

Movement into and out of cells revision notes

Cells must take in the substances they need and get rid of the substances they do not. This topic covers the three ways substances cross cell membranes: diffusion, osmosis and active transport. You also need to know how to investigate them, and how water movement keeps plant cells firm.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

1 Diffusion Spec 3.1

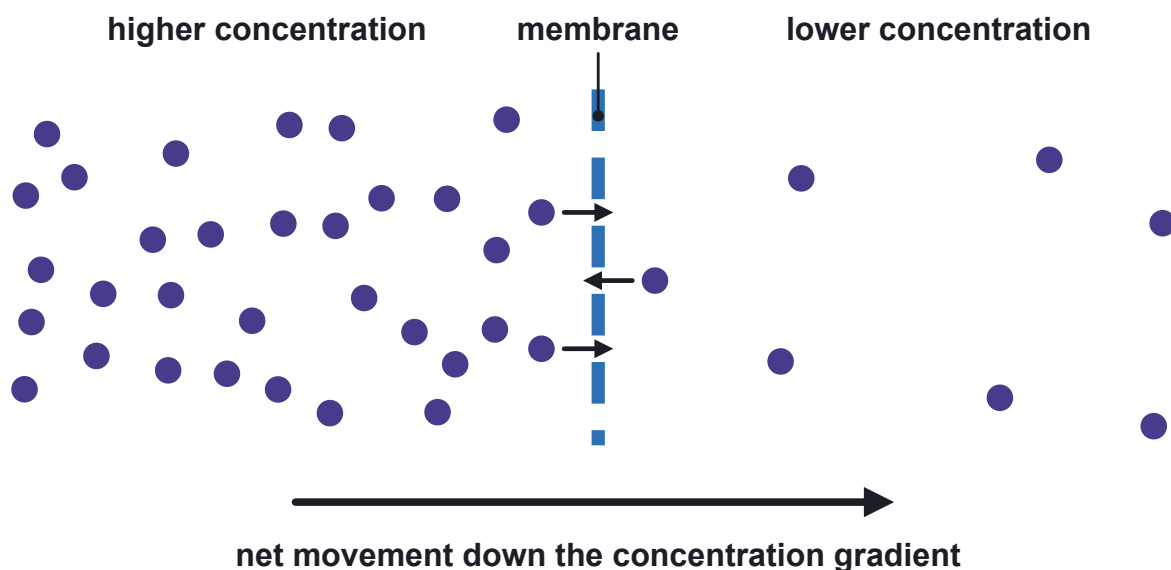
Diffusion Spec 3.1.1, 3.1.2, 3.1.3, 3.1.4

Particles in a gas or in a solution are always moving in random directions. This random movement spreads the particles out. The result is **diffusion**.

Diffusion

The net movement of particles from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement.

The energy for diffusion comes from the **kinetic energy** of the random movement of molecules and ions. The cell does not need to supply any energy of its own.



Particles move both ways, but there is a **net movement** from higher to lower concentration.

Some substances move into and out of cells by diffusion through the **cell membrane**. Small molecules such as oxygen, carbon dioxide and water can pass through easily.

Why diffusion is important

- Oxygen diffuses into cells for aerobic respiration, and carbon dioxide diffuses out as a waste product.
- In a leaf, carbon dioxide diffuses into the cells for photosynthesis and oxygen diffuses out.
- Digested food molecules (solutes) diffuse from the gut into the blood.
- Urea, a waste solute, diffuses out of cells into the blood plasma to be excreted.

Exam tip: Always write 'net movement' and 'down a concentration gradient'. Particles move in both directions, but more move from the region of higher concentration.

Common mistake: Do not say that particles 'want' to spread out or that the cell 'pulls' them in. Diffusion is passive: it only depends on random movement.

Investigating the factors that affect diffusion Spec 3.1.5

You need to investigate four factors that affect the rate of diffusion: **surface area**, **temperature**, **concentration gradient** and **distance**.

