Cambridge (CIE) IGCSE Biology

Your notes

Diffusion, Osmosis & Active Transport

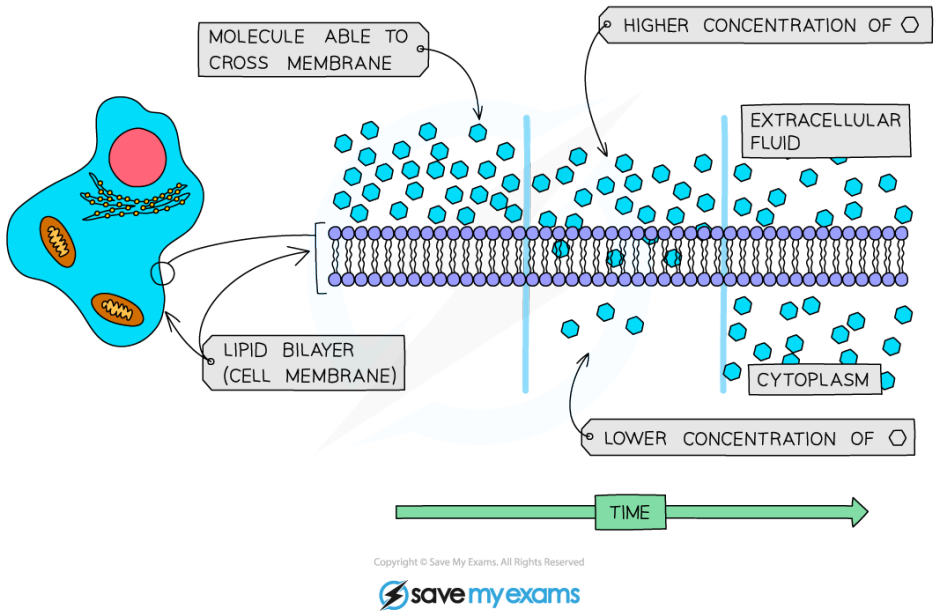
Contents

Your notes

Diffusion

What is Diffusion in Biology?

- Diffusion is the **movement of molecules** from a region of its **higher** concentration to a region of its **lower** concentration
- Molecules **move down a concentration gradient**, as a result of their **random movement**



Diffusion across the cell membrane

- For **living cells**, the principle of the movement down a concentration gradient is the same, but the cell is surrounded by a **cell membrane** which can **restrict the free movement of the molecules**
- The cell membrane is a **partially permeable membrane** - this means it allows some molecules to cross easily, but others with difficulty or not at all
- The simplest sort of selection is based on the size of the molecules
- Diffusion helps living organisms to:
  - obtain many of their **requirements**
  - get rid of many of their **waste products**
  - carry out **gas exchange for respiration**

Examples of diffusion in living organisms

- You will need to learn examples of substances that organisms obtain by diffusion
- Don't forget that **plants require oxygen for respiration at all times**, as well as **carbon dioxide for photosynthesis** when conditions for photosynthesis are right (e.g. enough light and a suitable temperature)

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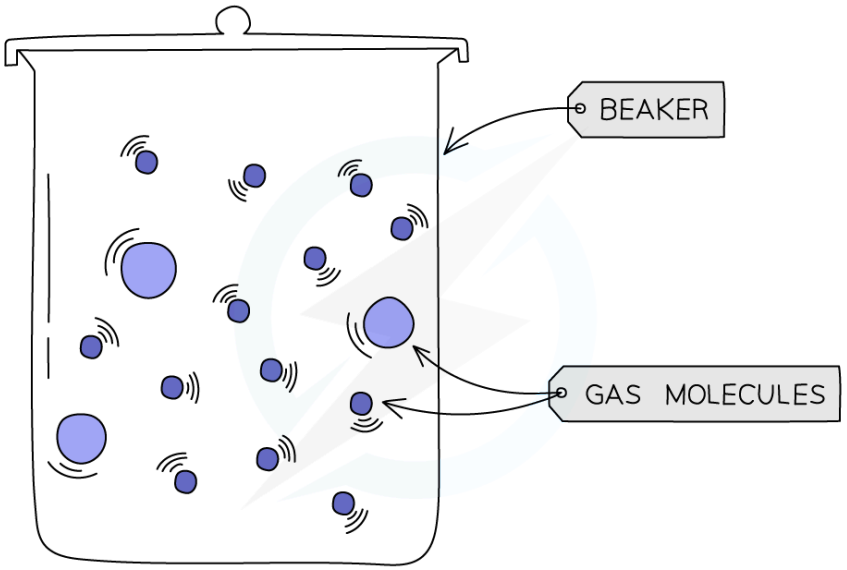
Examples of Diffusion Table

