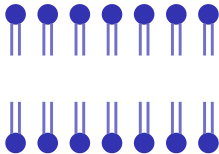


Cell Membranes & Transport

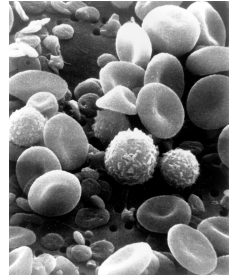
A-Level Biology ■ Topic 4

A-Level Biology



What we will cover

- 1 The fluid mosaic model
- 2 Cell signalling
- 3 Diffusion & osmosis
- 4 Active & bulk transport
- 5 Surface area : volume
- 6 Cells in solutions



each cell has a membrane



The fluid mosaic model

A phospholipid bilayer with proteins floating in it.

fluid

phospholipids
and proteins can
move sideways

mosaic

proteins scattered
like tiles – channels,
carriers, receptors

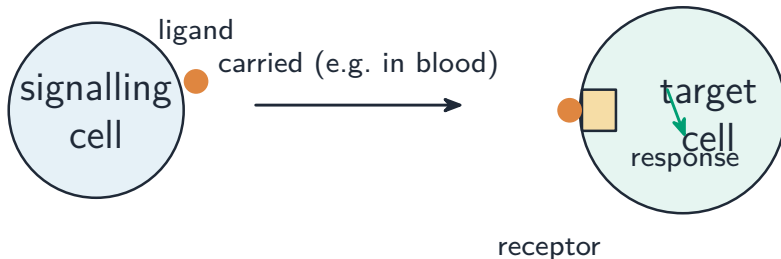
bilayer

hydrophobic tails
inside; hydrophilic
heads face water

Cell signalling

In **cell signalling** :

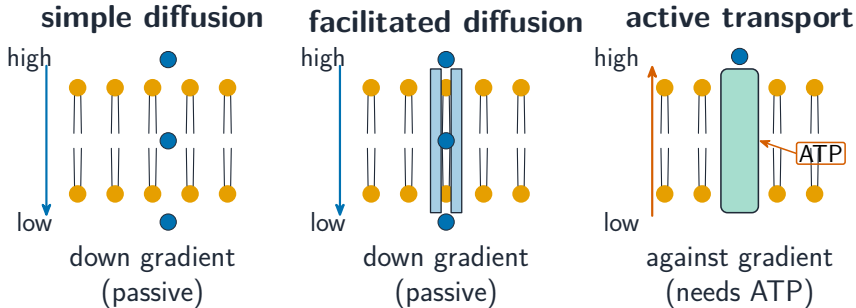
- a cell secretes a **ligand** (e.g. a **hormone**)
- it binds a matching **receptor** on the **target cell**
- only cells with that receptor respond





Crossing the membrane

- **simple diffusion** – small/non-polar straight through (passive)
- **facilitated diffusion** – ions & glucose via proteins (passive)
- **active transport** – **against** the gradient, needs ATP



What can cross by itself, and what cannot

Straight through

Only small or non-polar molecules diffuse through the phospholipid bilayer of the **cell surface membrane** – **oxygen**, **carbon dioxide**, steroids.

Needs a protein

Ions and polar molecules (glucose, amino acids) need a channel or carrier: facilitated diffusion if downhill, active transport if not.

Studying it

Diffusion across non-living material can be modelled with **dialysis tubing** (Visking tubing), which is partially permeable but has no proteins at all.

The bilayer is the barrier and the proteins are the doors – which is why membrane permeability is a property of the *protein* population.

