Edexcel GCSE Biology

Your notes

Movement of Substances Into & Out of Cells

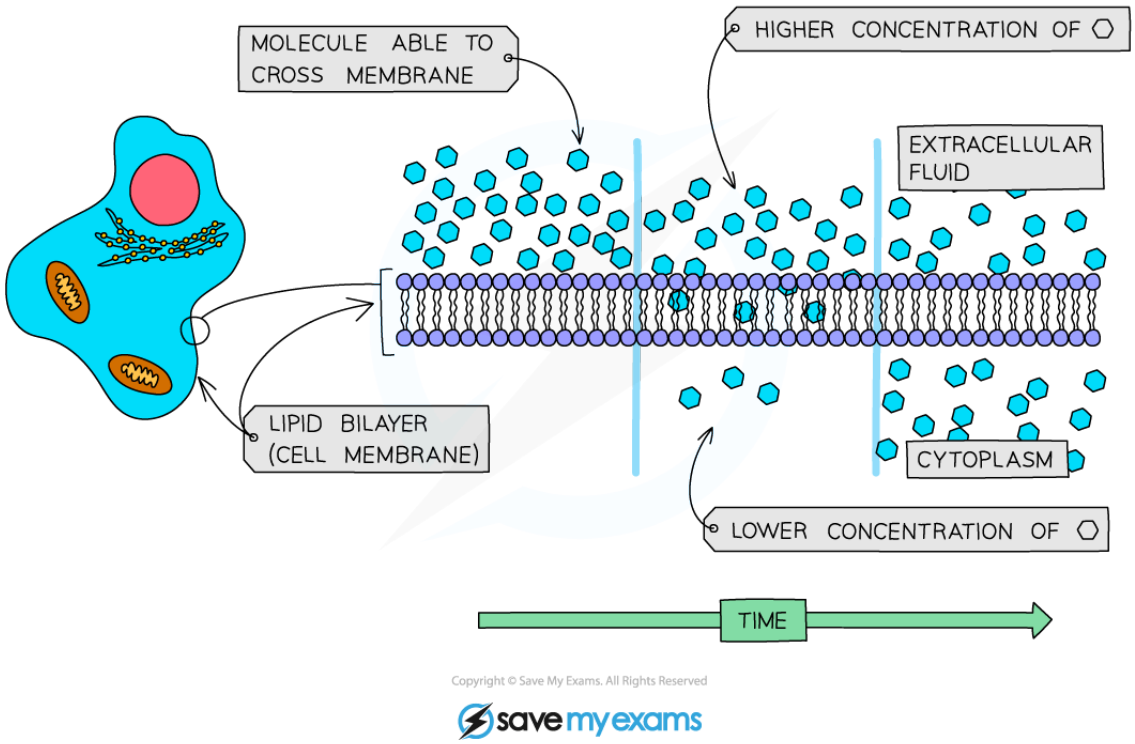
Contents

Diffusion

Your notes

Diffusion Theory

- 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

Diffusion in living organisms

- 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 (i.e. smaller molecules can diffuse across the membrane but larger molecules cannot)

- Diffusion helps living organisms to:
  - Obtain many of their **requirements**
  - Get rid of many of their **waste products**
  - Carry out **gas exchange for respiration**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Examples of diffusion in living organisms

- You will need to learn examples of substances that organisms obtain by diffusion

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

Examiner Tips and Tricks

Remember that diffusion is a passive process, so when it occurs in a living organism, the cells of that organism do not provide the particles involved with energy to diffuse. The particles that are moving about randomly have their own **kinetic energy**.

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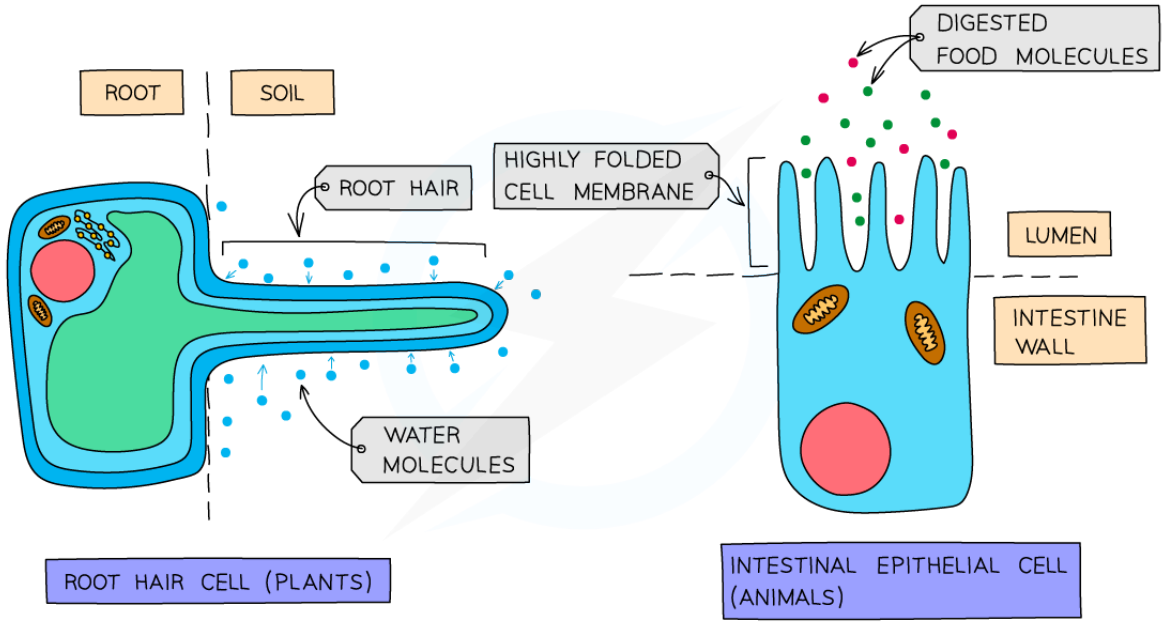
Factors that Influence Diffusion

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 - e.g. 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