SITE	MOLECULES MOVING	FROM	TO
SMALL INTESTINE	DIGESTED FOOD PRODUCTS – GLUCOSE, AMINO ACIDS, FATTY ACIDS AND GLYCEROL ETC.	LUMEN OF SMALL INTESTINE	BLOOD / LYMPH IN VILLI FOUND COVERING SMALL INTESTINE WALLS
LEAF	OXYGEN	AIR SPACES BETWEEN MESOPHYLL CELLS	MITOCHONDRIA IN ALL CELLS
LEAF	CARBON DIOXIDE	AIR SPACES BETWEEN MESOPHYLL CELLS	CHLOROPLASTS IN MESOPHYLL CELLS
LEAF	WATER VAPOUR	STOMATAL PORES	AIR OUTSIDE STOMATA
LUNGS	OXYGEN	ALVEOLAR AIR SPACE	BLOOD IN CAPILLARIES AROUND ALVEOLI
LUNGS	CARBON DIOXIDE	BLOOD IN CAPILLARIES AROUND ALVEOLI	ALVEOLAR AIR SPACE

Where does the energy for diffusion come from?

- All particles move randomly at all times
- This is known as Brownian motion
- The energy for diffusion comes from the kinetic energy of this random movement of molecules and ions



Brownian motion

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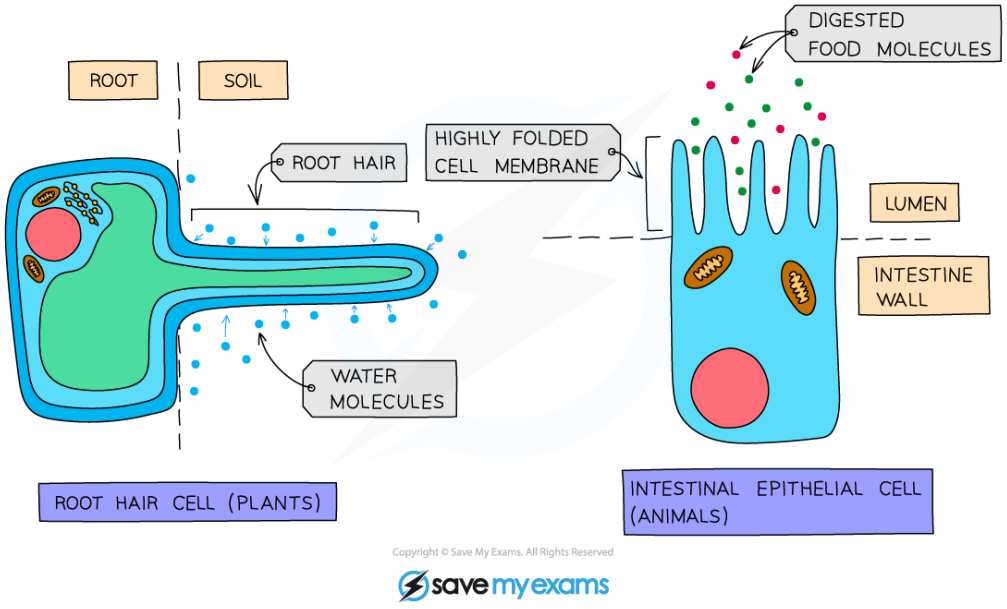
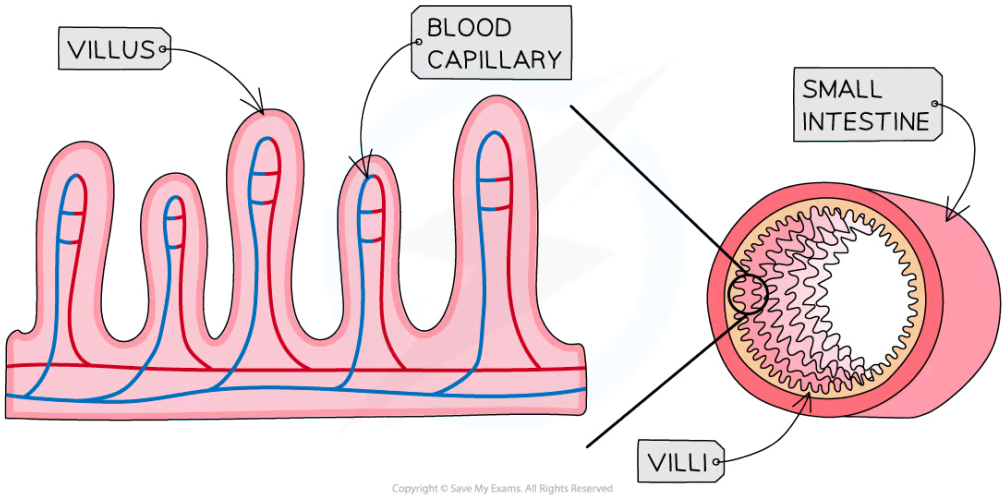
Factors that Influence Diffusion

Surface area to volume ratio

- The **bigger** a cell or structure is, the **smaller its surface area to volume ratio** is, slowing down the rate at which substances can move across its surface
- Many cells which are adapted for diffusion have **increased surface area** in some way - eg root hair cells in plants (which absorb water and mineral ions) and cells lining the ileum in animals (which absorb the products of digestion)



