RESPIRATION

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Contents

Summary

In the animal kingdom several breathing systems exist. In mammals lungs are the organs of gas exchange. Lung diseases are common problems. Viral and other respiratory diseases spread almost annually through the whole populations in most countries. However, in spite of spectacular advancement (and indeed many Nobel prizes) in the study of the many fascinating aspects of human respiration, many basic questions remain to be discovered. The main scientific interest is currently centered on topics like lung tissue reactions to irritants and inflammation, immune mechanisms in lung diseases, real-time imaging of the distribution of ventilation and circulation, new mediators in the autoregulation of bronchial smooth muscles and the interplay of neural regulation of breathing and circulation. The incidence and prevalence of asthma is increasing in the developed nations. Today it is thought that the natural immune system is directed towards variable environmental and food substances, because sanitary conditions are so much better that infectious and inflammatory challenges for the newborn have reduced.

1. Introduction

Respiration is the whole process of oxidation of the metabolites in the body to produce energy. Therefore it actually encompasses all organs and tissues. Breathing is the cyclic, automatic and centrally controlled function to bring oxygen in and take carbon dioxide out of the body. Circulation transports the respiratory gases to the different organs and structures of the body. Tissue metabolism uses oxygen and returns carbon dioxide to be exhaled and excreted. All the different parts of the process are intertwined and must proceed at a certain pace. This has been depicted in Figure 1, which shows the respiration as a cog-wheel system.

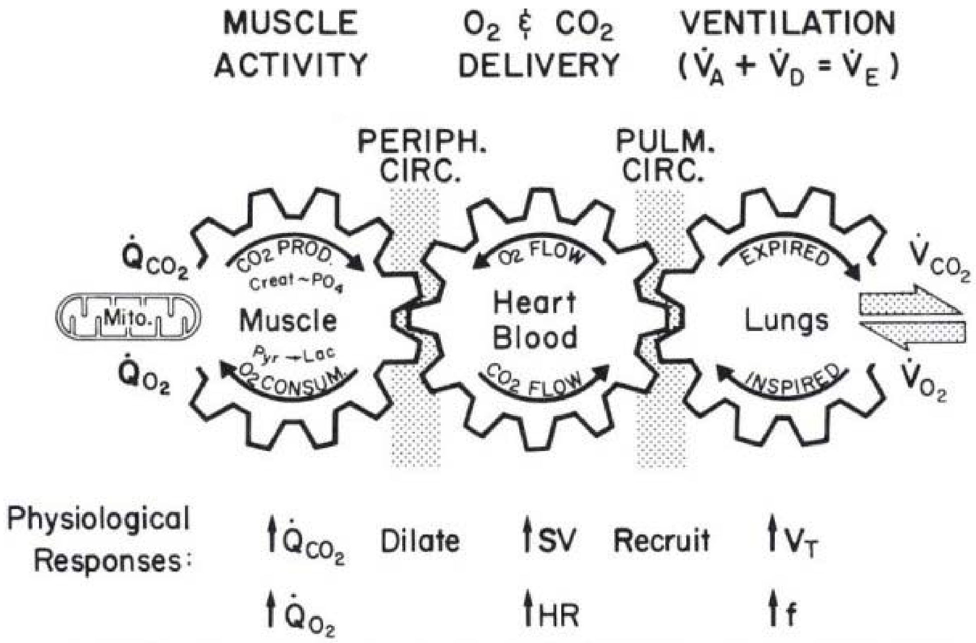

Figure 1. The relation of ventilation, circulation (see *Circulation*) and metabolism (see *Muscle Energy Metabolism*). HR: Heart rate. SV: Stroke volume. V_T: Volume. f: Frequency. Source: Karlmann Wasserman et al. Principles of exercise testing and interpretation. 2 ed. Williams and Wilkins 1994

The history of modern respiratory physiology is about 100 years old. Some of the early discoveries were made at the turn of the previous century. The second half of the twentieth century has been a very vigorous and intensive period of research. It has unraveled the respiratory process in such detail that respiration is now understood and can be controlled in most situations of human life.

Breathing has been studied in normal and exceptional conditions like mountaineering, deep sea diving and space travel.

The physiology and pathophysiology of respiration is understood so well that there are ways to treat patients in most medical emergencies starting from the preterm infant to adult respiratory insufficiency. Extracorporeal oxygenation is possible during cardiac by-pass operations and even lung transplantation is being widely used.

There is an extensive literature covering the scientific work on respiration, and the few references included only serve as a path to more reading. The Articles in this EOLSS Topic briefly describe the outlines of respiratory structures, gas exchange, transport of oxygen and carbon dioxide and control of respiration. Only simplified concepts can be presented and it is not possible to acknowledge properly the outstanding work of a huge group of investigators. The reader is again strongly urged to seek the many excellent textbooks and research publications.