Factors affecting the rate of diffusion		
Factor	Effect on rate	Reason
Surface area	Larger surface area, faster diffusion	More particles can cross at the same time
Temperature	Higher temperature, faster diffusion	Particles have more kinetic energy and move faster
Concentration gradient	Steeper gradient, faster diffusion	A bigger difference in concentration gives a greater net movement of particles
Distance	Shorter distance, faster diffusion	Particles have less far to travel

Practical skill: Investigate surface area using cubes of agar jelly containing indicator. Use phenolphthalein in dilute sodium hydroxide (pink in alkali) and place the cubes in dilute hydrochloric acid. The acid diffuses in and the pink colour disappears. Wear eye protection.

1. Cut agar cubes of different sizes (for example 0.5 cm, 1 cm and 2 cm sides) with a scalpel on a tile.
 2. Put each cube in the same volume of dilute hydrochloric acid at the same temperature.
 3. Time how long each cube takes to turn colourless all the way through.
 4. Repeat each size and calculate a mean time.
 5. To test temperature, use the same size of cube in acid at different temperatures, for example 20, 30, 40 and 50 °C.
- Independent variable: cube size (or temperature, or acid concentration).
 - Dependent variable: time taken to turn colourless.
 - Control variables: volume and concentration of acid, temperature, how the cubes are cut and timed.

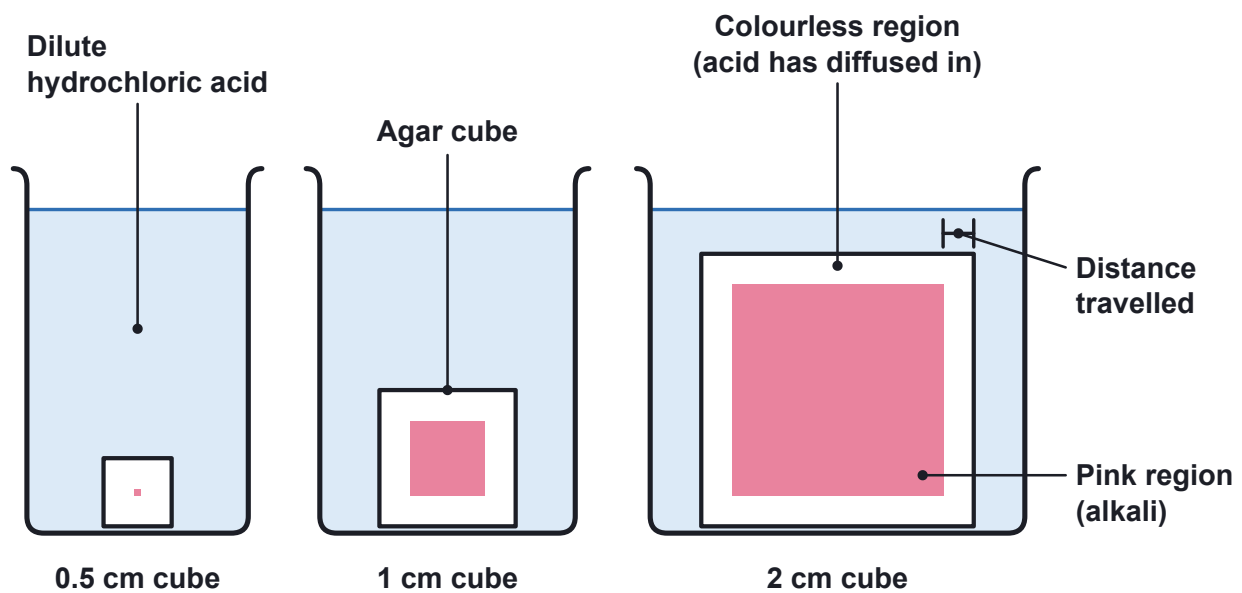
The smallest cube loses its colour first. Small cubes have a larger surface area compared with their volume, and the acid has a shorter distance to travel to the centre.

Surface area to volume ratio

Calculate the surface area to volume ratio of a 2 cm cube.

1. Surface area = $6 \times (2 \times 2) = 24 \text{ cm}^2$.
2. Volume = $2 \times 2 \times 2 = 8 \text{ cm}^3$.
3. Ratio = $24 \div 8 = 3$.

Answer: 3 : 1 (a 1 cm cube has a ratio of 6 : 1, so it is larger and diffusion into it is faster).



