Physiology

3rd stage

Lec.6

The Respiratory System

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Respiration

The process of gas exchange in the body, called respiration, has three basic steps:

1- Pulmonary ventilation (pulmon- = lung), or breathing, is the inhalation (inflow) and exhalation (outflow) of air and involves the exchange of air between the atmosphere and the alveoli of the lungs.

2- External (pulmonary) respiration is the exchange of gases between the alveoli of the lungs and the blood in pulmonary capillaries across the respiratory membrane. In this process, pulmonary capillary blood gains O2 and loses CO2.

3- Internal (tissue) respiration is the exchange of gases between blood in systemic capillaries and tissue cells. In this step the blood loses O2 and gains CO2. Within cells, the metabolic reactions that consume O2 and give off CO2 during the production of ATP are termed cellular respiration.

Respiration can have two quite different meanings:

(1) Utilization of oxygen in the metabolism of organic molecules by cells, often termed internal or cellular respiration

(2) The exchange of oxygen and carbon dioxide between an organism and the external environment, often called pulmonary physiology. Human cells obtain most of their energy from chemical reactions involving oxygen. In addition, cells must be able to eliminate carbon dioxide, the major end product of oxidative metabolism. A unicellular organism can exchange oxygen and carbon dioxide directly with the external environment, but this is obviously impossible for most cells of a complex organism like a human being. Therefore, the evolution of large animals required the development of specialized

structures for the entire animal to exchange oxygen and carbon dioxide with the external environment.

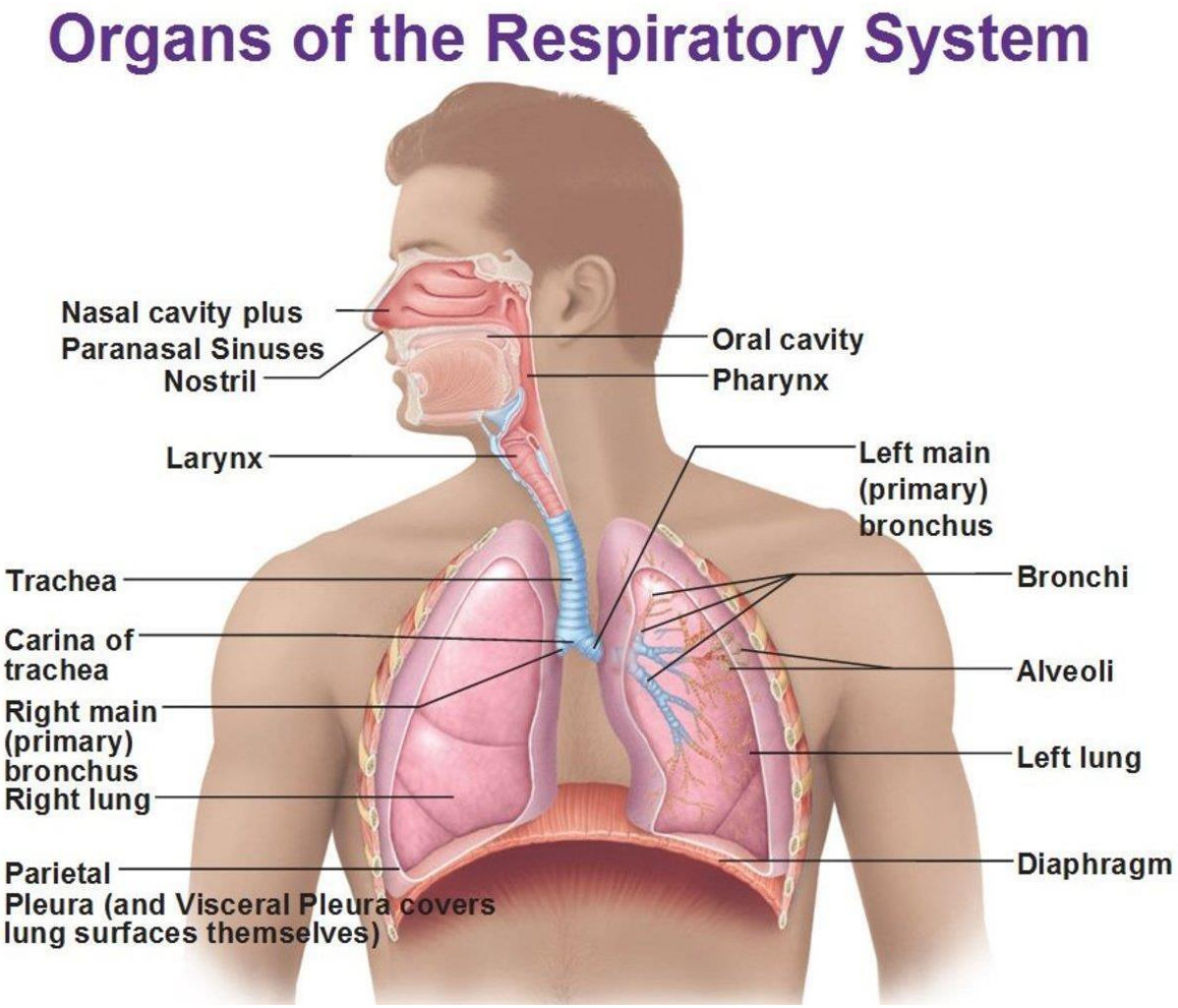
In humans and other mammals, the respiratory system includes the oral and nasal cavities, the lungs, the series of tubes leading to the lungs, and the chest structures responsible for moving air into and out of the lungs during breathing.
The principle that physiological processes are governed by the laws of chemistry and physics is demonstrated when describing the binding of oxygen and carbon dioxide to hemoglobin, the handling by the blood of acid produced by metabolism, and the factors that control the inflation and deflation of the lungs. The diffusion of gases is an excellent example of the general principle of physiology that states that controlled exchange of materials occurs between compartments and across cellular membranes.

