How cells and organisms carry out exchanges with their external environment to maintain their internal environment?

The exchange of substances in cells and organisms is vital for their survival. For exchange to take place substances must pass over the cell membrane and into or out of cell organelles. The majority of cells use diffusion to achieve exchange however active transport is required in some processes of exchange. The effectiveness of an organism at exchange depends on its SA: VOL ratio and metabolic rate. However, some organisms require specialized exchange surfaces as diffusion alone cannot carry out effective exchange with their external environment to maintain their internal environment.

The human body is a complex organism and requires several different ways to carry out exchanges with their external environment to maintain their internal environment including the gas-exchange system, digestion and absorption of digestive products.

Firstly, the gas-exchange system in humans includes specialised organs for exchange known as lungs to ensure efficient gas exchange between the air and the blood. Humans require to get oxygen into the blood to release energy in the form of ATP during respiration and to remove carbon dioxide, made by respiration cells, as its build-up can be harmful. Ventilation is the system by which humans are able to take in and release gas. This breathing in (inspiration) and breathing out (expiration) is controlled via nervous impulses from the respiratory centre in the medulla of the brain. The process of inspiration happens when external intercostal muscles contract causing the ribs and sternum move up and out. The width of thorax increases and the diaphragm contracts moving down and flattening causing the depth and volume of the thorax to increase air is forced in by the higher external atmospheric pressure. The process of expiration takes place when external intercostal muscles relax leading to the ribs and sternum to move down and inwards. The width of thorax decreases and the diaphragm relaxes and moves up causing the depth and volume of thorax decreases. The air pressure in the alveoli is more than the atmospheric pressure causing air to be forced out.

The lungs contain millions of tiny air sacs known as alveoli in where a diffusion gradient must be obtained to ensure constant supply of oxygen to the body. The alveoli are adapted, to ensure the internal demand for oxygen is met, by having a thin exchange surface as the alveolar epithelium is only one cell thick meaning it has a short diffusion pathway. Secondly, as there are millions of alveoli they have a larger surface area for gas exchange causing an increased rate in diffusion. There is also a high concentration gradient due to the alveoli being surrounded by a network of capillaries meaning a constant blood supply, which is the movement of the internal medium, and the ventilation of air known as movement of the environmental medium.

Furthermore, the rate of diffusion of gases is very rapid as the red blood cells are slowed in the capillaries increasing time for diffusion, the distance for diffusion between the alveoli and capillaries is reduced due to red blood cells flattened against the capillary walls and capillaries are one cell thick meaning a short diffusion pathway. Oxygen diffuses across the alveolar epithelium and capillary endothelium into the haemoglobin within red blood cells. Carbon dioxide diffuses out of the blood into the alveolar space which is then breathed out.

However, gas exchange in single celled organisms and insects is varied compared to humans. Single celled organisms as they release and absorb gases by diffusion through their outer surface. They are small therefore meaning a larger surface area to volume ratio but also have a thin surface and short diffusion pathway meaning there is no need for a gas exchange system.