Life in the Earth´s atmosphere is bound with respiration. The oxidative processes within cells are called *internal respiration*. The various processes helping the cells to maintain appropriate inflow of oxygen and outflow of carbon dioxide are called *external respiration*. Different organisms have developed a multitude of ways to deal with the environment and to regulate their internal milieu. Breathing is usually thought of as a bellows function of inhaling and exhaling gases, but in fact there are many processes working in smooth succession and simultaneously. The first process takes place between the organism and the surrounding medium which is either air or water.

2. Four Types of Surfaces for Gas Exchange

2.1. Body Surfaces

In some small animals exchange can occur directly between all cells of the body. Gas exchange across the body surface can also occur in some larger animals such as amphibians and earthworms, but they require a circulatory system to distribute the gases throughout the entire body. Air pouches can provide an internal surface for the exchange of respiratory gases. Frogs can "breath" through their skin and also with primitive lungs, as shown in the Figure 2.

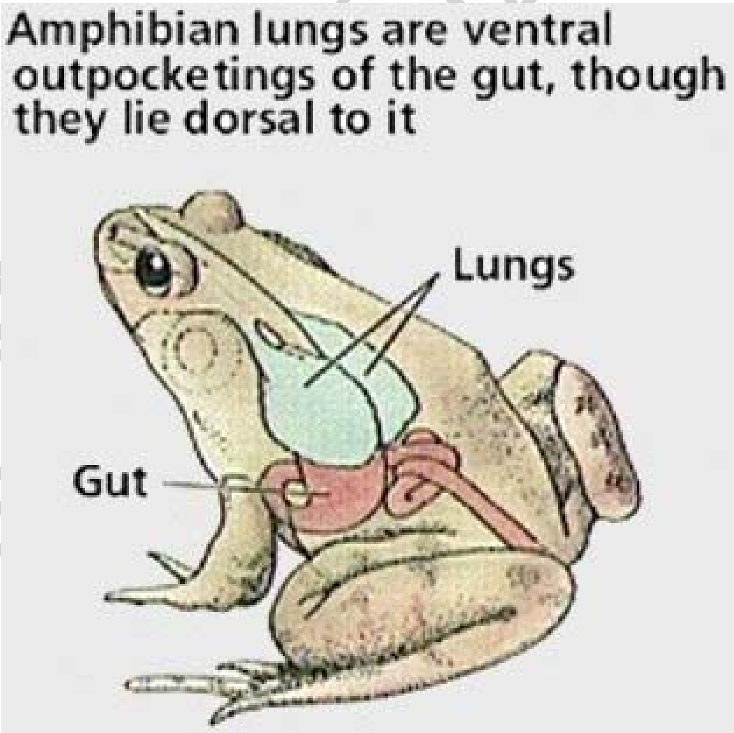

Figure 2. Gas exchange through skin and primitive lungs.

2.2. Gills

In aquatic animals such as the sea star, most molluscs, arthropods, and fish, gills provide a large surface area for the exchange of gas from the water which flows through them. Gills are rich in blood vessels so the gas exchanged can be circulated through the entire body. Fresh water flows in countercurrent fashion past the blood vessel flow as shown in Figure 3.

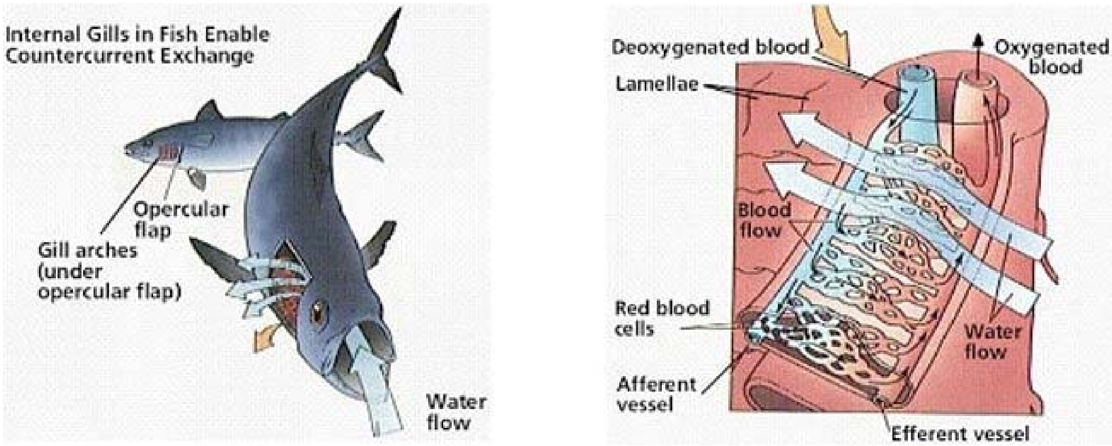

Figure 3. Breathing with gills.

