Respiration

The terms respiration and breathing are sometimes confused. In fact there are three distinct stages in respiration and the terms *ventilating the lungs, gaseous exchange* and *tissue (*or *cellular) respiration* are more precise and less easily confused.

The process of ventilation of the lungs

Ventilation of the lungs is the proper term for what many people call breathing. If you open a window, you can ventilate a room and get rid of all the nasty smells but if you open your mouth it is not enough to ventilate your lungs. You must actually suck air into your lungs. We do this by contracting the diaphragm when we are sitting down and "breathing" gently, and by raising and expanding our rib cage when we are "breathing" deeply. Sucking air into the lungs is called **inhaling**. Inhaled air is mixed with the stale air already in our lungs; so although the air we inhale contains 21% Oxygen, the air in our alveoli (alveolar air) only contains 14% Oxygen.

Don't expect all the stale used air to come out just by opening your mouth, it must be pushed out. This happens when the diaphragm relaxes and the muscles of the abdomen (tummy) push the lungs up. The rib cage can also be pulled down and in. So this is how you **exhale.** Although alveolar air only contains 14% Oxygen, it gets mixed with rather fresher air in your trachea. This means that exhaled air may contain 16% Oxygen. The air we breathe out has 100 times more carbon dioxide than the air we breathe in.

When I inhale and exhale as deeply as I possibly can, about 5.5 Litres of air comes in and out. When I inhale, oxygen enters the respiratory system through the mouth and the nose. The oxygen then passes through the larynx (where speech sounds are produced) and the trachea which is a tube that enters the chest cavity. In the chest cavity, the trachea splits into two smaller tubes called the bronchi. Each bronchus then divides again forming the bronchial tubes. The bronchial tubes lead directly into the lungs where they divide into many smaller tubes which connect to tiny sacs called alveoli, with walls only one cell thick. This is where gaseous exchange takes place.

The process of gaseous exchange

All forms of respiration require some form of gaseous exchange. In aerobic respiration, oxygen must enter our blood and carbon dioxide must leave the blood through our lungs. Gaseous exchange is **the exchange of oxygen and carbon dioxide across a respiratory surface**. Many animals which live in water or very wet places use gills for gaseous exchange. Animals which live on dry land use lungs. Our lungs have an **enormous surface area** so that oxygen can get into the blood quickly enough and carbon dioxide can get out of our blood quickly enough. Our lungs contain billions of very tiny sacs called alveoli. This is where gaseous exchange takes place, where oxygen in air gets into the lungs and carbon dioxide gets out. Each alveolus is microscopic; but if we took all the alveoli in someone's lungs and laid them flat side by side we would end up with a sheet the size of a tennis court. The average adult's lungs contain about 600 million of these spongy, air-filled sacs that are surrounded by capillaries. As well as having a very, very, very large surface area, the walls of our alveoli are **incredibly thin**, so the distance between the air in our lungs and the blood in our capillaries is very, very, very small.

These two features allow the respiratory gases (oxygen and carbon dioxide) to get in or out of the blood fast enough. If you don't believe this, find someone who has been smoking cigarettes for fifty years. They might have a disease called **emphysema.** What happens is that instead of having billions of very tiny alveoli, they have millions of larger ones; this means that the surface area of their lungs is not the size of a tennis court but just the size of a dining room table. People with emphysema get out of breath very quickly.

Gaseous exchange is also necessary for photosynthesis. Green plants do respire: at night time they exchange gases just as we do, oxygen in and carbon dioxide out. In the daytime they do just the opposite. Carbon dioxide enters a plant because it is needed for photosynthesis, and oxygen leaves. This is still called gaseous exchange.

The process of tissue respiration

The oxygen that diffuses into the blood capillaries from the air in the alveoli is carried around the body to all cells where tissue respiration occurs. Tissue respiration is the release of energy, usually from glucose, in the tissues of all animals, green plants, fungi and bacteria. All these living things require energy for other processes such as growth, movement, sensitivity, and reproduction.

The most efficient form of respiration is aerobic respiration: this requires oxygen.

Glucose + Oxygen → Carbon Dioxide + Water + Energy

This word equation for aerobic respiration means: "**Glucose and oxygen are turned into carbon dioxide and water; this releases energy**".

When oxygen is not available, some organisms can respire anaerobically i.e. without air or oxygen. Yeast can respire in both ways. Yeast gets more energy from aerobic respiration, but when it runs out of oxygen it does not die. It can continue to respire anaerobically, but it does not get so much energy from the sugar. Yeast produces ethanol (alcohol) when it respires anaerobically and ultimately the ethanol will kill the yeast. This is the word equation for anaerobic respiration in yeast.

