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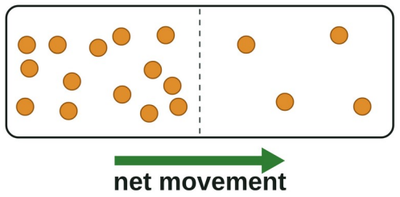
Osmosis, partially permeable membranes, and real cells beside a diagram

1. What osmosis is

In B1 L8 Diffusion you met **diffusion**: the net movement of particles from an area of higher concentration to an area of lower concentration.

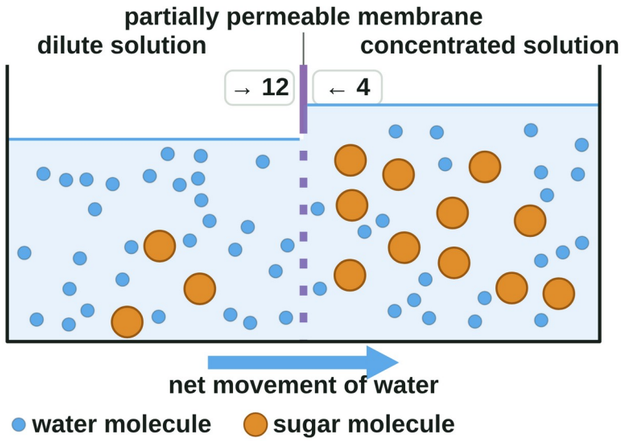
Osmosis is a special case of diffusion. It is the diffusion of **water** from a **dilute solution** to a **concentrated solution** through a **partially permeable membrane**.

Water moves into and out of every cell by osmosis, across the **cell membrane**.



2. Partially permeable membranes

- A **partially permeable membrane** lets small molecules, such as water, pass through, but not larger ones, such as sugar.
- The cell membrane is partially permeable. The **cell wall** is not: it lets water and dissolved substances through.
- Water molecules move all the time, in every direction. They cross the membrane **both ways**.
- More water molecules cross from the dilute side, because there are more of them there to hit the membrane. So there is a **net movement** of water into the more concentrated solution.
- Osmosis needs **no energy** from respiration. (Active transport does: B1 L10 Active transport and exchange surfaces.)



A model: blue dots = water molecules, orange dots = sugar molecules. Real molecules are far too small to see.

Watch out: only **water** moves by osmosis. Sugar and salt do not move by osmosis: the membrane stops them.

3. Dilute and concentrated solutions

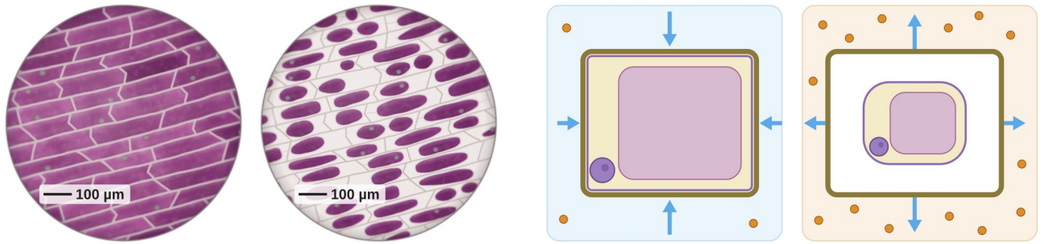
A **solution** is made when a **solute**, such as sugar or salt, dissolves in a liquid, such as water.

	Dilute solution	Concentrated solution
Solute	a little	a lot
Concentration of water	high	low
Water moves by osmosis (across a partially permeable membrane between them)	out of it	into it

Pure water has no solute, so it has the highest concentration of water.

Watch out: write “water moves from a **dilute** solution to a more **concentrated** solution”. If you write about high and low concentrations, say “of water” every time. A concentrated solution has **less** water, not more.

4. Real cells and a diagram



Real red onion cells (painting) — A diagram

A painting based on light micrographs. The purple is the cell sap's own colour: no stain.

Red onion cells have purple **cell sap** in their **permanent vacuole**, so you can see the vacuole without a stain.