After the same time the acid has travelled the **same distance** into each cube, so the smallest cube turns colourless first.

Quick check

1. Describe diffusion.
2. Where does the energy for diffusion come from?
3. Name two substances that move into or out of cells by diffusion.
4. Name the four factors you investigate that affect the rate of diffusion.

2 Osmosis Spec 3.2

Water and osmosis Spec 3.2.1, 3.2.2, 3.2.3, 3.2.6

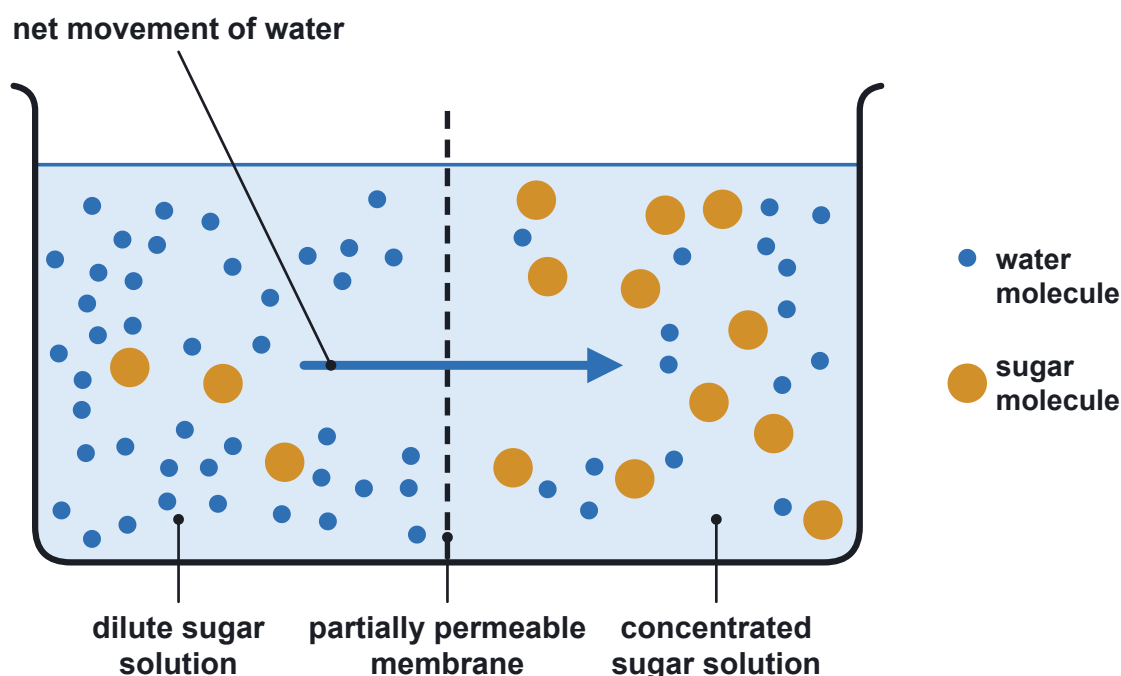
Water as a solvent

Water is a **solvent**: many substances dissolve in it. This is important in organisms in three ways.

- Digestion: food molecules dissolve in water so enzymes can break them down and the products can be absorbed.
- Excretion: waste substances such as urea dissolve in water and are removed in urine.
- Transport: substances dissolve in the water of blood plasma (animals) and of sap in xylem and phloem (plants) and are carried around the organism.

Osmosis

Water diffuses through **partially permeable membranes** by **osmosis**. A partially permeable membrane lets small molecules such as water through, but not larger molecules such as sucrose or proteins. Water moves into and out of cells by osmosis through the cell membrane.



Water molecules pass through the partially permeable membrane, but the larger sugar molecules cannot. There is a net movement of water from the **dilute** solution into the **concentrated** solution.

Common mistake: Osmosis is only about water. Do not write that 'sugar moves by osmosis' or that osmosis is 'water moving through any membrane'.

Support in plants

Plant cells take in water by osmosis. The water inside the cells presses outwards on the cell wall. This **pressure of water** pushes the cell wall outwards and makes the cells firm. The firm cells support the plant, especially the stems and leaves of non-woody plants.

