

Movement of substances into and out of cells

Revision notes · Diffusion, osmosis and active transport, what affects their rate, and practicals using living and non-living systems.

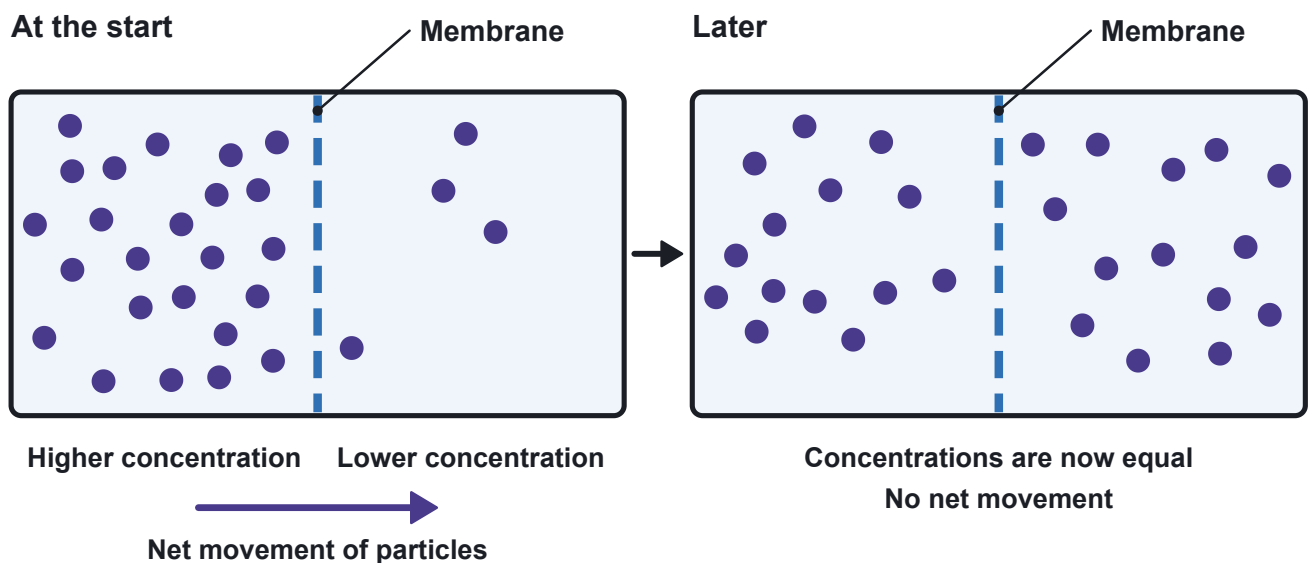
For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

Movement of substances into and out of cells Spec 2.15-2.17

Diffusion Spec 2.15

Diffusion is the net movement of particles from an area of higher concentration to an area of lower concentration. The particles move **down a concentration gradient**. It is a passive process, so it does not need energy from respiration.

Oxygen, carbon dioxide and dissolved substances such as glucose can diffuse into and out of cells through the cell membrane. For example, oxygen diffuses into a respiring cell because the concentration of oxygen is lower inside the cell, where it is being used up.



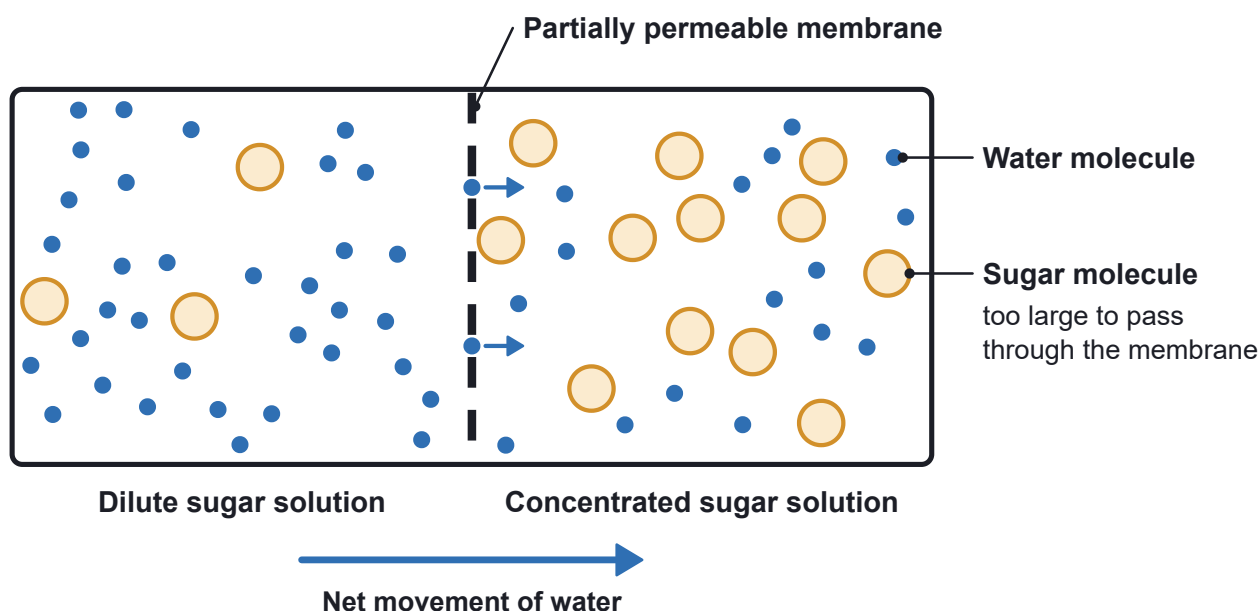
Diffusion: net movement of particles **down a concentration gradient** until the concentrations are equal.

