

Topic: Respiratory systems

Reading: Chapter 33

Main concepts:

Warning! Confusing use of terminology ahead!

- **Respiratory systems** are systems designed for gas exchange in animals.
- **Cellular respiration** is the aerobic breakdown of carbon compounds in the mitochondria for energy.
- Oxygen is required by cellular respiration in the mitochondria. At the end of cellular respiration, free electrons and hydrogen ions (protons) are picked up by oxygen, creating molecules of water.
- Carbon dioxide is a waste product of cellular respiration. As carbon compounds are broken down to release the energy in their bonds, carbons and oxygen atoms are discarded as carbon dioxide.
- In animals with specialized organ systems, the respiratory system takes in oxygen from the atmosphere and expels carbon dioxide through lungs, gills, moist skin (in the case of amphibians), or other respiratory surfaces. The circulatory system distributes oxygen and collects carbon dioxide.
- Structures of the mammalian respiratory system:
 - Trachea: tube connecting the mouth and nose with the lungs, held open with rings of cartilage.
 - Bronchi: the first division of the trachea. Each bronchus leads into a lung, and divides into smaller bronchioles.
 - Alveoli: small bubble-shaped cavities in the lungs lined with a very thin mucus membrane and with a rich blood supply. This is the site of gas exchange. Alveoli must remain moist to function properly.
- Other animal respiratory systems:
 - Flatworms, sea jellies, sponges: animals that do not have a specialized respiratory system exchange gases over their body surfaces.
 - Insects: spiracles (holes in the exoskeleton) allow air to diffuse through tiny trachae to aerate the hemolymph in the hemocoel.
 - Fish, sharks, larval amphibians, aquatic arthropods: gill systems draw water across gills, allowing exchange of dissolved gases.
 - Land vertebrates: lungs are an internal moist gas exchange surface. In addition, many adult amphibians can exchange gases across their moist skins (some salamanders, in fact, are lungless).
- In the mammalian lung:
 - Air that is relatively high in oxygen is carried across the respiratory surface (in the lung) as we breathe in.
 - Deoxygenated blood is low in oxygen, and is brought to the respiratory surface by the capillaries.
 - Oxygen diffuses across the surface and into the capillaries, where oxygen that dissolves in the plasma is quickly taken up by hemoglobin. This keeps the concentration of oxygen in the plasma itself low, and keeps diffusion of oxygen into the blood going.
 - Carbon dioxide moves out of the blood stream by diffusion and is expelled when we breathe out. The next breath that comes in is lower in carbon dioxide than the deoxygenated blood is, which keeps diffusion of carbon dioxide going from the blood into the lungs.
- In the body tissues:
 - Oxygenated blood is carried to body cells that need oxygen. Because the concentration of oxygen in the cells is low, diffusion moves oxygen into the body cells.
 - Free oxygen is toxic, so cells use it quickly. Muscle cells may bind oxygen into myoglobin to store it safely. All cells use up oxygen as part of cellular respiration, where oxygen is bonded with hydrogen ions to make water. This keeps the concentration of oxygen in the cells low.
 - The fresh supply of blood moving past body cells is low in carbon dioxide, while the cells are continuously making carbon dioxide as a waste product of cellular respiration. This difference in concentration keeps carbon dioxide moving out of the cells and into the blood.

Common misconceptions:

- Most students are confused by the word “respiration” when it is applied both to the process of gas exchange and the processes that take place in the mitochondria. It is unfortunate that the same term is used for both. While “respiration” (gas exchange across a lung or other respiratory surface) is necessary to bring oxygen

into cells for cellular respiration, it is important to remember that cellular respiration is NOT “a cell’s way of breathing” as some students suppose on first hearing the term.

- Some people confuse “air” with “oxygen” and assume either that the stuff we breathe is “oxygen,” or that somehow our lungs only take in oxygen. What we breathe in is air, which is nearly 70% nitrogen, about 20% oxygen, and contains small fractions of carbon dioxide and many other gases.
- Most students understand that we breathe to take in oxygen and get rid of carbon dioxide. Few students know *why*, except that we somehow “need” oxygen. Oxygen is necessary for picking up electrons and protons at the end of the electron transport chain (part of the cellular respiration mechanism) in the mitochondria. Carbon dioxide is the waste product of the Krebs cycle (also part of cellular respiration).
- Many people believe that oxygen is highly beneficial, and the more we get, the better. A few even try to improve their health by breathing pure oxygen or drinking hydrogen peroxide. In fact, free oxygen is toxic. Healthy lungs are designed to take in as much oxygen as we need by the act of breathing. Hydrogen peroxide is NOT a good source of oxygen. It is, in fact, damaging to tissues and should only be used externally to clean wounds.

Reading notes:

- Describe how animals that do not have respiratory systems carry out gas exchange.
- List the steps of gas exchange by diffusion (see page 573).
- Describe several respiratory systems seen in animals.
- List the parts of the human respiratory system, and the functions of each.
- Describe how gas exchange works in the human lung, and in human body tissue. Note the differences in the ways that oxygen and carbon dioxide are transported.
- Describe the destructive effects of smoking and “passive” smoking on the lungs. (Note: ALL substances that are smoked, not just tobacco, can cause similar damage. Tobacco is especially noxious because of an addictive toxin, nicotine, that causes users to crave a smoke and thus continue to breathe in damaging substances. THC in cannabis is also mildly addictive.)

Useful websites:

- “Fish Ventilation” http://www.kscience.co.uk/animations/anim_3.htm is an animation illustrating how gas exchange across fish gills works.
 - “Respiratory Tract Anatomy” <http://sprojects.mmi.mcgill.ca/resp/anatomy.swf> is an online tutorial looking at the human respiratory system in more detail.
 - “Changes in partial pressure of oxygen and carbon dioxide” http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter44/animations.html# is an audio-visual tutorial explaining gas exchange in the lungs.
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