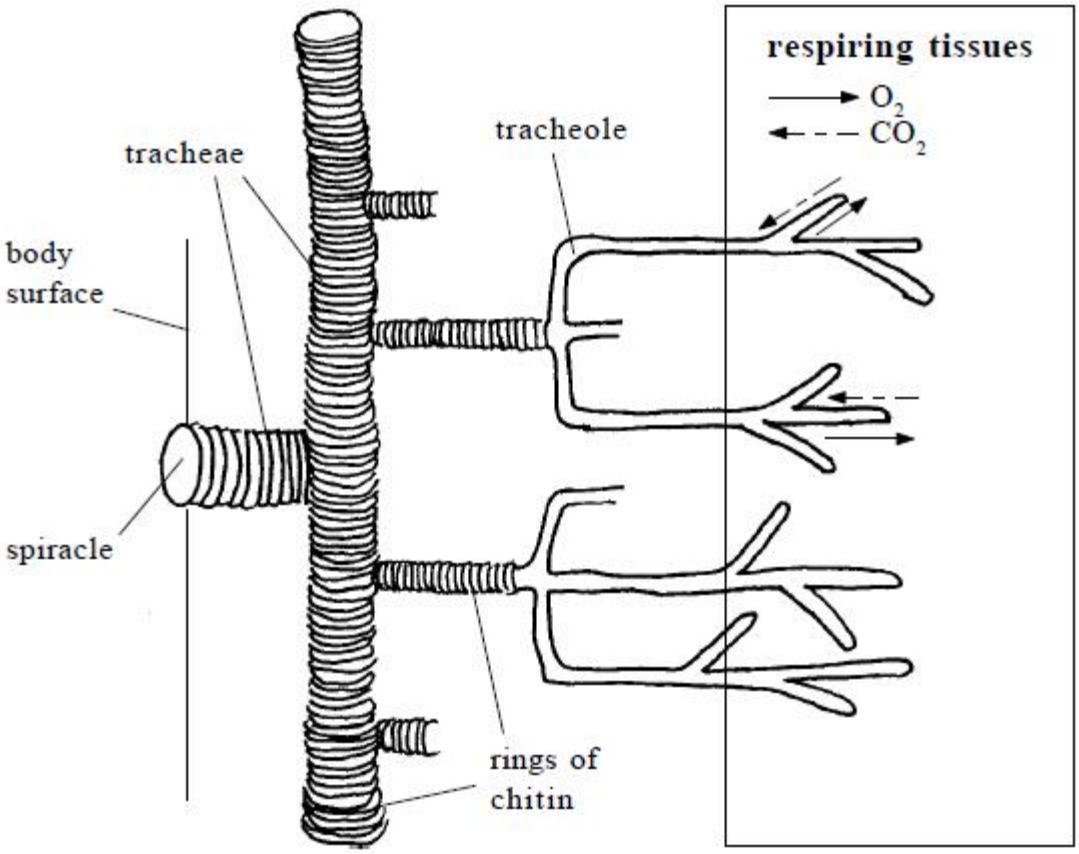
Gaseous exchange in insects



The hard exoskeleton of insects is unsuitable for gas exchange but their internal gas exchange surfaces differ significantly from those of mammals. The most significant difference is the lack of a transport system.

Gases diffuse passively through the spiracles, trachea and tracheoles directly to the tissues. Some species of insect produce rhythmical muscle contractions to assist the passive diffusion of gases. This is a type of ventilation.

Insects can control their rate of gas exchange. When respiration levels are high, the concentration of lactic acid in tissues increases. This sets up an osmotic pressure causing fluid to diffuse from the tracheoles into the tissues by osmosis. Gas exchange then occurs more rapidly because the gases can diffuse at a faster rate through a gaseous medium (the residual air in the tracheoles) rather than a liquid medium.

Oxygen penetrates all parts of the body of an insect by a branched network of tubes which form the tracheal system. Each trachea consists of a squamous epithelium which secretes a chitanous lining. To prevent the tubes from collapsing, they are strengthened by further spiral bands of chitin. The trachea diminish in size as they branch and they finally end in minute intracellular tracheoles which lack the chitinous lining.these tracheoles penetrate the tissues of the body and

ensure that each cell is supplied with oxygen. When the insect is not active, diffusion of oxygen through the spiracles suffices for its needs but when the insect is active e.g. during flight, special rhythmical movements of the thorax or abdomen takes place. This is due to the dorsal ventral muscle.
If the spiracles are open contraction of muscles will force air out e.g. in locust it takes place in the abdominal spiracles. If the spiracles are closed the contractions will force the air deep into the tracheoles.
The vast numbers of tiny tracheoles give a large surface area for gaseous exchange. The tracheoles containing a watery fluid towards the end of their length limits the penetration of gases for diffusion. However when oxygen demands build up e.g. when insect is flying, lactic acid accumulation in the tissues causes water to be withdrawn from the tracheoles by osmosis and expose additional surface area for gaseous exchange.
All the oxygen needed by the insects cells is supplied to them by the respiratory system, how ever upto 25% of the carbondioxide produced by the cells is lost directly throughout the whole cuticle.
The extent of respiration in most insects is controlled by the opening of the spiracles. There are respiratory centres in both the ganglia of the nerve cord and the brain. They are stimulated by increasing CO_2 levels and by lactic acid which builds up in the active tissues when there is lack of oxygen. A combination of lack of oxygen and carbondioxide build up work together to provide the insect with a flexible and responsive respiratory system.

Very active insects.

The type of respiratory system described so far works well for small insects and for large but slow ones. Those insects with more active lifestyles e.g. larger beetles locusts, grass hopers, bees, wasps and flies have much higher energy demands. To supply the extra oxygen needed, alternative methods of increasing the level of gaseous exchange are used.

1. Some form of mechanical ventilation of tracheal system may be introduced i.e. air is actively pumped through the system. This is brought by the increased opening of the spiracles along with muscular pumping movement of the thorax and or abdomen.

2. Some active insects have collapsed trachea or air sacs which act as air reservoirs and are used to increase the amount of air moved through the respiratory system. They are usually inflated and deflated by the ventilation movements of the thorax and abdomen e.g. locusts.