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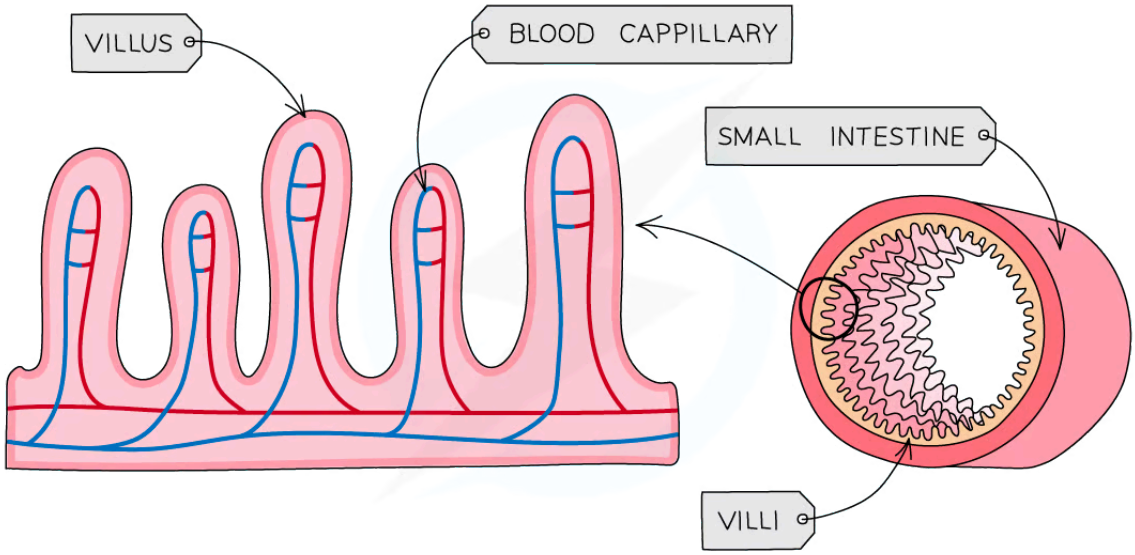

The highly folded surface of the small intestine increases its surface area

- You should be able to **calculate and compare** surface area to volume ratios
- You can model the effect of how increasing size affects surface area to volume ratio using simple cubes:

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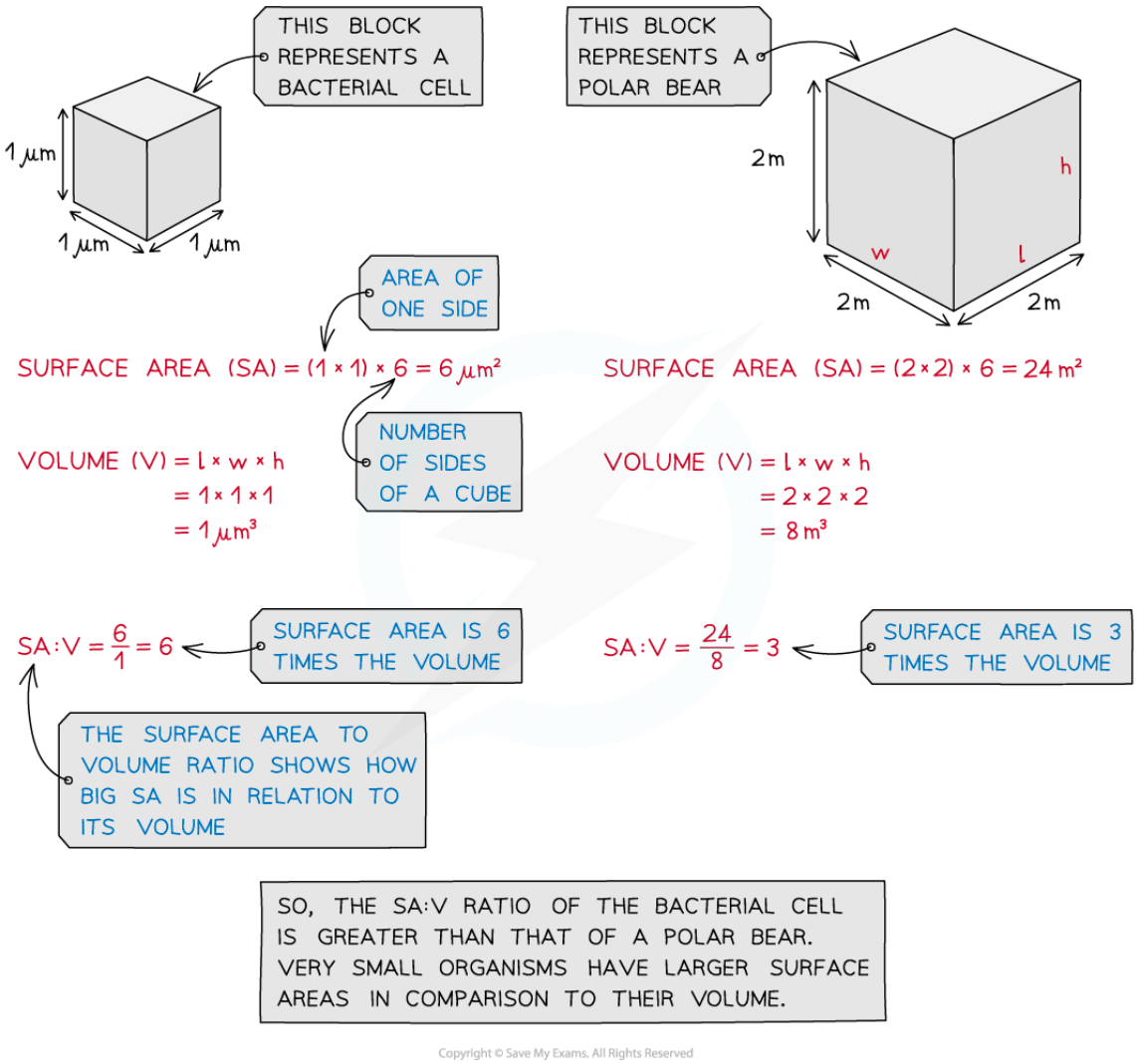

Calculating the surface area to volume ratio

Diffusion 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

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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

Summary of Diffusion Factors Table

Factor	How it affects diffusion
Difference in concentrations (concentration gradient)	The greater the difference in concentration between two regions, the faster the overall rate of diffusion.
Temperature	The higher the temperature, the more kinetic (movement) energy the particles of that substance will have. They will move / spread faster compared to when at a lower temperature when they have less kinetic energy
Surface area of a membrane separating two regions	A membrane with a greater surface area will have a greater rate of diffusion across it (think of there being more 'entry or exit points' for particles to cross).

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.