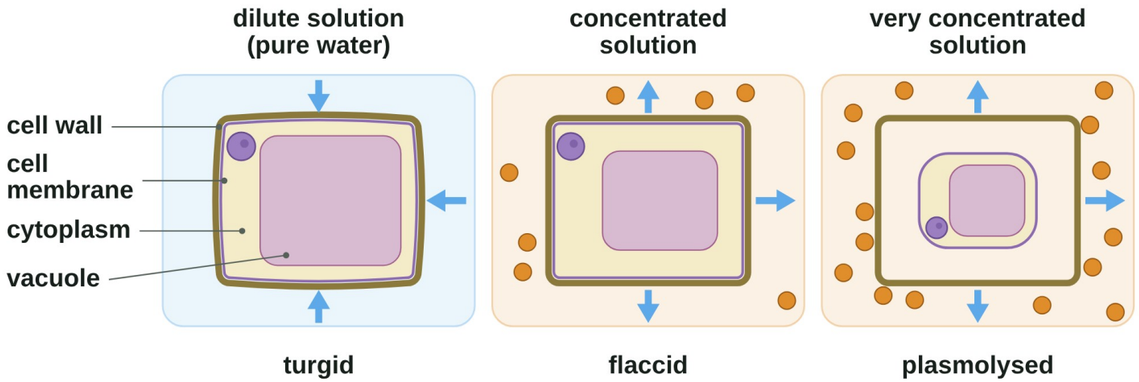
- In **pure water** (left), each vacuole is full and presses against the cell wall.
- In strong **salt solution** (right), water leaves by osmosis. The vacuole shrinks and the cytoplasm pulls away from the wall.

A diagram is simplified: it shows one neat cell in each solution, with arrows for the water. Real cells are packed together and share walls, they shrink unevenly, and you cannot see the water move. The clear gap in a shrunken cell is full of salt solution, not air.

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Plant cells, animal cells and root hair cells

5. Plant cells



Blue arrows show which way water moves. You cannot see water move.

- **In a dilute solution** (such as pure water), the cell's contents are more concentrated than the solution. Water moves **in** by osmosis. The vacuole swells and pushes the cytoplasm against the cell wall. The cell is **turgid**: swollen and firm.
- The **cell wall** is strong. It pushes back, so the cell cannot take in more water. A plant cell **never bursts**.
- **In a concentrated solution**, water moves **out** by osmosis. The vacuole shrinks. The cell is **flaccid**: soft.
- If the cell loses more water, the cytoplasm and cell membrane pull away from the cell wall. This is **plasmolysis**. The wall keeps its shape, and the gap fills with the outside solution.

Watch out: plant cells do not burst in water. The cell wall stops them.

6. Why plants wilt

Turgid cells press against each other. This holds up the stems and leaves of plants that are not woody, and keeps leaves flat to the light.

When a plant is short of water, its cells lose water and become flaccid. They no longer hold the plant up, so it **wilts**. Water it, and water moves back into the cells by osmosis: they become turgid again. (Why leaves keep losing water is B2 L14 Transpiration and the potometer.)

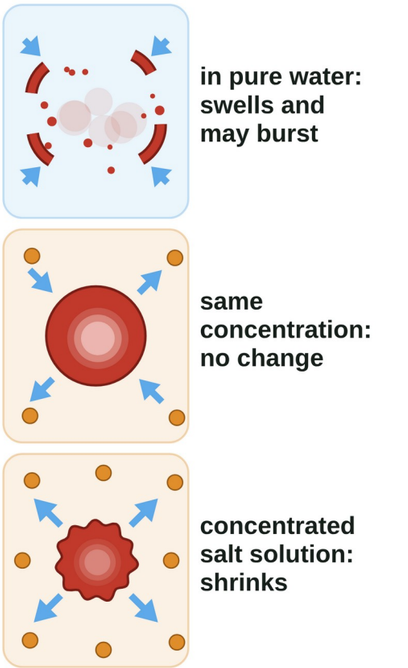
7. Animal cells

Animal cells, such as **red blood cells**, have a cell membrane but **no cell wall**.

- In **pure water**, water moves in by osmosis. Nothing stops the cell swelling, so it may **burst**.
- In a solution with the **same concentration** as the cell, there is no net movement of water.
- In a **concentrated** salt solution, water moves out by osmosis and the cell **shrinks**.

This is why a hospital drip is a salt solution about as concentrated as the inside of blood cells, and never pure water.