Basic Structure of the Respiratory System

The respiratory system consists of four main layers:
1. the respiratory mucosa (epithelium and supporting lamina propria)
2. Submuscosa
3. Cartilage and/or muscle layer
4. Adventitia

Organization of the Respiratory System

There are two lungs, the right and left, each divided into lobes. The lungs consist mainly of tiny air-containing sacs called alveoli (singular, alveolus), which number approximately 300 million in an adult. The alveoli are the sites of gas exchange with the blood. The airways are the tubes that air flows through from the external environment to the alveoli and back. Inspiration (inhalation) is the movement of air from the external environment through the airways into the alveoli during breathing. Expiration (exhalation) is movement in the opposite direction. An inspiration and expiration constitute a respiratory cycle.



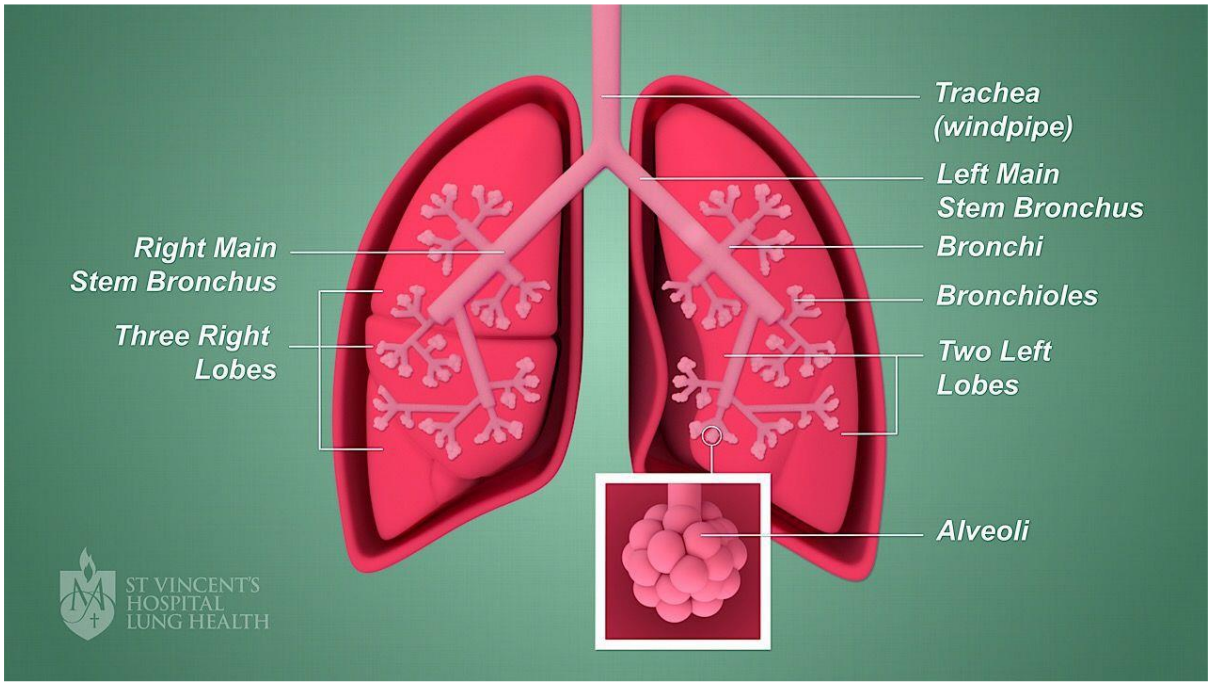
During the entire respiratory cycle, the right ventricle of the heart pumps blood through the pulmonary arteries and arterioles and into the capillaries surrounding each alveolus.

*In a healthy adult at rest, approximately 4 L of fresh air enters and leaves the alveoli per minute, while 5 L of blood, the cardiac output, flows through the pulmonary capillaries.

*During heavy exercise, the airflow can increase 20-fold, and the blood flow five- to six-fold.

The lung

The histology of the intrapulmonary bronchi is similar to that of the trachea and extrapulmpnary bronchi , except that in the intrapulmonary bronchi, the C- shaped cartilage rings of the trachea are replaced by cartilage plates . all cartilage in the trachea and lung is hyaline Cartilage . the bronchus is also lined by pseudostratified columnar ciliated epithelim with goblet cells. The wall in the intrapulmonary bronchus consist of a thin lamina propria , a narrow layer of smooth muscle, a submucosa with bronchial glands, hyaline Cartilage Plates, and adventitia.



Gas Exchange between tissues and blood

As the systemic arterial blood enters capillaries throughout the body, it is separated from the interstitial fluid by only the thin capillary wall, which is highly permeable to both oxygen and carbon dioxide. The interstitial fluid, in turn, is separated from the intracellular fluid by the plasma membranes of the cells, which are also quite permeable to oxygen and carbon dioxide. Metabolic reactions occurring within cells are constantly consuming oxygen and producing carbon dioxide.

Therefore, as shown in **Figure 2**, intracellular PO2 is lower and PCO2 higher than in arterial blood. The lowest PO2 of all (less than 5

mmHg) is in the mitochondria, the site of oxygen utilization. As a result, a net diffusion of oxygen occurs from blood into cells and, within the cells, into the mitochondria, and a net diffusion of carbon dioxide occurs from cells into blood. In this manner, as blood flows through systemic capillaries, its PO2 decreases and its PCO2 increases. This accounts for the systemic venous blood values.