Osmosis

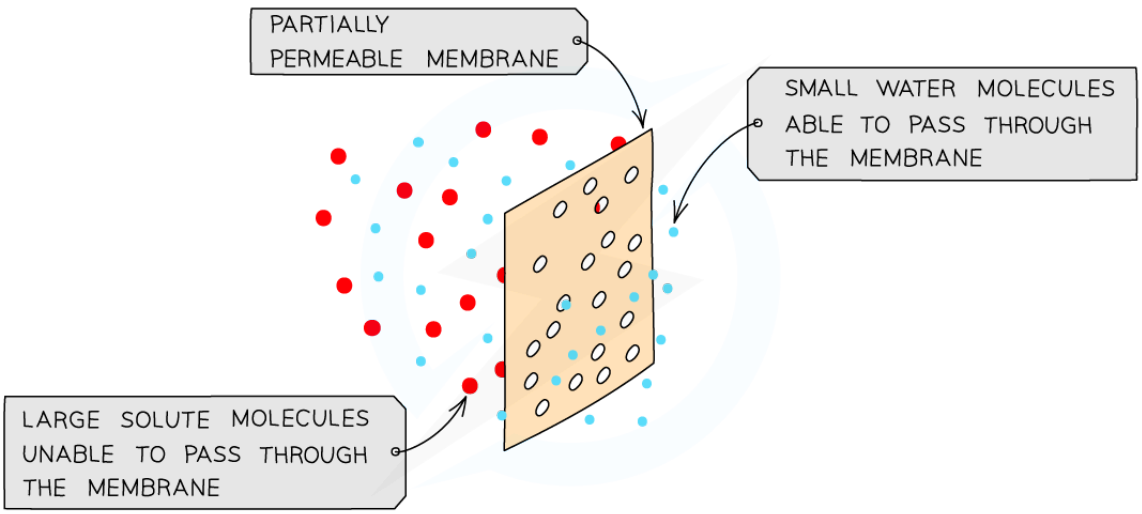
Your notes

Osmosis Theory

- **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

- Like, diffusion, **osmosis** is a form of **passive transport** (does not require energy) but it **only applies to water**
- The cell membrane is partially permeable which means it allows **small molecules** (like water) through but **not larger molecules** (like solute molecules)
- **Water** can move **in and out** of cells by **osmosis**
- It will move **down** its **concentration gradient**



Osmosis and the partially permeable membrane

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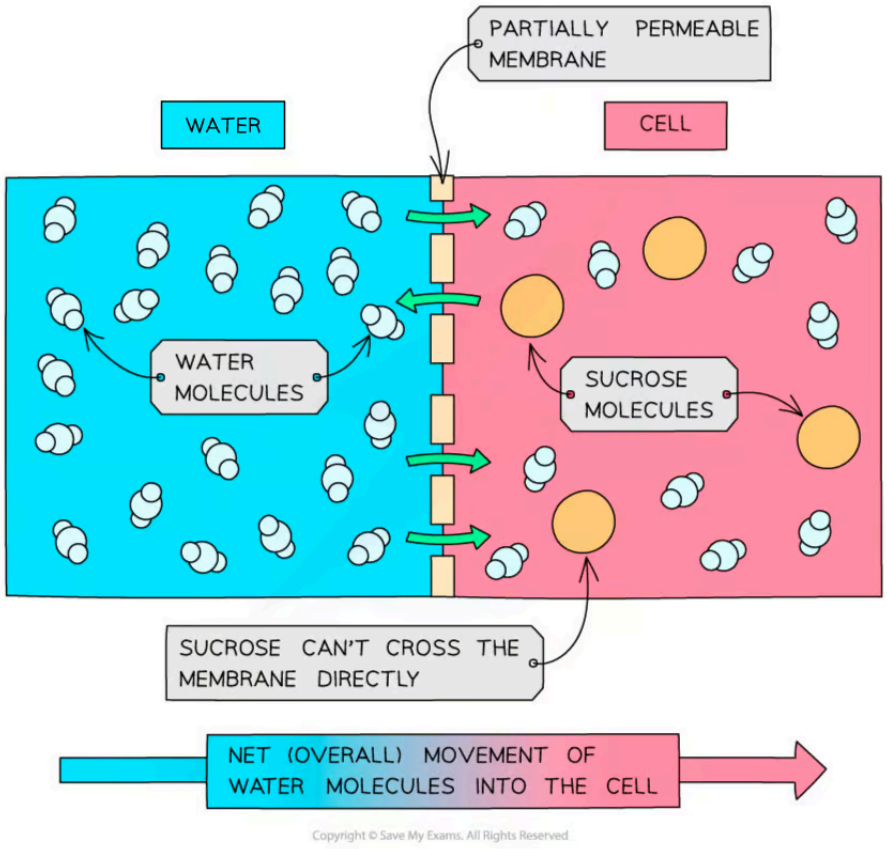

Osmosis in cells

- It can get a little confusing to talk about the 'concentration of water' when we also talk about solutions being 'concentrated' (having a lot of solute in them)
- Instead, we can say that a **concentrated solution** has a **low water potential** (the left-hand side of the diagram below) and a **dilute solution** has a high water potential (the right-hand side of the diagram below)

