11.1: The Function of Respiration

The 3 components for a Respiratory System:

\[ a) \text{ Gas Exchange surface area. (lungs, gills, skin or trachea) } \]
\[ b) \text{ Moist and thin membrane to dissolve and diffuse gases. } \]
\[ c) \text{ Transport medium – blood } \]

Your cells require a continuous supply of oxygen gas (O\textsubscript{2}).

Your cells use the oxygen for a process called cellular respiration, which occurs in the mitochondria, an organelle found in the cell.

\[
\text{Glucose} + \text{ Oxygen} + \text{ Water} \rightarrow \text{ Carbon dioxide} + \text{ Water} + \text{ ATP}
\]

\[
C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 6CO_2 + 12H_2O + \text{ATP}
\]

The chemical potential energy produced in the form of Adenosine Triphosphate, is used by the cell for cellular activities.

The Main function of the Respiratory system is to supply oxygen to the body to be used by the cells and remove waste gas in the form of carbon dioxide.

**Respiratory System:** the group of organs that provides living things with oxygen from outside the body and disposes of waste products such as carbon dioxide.

**Respiration:** all of the processes involved in bringing oxygen into the body, making it available to each cell, and eliminating carbon dioxide as waste.
Respiration and Gas Exchange

Stages of Respiration

1. **Breathing**: involves two processes, inspiration (breathing in or inhaling) and expiration (breathing out or exhaling).

   *Inspiration*: the action of drawing oxygen-rich air into the lungs.

   *Expiration*: the action of releasing waste air from the lungs.

2. **External Respiration**: This is the exchange of oxygen from the lungs to the blood of the pulmonary system. This is the location of gas exchange. Here, oxygen truly enters the body.

   *Gas exchange*: the transfer of oxygen from the inhaled air into the blood, and of carbon dioxide from the blood into the lungs; it is the primary function of the lungs.

3. **Internal Respiration**: oxygen moves from the circulatory system into the cells of the body and carbon dioxide is diffused from the cells into the blood.

4. **Cellular Respiration**: at this point the oxygen is used by the cell (energy-releasing) to breakdown glucose to produce another chemical potential energy called Adenosine Triphosphate (ATP). This energy is used for cell metabolic reactions.
Respiratory Surfaces

*The two requirements of a gas exchange surface area are;*

i) Surface area is large enough to service the organism with enough oxygen to survive under the most extreme activity.

ii) Moist and thin membrane is important. Diffusion will not take place unless the gases are dissolved in water. These gases will then move from an area from high to low concentration. (oxygen and carbon dioxide)
Ventilation: the process of drawing, or pumping, an oxygen-containing medium over a respiratory surface.

Single celled organisms used direct diffusion to obtain oxygen from the surrounding environment.

Earthworm, larger and requires more oxygen to survive. The earthworm’s skin acts as its gas exchange area. The area is sufficiently large enough to support the organism, and the skin is kept moist by mucous secretion. Oxygen dissolves in the mucous and then diffuses across the skin membrane into the capillaries located just below.
**Fish** live in an aquatic environment. The water has dissolved oxygen in it. As the water moves across the gills, oxygen diffuses across the gill filaments into the circulatory system. The surface area of the gills, are always moist because of the aquatic environment.

**Insects** have a tracheal system for gas exchange. There are a series of spiracles along their abdomen. Here air enters and flows along the trachea and diffuses direct into the body and the tissue cells.
Large complex organisms have a high demand for oxygen. These organisms require a mechanism to draw air into a set of lungs for gas exchange. The many alveoli in the lungs increase the surface area for gas exchange. The alveoli are surround by capillaries, which receives the oxygen by diffusion.

Learning Check: page. 444, Questions 1 – 6
Gas Exchange in Aquatic Environments

Fish have specialized to suit their environment. The development of gills allows fish to obtain oxygen from their aquatic surroundings. The surface area is suitable to support the active life of the fish. Water enters the fish’s mouth and ventilating it across a series of gill filaments found within the gills. As the water passes over the gill filaments oxygen diffuses (diffusion gradient) from the water across the membrane and into the capillaries found lining the gills. Carbon dioxide travels in the reverse direction.

The fish has a counter–current exchange mechanism. If the water is passing over the gills from left to right, the blood flow enters from the right side (de–oxygenated) to the left side and leaves oxygenated. This maximizes the gas exchange surface area, for diffusion.

Figure 11.2: Counter-current flow in the gill of a fish provides a greater diffusion of oxygen from the water into the fish’s bloodstream. The light blue arrows represent water flowing over a gill, while the dark blue arrows represent blood flow through the blood vessels and through capillaries in the gill tissue.
Gas Exchange on Land

Land animals had to become adapted to their environment to maximize their gas exchange. The development of lungs was an evolutionary necessity for larger mammals to obtain oxygen.

Mechanics of Breathing

Air had to move from the external environment to internal environment of the lungs. The air is not able to flow into and out of the lungs. This breathing movements are controlled by the brain, breathing rate can increase or decrease when necessary.

The diaphragm and the intercostal rib muscles are responsible for changes of air pressure in the lungs.

**Diaphragm:** a sheet of muscle that separates the thoracic cavity from the abdominal cavity.

**Intercostal Rib Muscles:** are found between the ribs and along the inside surface of the rib cage.

The diaphragm and intercostals muscles are able to change the volume of the chest. This change can either increase or decrease air pressure in the lungs.
Air Pressure in the Lungs

As the diaphragm contracts (flattens) and the intercostals muscles pull the ribs upward, the volume of the thoracic cavity increases. When the volume increases the pressure will decrease in comparison to the atmospheric pressure. Therefore the air moves from an area of high pressure to an area of low pressure inside the lungs. This is inspiration.

When the diaphragm and intercostals muscles relax, the volume of the thoracic cavity will decrease. This causes an increase in air pressure in the lungs which is greater than the atmospheric air pressure. Air leaves the lungs, exhalation.

Figure 11.3: During inhalation, the intercostals muscles contract lifting the rib cage upward and outward. At the same time, the diaphragm contracts and pulls downward. As the lungs expand, air moves in. During exhalation, the intercostals muscles relax, allowing the rib cage to return to its normal position. The diaphragm also moves upward, resuming its domed shape. As the lungs contract, air moves out.
Respiratory Volume

Under normal circumstances, your normal breathing does not use the full capacity of the lungs. As your needs for oxygen increases, during exercise, you have the ability to take in more air into your lungs.

Spirograph: a graph representing the amount (volume) and speed (rate of flow) of air that is inhaled and exhaled, as measured by a spirometer.

Spirometer: measures the volume of air that is inhaled and exhaled over a period of time.

Tidal Volume: the volume of air inhaled and exhaled during normal breathing.

Inspiratory Reserve Volume: the volume of air that can be taken into the lungs beyond the regular tidal inhalation.

Expiratory Reserve Volume: the volume of air that can be expelled from the lungs beyond the regular tidal exhalation.

Vital Capacity: the total maximum volume of air that can be moved into and out of the lungs during a single breath.

Residual Volume: the volume of air that remains in the lungs after a complete exhalation.
Figure 11.4: This spirograph shows typical values for human vital capacity: the maximum volume of air that can be moved into and out of the lungs during a single breath.

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- inspiratory reserve volume
- vital capacity
- total lung volume
- tidal volume
- expiratory reserve volume
- residual volume
- residual volume