If a plant loses water, the pressure falls, the cells become soft and the plant wilts.

Exam tip: For plant support, say 'water pressing outwards on the cell wall'. 'The water makes the cell stiff' alone does not gain the mark.

Investigating osmosis Spec 3.2.4, 3.2.5

You need to be able to investigate osmosis using dialysis (Visking) tubing, and to investigate the effects of different concentrations of solution on plant tissues.

Dialysis tubing

1. Soak a length of dialysis tubing, tie one end tightly and fill it with a concentrated sucrose (sugar) solution.
2. Tie the other end, rinse the outside and blot dry. Measure the mass.
3. Place the bag in a beaker of water for a set time.
4. Remove the bag, blot dry and measure its mass again.

The mass of the bag increases because water moves into the bag by **osmosis** through the **partially permeable** tubing. The sucrose molecules are too large to pass out. If the bag contains water and is placed in concentrated sucrose solution, its mass decreases.

Plant tissue

Practical skill: Use identical cylinders of potato, cut with a cork borer, in a range of sugar solution concentrations including distilled water. Take care with the cork borer and scalpel, and cut on a tile.

1. Cut cylinders of potato of the same length and diameter. Blot each dry and measure its mass.
 2. Place one cylinder in each of a range of sugar solutions (for example 0.0, 0.2, 0.4, 0.6, 0.8 mol/dm³), using the same volume in each tube.
 3. Leave for the same time at the same temperature.
 4. Remove, blot dry in the same way and measure the mass again.
 5. Calculate the **percentage change in mass** for each cylinder.
- Independent variable: concentration of the sugar solution.
 - Dependent variable: percentage change in mass.
 - Control variables: type and size of potato, volume of solution, temperature, time, how the tissue is dried.

In dilute solutions, the potato gains mass because water enters its cells. In concentrated solutions, it loses mass because water leaves its cells. Where the line on a graph of percentage change against concentration crosses the x-axis, there is no change in mass, so the solution has the same concentration as the inside of the potato cells.

$$\text{percentage change in mass} = (\text{final mass} - \text{initial mass}) \div \text{initial mass} \times 100$$