Cell adaptations for diffusion



The highly folded surface of the small intestine increases its surface area

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Distance

- The smaller the distance molecules have to travel the faster transport will occur
- This is why blood capillaries and alveoli have walls which are only one cell thick, ensure the rate of diffusion across them is as fast as possible

Temperature

- The higher the temperature, the faster molecules move as they have more energy
- This results in more collisions against the cell membrane and therefore a faster rate of movement across them

Concentration Gradient

- The greater the difference in concentration on either side of the membrane, the faster movement across it will occur
- This is because on the side with the higher concentration, more random collisions against the membrane will occur

Examiner Tips and Tricks

You should have carried out investigations into the factors that influence the rate of diffusion and as so should be able to use the information above to **explain experimental results** in an exam. You should also be able to **plan and carry out an experiment** which can investigate the effect of one of these factors.

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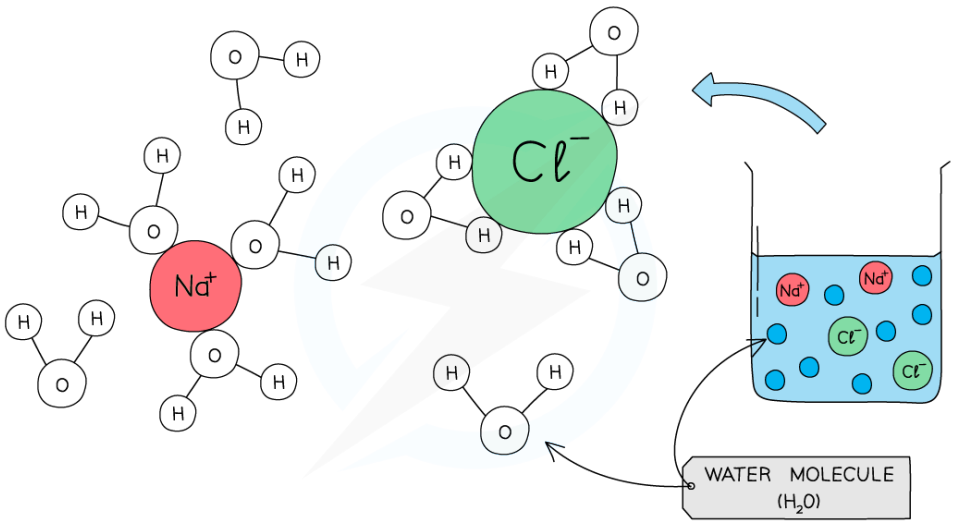
Water as a Solvent

- Water is important for all living organisms as **many substances are able to dissolve in it** (it is a **solvent**)
- This makes it incredibly useful and essential for all life on Earth
- Water is important as a solvent in the following situations within organisms:
  - Dissolved substances can be **easily transported** around organisms - eg xylem and phloem of plants and dissolved food molecules in the blood
  - **Digested food molecules** are in the alimentary canal but need to be **moved to cells** all over the body - without water as a solvent this would not be able to happen
  - Toxic substances such as **urea** and substances in excess of requirements such as **salts** can dissolve in water which makes them easy to **remove from the body in urine**
  - Water is also an important part of the **cytoplasm** and plays a role in ensuring **metabolic reactions can happen** as necessary in cells



Water as a solvent

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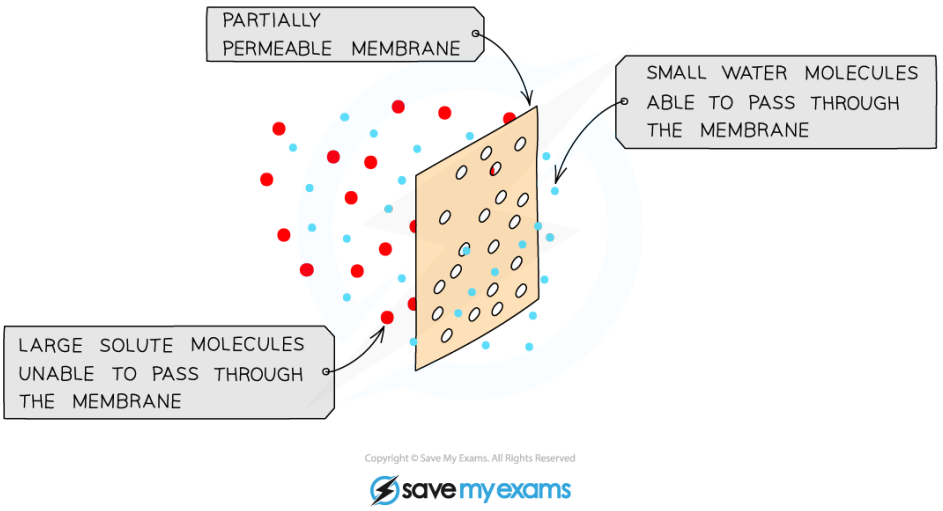
Osmosis

