Gaseous Exchange in Aquatic Invertebrates

All aerobic organisms need a regular supply of oxygen from their environment in order to respire. This is much easier for terrestrial animals, as 21% of the air is made up of oxygen, compared to less than 1% i n water. Aquatic animals have to overcome the problem of getting enough oxygen to support metabolic reactions in an environment where there is very little of it.

Some simple organisms such as amoebae and flatworms are able to carry out gaseous excha nge over their whole surface area, as they have a high surface area to volume ratio. As they are submerged in water, gasses can easily diffuse in and out of the organism using osmosis.

As animals become bigger and more complex, the surface area to volume ratio decreases, and it becomes impossible for the organism to get enough oxygen for metabolic reactions through its surface. Instead, they need to have specialised respiratory surfaces. Many aquatic insects have 'respiratory siphons' which a llow the insect to breathe air from above the surface of the water while their bodies remain submerged. The insect breathes through 'spiracles', which are pores in the skin, which can be opened and closed by valves. These lead into tracheoles, which end in the tissues. Only the posterior spiracles are used, which are located at the end of the siphon. Insects such as drone flies and mosquito larvae use this technique.

One problem with respiratory siphons is that they limit the organism to the upper levels of the water. Some insects, such as diving beetles, have managed to overcome this by carrying air stores along with them when they dive. By keeping air stores in contact with the spiracles, they are able to draw upon these air stores to meet with their oxygen requirements.

The benefit of using air stores it that the bubble itself can act like a physical gill, and draw oxygen from the surrounding water. This occurs because after the beetle dives, a disequilibrium in the bubble occurs. The oxygen is removed from the bubble, causing a decrease in the partial pressure of the oxygen, and an increase in the partial pressure of nitrogen. Oxygen then diffuses from the water into the bubble, and nitrogen diffuses from the bubble into the water. This technique provides enough oxygen for small, inactive insects to remain underwater for months, however, bigger, and more active insects need to surface every few minutes to replenish their oxygen supplies. Water temperature affects the amount of oxygen that can be dissolved in water. As the temperature increases, the amount of water that can be dissolved decreases. The amount of oxygen required by the beetle, however, increases, thus the physical gill is of little use.

A solution for some invertebrates is to develop a true physiological gill to extract oxygen from the water. Gills are appendages for gas exchange, with tracheae.

Oxygen diffuses from the water into the tracheae, and moves through the tracheal system in to the tissues. Organisms that use gills for respiration include mayfly nymphs, damsel fly larvae, and stone fly nymphs.

Finally, some organisms are able to obtain oxygen whilst underwater by extracting it from aquatic plants by thrus ting their spiracles into the aerenchyma of plants.