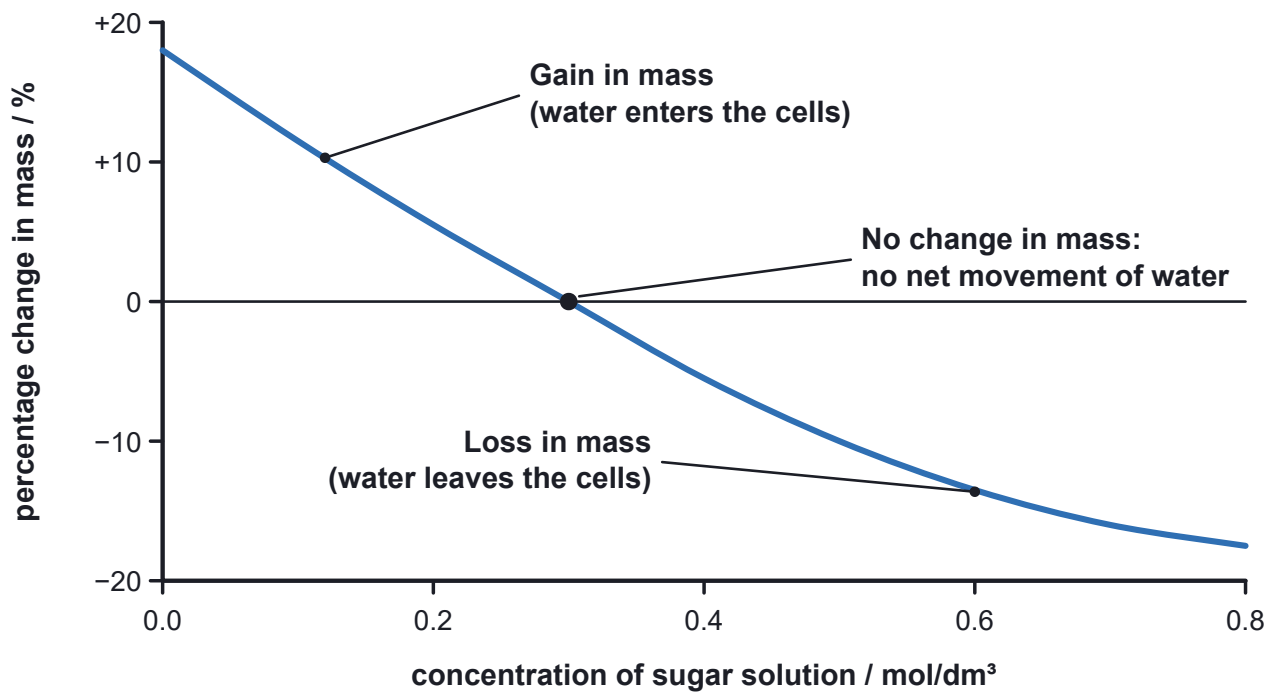
Percentage change in mass

A potato cylinder has a mass of 4.0 g at the start and 3.4 g after 30 minutes in a sugar solution. Calculate the percentage change in mass.

1. Change in mass = 3.4 – 4.0 = –0.6 g.
2. Percentage change = –0.6 ÷ 4.0 × 100 = –15%.

Answer: –15% (a 15% decrease in mass).

Exam tip: Use the initial mass as the divisor and show the sign: a loss is negative. When you draw the graph, put concentration on the x-axis and use a line of best fit.



Where the line crosses the x-axis there is **no net movement of water**.

Water potential Spec 3.2.7, 3.2.9 Supplement

Supplement

Water potential describes how freely water molecules can move. A dilute solution has a **high water potential**. A concentrated solution has a **low water potential**. Pure water has the highest water potential.

Supplement

Osmosis

The net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane.

Supplement

When a dilute sugar solution and a concentrated sugar solution are separated by a partially permeable membrane, the dilute solution has the higher water potential and the concentrated solution has the lower water potential. Water moves through the **partially permeable membrane** down this water potential gradient.

Supplement

Exam tip: Use the phrase 'water potential' and the word 'net'. Say 'from a higher water potential to a lower water potential', not 'from a weak solution to a strong solution' alone.

Supplement

Importance in organisms

Supplement

- Plants: root hair cells have a lower water potential than the soil water, so water enters them by osmosis. The water then moves from cell to cell along a water potential gradient into the xylem.
- Plants: loss of water from leaf cells lowers their water potential, so water is drawn in from neighbouring cells.
- Animals: if the blood has a lower water potential than the cells, water leaves the cells. If the blood has a higher water potential, water enters the cells. Animal cells have no cell wall, so they can burst or shrink.
- Organisms must keep the water potential of their body fluids in a narrow range so that cells neither swell too much nor lose too much water.

Supplement

Common mistake: Do not describe water potential as the 'amount of water'. Explain what happens by comparing the water potential of the solution with that of the cell.

Turgor, flaccid cells and plasmolysis Spec 3.2.8 Supplement

Supplement

Plant cells have a strong cell wall outside the cell membrane. This changes what happens to them in different solutions.

Supplement

Plant cells in solutions of different concentrations

Solution compared with the cell	Movement of water	Result
Higher water potential (dilute; for example pure water)	Water enters the cell by osmosis	The vacuole swells and presses the cell contents against the cell wall. The cell becomes turgid . The turgor pressure is the pressure of the cell contents on the cell wall. The wall stops the cell bursting.
Same water potential	No net movement of water	The cell neither gains nor loses water, so it does not change.
Lower water potential (concentrated)	Water leaves the cell by osmosis	The cell loses turgor pressure and becomes flaccid . If more water leaves, the cytoplasm shrinks and the cell membrane pulls away from the cell wall. This is plasmolysis .

Supplement

Turgid cells keep a plant upright and leaves held out to catch light. When cells lose water and become flaccid, the plant wilts.