- All cells are surrounded by a cell membrane which is **partially permeable**
- **Water** can move in and out of cells by osmosis
- Osmosis is the diffusion of water molecules from a **dilute solution** (low solute concentration) to a **more concentrated solution** (high solute concentration) across a **partially permeable membrane**
- In doing this, water is moving down the **concentration gradient from where there is more water to where there is less**
- The cell membrane is partially permeable which means it allows **small molecules** (like water) through but not larger molecules (like solute molecules)



Osmosis and the partially permeable membrane

Examiner Tips and Tricks

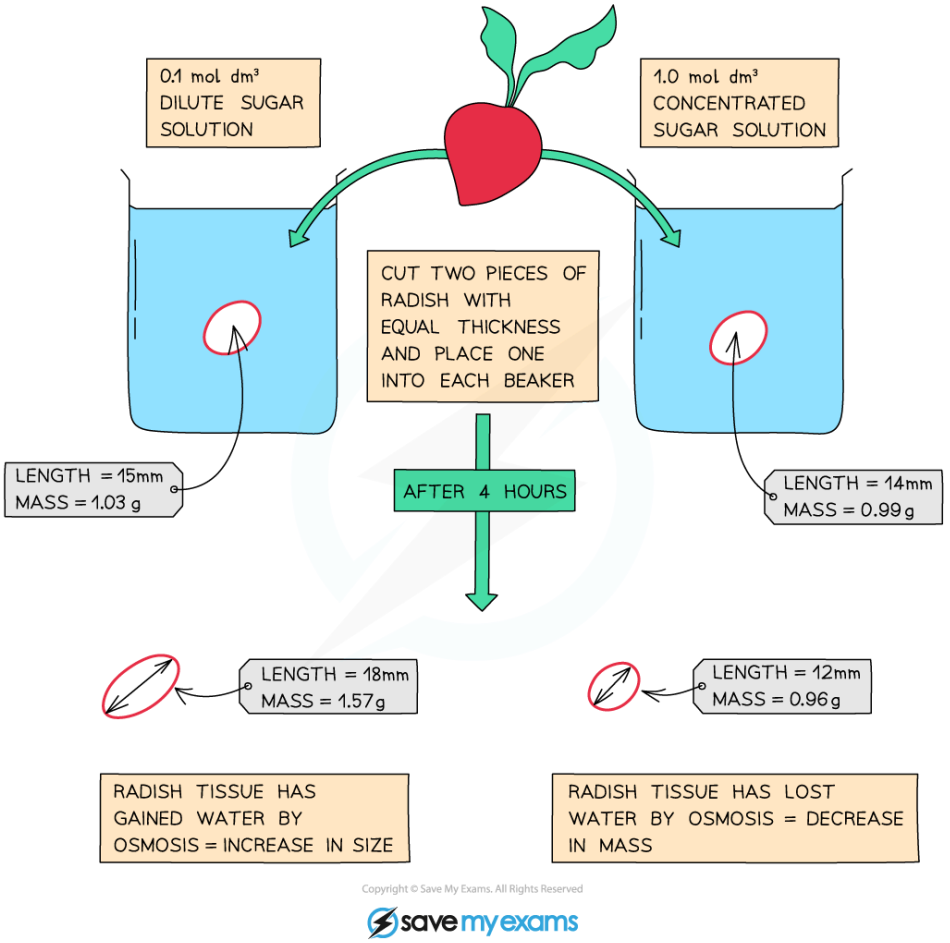
Note that for extended students, it is important to be able to explain the process of osmosis with reference to water potential gradients, as detailed in the revision note page titled 'Osmosis in Animals & Plants'

Your notes

Osmosis Experiments

Immersing plant cells in solutions of different concentrations

- The most common osmosis practical involves cutting **cylinders of root vegetables** such as potato or radish and placing them into **distilled water** and **sucrose solutions** of increasing concentration
- The cylinders are weighed before placing into the solutions
- They are left in the solutions for 20 - 30 minutes and then removed, dried to remove excess liquid and reweighed



Potatoes are usually used in osmosis experiments to show how the concentration of a solution affects the movement of water, but radishes can be used too

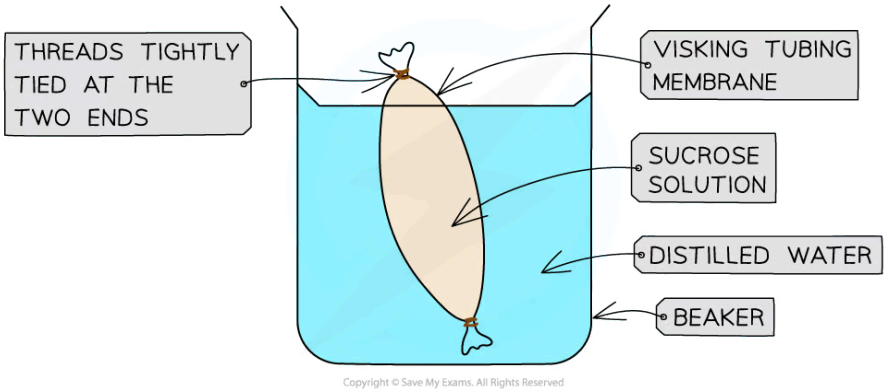
- If the plant tissue gains mass:

