Key Aims

1. *Diffusion Basics*
2. *Factors Affecting Diffusion*
3. *Surface Area: Volume Ratios*
4. *Exchange in Large Organisms*

AQA Specification

Substances may move into and out of cells across the cell membranes via diffusion.

AQA Specification

Diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration.

1.3.1. Diffusion

Organisms need to take in substances and give out substances. This is known as transport. There are many mechanisms to do this. We will first look into diffusion.

- **Diffusion is the movement of a substance across a cell membrane.** Diffusion is the passive movement of a substance in a solution from an area of high concentration to an area of lower concentration.

- **Diffusion is passive.** Diffusion is **passive** and so does not require energy.

- **Diffusion occurs in fluids.** Diffusion occurs in liquids and gases. Therefore it can occur in the **cytoplasm**.

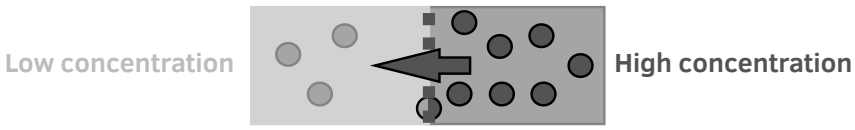

Fig 1. Diffusion. This involves movement of a substance from an area of high to low concentration.

- **Diffusion occurs in the lungs.** Diffusion occurs in the **alveoli**, as oxygen diffuses from a high concentration in the alveoli into the blood across the capillaries and carbon dioxide diffuses from the blood into the alveoli, along the concentration gradient.

AQA Specification

Some of the substances transported in and out of cells by diffusion are oxygen and carbon dioxide in gas exchange, and of the waste product urea from cells into the blood plasma for excretion in the kidney.

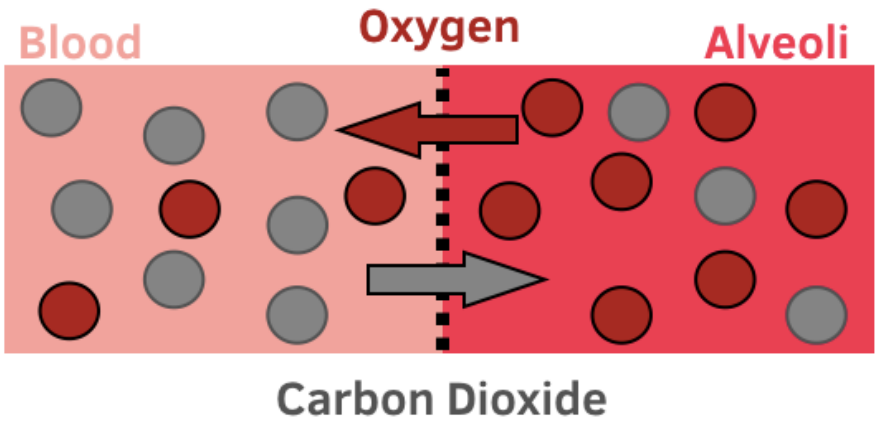

Fig 2. Diffusion in the Blood.

- **Diffusion occurs in the kidney and liver.** Urea is produced by the liver as a waste product of the body. It diffuses from the liver cells into the blood, from an area of high concentration to an area of low concentration. The urea then goes to the kidneys to be excreted.

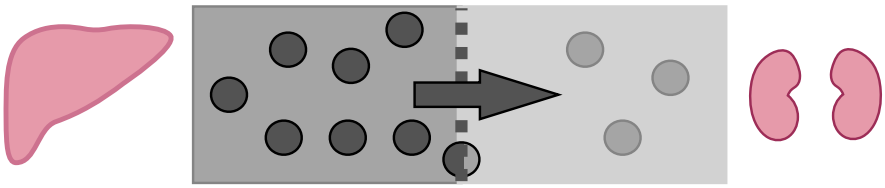

Fig 3. Diffusion of Urea from the Liver to the Kidneys.

AQA Specification

Students should be able to explain how different factors affect the rate of diffusion.

- **Difference in concentration affects the rate of diffusion.** The greater the concentration gradient, the quicker diffusion takes place. For example, if there is a very high concentration of oxygen in the alveoli, and a very low concentration in the blood, diffusion will take place very quickly. However, if there is an almost equal concentration in both, the rate of diffusion will be very low.

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Factors which affect the rate of diffusion are the difference in concentrations (concentration gradient), the temperature and the surface area of the membrane.

- **The temperature affects the rate of diffusion.** As the temperature increases, particles gain more kinetic energy and so can diffuse across a membrane more quickly. Therefore, as the temperature increases, the rate of diffusion increases.
- **The surface area of the membrane affects the rate of diffusion.** As the surface area of the membrane increases, the rate of diffusion also increases, as there is more space for molecules to diffuse across the membrane.

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A single-celled organism has a relatively large surface area to volume ratio.

