



Membranes and membrane transport

Revision notes · IB Biology B2.1: lipid bilayers, simple diffusion, osmosis and aquaporins, channels and pumps, and the fluid mosaic model.

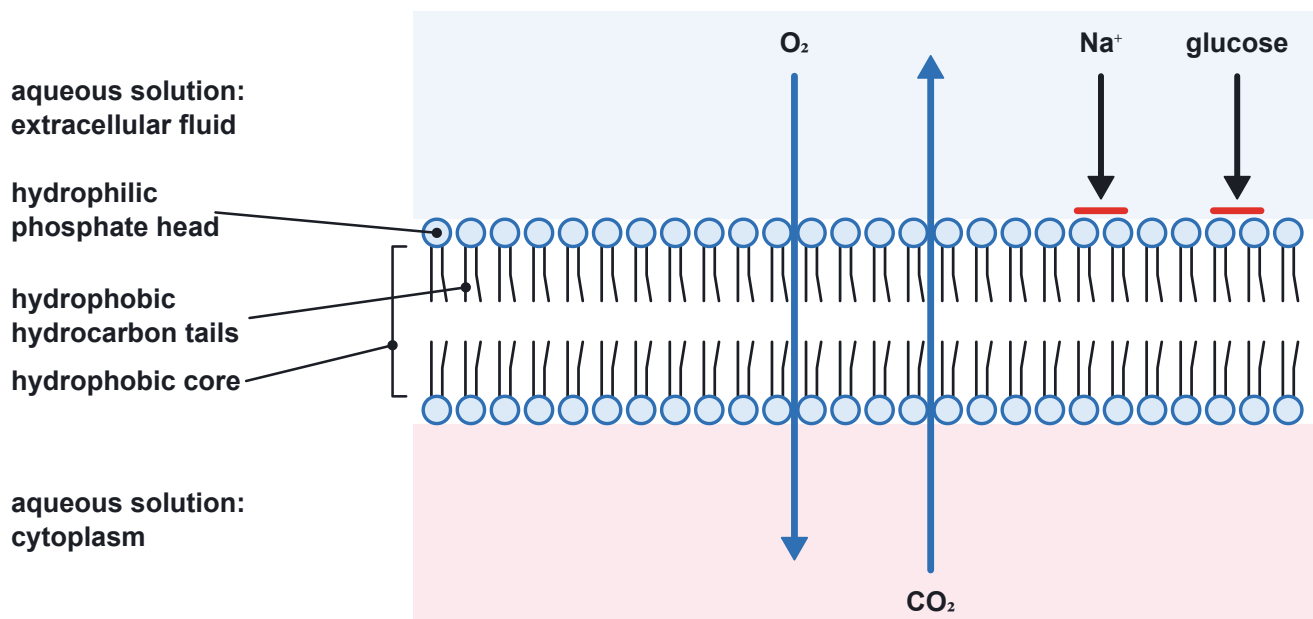
For IB Diploma Biology SL undefined. **HL only** is additional higher level content, for HL students only.

Membranes and membrane transport Spec B2.1

Lipid bilayers, barriers and simple diffusion Spec B2.1.1-B2.1.3

A phospholipid is **amphipathic**: it has a hydrophilic (water-attracting) phosphate head and two hydrophobic (water-repelling) hydrocarbon tails. Other membrane lipids, such as cholesterol and glycolipids, are also amphipathic.

In water, phospholipids naturally arrange themselves into a **lipid bilayer**. The heads face outwards into the water on both sides and the tails point inwards, away from the water. The bilayer forms continuous sheets, which close up so that no tails are left exposed at an edge. No energy input is needed. This bilayer is the basis of every cell membrane.



O_2 and CO_2 diffuse between the phospholipids;
 Na^+ and glucose cannot enter the hydrophobic core

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Small non-polar O_2 and CO_2 cross the **hydrophobic core**; ions such as Na^+ and polar molecules such as glucose cannot.

Bilayers as barriers

The hydrocarbon chains that form the core of the membrane are non-polar. Hydrophilic particles cannot easily enter this region, so the core has **low permeability** to large molecules and to hydrophilic particles, including ions (such as Na^+ and Cl^-) and polar molecules (such as glucose). Membranes are therefore effective barriers between two aqueous solutions, such as the cytoplasm and tissue fluid.