Exam tip: Always say **net** movement. Particles move in all directions, but more move down the gradient than up it.

Osmosis Spec 2.15

Osmosis is the diffusion of water from a dilute solution to a more concentrated solution through a **partially permeable membrane**. A partially permeable membrane lets small molecules such as water through, but not larger molecules.

Osmosis is a passive process. It does not need energy from respiration. Cell membranes are partially permeable, so cells gain or lose water by osmosis when the solution around them is more dilute or more concentrated than the cytoplasm.



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

Common mistake: Osmosis is only about water. Do not write that 'particles' move by osmosis, and do not forget the partially permeable membrane.

Active transport Spec 2.15

Active transport is the movement of substances from a more dilute solution to a more concentrated solution, which is **against a concentration gradient**. It needs **energy from respiration**.

Active transport allows cells to take in substances they need even when they are in short supply outside the cell. For example, root hair cells take in mineral ions from the soil when the concentration of the ions is higher inside the cell than in the soil.

Three ways substances move into and out of cells			
	What moves	Direction	Energy from respiration?
Diffusion	Particles, such as oxygen and carbon dioxide	High to low concentration	No
Osmosis	Water only, through a partially permeable membrane	Dilute to concentrated solution	No
Active transport	Substances such as mineral ions	Low to high concentration, against the gradient	Yes

Factors affecting the rate of movement Spec 2.16

Four factors affect how fast substances move into and out of cells by diffusion and osmosis.

Factors affecting the rate of movement

Factor	Effect on the rate	Example
Surface area to volume ratio	A larger ratio means a faster rate for the size of the cell, because more surface is available for each unit of volume	Root hair cells have a long projection that gives a large surface area
Distance	A shorter distance means a faster rate	The wall of an alveolus is one cell thick
Temperature	A higher temperature means a faster rate, because particles have more kinetic energy and move faster	Diffusion is faster in a warm solution than in a cold one
Concentration gradient	A steeper gradient (a bigger difference in concentration) means a faster rate	Blood flow keeps the oxygen concentration lower in the blood than in the alveoli

Surface area to volume ratio

The **surface area : volume ratio** tells you how much surface an organism or cell has compared with its size. The bigger the object, the smaller this ratio becomes.

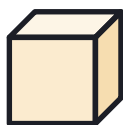
$$\text{surface area : volume ratio} = \text{surface area} \div \text{volume}$$

Surface area : volume ratio of a cube

A cube-shaped block of tissue has sides of 3 cm. Calculate its surface area : volume ratio.

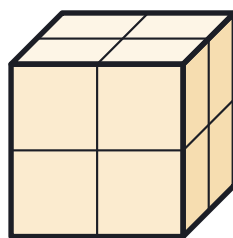
1. A cube has 6 faces. Area of one face = $3 \times 3 = 9 \text{ cm}^2$.
2. Surface area = $6 \times 9 = 54 \text{ cm}^2$.
3. Volume = $3 \times 3 \times 3 = 27 \text{ cm}^3$.
4. Ratio = $54 : 27$. Divide both sides by 27.