Six ways across, passive and active

The membrane is **partially permeable** : some things cross easily, others are blocked. Six processes do the crossing – **passive** ones need no energy, **active** ones spend ATP.

simple diffusion

down a **concentration** gradient, straight through the bilayer

facilitated diffusion

down the gradient, but through a channel or carrier protein

osmosis

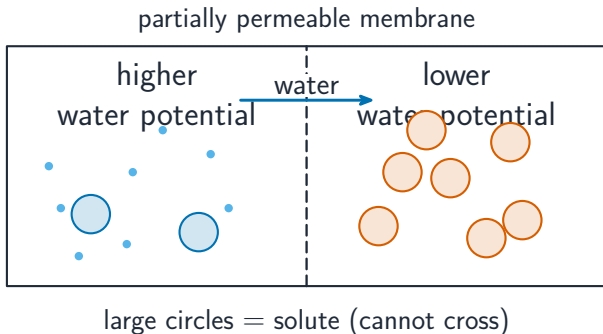
water down a **water potential** gradient

active transport

up a gradient, a pump protein spending ATP

Plus **endocytosis** and **exocytosis** for anything too big to pass a protein – both active.

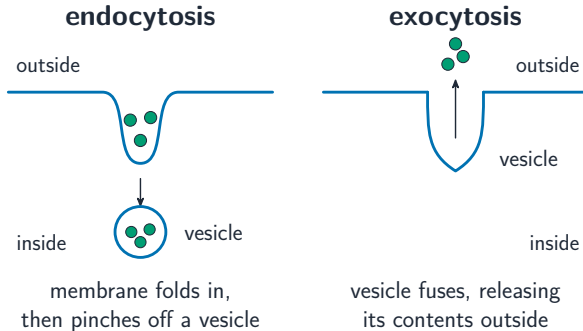
Osmosis and water potential



Osmosis is the diffusion of water across a partially permeable membrane.

Water moves from a **higher** to a **lower water potential**. Pure water is highest; a **solute** lowers it.

Bulk transport



These move material in bulk, using ATP:

- **endocytosis** – the membrane folds in to form a **vesicle**
- **exocytosis** – a vesicle fuses & releases its contents



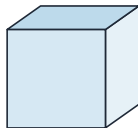
Surface area to volume ratio

For a cube of side L : $\frac{SA}{V} = \frac{6L^2}{L^3} = \frac{6}{L}$.

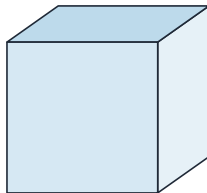
As a cell grows, the ratio **falls** – so small or thin, flat cells exchange materials fastest.



side $L = 1$
SA:V = 6 : 1



side $L = 2$
SA:V = 3 : 1



side $L = 3$
SA:V = 2 : 1

Why size limits diffusion

the ratio

as an object grows, volume rises as the **cube** of length and surface area as the **square**

so

a larger organism has a **smaller** surface area to volume ratio

the consequence

diffusion alone cannot supply a large organism, which is why transport systems exist

the agar experiment

blocks of different sizes soaked in dye or acid – the **smallest**, with the largest ratio, changes colour throughout first

estimating water potential

place plant tissue in sucrose solutions; the solution causing **no change** in mass has the same water potential as the tissue

Cut a cube in half and its surface area to volume ratio **doubles**. Villi, alveoli and root hairs are all that trick applied.

Cells in solutions

- plant cell: **turgid** (water in) or **plasmolysed** (water out)
- animal cell: bursts (**haemolysis**) or shrinks – no wall to protect it

higher water potential **lower water potential**
(water enters) **(water leaves)**

plant cell

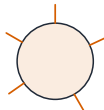


turgid



plasmolysed:
contents pull away

animal cell



What a cell does in each solution

Higher water potential

In a solution of **higher** water potential – **distilled water**, say – water enters. An animal cell bursts; a plant cell becomes turgid.

Equal

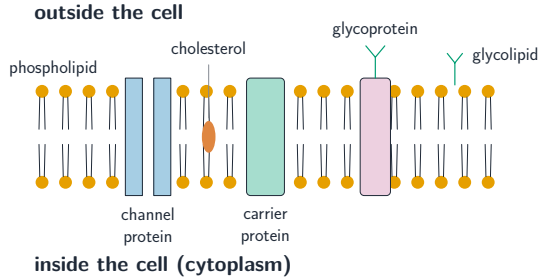
No net movement. An animal cell is normal; a plant cell is flaccid, and a soft plant wilts.