Permeability of a lipid bilayer without membrane proteins

Particle	Example	Crosses the hydrophobic core?
Small non-polar molecule	O ₂ , CO ₂	Yes, readily
Small polar molecule	H ₂ O	Slowly
Large polar molecule	Glucose	Hardly at all
Ion	Na ⁺ , K ⁺ , Cl ⁻	Hardly at all (charged)

Simple diffusion

Simple diffusion is the net movement of particles from a region of higher concentration to a region of lower concentration, caused by their random movement. It is passive: no energy from ATP is used. Oxygen and carbon dioxide are small and non-polar, so they diffuse directly between the phospholipids. In a respiring cell oxygen is used up, so it diffuses in; carbon dioxide is produced, so it diffuses out.

Common mistake: Particles do not move because of the gradient. They move randomly in all directions, but more cross from the side with the higher concentration, so the net movement is down the gradient.

Osmosis, channel proteins and pump proteins Spec B2.1.5-B2.1.8

Osmosis

Osmosis is the net movement of water molecules across a partially permeable membrane from a region of lower solute concentration to a region of higher solute concentration.

1. Water molecules move randomly and cross the membrane in both directions.
2. The membrane is impermeable to the solute, so solute particles stay on their own side.
3. On the side with the higher solute concentration, solute particles take up part of the solution, so the concentration of water molecules free to move across the membrane is lower there.
4. More water molecules therefore cross from the side with the lower solute concentration than move back, giving a net movement of water towards the higher solute concentration.
5. Osmosis is passive and continues while the difference in solute concentration remains.

Water is polar, so it crosses the lipid bilayer only slowly. **Aquaporins** are integral channel proteins that let water molecules pass through in single file, increasing the permeability of the membrane to water many times over. The pore is too narrow for most solutes, and charges inside it repel ions, so only water passes. Cells that move large volumes of water, such as kidney collecting duct cells and root cells, have many aquaporins.

Channel proteins and facilitated diffusion

Facilitated diffusion is passive diffusion of particles through a membrane protein. A **channel protein** is an integral protein with a hydrophilic pore through the membrane. The diameter of the pore and the charges lining it allow only specific ions (for example K⁺) to pass. Many channels are gated: ions diffuse through when the channel is open but not when it is closed, so the cell can control permeability.

Pump proteins and active transport

Active transport is the movement of particles across a membrane against a concentration gradient, using energy from ATP. Pump proteins bind a specific particle on one side, use energy from ATP to change shape, and release the particle on the other side. Pumps move particles in one direction only, so they can build up concentration gradients.

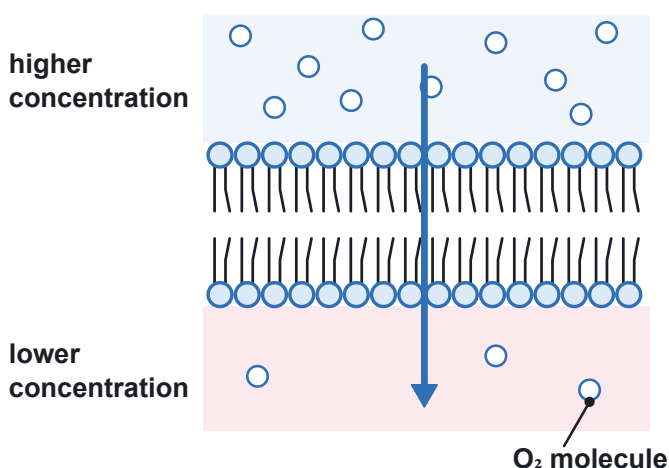
Comparing transport across membranes			
Feature	Simple diffusion	Facilitated diffusion	Active transport
Direction	Down the concentration gradient	Down the concentration gradient	Against the concentration gradient
Energy from ATP	No	No	Yes
Membrane protein	None (between phospholipids)	Channel protein	Pump protein
Selective?	No: depends only on size and polarity	Yes: specific ions	Yes: specific particles
Example	O ₂ and CO ₂	K ⁺ through a potassium channel	Mineral ions into root hair cells

Selectivity in membrane permeability

Facilitated diffusion and active transport give membranes **selective permeability**: the channel and pump proteins present decide which ions and molecules can cross. Permeability by simple diffusion is not selective. It depends only on the size of a particle and whether it is hydrophilic or hydrophobic.