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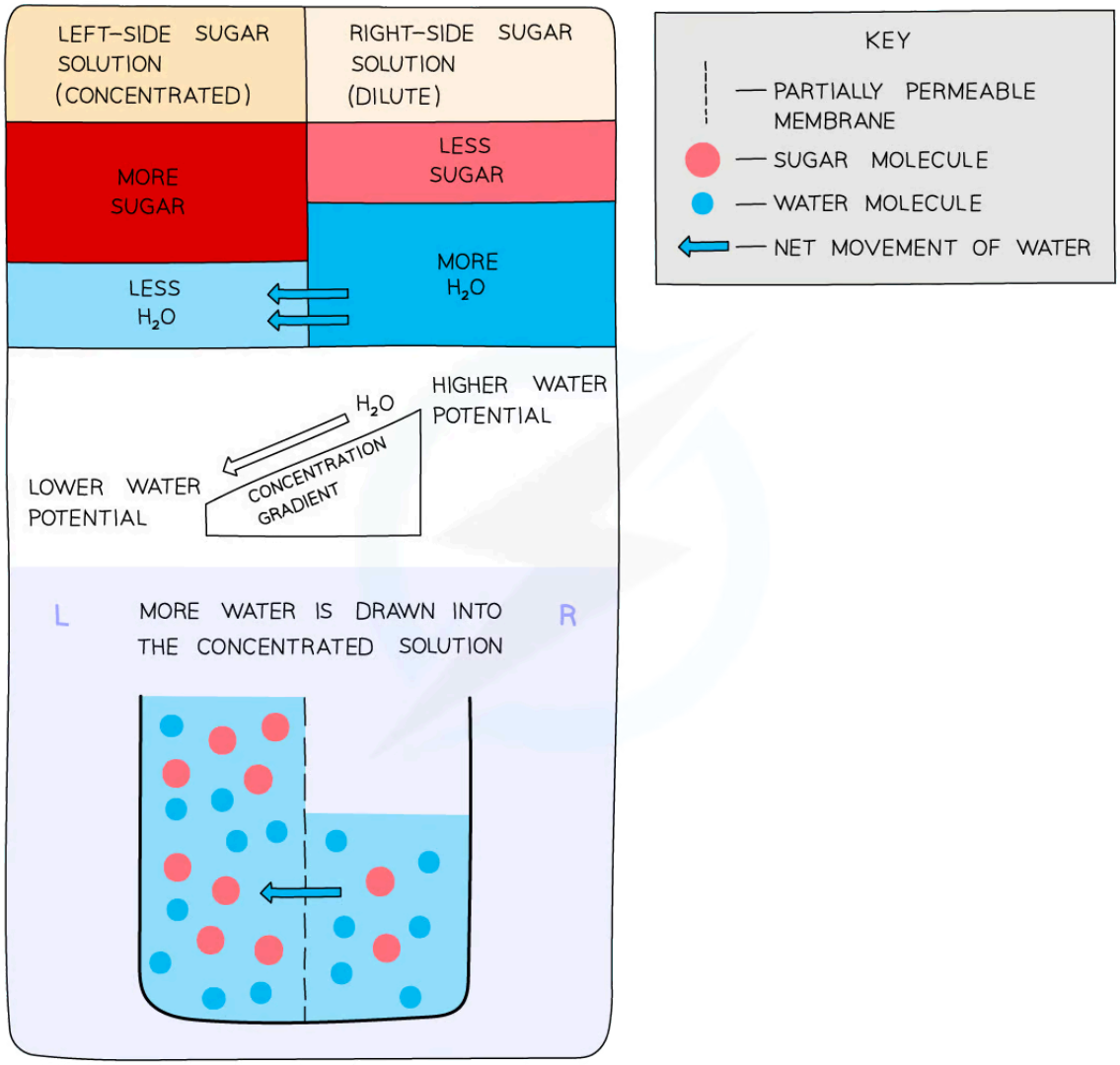

How osmosis works

Osmosis in animal cells

- **Animal cells** lose and gain water as a result of osmosis
- As animal cells **do not have a supporting cell wall**, the results of osmosis can be 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)

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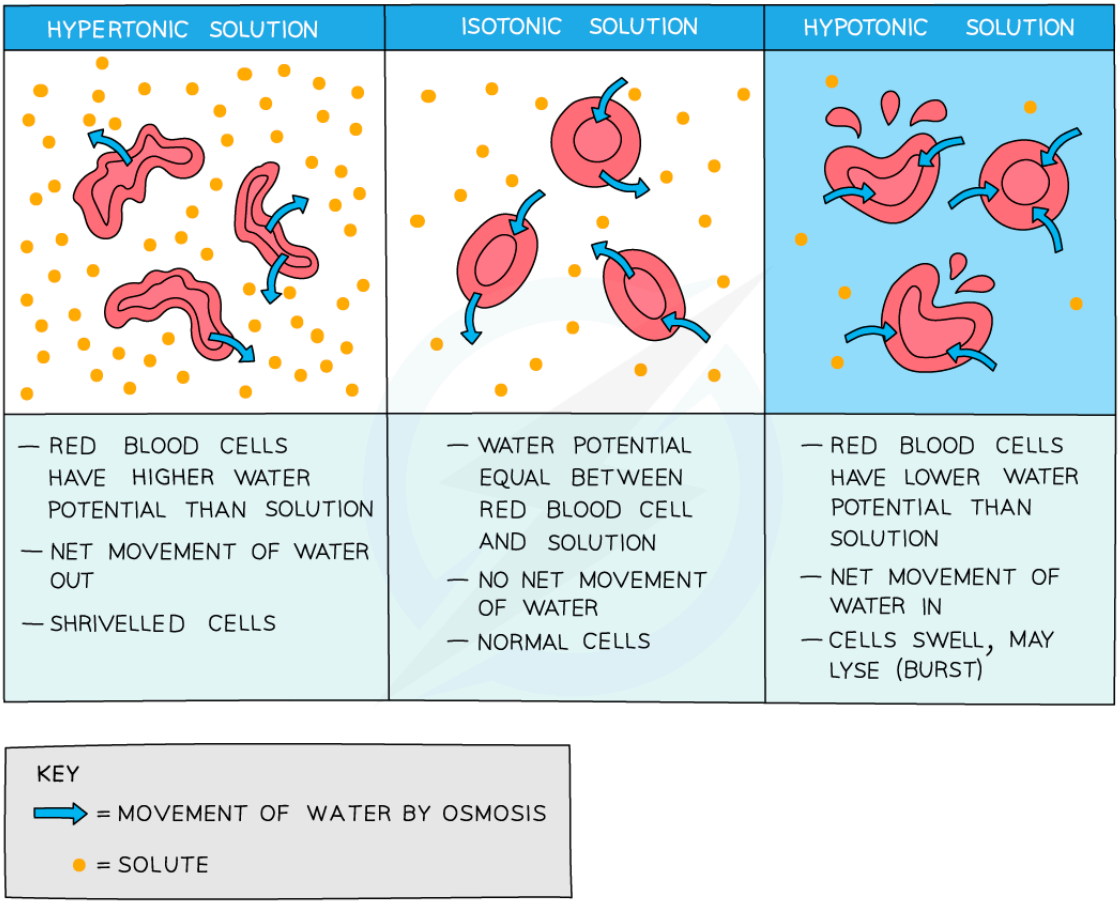
- If an animal cell is placed into **distilled water** (with a higher water potential than the cell), it will gain water by osmosis as it has **no cell wall to create turgor pressure**
- It will continue to gain water until the cell membrane is stretched too far and **it bursts**



Effect of osmosis on animal cells

Osmosis in plant cells

- **Plant cells** lose or gain water as a result of osmosis
  - 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

