

Osmosis

Revision notes · Osmosis is the diffusion of water through partially permeable membranes; water potential, turgor and plasmolysis explain what happens to plant cells.

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

Osmosis Spec 3.2

Water and osmosis Spec 3.2.1, 3.2.2, 3.2.3, 3.2.6

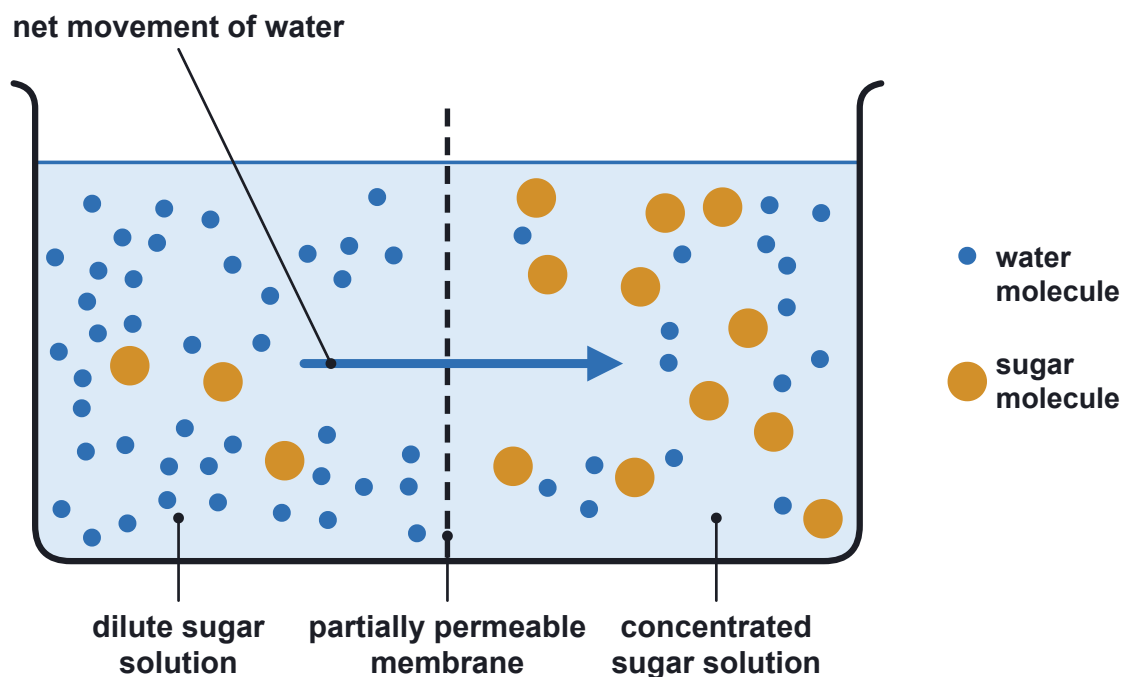
Water as a solvent

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.