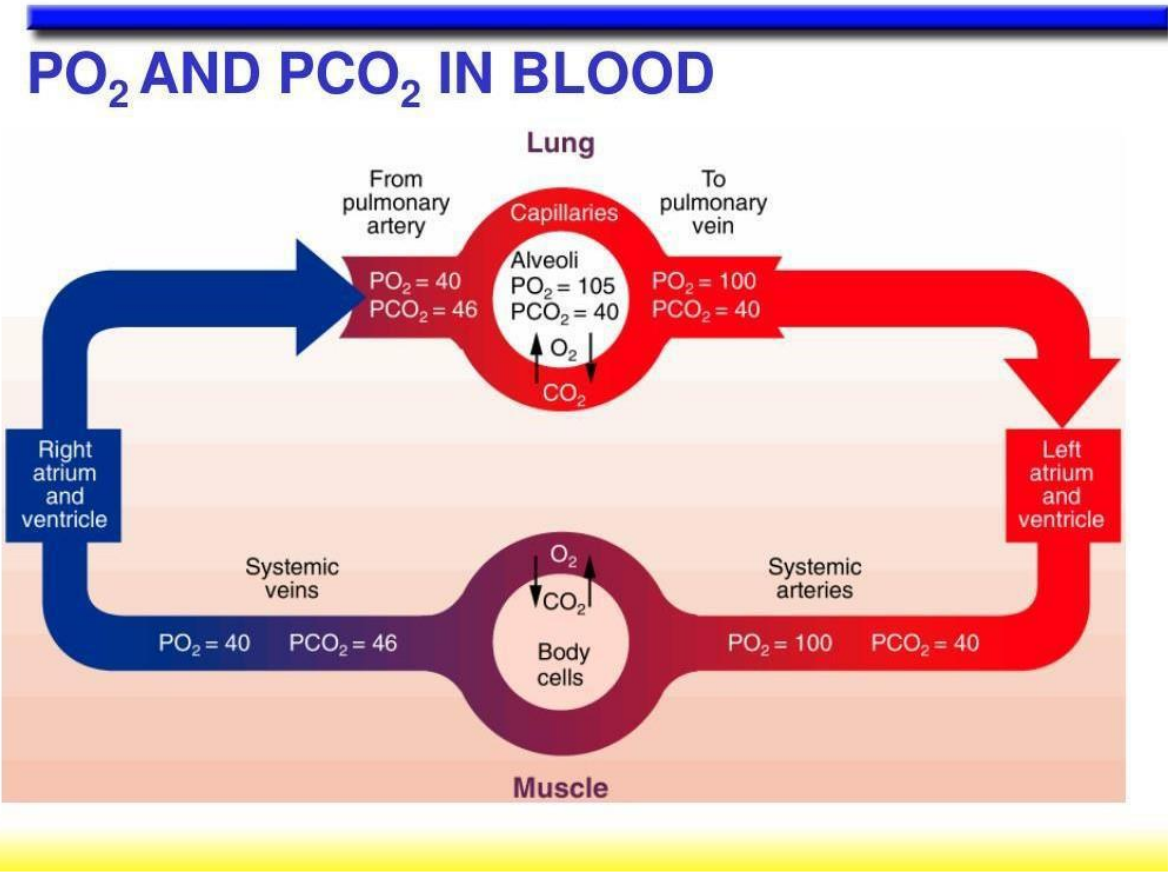


Figure 2: Partial pressures of carbon dioxide and oxygen in inspired air at sea level and in various places in the body.

Ventilation

Ventilation is defined as the exchange of air between the atmosphere and alveoli. Like blood, air moves by bulk flow from a region of high pressure to one of low pressure.

The steps of respiration

1- Ventilation: Exchange of air between atmosphere and alveoli by bulk flow.

2- Exchange of O2 and CO2 between alveolar air and blood in lung capillaries by diffusion.

3- Transport of O2 and CO2 through pulmonary and systemic circulation by bulk flow.

4- Exchange of O2 and CO2 between blood in tissue capillaries and cells in tissues by diffusion.