- Water must have moved into the plant tissue from the solution surrounding it by osmosis
- The solution surrounding the tissue is more dilute than the plant tissue (which is more concentrated)

- If plant tissue loses mass:
  - Water must have moved out of the plant tissue into the solution surrounding it by osmosis
  - The solution surrounding the tissue is more concentrated than the plant tissue (which is more dilute)
- If there is no overall change in mass:
  - There has been no **net** movement of water as the concentration in both the plant tissue and the solution surrounding it must be equal
  - Remember that water will still be moving into and out of the plant tissue, but there wouldn't be any net movement in this case

Investigating osmosis using dialysis tubing

- **Dialysis tubing** (sometimes referred to as visking tubing) is a non-living **partially permeable** membrane made from cellulose
- Pores in this membrane are small enough to **prevent the passage of large molecules** (such as **sucrose**) but allow **smaller molecules** (such as **glucose and water**) to pass through by **diffusion** and **osmosis**
- This can be demonstrated by:
  - Filling a section of dialysis tubing with concentrated sucrose solution
  - Suspending the tubing in a boiling tube of water for a set period of time
  - Noting whether the water level outside the tubing decreases as water moves into the tubing via osmosis
    - Water moves from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane



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An example setup of a dialysis tubing experiment

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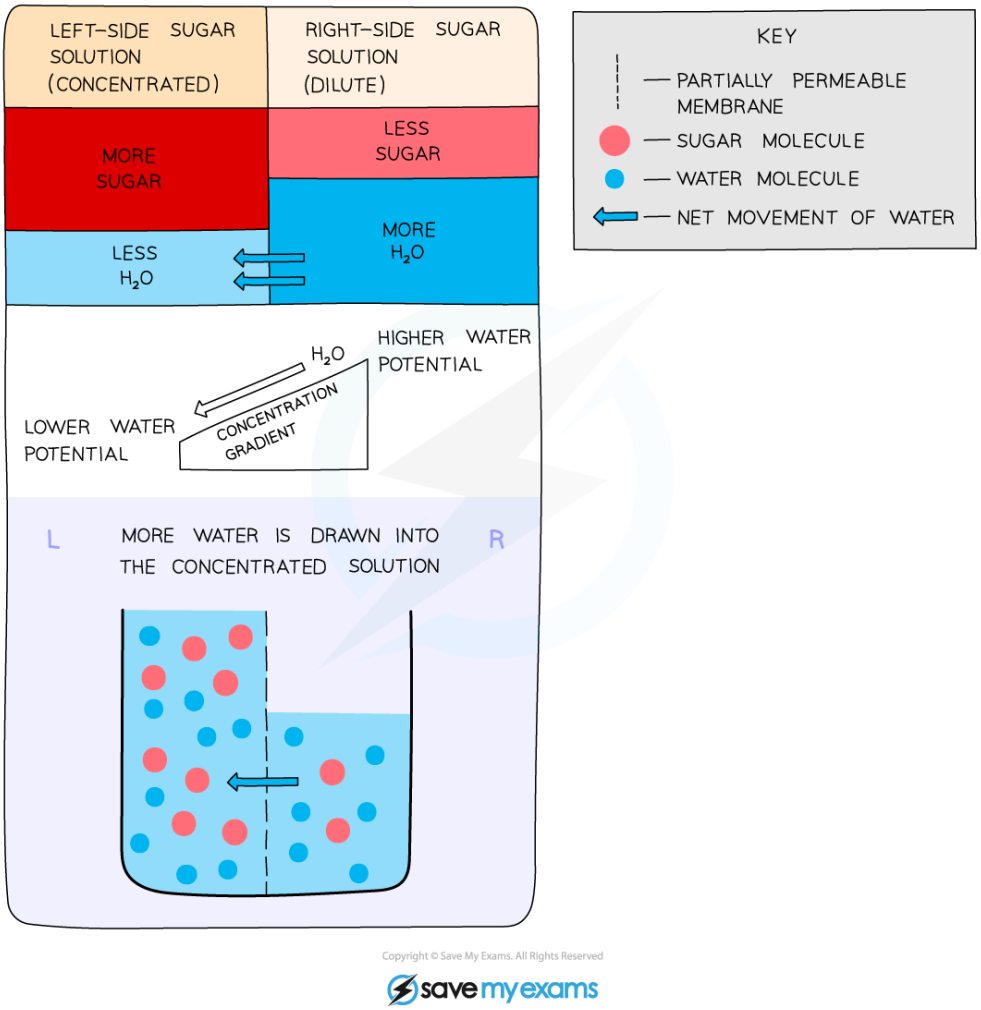
Osmosis in Plant Tissues