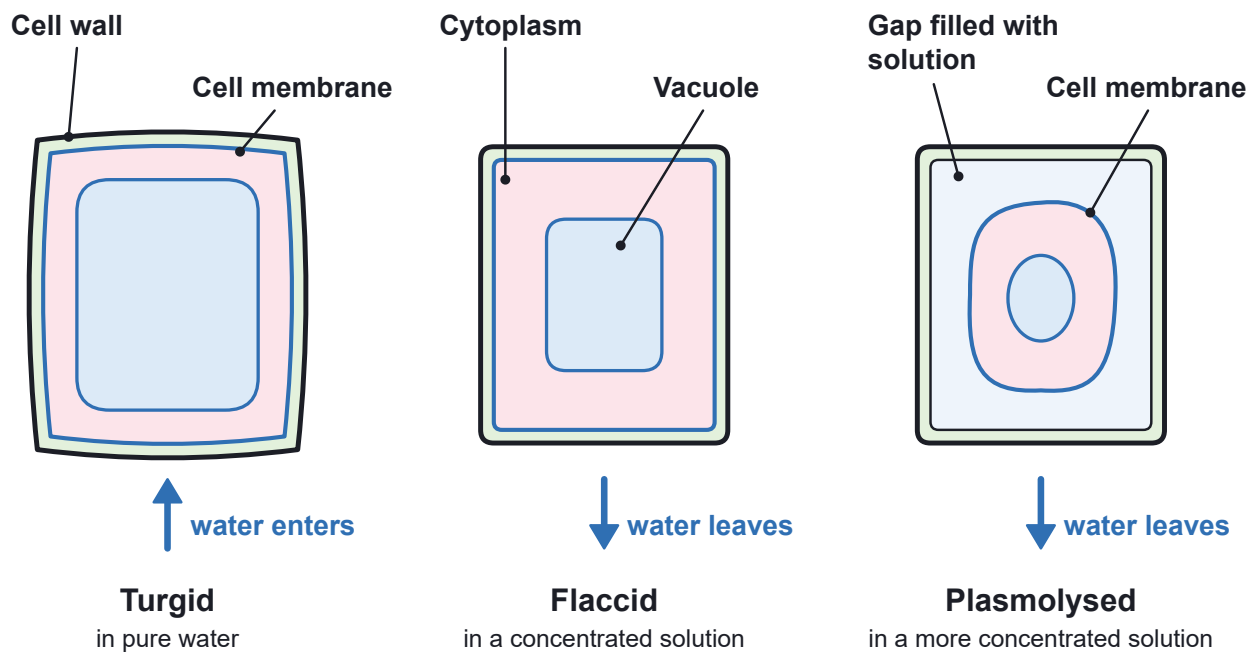
Supplement

Exam tip: Use all four terms where asked: turgid (full of water, firm), turgor pressure (pushes on the wall), flaccid (soft, turgor pressure lost), plasmolysis (membrane pulled away from wall).

Supplement

Common mistake: Plant cells do not burst in pure water because the cell wall resists the pressure. Animal cells have no wall, so they can burst.

Supplement



Water enters a plant cell in pure water, making it **turgid**. In concentrated solutions water leaves: the cell becomes **flaccid**, then **plasmolysed**.

Quick check

1. Give three ways in which water's role as a solvent is important in organisms.
2. What is moved by osmosis?
3. How does the pressure of water in plant cells support a plant?
4. **Supplement** Define osmosis using water potential.
5. **Supplement** What is plasmolysis?

3 Active transport Spec 3.3

Active transport Spec 3.3.1, 3.3.2, 3.3.3

Active transport

The movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration.

Diffusion and osmosis are passive: they need no energy from the cell. Active transport needs **energy from respiration**, so it stops if respiration stops.

Supplement

Why active transport is important

Supplement

Active transport lets cells take in useful molecules or ions even when they are in a lower concentration outside the cell than inside. It also lets cells move molecules or ions out of the cell against a gradient.

Supplement

An example is **ion uptake by root hairs**. The soil contains very low concentrations of mineral ions such as nitrate. Root hair cells absorb these ions against their concentration gradient. The plant needs them for healthy growth. Root hair cells have many mitochondria to release the energy needed.

Supplement

Protein carriers

Supplement

Active transport uses **protein carriers** in the cell membrane to move molecules or ions across the membrane.