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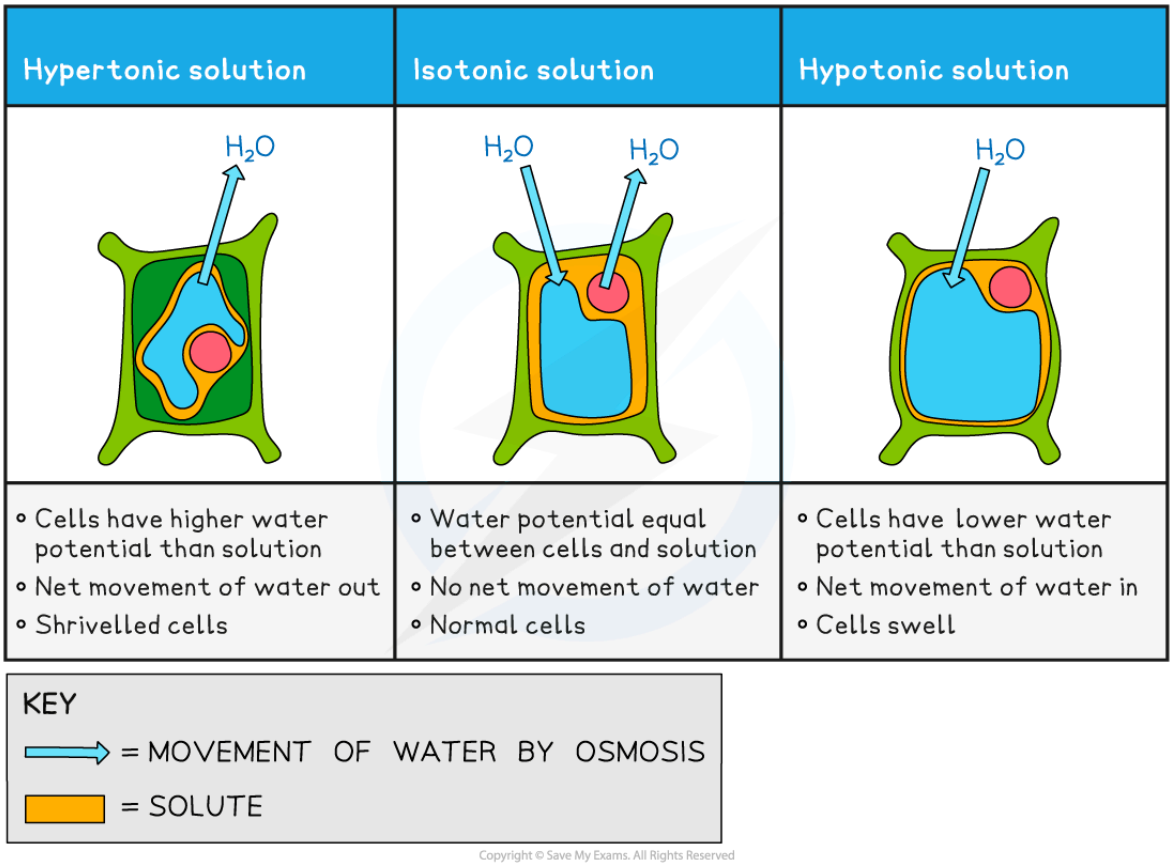
- If plants do not receive enough water the cells cannot remain rigid and firm (turgid) and the plant **wilts**
- As plant cells **have a supporting cell wall**, they are protected from cell lysis
- If a plant cell is placed into a **strong sugar solution** (with a lower water potential than the cell), it will lose water by osmosis
  - The vacuole gets **smaller** and the cell membrane **shrivels away from the cell wall**
  - It becomes **flaccid or plasmolysed** (shrivelled up)
- If a plant cell is placed into **distilled water** (with a higher water potential than the cell), it will gain water by osmosis
  - The vacuole gets **bigger**, **pushing the cell membrane against the cell wall**
  - The plant cell is described as being **turgid** or as containing a **high turgor pressure** (the pressure of the cytoplasm pushing against the cell wall)



The effect of osmosis on plant cells

Examiner Tips and Tricks

Osmosis refers only to the **movement of water molecules**, so if in an exam you are talking about the movement of water, make sure you mention osmosis as this will often earn you a mark.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 this concept and use it in your explanations.

Your notes

Practical: Factors that Influence Osmosis

- We can investigate osmosis by using **cylinders of potato** and placing them into **distilled water** and **sucrose solutions** of increasing concentration

Apparatus

- Potatoes
- Cork borer
- Knife
- Sucrose solutions (from 0 Mol/dm^3 to 1 mol/dm^3)
- Test tubes
- Balance
- Paper towels
- Ruler
- Test tube rack

Method

- Prepare a range of sucrose (sugar) solutions ranging from 0 mol dm^{-3} (distilled water) to 1 mol dm^{-3}
- Set up 6 labelled test tubes with 10cm^3 of each of the sucrose solutions
- Using the knife, cork borer and ruler, cut 6 equally-sized cylinders of potato
- Blot each one with a paper towel and weigh on the balance
- Put 1 piece into each concentration of sucrose solution
- After 4 hours, remove them, blot with paper towels and reweigh them