5- Cellular utilization of O2 and production of CO2.

Nonrespiratory Functions of the Lungs

 The lungs influence arterial blood concentrations of biologically active substances by removing some from systemic venous blood and adding others to systemic arterial blood

The lungs also act as sieves that trap and dissolve small clots formed in the systemic tissues.

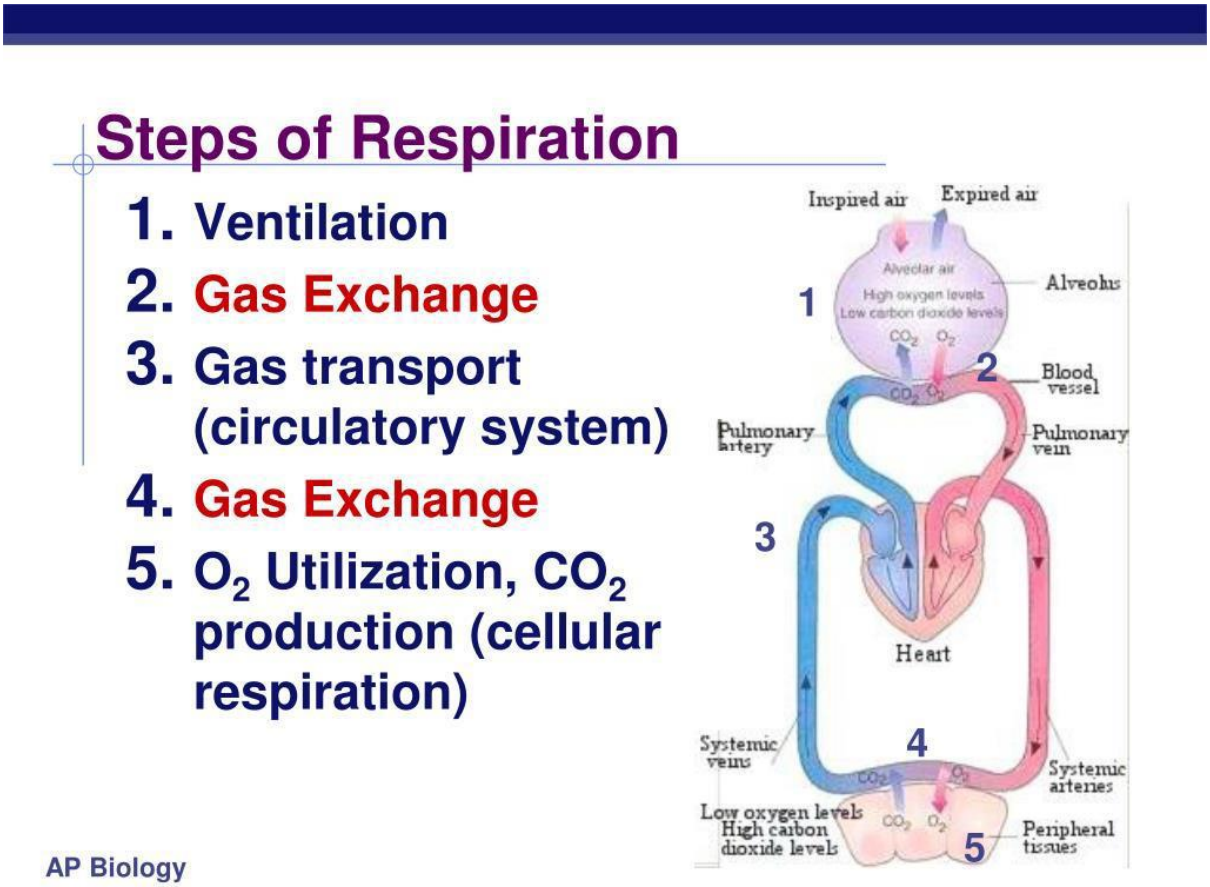


Figure 3: The steps of respiration