2.3. Tracheal System

The respiratory system of an insect contains branched tubes. They deliver air directly to the body cells. The system does not distribute dissolved oxygen—it distributes air. The gas diffuses into cells that are in contact with the tracheal system (Figure 4). This type of gas exchange limits the size of insects, because they do not have a circulatory system to move dissolved oxygen through a large body.

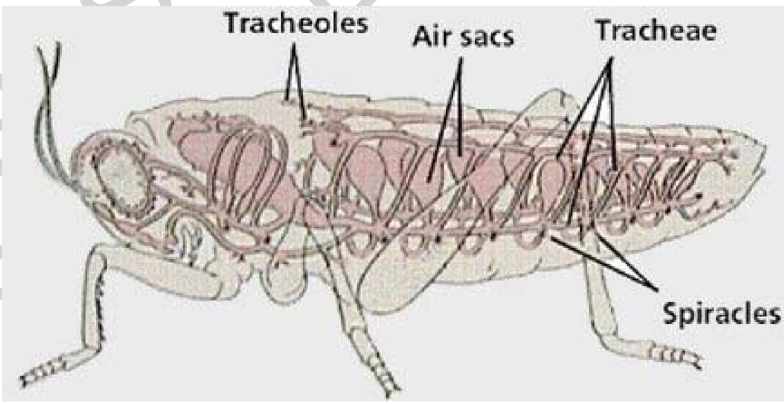

Figure 4. Insect tracheal breathing system.

2.4. Lungs

Lungs are gas exchange surfaces that are restricted to one location in an animal body. They are found in many animals including amphibians, reptiles, birds, and mammals. Birds have specialized air sacs that assist with gas exchange (Figure 5). In mammals no air sacs exist (Figure 6).

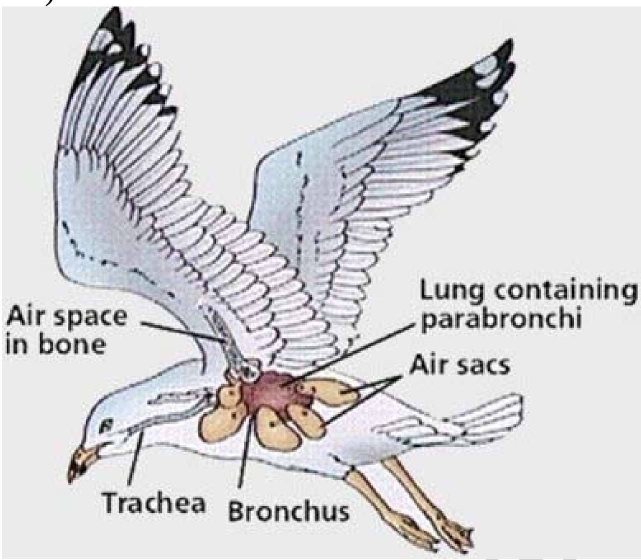

Figure 5. Bird lungs.

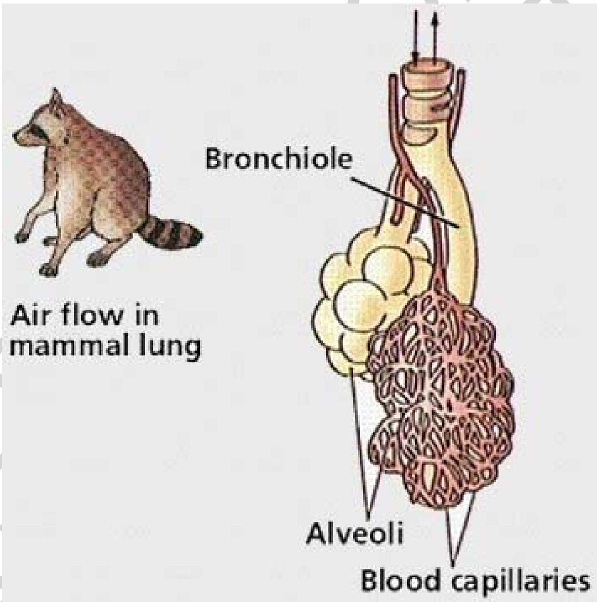

Figure 6. Mammalian lungs.

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These steps will be later described in detail as seen in the human (or other mammal) respiratory system.

In spite of the great advances in the understanding of human respiratory physiology during the last five decades, many problems still remain, and some of them are briefly described in this introductory chapter.

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Biographical Sketches

Yrjö Salorinne, MD, PhD, is presently chief physician in the department of clinical physiology and nuclear medicine at Helsinki University Hospital and associate professor of clinical physiology in the medical faculty of the University of Helsinki, Finland. His scientific works are mainly on respiratory physiology and lung diseases, and he is a co-author on many textbooks and reviews. He has been active in medical organizations and a co-editor in the Journal of Clinical Physiology.

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