Answer: 2 : 1



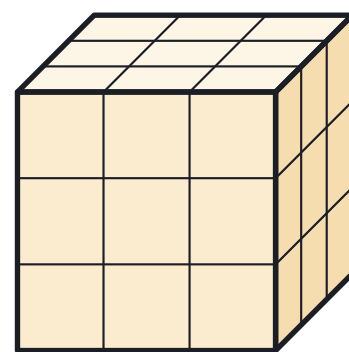
1 cm

surface area = 6 cm^2
 volume = 1 cm^3
 surface area : volume
 = 6 : 1



2 cm

surface area = 24 cm^2
 volume = 8 cm^3
 surface area : volume
 = 3 : 1



3 cm

surface area = 54 cm^2
 volume = 27 cm^3
 surface area : volume
 = 2 : 1

As the cube gets bigger, its **surface area : volume ratio gets smaller**.

- A single-celled organism has a **large surface area : volume ratio**. Substances only have a short distance to diffuse, so diffusion across the surface is fast enough.
- A multicellular organism has a **small surface area : volume ratio**. Many cells are deep inside the body, so the diffusion distance is long and diffusion across the body surface is too slow.

Common mistake: A thin membrane or wall gives a short diffusion distance. It does not give a larger surface area; these are two separate factors.

Practical: diffusion and osmosis Spec 2.17

You need to be able to investigate diffusion and osmosis using **living** systems (such as potato tissue) and **non-living** systems (such as Visking tubing and agar).

Living system: osmosis in potato cylinders

Practical: Independent variable: concentration of the solution; dependent variable: change in mass. Blot each cylinder dry before you weigh it, because surface water adds mass that is not from osmosis.

1. Use a cork borer to cut cylinders from one potato, and trim them to the same length.
2. Measure and record the mass of each cylinder.
3. Put each cylinder in a different concentration of sugar (or salt) solution, including pure water, using the same volume of solution each time.
4. Leave them for the same length of time at the same temperature.
5. Remove the cylinders, blot them dry with paper towel and measure their final mass.
6. Calculate the percentage change in mass for each cylinder and plot a graph of percentage change against concentration.

Result	Explanation
Mass increases	The solution is more dilute than the cell contents, so water moves into the potato by osmosis
Mass decreases	The solution is more concentrated than the cell contents, so water moves out of the potato by osmosis
No change in mass	The solution has the same concentration as the cell contents, so there is no net movement of water

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

Percentage change in mass

A potato cylinder has a mass of 3.00 g. After 30 minutes in a salt solution its mass is 2.55 g. Calculate the percentage change in mass.

1. change in mass = 2.55 – 3.00 = –0.45 g
2. $-0.45 \div 3.00 = -0.15$
3. $-0.15 \times 100 = -15\%$

Answer: –15% (a loss of 15%)

Where the graph line crosses the x-axis (0% change), the concentration of the solution equals the concentration of the potato cell contents. Control the potato, the size of the cylinders, the volume of the solution, the time and the temperature. Cut on a tile away from your fingers, because cork borers and scalpels are sharp.

Non-living system: Visking tubing

Visking tubing is a partially permeable membrane with tiny pores. It lets small molecules such as water and glucose through, but not large molecules such as starch.