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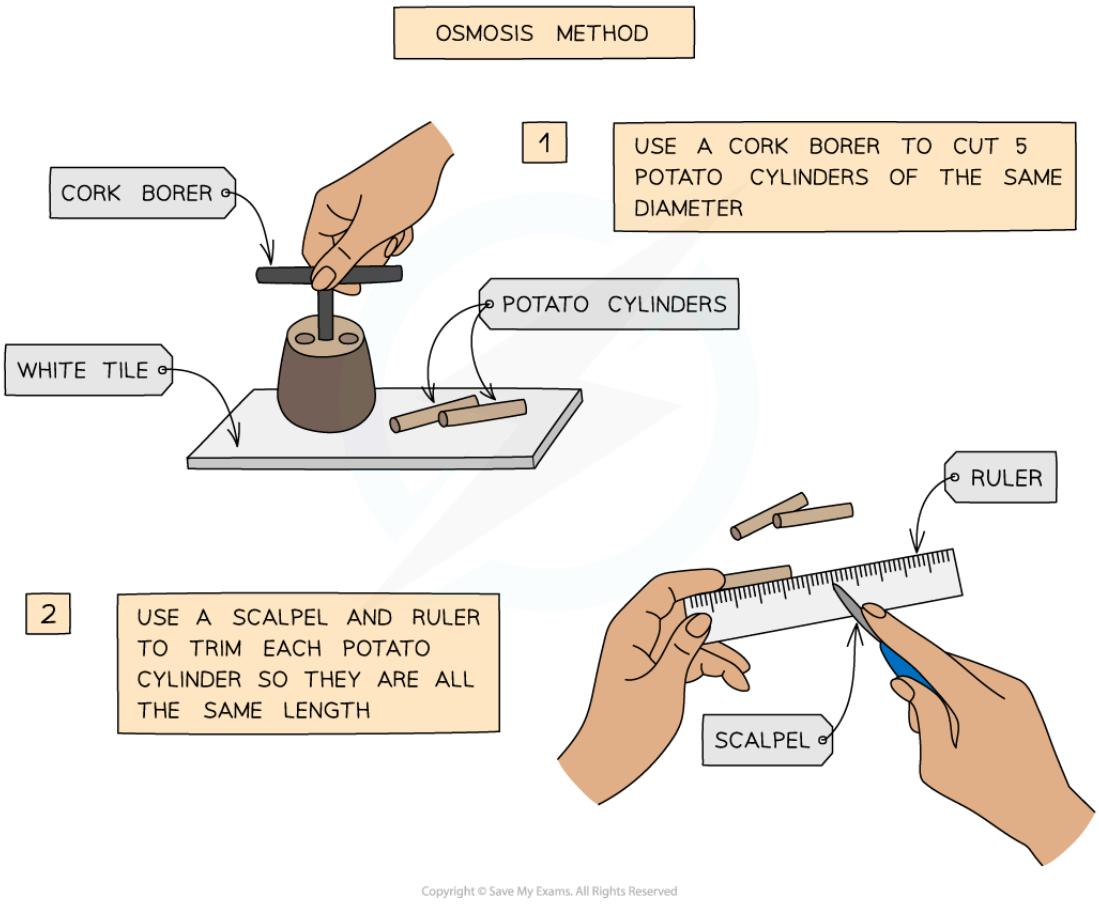
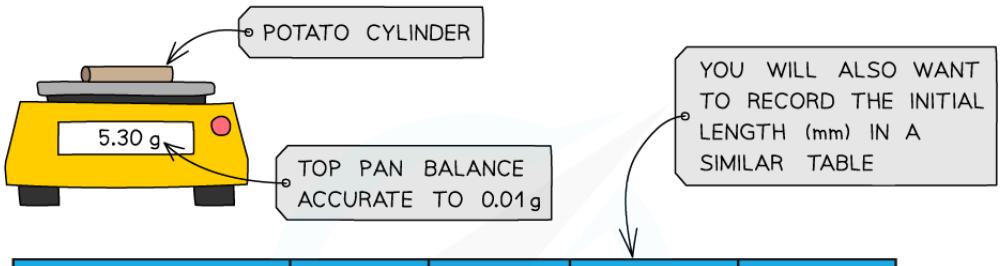


Your notes

3 MEASURE THE MASS OF EACH POTATO CYLINDER AND RECORD IN A TABLE OF RESULTS



Concentration of sucrose solution mol/dm^3	Initial mass (g)	Final mass (g)	Change in mass (g)	% change in mass
0 (distilled water)	5.30			
0.25	5.32			
0.50	5.29			
0.75	5.31			
1.00	5.29			

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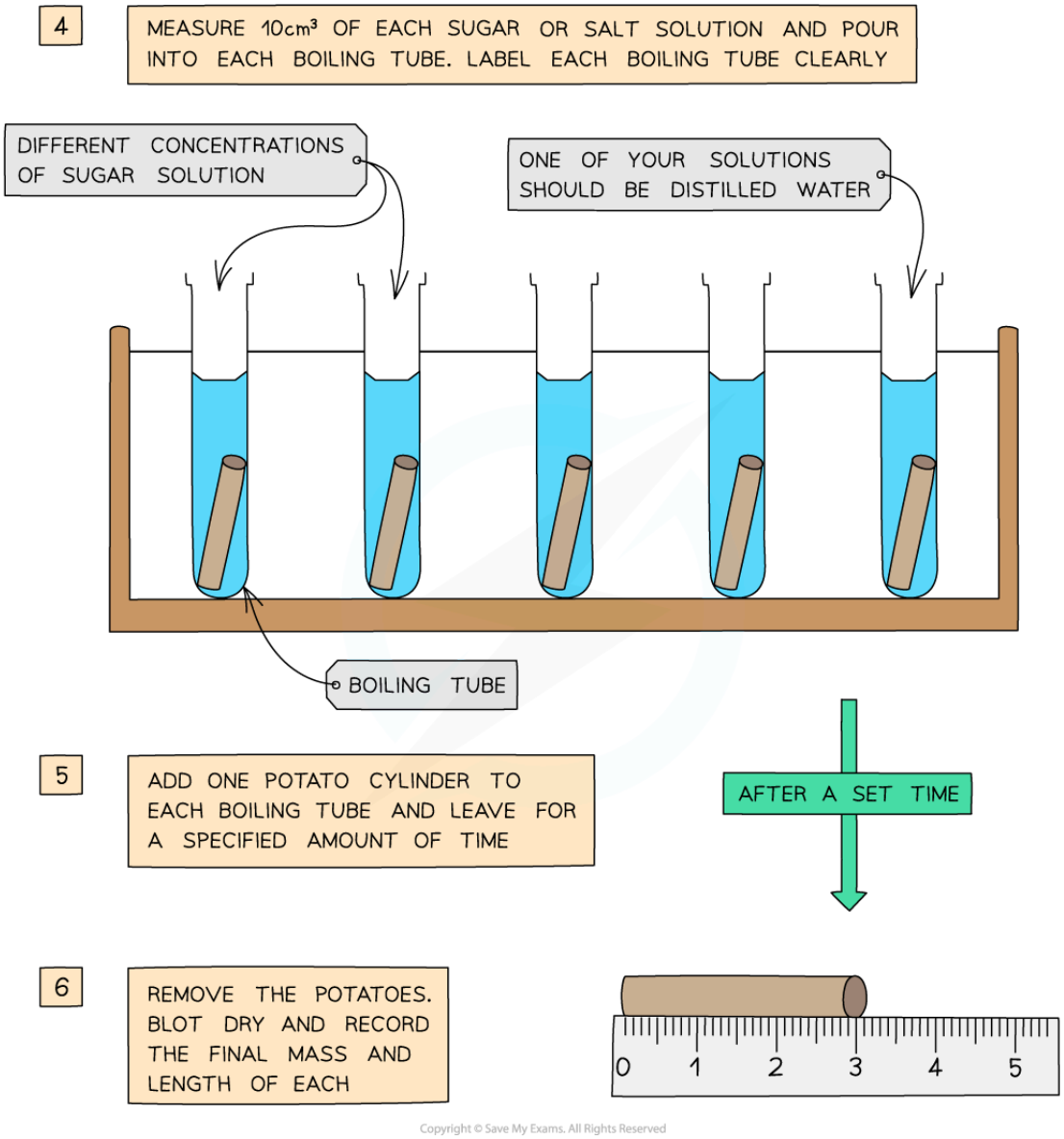