Watch out: an animal cell may burst in pure water, but a plant cell never does. Use **turgid** for plant cells only.

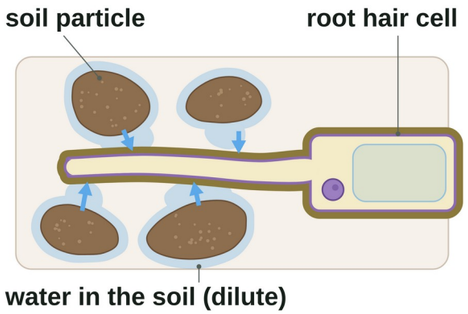


8. Root hair cells

Root hair cells take in water from the soil by osmosis. The water in the soil is more dilute than the inside of the root hair cell, so the net movement of water is into the cell.

The long, thin extension gives a large surface area, so more water is taken in (B1 L5 Specialised cells).

Mineral ions enter root hair cells a different way, by **active transport** (B1 L10 Active transport and exchange surfaces).



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Required practical 2 (Combined Science) · 3 (Biology): potato cylinders

9. The method

Aim: find out how the concentration of a sugar (or salt) solution affects the mass of potato tissue.

1. Use a cork borer to cut potato cylinders. Trim them all to 3 cm with a scalpel on a tile. Take off any skin.
2. Put 10 cm³ of sugar solution into each of six labelled boiling tubes: 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 mol/dm³.
3. Blot each cylinder gently with a paper towel. Find its mass on a balance: the **starting mass**.
4. Put one cylinder into each tube. Leave them overnight at room temperature.
5. Take each cylinder out, blot it gently in the same way, and find its mass again: the **final mass**.
6. Calculate the percentage change in mass. Do three cylinders at each concentration and find the mean.

Safety: cut onto a tile, away from your fingers; take care with the cork borer and the scalpel; wipe up spills; do not eat the potato.

Variable	In this practical
Independent (you change it)	the concentration of the sugar (or salt) solution
Dependent (you measure it)	the percentage change in mass
Control (you keep it the same)	the same potato; the size of the cylinders; the volume of solution; the time; the temperature; blotting the same way

10. Percentage change in mass

percentage change in mass = (final mass − starting mass) ÷ starting mass × 100

Worked example: a cylinder in 0.6 mol/dm³ goes from 2.00 g to 1.70 g.

Change in mass = 1.70 − 2.00 = −0.30 g.

Percentage change = −0.30 ÷ 2.00 × 100 = **−15 %**.

Check: the solution is concentrated, so the cylinder should lose mass. It did: the answer is negative.

- A **gain** (+) means water moved **in**. A **loss** (−) means water moved **out**.
- Use a percentage because the cylinders start with different masses: it compares them fairly.

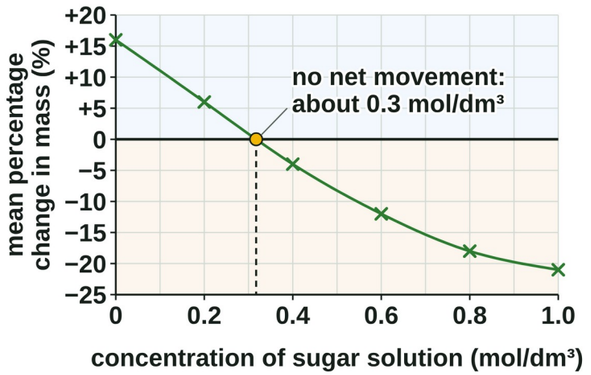
Rate of water uptake = gain in mass ÷ time. A cylinder that gains 0.30 g in 20 hours takes in water at 0.30 ÷ 20 = **0.015 g per hour**.

Watch out: divide by the **starting** mass, not the final mass. Keep the minus sign for a loss.