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

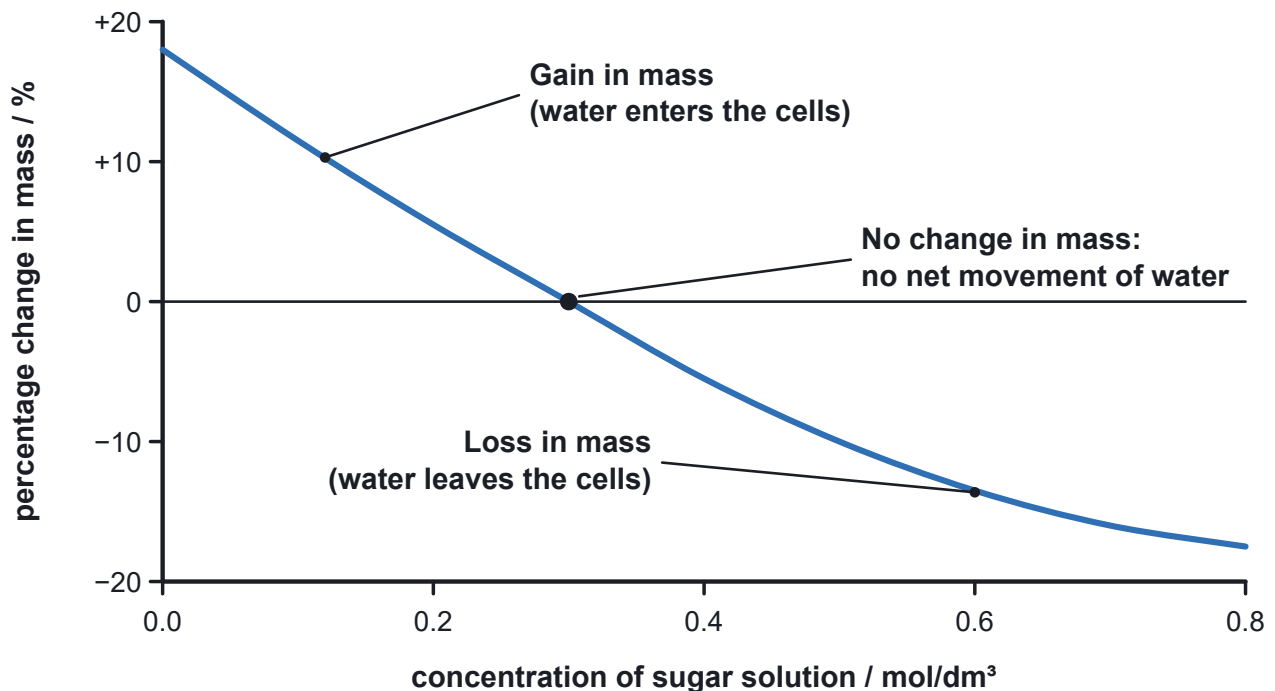
Percentage change in mass

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 = $-0.6 \div 4.0 \times 100 = -15\%$.

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.

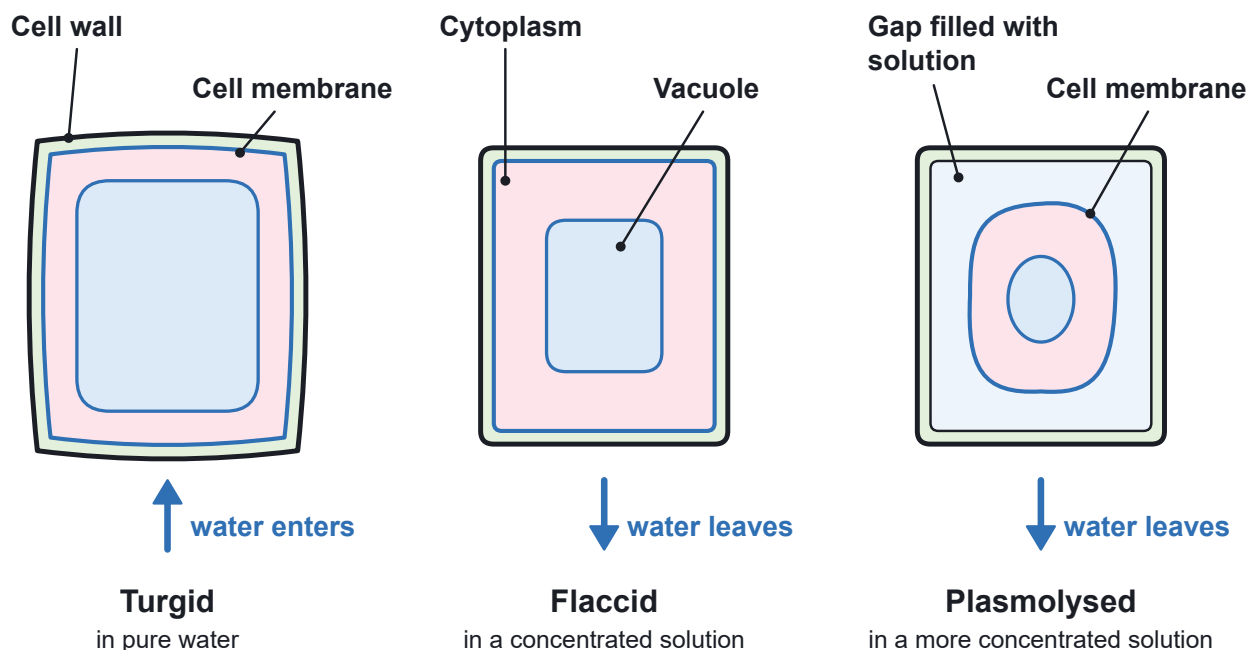
Supplement

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?

Quick check answers

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.