- When water moves into a plant cell, the vacuole gets bigger, **pushing the cell membrane against the cell wall**
- Water entering the cell by osmosis makes the cell **rigid and firm**
- This is important for plants as the effect of all the cells in a plant being firm is to **provide support and strength for the plant** - making the plant stand upright with its leaves held out to catch sunlight
- The pressure created by the **cell wall** stops too much water entering and **prevents the cell from bursting**
- If plants do not receive enough water the cells cannot remain rigid and firm (turgid) and the plant **wilts**

Osmosis: Extended

- Osmosis is 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**
- **To understand this topic with clarity, it is important to understand the following**
  - High water potential = dilute solution = low solute concentration (right side of diagram)
  - Low water potential = concentrated solution = high solute concentration (Left side of diagram)



How osmosis works

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Examiner Tips and Tricks

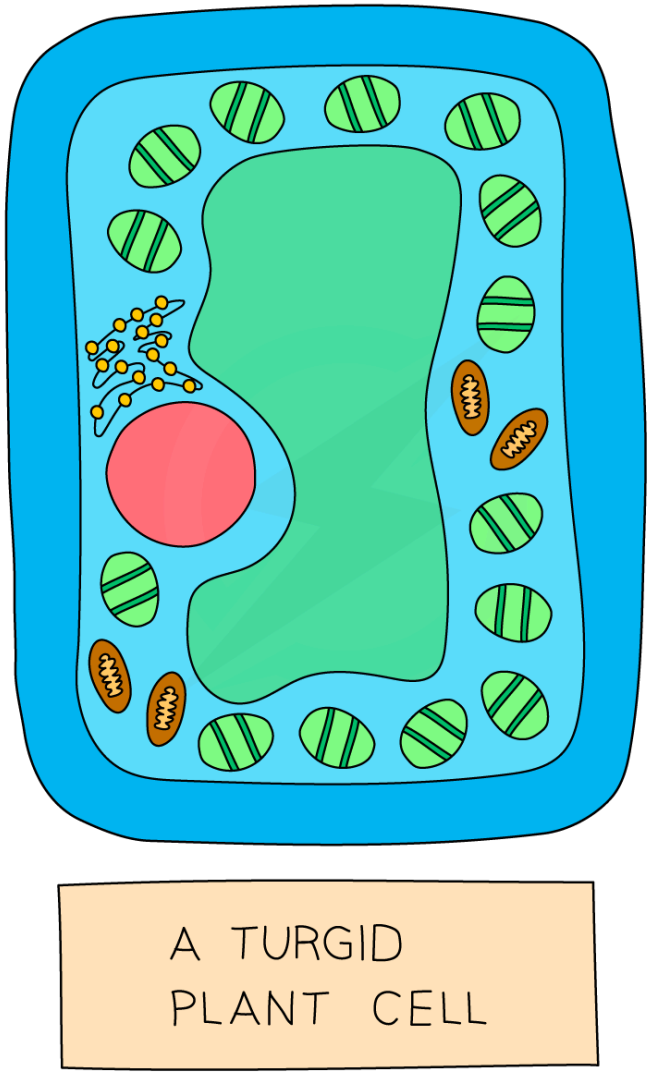
The best explanations to do with osmosis will refer to **water potential**, so if you are aiming for a 7, 8 or 9 you will need to understand the concept and use it in your explanations.

Osmosis in Animals & Plants: Extended

Plant cells in solutions of different concentrations

- When plant cells are placed in a solution that has a **higher water potential** (dilute solution) than inside the cells (e.g. distilled water) then water moves into the plant cells via osmosis

- These water molecules push the cell membrane against the cell wall, increasing the **turgor pressure** in the cells which makes them **turgid**



A turgid plant cell

- When plant cells are placed in a **concentrated** solution (with a lower water potential than inside the cells) water molecules will move **out of the plant cells by osmosis**, making them flaccid
  - If plant cells become flaccid it can negatively affect the plant's ability to support itself
- If looked at underneath the microscope, the plant cells might be **plasmolysed**, meaning the cell membrane has pulled away from the cell wall