Experimental method for investigating osmosis in potato cylinders

Results and analysis

- The **percentage change in mass** can be calculated for each piece of potato

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OSMOSIS ANALYSIS

Concentration of sucrose solution mol/dm³	Initial mass (g)	Final mass (g)	Change in mass (g)	% change in mass
0 (distilled water)	5.30	5.80	+0.50	9.4
0.25	5.32	5.42	+0.10	?
0.50	5.29	5.24	−0.05	−1.0
0.75	5.31	5.11	−0.20	−3.8
1.00	5.29	5.02	−0.27	−5.1

1 CALCULATE THE PERCENTAGE CHANGE IN MASS FOR EACH CYLINDER

$$\frac{(\text{FINAL MASS} - \text{INITIAL MASS})}{\text{INITIAL MASS}} \times 100$$

e.g. FOR 0.25 mol dm³

$$= \frac{(5.42 - 5.32)}{5.32} \times 100$$

$$= 1.9\%$$

Calculating percentage change in mass

- The potato cylinder in the distilled water will have **increased its mass** the most as there is a greater concentration gradient in this tube between the distilled water (high water potential) and the potato cells (lower water potential)
- This means more water molecules will move **into the potato cells by osmosis**, pushing the cell membrane against the cell wall and so increasing the **turgor pressure** in the cells which makes them **turgid** - the potato cylinders will feel hard
- The potato cylinder in the strongest sucrose concentration will have **decreased its mass the most** as there is a greater concentration gradient in this tube between the potato cells (higher water potential) and the sucrose solution (lower water potential)

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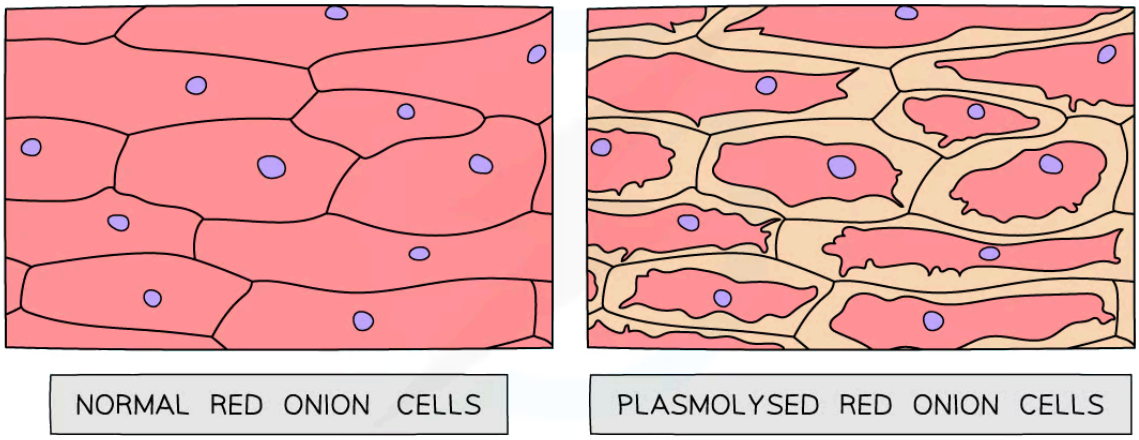
- This means more water molecules will move **out of the potato cells by osmosis**, making them flaccid and decreasing the mass of the cylinder - the potato cylinders will feel floppy
- If looked at underneath the microscope, cells from this potato cylinder might be **plasmolysed**, meaning the cell membrane has pulled away from the cell wall



Plasmolysed red onion cells

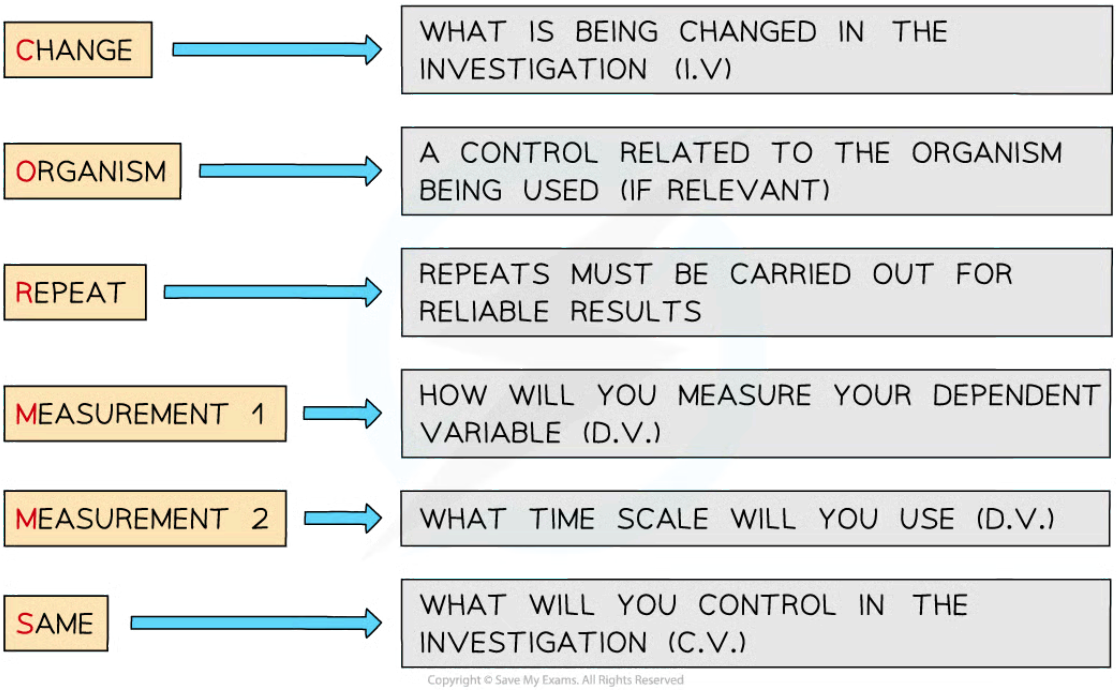
- If there is a potato cylinder that has not increased or decreased in mass, it means there was **no overall net movement of water** into or out of the potato cells
- This is because the solution that the cylinder was in was the same concentration as the solution found in the cytoplasm of the potato cells, so there was **no concentration gradient**