Surface Area: Volume Ratios

Single celled organisms do not have a specific transport. They instead can meet their demands of substances through diffusion.

They are able to do this as they have a large surface area to volume ratio. Therefore, the rate of diffusion is great enough to allow all of the transport through this medium only.

AQA Specification

This allows sufficient transport of molecules into and out of the cell to meet the needs of the organism.

Calculate Sa:Vol ratio

Divide the surface area by the volume. Therefore, if an organism has a surface area of 4 meters squared and a volume of 2 meters cubed, the Sa:Vol ratio is 2.

AQA Specification

Students should be able to calculate and compare surface area to volume ratios.

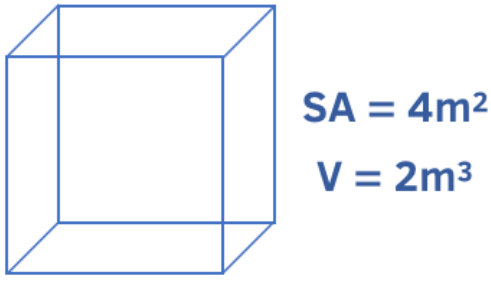

Fig 4. Surface Area : Volume Ratio.

AQA Specification

Students should be able to explain the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area to volume ratio.

Single celled organisms have a very large surface area to volume ratio, however large organisms on the other hand have a greater volume, with a smaller increase in surface area. Therefore, the rate of diffusion would be too slow in large organism to provide all of the transport. Therefore, these organisms require a transport system.

Mechanisms for Exchange in Large Organisms

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Students should be able to explain how the small intestine and lungs in mammals, gills in fish, and the roots and leaves in plants, are adapted for exchanging materials.

- **The small intestine is adapted for transport.** The small intestine contains villi. These villi even have microvilli. This increases the surface area for transport. Moreover, it has a very rich blood supply to increase the rate of diffusion and a short diffusion path.
- **The lungs are adapted for transport.** The lungs have alveioli, to increase their surface area for diffusion. The alveoli also have a rich blood supply, thus keeping the concentration gradient going.
- **Fish have gills for transport.** The gills are a part of the fish that act as an exchange surface between blood and the water. They have an operculum, a flap, that keeps the water flowing over the gills. This maintains the concentration gradient. Within the fish, blood keeps flowing, thus maintaining the concentration gradient.

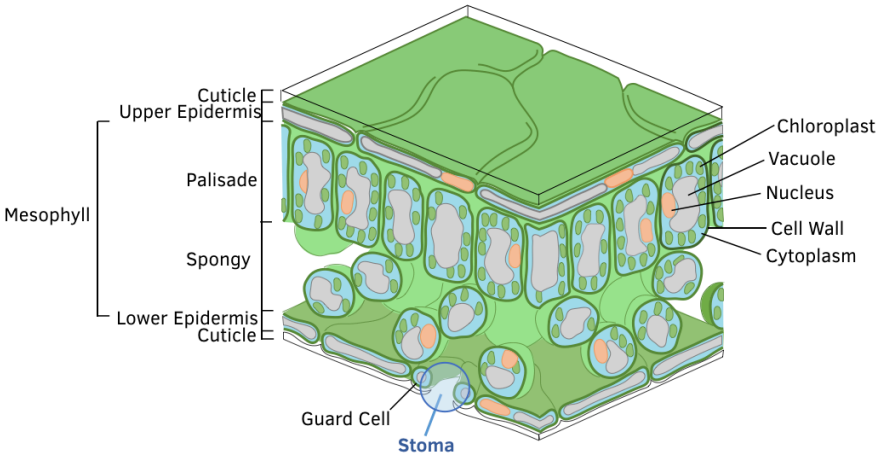

Fig 5. Plant leaf structure. Gas exchange occurs through the stomatal pore.

Study Mind Tip

Learn all of these adaptations. AQA often ask about specific ones.

AQA Specification

In multicellular organisms, surfaces and organ systems are specialised for exchanging materials.

- **Plants have roots for transport.** These roots are very long. This increases their surface area. The surface area is further increased by root hair cells.

- **Plants have leaves for transport.** The leaves of plants are very flat, which increases their surface area. They also have stomata to maintain the concentration gradient and allow gases to move into and out of the leaves.

AQA Specification

This is to allow sufficient molecules to be transported into and out of cells for the organism's needs.

As we have grasped, larger, multicellular organisms need to have a specialised system to allow transport. There are a few prerequisites for this.

AQA Specification

The effectiveness of an exchange surface is increased by having a large surface area, a membrane that is thin, to provide a short diffusion path, (in animals) having an efficient blood supply and (in animals, for gaseous exchange) being ventilated.

1. They must have a large surface area
2. They must have a thin membrane, to reduce the length of the diffusion pathway
3. They must have an efficient blood supply in animals to maintain the concentration gradient
4. Ventilation must be constant in animals for gaseous exchange.