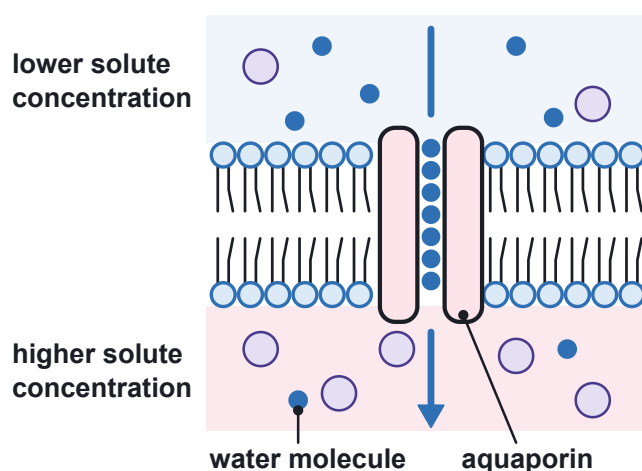
1 Simple diffusion

passive



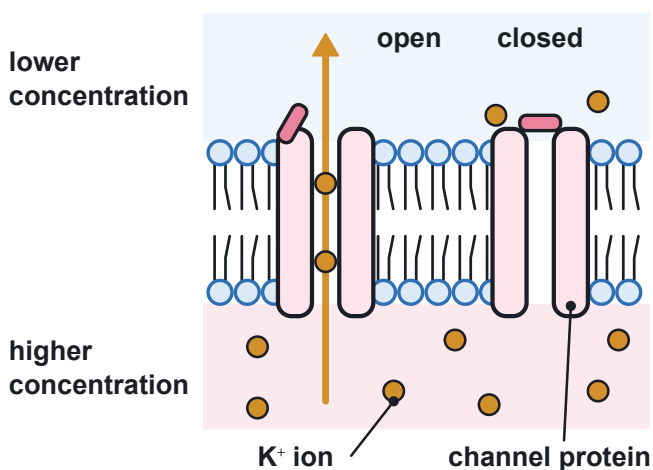
2 Osmosis (aquaporin)

passive



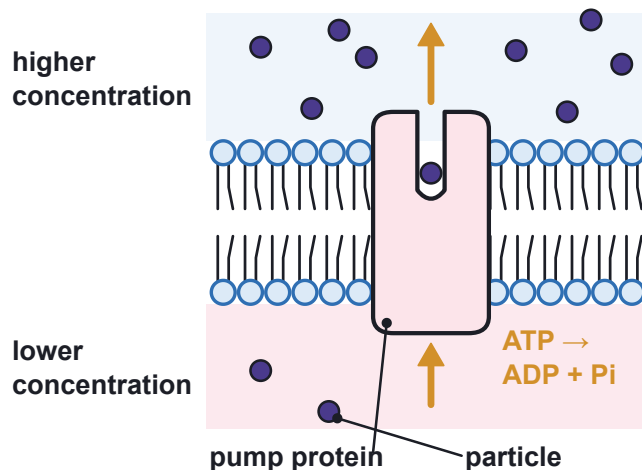
3 Facilitated diffusion

passive



4 Active transport

active



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Diffusion, osmosis and facilitated diffusion are **passive**; pump proteins use ATP for **active transport** against the gradient.

Exam tip: Linking question: what processes depend on active transport? Think of mineral ion uptake by roots, nerve impulses and the absorption of glucose in the gut.

Membrane proteins, glycoproteins and the fluid mosaic model Spec B2.1.4, B2.1.9, B2.1.10

Integral and peripheral proteins

Membrane proteins have diverse structures, locations and functions. **Integral proteins** are embedded in one or both of the lipid layers. Those that span both layers have hydrophobic regions in contact with the hydrocarbon core and hydrophilic regions facing the water on each side. **Peripheral proteins** are attached to one or other surface of the bilayer, often bound to an integral protein, and do not enter the hydrophobic core.

- Transport: channels and pumps (integral proteins).
- Receptors: bind signalling chemicals such as hormones or neurotransmitters.
- Enzymes: catalyse reactions at the membrane surface.
- Cell adhesion: bind cells to each other.
- Cell recognition: identify a cell to other cells.

