective tissues with nourishing, O2-rich blood. The **pulmonary veins** transport highly oxygenated blood from the alveoli to the left atrium.

- Connective tissue septa partitioned the bronchopulmonary segments into many polygonal-shaped **pulmonary lobules** (**the structural unit of the lung)**.

Pulmonary defense mechanisms

1- Inspired air is warmed, and humidified, and airborne particulates can deposit on the nasal mucosa with inspiration.

2- The **mucociliary escalator.**

3- The **cough** and **sneeze** reflexes caused by mucosal irritation.

4- **Mast cells** associated with the mucosal epithelium provide immediate histamine release responses triggered by antigens.

5- **Mucosal-** (**MALT**) or **bronchial-associated lymphoid tissues** (**BALT**) with immune cells that provide specific acquired immunity with IgA secretion on mucosal surfaces.
6- The **tonsils** provide a ring of MALT tissue at the nasopharynx to provide protection for both the oral and pulmonary systems.
7- Smell is sensed by the **olfactory epithelium** in the roof and walls of the nasal cavity.

Respiratory tract immunology: In response to inhaled particles and antigens, the airway mucosa has specific types of immune-mediated reactions to defend the respiratory tract against foreign antigens. **There are four types of hypersensitivity reactions:**

Type	Mechanism	Example
Type I: (immediate, IgE-mediated).	IgE antibody-mediated **mast cell** activation and degranulation.	Bronchial asthma.
Type II: (cytotoxic hypersensitivity).	Cytotoxic (IgG, IgM) antibodies formed against cell surface antigens; complement usually involved.	fibrotic lung tissue disorders.
Type III: (immune complex).	Antibodies (IgA, IgG, IgM) formed against exogenous or endogenous antigens; leukocytes often involved.	Pneumonitis.
Type IV: (cell-mediated, delayed hypersensitivity)	Mononuclear cells (T lymphocytes, macrophages) with interleukin and lymphokine production.	Tuberculosis.

Pulmonary age-related changes

- The number of alveoli and the alveolar surface area are increased from birth till adulthood.
- The degenerative changes of ageing make parts of the lung useless for gas exchange.

Reference:

- **USMLE Step 1 Lecture Notes 2021. Anatomy. KAPLAN MEDICAL. Part II Chapter 2. Pages: 50-53.**
- **Lippincott Illustrated Reviews: Integrated Systems (2015), p: 211-226.**

ASSESS YOUR KNOWLEDGE

Choose the correct answer:

1. **Lamellar bodies are present in:**
    a. Type I alveolar cells.
    b. Alveolar macrophages.
    c. Clara cells.
    d. Type II alveolar cells.
    e. Capillary endothelial cells.

2. **The blood air barrier is:**
    a. Present between air in the alveoli and the capillary blood.
    b. Containing cartilage.
    c. Covered with stratified Squamous epithelium.
    d. Containing smooth muscle fibers.
    e. Covered with respiratory epithelium.

3. **Type I alveolar cells are:**
    a. Round cells.
    b. Squamous cells.
    c. Ciliated columnar cells.
    d. Phagocytic cells.
    e. Endothelial cells.

4. **Respiratory bronchiole is characterized by:**
    a. Absence of muscle layer.
    b. Absence of an epithelial lining.
    c. Presence of goblet cells.
    d. Presence of cartilage plates.
    e. Presence of sporadic alveoli.

5. **The pleura is:**
    a. lined by stratified squamous non-keratinized epithelium.
    b. A mucous membrane.
    c. Composed of visceral layer only.
    d. Composed of parietal layer only.
    e. Lined with mesothelium.