Lower water potential

Water leaves. An animal cell crenates; in a plant cell the contents shrink and the membrane pulls away from the wall – **plasmolysis**.

The cell wall is the whole difference: it cannot stop water moving, but it can stop the cell bursting.

What floats in the membrane



Each **phospholipid** has a **hydrophilic** head and two **hydrophobic** tails, so the bilayer forms with tails inward. **Cholesterol** sits between the tails, controlling **fluidity** and adding strength; proteins act as channels, carriers and receptors; carbohydrate chains on the outside are for recognition.

What is in the membrane, and what each part does

phospholipids

the two layers – they **form the basic barrier**

cholesterol

between the tails – regulates **fluidity** and adds **stability**

channel proteins

a water-filled pore for facilitated diffusion of ions

carrier proteins

change shape to move a specific molecule – facilitated diffusion or active transport

glycoproteins and glycolipids

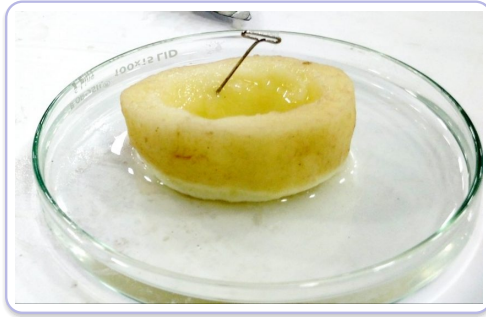
carbohydrate chains on the outside – cell recognition, **antigens**, and receptors

together

they give the membrane its stability, its fluidity, and its **permeability**

“Fluid mosaic”: **fluid** because the phospholipids move past one another, **mosaic** because the proteins are scattered through them.

Osmosis



A potato osmometer: the sugar solution rises up the tube as water enters the potato by osmosis

Exam tips

- Describe the membrane as a **fluid mosaic**: a phospholipid bilayer with proteins, cholesterol and glycoproteins.
- Sort each process: diffusion, facilitated diffusion and osmosis are **passive** (down a gradient); active transport and endo/exocytosis need **ATP** and can go against it.
- For osmosis always use **water potential** (Ψ): water moves from **high (less negative) to low (more negative)** Ψ ; pure water is 0, the highest.
- State the outcome by cell type: plant cell turgid/plasmolysed; animal cell lyses/crenates – link it to the water-potential gradient.



Worked example – surface area : volume

Compare the surface area : volume ratio of a cube of side 4 with one of side 10.

- Side 4: $SA = 6 \times 4^2 = 96$; $V = 4^3 = 64$; ratio = $96/64 = 1.5$
- Side 10: $SA = 6 \times 10^2 = 600$; $V = 10^3 = 1000$; ratio = $600/1000 = 0.6$
- The **smaller** cube has the **larger** ratio.
- SA scales with length^2 but volume with length^3 , so **ratio falls as size rises**.

This is why cells are small and why big organisms need **gas-exchange and transport systems**: diffusion alone cannot serve a low SA:V.

Topic 4 – key takeaways

1

Fluid mosaic

a fluid bilayer dotted with proteins

2

Passive vs active

diffusion down gradient; active needs ATP

3

Osmosis

water moves to lower water potential

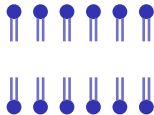
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Water balance

turgid/plasmolysed; burst/shrink

Check yourself

- 1 Why is the model called “fluid”?
- 2 Which transport process needs ATP and goes against the gradient?
- 3 Osmosis moves water towards which water potential?
- 4 What is a plant cell called when it loses water and plasmolyses?

**Answers**

1. phospholipids slide past each other
2. active transport
3. lower water potential
4. plasmolysed