Limitations

- Slight differences in the potato cylinders may mean that the results aren't reliable or comparable. A possible solution to this limitation could be:
  - For each sucrose concentration, **repeat** the investigation with **several** potato cylinders. Making a series of repeat experiments means that any **anomalous results** can be **identified** and **ignored** when a **mean** is calculated

Applying CORMS evaluation to practical work

- When working with practical investigations, remember to consider your CORMS evaluation



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CORMS evaluation

- In this investigation, your evaluation should look something like this:
  - **C** - We are changing the concentration of sucrose solution
  - **O** - The potato cylinders will all be taken from the same potato or potatoes of the same age
  - **R** - We will repeat the investigation several times to ensure our results are reliable
  - **M1** - We will measure the change in mass of the potato cylinders
  - **M2** - ...after 4 hours
  - **S** - We will control the volume of sucrose solution used, the dimensions of the potato cylinders and each cylinder must be blotted before it is weighed each time

Examiner Tips and Tricks

Questions involving osmosis experiments are common and you should be able to use your knowledge of these processes to **explain the results**.Don't worry if it is an experiment you haven't done. Simply **figure out where the higher concentration of water molecules is** (this is the solution

with the higher water potential) and explain which way the molecules move due to the **differences in water potential**.


Your notes

Active Transport

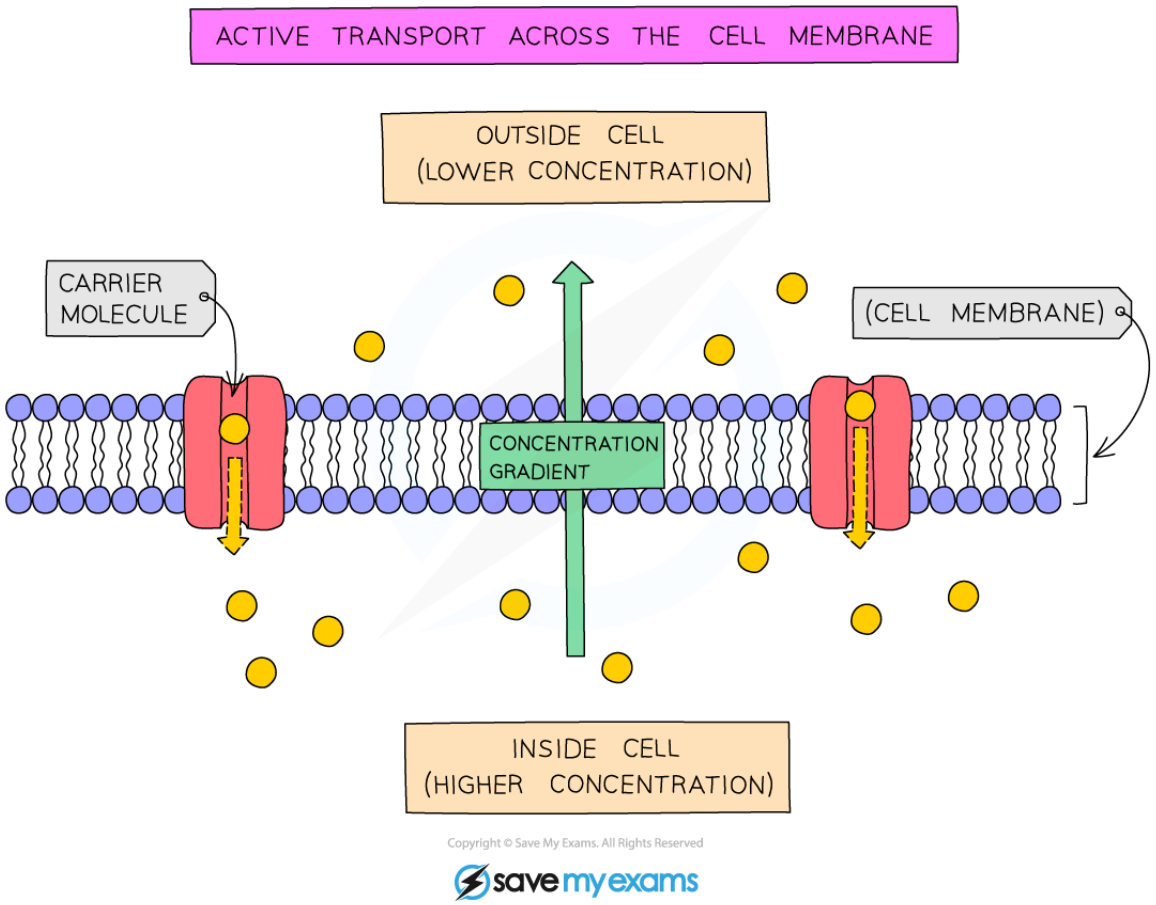
Your notes

Active Transport Theory

- **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

- **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 across the cell membrane involves **protein carrier molecules** embedded in the cell membrane



Active transport across the cell membrane – the molecules here are being transported against the concentration gradient, from a region of lower concentration (outside the cell) to a region of higher concentration (inside the cell)

Your notes

Active Transport in Organisms

Animals

- Food molecules (such as the sugar **glucose**) can be absorbed across the wall of the small intestine by diffusion, but this is **dependent on a concentration gradient** existing between the lumen of the intestine and the bloodstream
- **Active transport** allows molecules such as glucose to be transported into the bloodstream from the lumen of the small intestine (the gut) when the concentration of sugar molecules in the blood is higher
- The **active uptake of glucose** by epithelial cells in kidney tubules in the kidney nephron allows for the **reabsorption** of glucose back into the blood so that none is lost in the urine
- Sugar molecules are used in respiration to **release** energy for cells to function

Plants

- **Root hair cells** lining the surface of plant roots need to move **minerals** such as magnesium ions from a region of lower concentration (the very dilute solution of minerals in the soil surrounding the roots) to a region of higher concentration (inside the cytoplasm of the cell)
- Mineral ions are needed by plants to function
  - **Magnesium ions** are required to make **chlorophyll**
  - **Nitrate ions** are needed to make **amino acids** for **protein synthesis** (and subsequently growth)