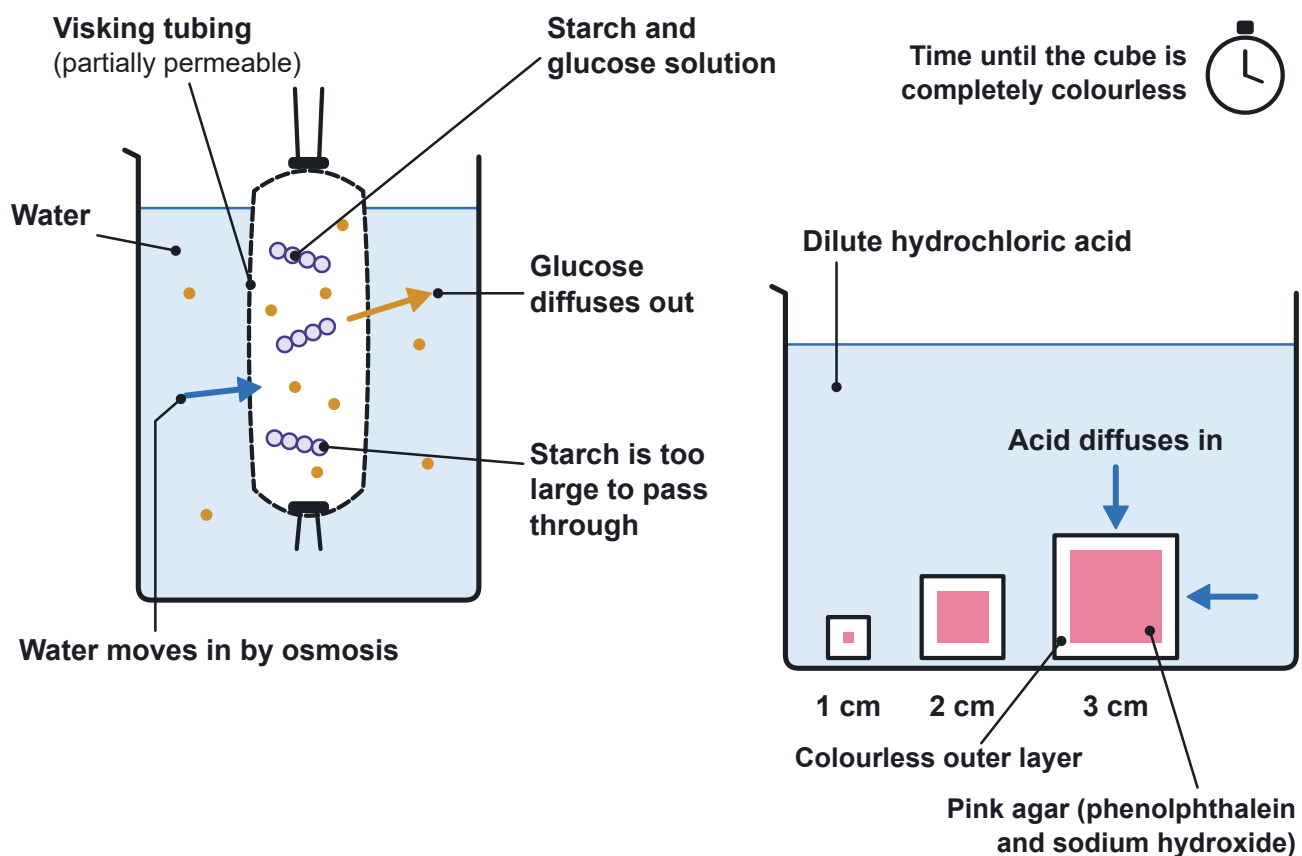
1. Tie one end of a length of soaked Visking tubing and fill it with a mixture of starch and glucose solution. Tie the other end.
2. Rinse the outside, then place the tube in a beaker of water.
3. After about 20 to 30 minutes, test the water in the beaker with Benedict's solution (for glucose) and with iodine solution (for starch).

Typical results: the water in the beaker gives a positive Benedict's test, so glucose has diffused out through the pores. It does not turn blue-black with iodine, so the starch molecules were too large to pass through. To show osmosis, fill the tube with a concentrated sugar solution and place it in water. The tube becomes firmer and gains mass as water moves in.

Non-living system: agar cubes

Agar jelly cubes can show diffusion and the effect of surface area to volume ratio. Make agar containing phenolphthalein indicator and a little dilute sodium hydroxide (an alkali), so it is pink. Cut cubes of different sizes, for example 1 cm, 2 cm and 3 cm. Place each cube in the same volume of dilute hydrochloric acid at the same temperature. As the acid diffuses in, it neutralises the alkali and the indicator turns colourless. Time how long each cube takes to become completely colourless.

Typical results: small cubes, with a larger surface area : volume ratio and a shorter distance to the centre, change colour all the way through sooner than large cubes. Wear eye protection when using acid and alkali.



Non-living models: **glucose** passes through the pores of Visking tubing but **starch** cannot; acid diffuses into small agar cubes faster than large ones.

Quick check

- 1 . Define diffusion.
- 2 . What is osmosis?
- 3 . Which of diffusion, osmosis and active transport needs energy from respiration?
- 4 . What happens to the surface area to volume ratio as an organism gets bigger?
- 5 . Why does a potato cylinder lose mass in a concentrated sugar solution?

Quick check answers

Movement of substances into and out of cells

1. The net movement of particles from an area of higher concentration to an area of lower concentration.
2. The diffusion of water from a dilute solution to a more concentrated solution through a partially permeable membrane.
3. Active transport.
4. It gets smaller.
5. Water moves out of the potato cells into the more concentrated solution by osmosis.