Movement In and Out of Cells

Water as a solvent, diffusion and the factors that affect it, osmosis and water potential, turgor and plasmolysis in plant cells, and active transport.

3.1 Diffusion and osmosis

Water as a solvent

Water is the solvent in living things, because many substances dissolve in it. This is important in:

- **digestion**: digested food molecules dissolve in water and can be absorbed;
- **excretion**: urea and excess salts dissolve in water and are carried out in urine;
- **transport**: substances such as glucose, ions and hormones dissolve in the water of blood plasma (and sap in plants) and are carried around the body.

Diffusion

> **Diffusion is the net movement of molecules or ions from a region of their higher concentration to a region of their lower concentration (down a concentration gradient), as a result of their random movement.**

Diffusion is a **passive** process: it needs no energy from respiration. The energy comes from the **kinetic energy** of the random movement of the molecules and ions.

Examples: oxygen diffusing from the air in the alveoli into the blood; carbon dioxide diffusing into a leaf for photosynthesis; digested food diffusing from the small intestine into the blood.

Factors that affect the rate of diffusion.

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Factor	Effect on the rate
surface area	a larger surface area gives a faster rate
temperature	a higher temperature gives a faster rate, because the particles have more kinetic energy
concentration gradient	a steeper gradient gives a faster rate
distance	a shorter distance gives a faster rate

Investigation. Agar jelly cubes that contain an indicator can be placed in acid to show how fast the acid diffuses in. Smaller cubes (a larger surface area compared with their volume) change colour all the way through faster. Another way is to time how long it takes for the colour of a dye to spread through water at different temperatures.

Osmosis

> **Osmosis is the net movement of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane.**

- A **dilute** solution has a **high** water potential (a lot of water). A **concentrated** solution has a **low** water potential.
- A **partially permeable membrane** lets small molecules such as water through, but not larger solute molecules.
- Water moves **down the water potential gradient**, from the dilute solution to the concentrated solution.
- Osmosis is a type of diffusion and, like diffusion, uses the kinetic energy of the molecules.

Investigating osmosis with dialysis (Visking) tubing. A tube is filled with a concentrated sugar solution, tied at both ends and placed in a beaker of water. Water moves into the tube by osmosis, so the tube becomes swollen and heavier. If the tube contains water and is placed in sugar solution, it loses mass.

Osmosis in plant tissue

Pieces of potato or other plant tissue can be placed in solutions of different concentrations. They are weighed or measured before and after.

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Solution	Water movement	Result
pure water or a dilute solution (higher water potential than the cells)	water moves **into** the cells	the tissue gains mass and becomes **firm**
concentrated solution (lower water potential than the cells)	water moves **out of** the cells	the tissue loses mass and becomes **soft**
a solution with the same water potential	no net movement	no change in mass

Plotting percentage change in mass against concentration gives a graph that crosses zero where the solution has the **same water potential** as the cells.

Terms for plant cells.

- **Turgid:** a cell that is full of water, with the cell membrane pushing against the cell wall.
- **Turgor pressure:** the pressure of the water inside the cell pressing outwards on the cell wall. It **supports** plants (non-woody parts keep their shape because their cells are turgid).
- **Flaccid:** a cell that has lost some water, so it is soft and limp. If a plant loses enough water, it wilts.
- **Plasmolysis:** when so much water leaves that the cytoplasm and membrane pull **away from the cell wall**.

The cell wall prevents a plant cell from bursting when it takes in water, but **animal cells** have no cell wall. In pure water, an animal cell such as a red blood cell takes in water and may **burst**. In a concentrated solution, it loses water and **shrinks**.

> **TRY IT**
>
> A piece of potato gains mass in solution X and loses mass in solution Y. What does this show about the two solutions compared with the cells of the potato?

Solution X has a **higher water potential** (more dilute) than the potato cells, so water moved in by osmosis. Solution Y has a **lower water potential** (more concentrated), so water moved out.

> **NOTE**
>
> Say "**water potential**" and "**partially permeable membrane**", and always say that water moves **down** a water potential gradient. Do not say that water moves "to where there is more salt" without explaining.

Importance in plants. Root hair cells have a lower water potential than the soil water, so water enters them by osmosis. Water then moves from cell to cell across the root down a water potential gradient.

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3.3 Active transport

Active transport is the movement of molecules or ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration (against a concentration gradient), using energy released during respiration.

	Diffusion	Active transport
direction	down the concentration gradient	against the concentration gradient
energy from respiration	not needed	needed
membrane proteins	not needed	carrier proteins pump the substance

Importance in ion uptake by root hair cells. The concentration of mineral ions such as nitrate in the soil is lower than in the root hair cells, so the ions cannot enter by diffusion. Root hair cells take them up by **active transport**, using energy from respiration. The cells have many mitochondria to supply the energy. This lets plants take in the ions they need even when the soil contains very little of them.

Active transport also takes **glucose** from the small intestine and the kidney tubules into the blood when the concentration in the blood is higher.

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