Glucose → Carbon Dioxide + Ethanol + Energy

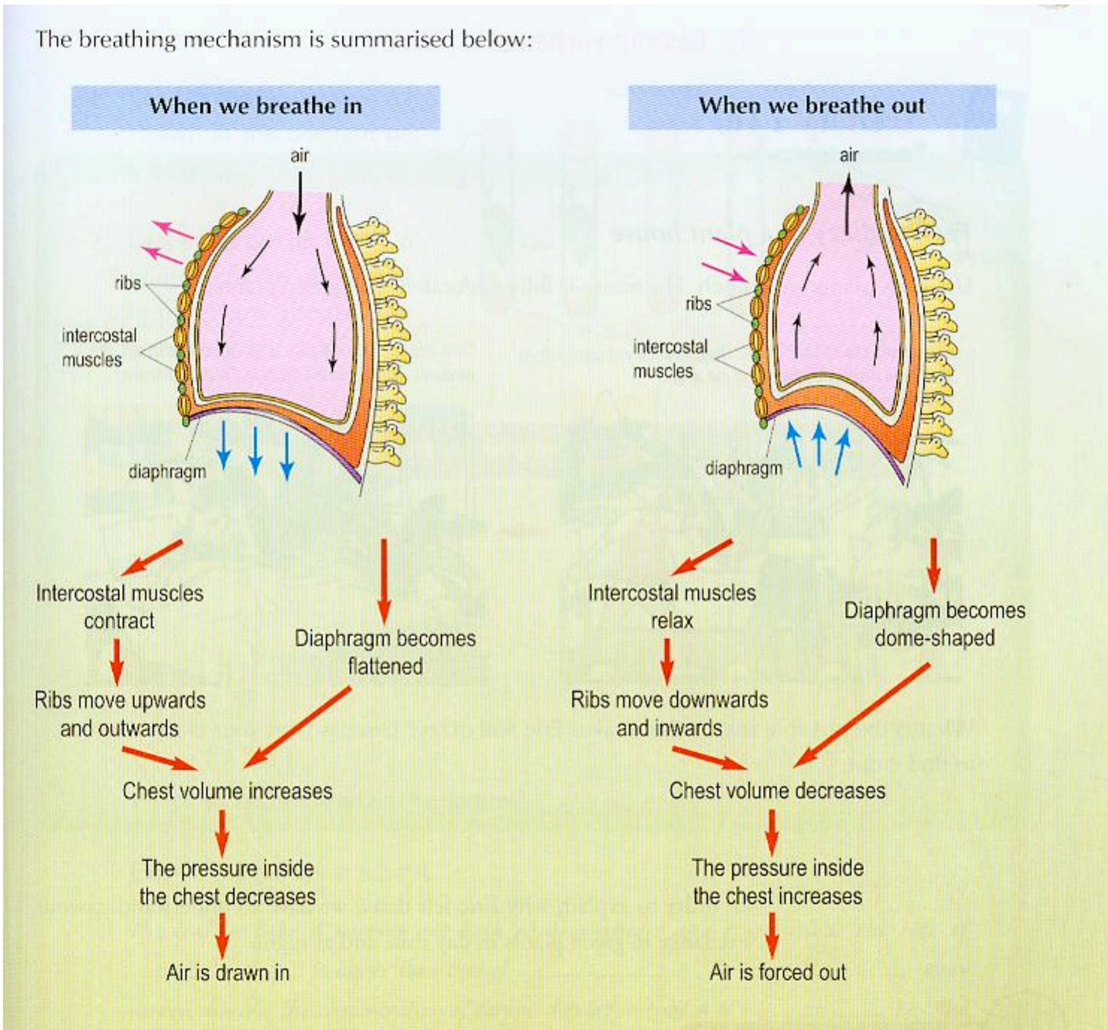
We can respire in both ways too. Anaerobic respiration takes place when you exercise. When you exercise hard, your muscles need to release more energy from glucose and your body can't get enough oxygen to the cells. So, you use anaerobic respiration. This is where the body respires without oxygen and produces lactic acid. In anaerobic respiration the glucose is only partially broken down, and lactic acid is produced - together with a much smaller amount of energy. Your cells cannot respire anaerobically for very long because lactic acid is poisonous, causing pains and cramp in your muscles. To get rid of the cramp, we have to breathe very deeply for a few seconds to break up the lactic acid.

Respiration and photosynthesis in plants

Plants respire all the time and use the food made by photosynthesis in respiration. Photosynthesis usually results in the plant gaining food, however, once respiration has been accounted for. They respire in darkness or light and so they are always taking in oxygen and releasing carbon dioxide. But they also photosynthesise when they are in the light - and remember that plants take in carbon dioxide and release oxygen when they photosynthesise. The net result for a plant overall, over any given period, depends on whether it is in the dark or the light, and how bright the light is:

Conditions	Photosynthesis v respiration	Overall result
Dark	Respiration No photosynthesis	Oxygen taken in Carbon dioxide given out
Dim light	Photosynthesis rate equals respiration rate	No net gain/loss of oxygen or carbon dioxide
Bright light	Photosynthesis rate greater than respiration rate	Carbon dioxide taken in Oxygen given out

[Adapted from http://www.purchon.com/biology/respire.htm **(5/09/08) and http://www.bbc.co.uk/schools/ks3bitesize/science/biology/green_plants_5.shtml]**



[Taken from Chan, W.K., Luk, W.Y., & Kong, S.W. (2005). Understanding integrated science for the 21st century. Hong Kong: Aristo Educational Press Ltd.]