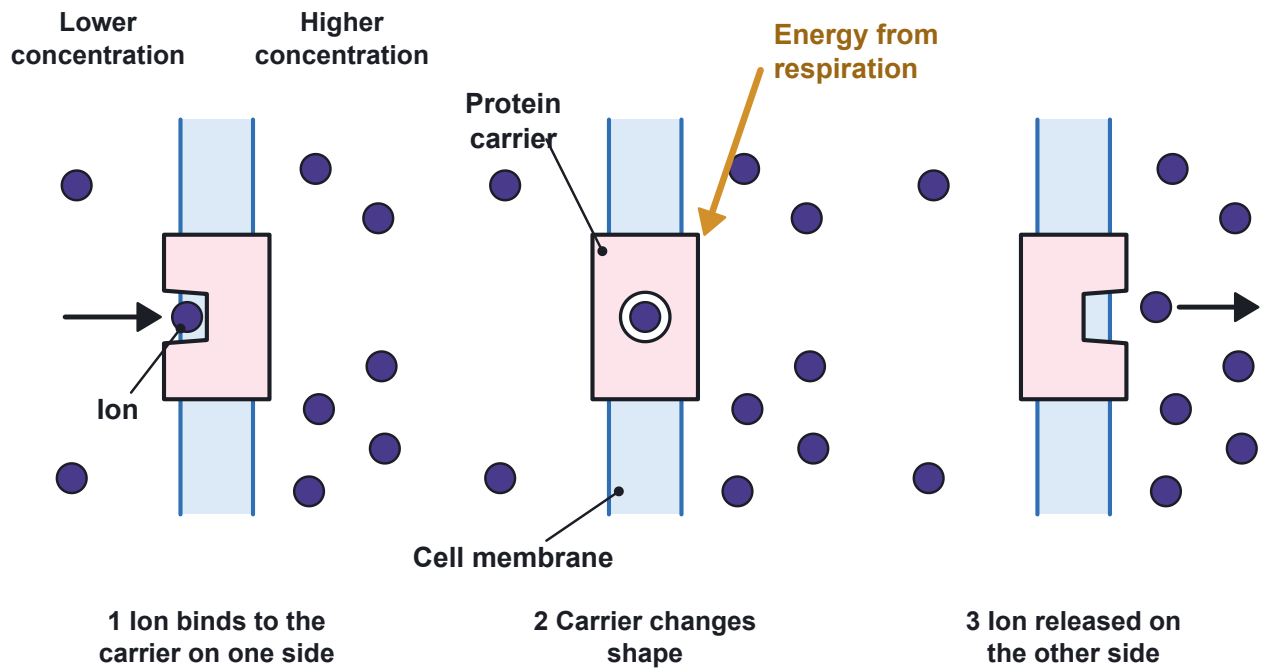
Supplement

1. A molecule or ion binds to a carrier protein on one side of the membrane.
2. The carrier uses energy from respiration and changes shape.
3. The molecule or ion is released on the other side of the membrane, against its concentration gradient.

Diffusion and active transport

	Diffusion	Active transport
Direction	Down a concentration gradient	Against a concentration gradient
Energy from respiration	Not needed	Needed

Supplement



A **protein carrier** uses **energy from respiration** to move an ion against its concentration gradient.

Exam tip: Compare in the same way each time: 'active transport needs energy from respiration whereas diffusion does not'. Never say active transport 'makes' energy.

Quick check

1. Define active transport.
2. Where does the energy for active transport come from?
3. **Supplement** Give an example of active transport in plants.
4. **Supplement** What moves molecules or ions across a membrane in active transport?

Quick check answers

Diffusion

1. The net movement of particles from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement.
2. The kinetic energy of the random movement of molecules and ions.
3. Any two from: oxygen, carbon dioxide, urea, digested food molecules.
4. Surface area, temperature, concentration gradient and distance.

Osmosis

1. Digestion, excretion and transport (substances dissolve in it).
2. Water, through a partially permeable membrane.
3. Water inside the cells presses outwards on the cell walls, making the cells firm.
4. The net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane.
5. The cell membrane and cytoplasm pulling away from the cell wall because water has left the cell by osmosis.

Active transport

1. The movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration.
2. Respiration.
3. Ion uptake by root hairs.
4. Protein carriers.