11. Results, the graph and the conclusion

Concentration (mol/dm³)	0.0	0.2	0.4	0.6	0.8	1.0
Cylinder 1 (%)	+12	+5	−4	−15	−18	−20
Cylinder 2 (%)	+17	+7	−3	−10	−19	−22
Cylinder 3 (%)	+19	+18 (anomaly)	−5	−11	−17	−21
Mean (%)	+16	+6	−4	−12	−18	−21

- At 0.2 mol/dm³, +18 % is an **anomaly**: it does not fit the pattern of the other results. Leave it out. Mean = (5 + 7) ÷ 2 = +6 %.
- Put the concentration along the bottom and the mean percentage change up the side.
- The y-axis must go **below zero**: some cylinders lost mass.
- Plot small crosses. Draw one smooth **line of best fit**, not dot to dot.
- **Conclusion.** Below about 0.3 mol/dm³ the potato **gains** mass: the solution is more dilute than the potato cells, so water moves in by osmosis.



- Above about 0.3 mol/dm³ the potato **loses** mass: water moves out.
- Where the line crosses 0 %, at about **0.3 mol/dm³**, there is **no net movement** of water. The potato cells' contents are about as concentrated as this solution.

Watch out: at 0 % change, water still moves both ways. There is no **net** movement, not “no movement”.

12. Evaluating

- **Blotting:** blotting harder or more gently changes the mass. Blot every cylinder the same way.
- **Drying:** a cylinder left out on the bench loses water to the air. Find the mass straight away.
- **The balance:** a balance that reads to 0.01 g has a better resolution than one that reads to 0.1 g: it shows smaller changes in mass.
- **Different pieces of potato** can behave differently. Use one potato, and do three cylinders at each concentration: if the results are close, they are **repeatable**.

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Key words, exam tips and check yourself

Key words

Anomaly: a result that does not fit the pattern of the other results.

Concentrated solution: a solution with a lot of solute dissolved in it, so it has a low concentration of water.

Control variable: a variable that is kept the same, so the test is fair.

Cork borer: a metal tube with a sharp end, used to cut cylinders of tissue with the same diameter.

Dependent variable: the variable that you measure.

Diffusion: the net movement of particles from an area of higher concentration to an area of lower concentration.

Dilute solution: a solution with only a little solute dissolved in it, so it has a high concentration of water.

Flaccid: describes a plant cell that is soft because it has lost water.

Independent variable: the variable that you change.

Mean: the total of the results divided by the number of results.

Net movement: the overall movement in one direction, after taking away the movement the other way.

Osmosis: the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.

Partially permeable membrane: a membrane that lets small molecules, such as water, pass through, but not larger ones, such as sugar.

Percentage change in mass: the change in mass divided by the starting mass, multiplied by 100.

Plasmolysis: when a plant cell loses so much water that its cytoplasm and cell membrane pull away from the cell wall.

Solute: the substance that dissolves in a liquid, such as sugar or salt.

Solution: a mixture made when a solute dissolves in a liquid, such as water.

Turgid: describes a plant cell that is swollen and firm because its vacuole is full of water.

Check yourself

Cover the answers, then check.

1. Give the definition of osmosis.
2. What does a partially permeable membrane let through, and what does it stop?
3. Which has more water in it: a dilute solution or a concentrated solution?
4. A plant cell is put in pure water. Which way does water move, and what word describes the cell afterwards?
5. What is plasmolysis?
6. Why can a red blood cell burst in pure water when a plant cell cannot?
7. A potato cylinder goes from 1.60 g to 1.48 g. Calculate the percentage change in mass.
8. On the graph of the potato practical, what does the point where the line crosses 0 % show?

Answers

1. The diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.
2. It lets small molecules such as water through, but stops larger ones such as sugar.
3. A dilute solution.
4. Into the cell, by osmosis. The cell becomes turgid.
5. When a plant cell loses so much water that its cytoplasm and cell membrane pull away from the cell wall.
6. A red blood cell has no cell wall. A plant cell's wall stops it bursting.
7. (1.48 − 1.60) ÷ 1.60 × 100 = −7.5 %.
8. No net movement of water: the solution is about as concentrated as the inside of the potato cells.

Exam tips

- Say **water** every time: osmosis is the movement of water, never of sugar or salt.
- Write “from a **dilute** solution to a more **concentrated** solution”. If you use “high” and “low”, add “of water”.
- Use the words **turgid**, **flaccid** and **plasmolysis** for plant cells. Animal cells **swell and may burst**, or **shrink**.
- Say why a plant cell does not burst: the **cell wall**.
- Percentage change = (final − starting) ÷ starting × 100. Keep the minus sign for a loss.
- At 0 % change there is **no net movement** of water, not “no movement”.