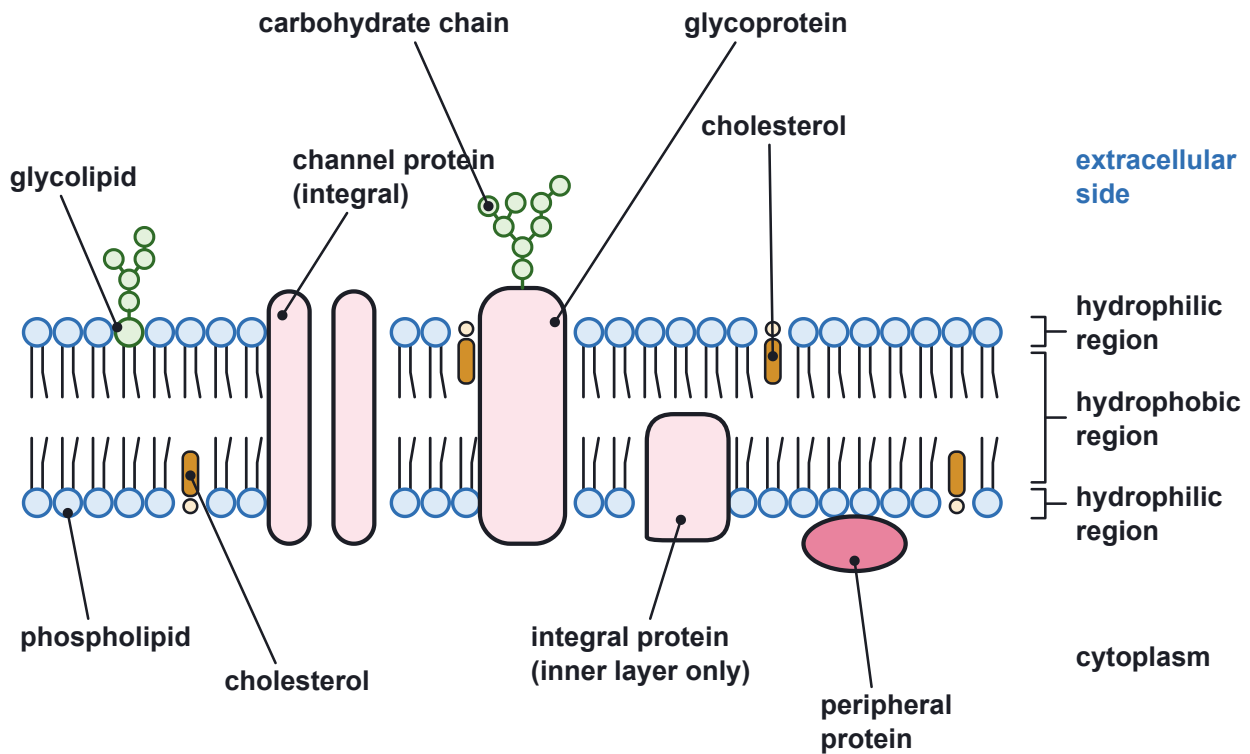
Glycoproteins and glycolipids

Glycoproteins are proteins with carbohydrate chains attached, and **glycolipids** are lipids with carbohydrate chains attached. In the plasma membrane the carbohydrate is always on the **extracellular side**, where it forms a sugary coat on the cell surface.

- Cell recognition: the carbohydrate chains act as markers, so other cells, such as cells of the immune system, can recognise a cell as self or non-self.
- Cell adhesion: carbohydrate chains help cells attach to each other to form tissues.

The fluid mosaic model

The membrane is described as **fluid** because phospholipids and many proteins can move sideways within each layer, and **mosaic** because proteins are scattered through the bilayer like tiles in a mosaic.



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The fluid mosaic model: carbohydrate chains only on the **extracellular side**, cholesterol among the tails in the **hydrophobic region**.

Exam tip: In a drawing, put carbohydrate chains only on the outside, draw cholesterol among the tails, and label the hydrophilic and hydrophobic regions, not just the heads and tails.

Quick check

1. Which part of a phospholipid is hydrophobic?
2. Name the channel protein that lets water cross membranes rapidly.
3. What does a pump protein use to move particles against a concentration gradient?
4. On which side of the plasma membrane are the carbohydrate chains of glycoproteins?

Quick check answers

Membranes and membrane transport

1. The two hydrocarbon (fatty acid) tails.
2. Aquaporin.
3. Energy from ATP.
4. The extracellular side.