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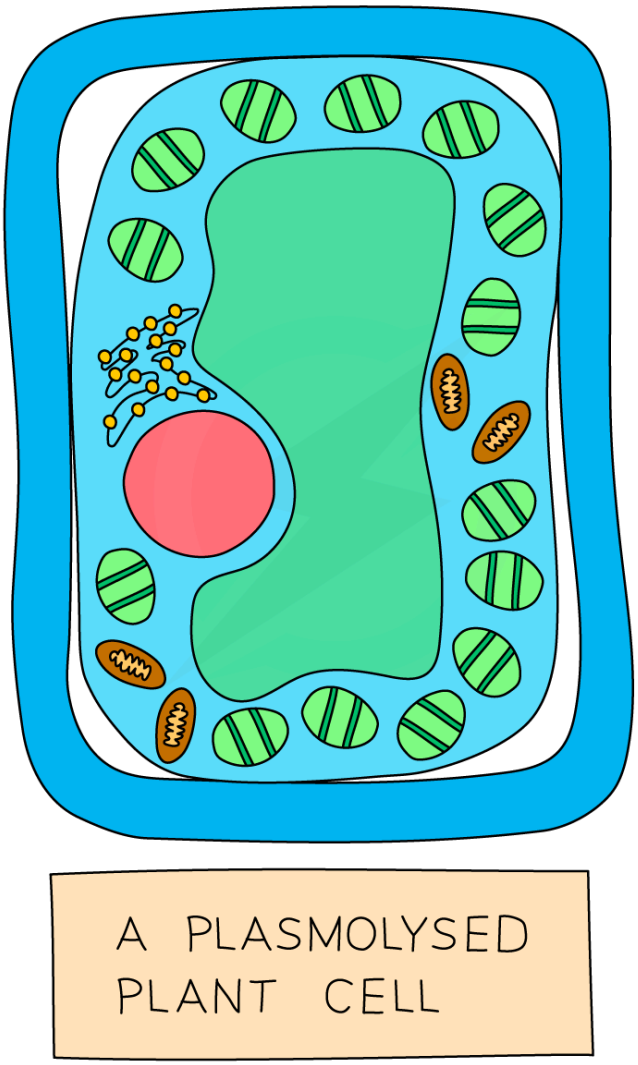

A plasmolysed plant cell

Animal cells in solutions of different concentrations

- **Animal cells** also lose and gain water as a result of osmosis
- As animal cells **do not have a supporting cell wall**, the results on the cell are more severe
- If an animal cell is placed into a **strong sugar solution** (with a lower water potential than the cell), it will lose water by osmosis and become **crenated** (shrivelled up)
- If an animal cell is placed into **distilled water** (with a higher water potential than the cell), it will gain water by osmosis and, as it has **no cell wall to create turgor pressure**, will continue to do so until the cell membrane is stretched too far and **it bursts**

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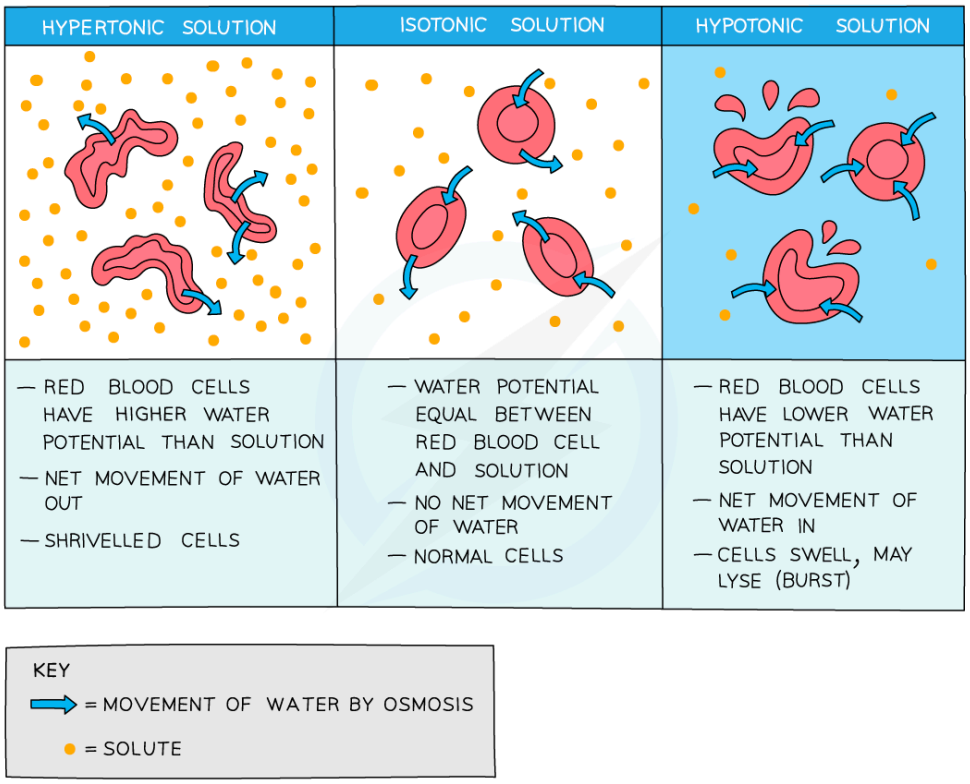

