Gas exchange

Gas exchange occurs as a result of respiration, when carbon dioxide is excreted and oxygen taken up, and photosynthesis, when oxygen is excreted and carbon dioxide is taken up.

The rate of gas exchange is affected by:

- the area available for diffusion
- the distance over which diffusion occurs
- the concentration gradient across the gas exchange surface
- the speed with which molecules diffuse through membranes.

Efficient gas exchange systems must:

- have a large surface area to volume ratio
- be thin
- have mechanisms for maintaining steep concentration gradients across themselves
- be permeable to gases.

Single-celled organisms are aquatic and their cell surface membrane has a sufficiently large surface area to volume ratio to act as an efficient gas exchange surface.

In larger organisms, permeable, thin, flat structures have all the properties of efficient gas exchange surfaces but need water to prevent their dehydration and give them mechanical support. Since the solubility of oxygen in water is low, organisms that obtain their oxygen from water can maintain only a low metabolic rate.

In small and thin organisms, the distance from gas exchange surface to the inside of the organism is short enough for diffusion of gases to be efficient. Diffusion gradients are maintained because gases are continually used up or produced. In larger organisms, simple diffusion is not an efficient way of transporting gases between cells in the body and the gas exchange surface. In many animals a blood circulatory system carries gases to and from the gas exchange surface. The gas-carrying capacity of the blood is increased by respiratory pigments, such as haemoglobin.

Animals with an internal gas exchange surface ventilate it by passing fresh air or water through their respiratory system. Air usually flows in and out through the same pathway; being light this requires little muscular activity. Denser water is passed in a one-directional pathway over gills.

In terrestrial plants diffusion of gases through pores is sufficient to service the few living cells in its stem cortex and its thalloid leaves. In the roots, gas exchange is restricted to a small permeable area.

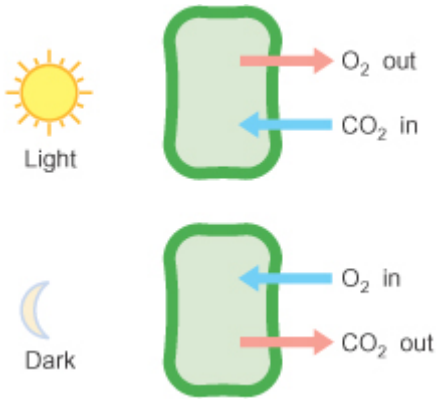
See also:

> In and out of cells
> Transport of respiratory gases
> Respiration
> Photosynthesis

Gaseous exchange in flowering plants

Flowering plants exchange gases through their leaves:

- in the light there is a net intake of carbon dioxide for photosynthesis and a net output of oxygen from respiration
- in the dark there is a net intake of oxygen for respiration and a net output of carbon dioxide



Movement of water

Stomata are holes or empty gaps between guard cells. They are mainly situated in the leaf's lower epidermis (underside, away from the sun). The movement of water in and out of the guard cells opens and closes the stomata.

The inner walls, lining the stomata, are made rigid by cellulose microfibrils. When potassium ions (K^+) are pumped into the guard cells the water potential in the cells decreases and water passes out of adjacent cells into the guard cells by osmosis. The guard cells become turgid (swollen with water). This opens the stomata and allows water loss (and gas exchange).

> See the topic about In and out of cells

Gas exchange

In the dark the plant's **potassium pumps** stop and potassium ions diffuse back out of the guard cells, they lose turgidity and the stomata close. Sufficient oxygen for respiration can still get into the leaf cells by diffusion.

Gas exchange is achieved by diffusion. This is a process by which particles move naturally from a region where they are in high concentration to a region where they are in lower concentration. They move down a concentration gradient: the steeper the gradient, the faster the rate of diffusion.

With the stomata open, production and consumption of oxygen and carbon dioxide in the leaf is sufficient to maintain a concentration gradient steep enough to facilitate gas exchange with the atmosphere.

In potential drought conditions, a mechanism triggered by the plant hormone **abscissic acid (ABA)**, causes potassium ions to be pumped out of the guard cells into adjacent cells. This reduces turgidity in the guard cells and causes the stomata to close which reduces the rate of gas exchange. Plants living in areas prone to drought usually have adaptations to cut down water loss or even store water.

Test your knowledge

Take quiz on *Gas Exchange*