Effect of osmosis on animal cells

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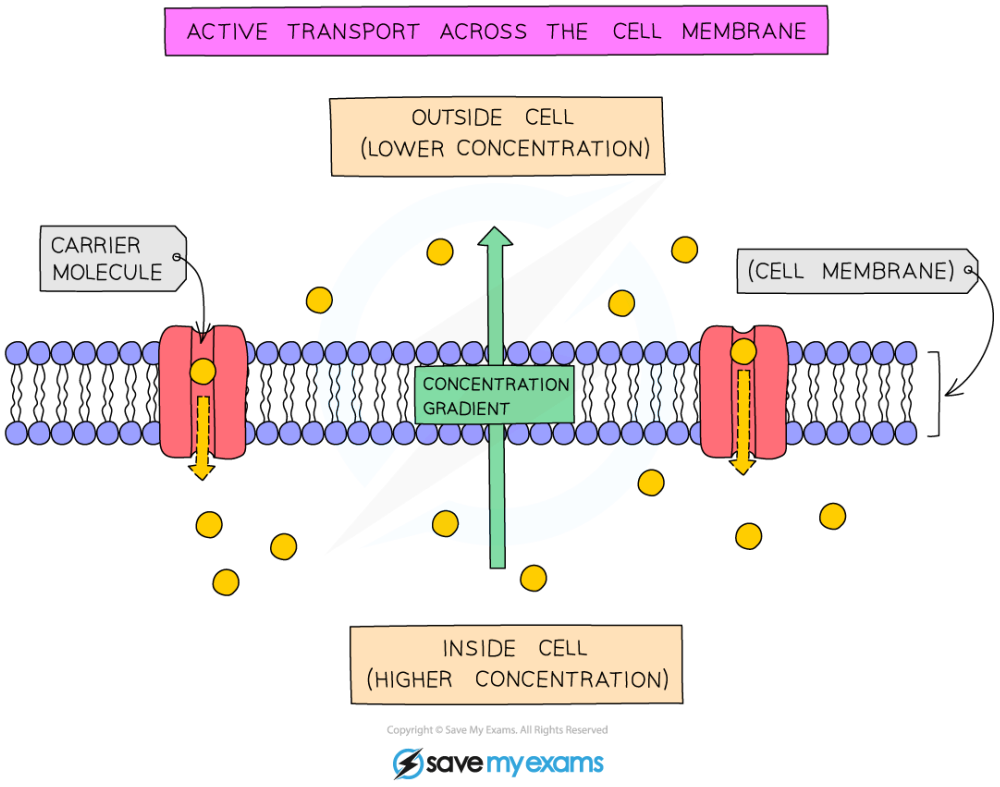
Active Transport

- Active transport is the movement of particles through a cell membrane from a region of **lower concentration** to a region of **higher concentration** using **energy from respiration**



The process of active transport

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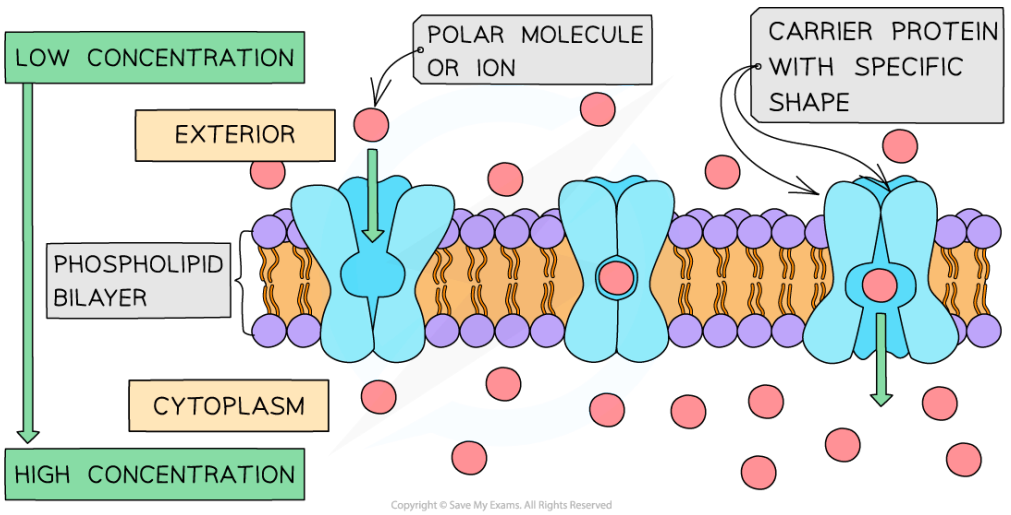
Importance of Active Transport: Extended

- Energy is needed because particles are being moved **against a concentration gradient**, in the opposite direction from which they would naturally move (by diffusion)
- Active transport is vital process for the movement of molecules or ions across membranes
- Including:
  - **uptake of glucose** by epithelial cells in the villi of the small intestine and by kidney tubules in the nephron
  - **uptake of ions** from soil water by root hair cells in plants

Protein Carriers: Extended

- Active transport works by using **carrier proteins** embedded in the cell membrane to pick up specific molecules and take them through the cell membrane against their concentration gradient:

1. Substance combines with carrier protein molecule in the cell membrane
2. Carrier transports substances across membrane using energy from respiration to give them the kinetic energy needed to change shape and move the substance through the cell membrane
3. Substance released into cell



Carrier proteins in active transport

Examiner Tips and Tricks

You don't need to know anything about the phospholipid bilayer when it comes to active transport!

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