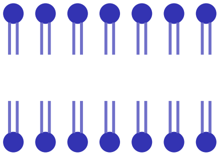
Cell Membranes & Transport

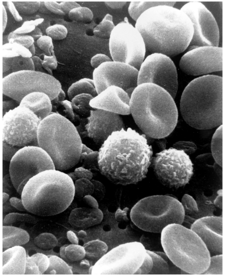
A-Level Biology ▪ Topic 4

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

1 The membrane

The fluid mosaic model

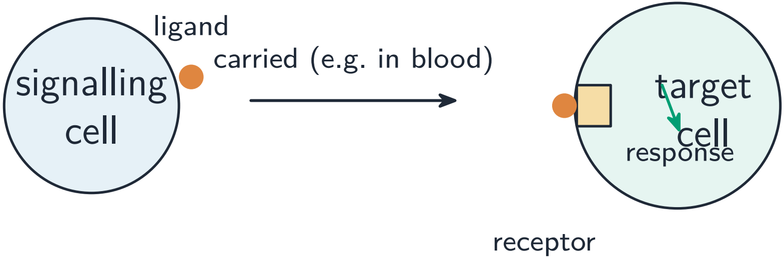
A phospholipid bilayer with proteins floating in it.

fluid	**mosaic**	**bilayer**
phospholipids and proteins can move sideways	proteins scattered like tiles – channels, carriers, receptors	hydrophobic tails inside; hydrophilic heads face water

Cell signalling

In **cell signalling** 细胞信号传递:

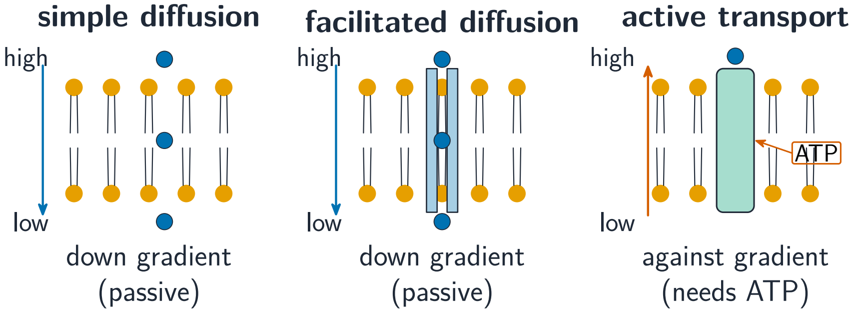
- a cell secretes a **ligand** 配体 (e.g. a **hormone** 激素)
- it binds a matching **receptor** 受体 on the **target cell** 靶细胞
- only cells with that receptor respond



2 Transport

Crossing the membrane

- **simple diffusion** 简单扩散 – small/non-polar straight through (passive)
- **facilitated diffusion** 易化扩散 – ions & glucose via proteins (passive)
- **active transport** 主动运输 – 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** 细胞表面膜 – **oxygen** 氧气, **carbon dioxide** 二氧化碳, 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** 透析袋 (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** 半透膜: some things cross easily, others are blocked. Six processes do the crossing – **passive** 被动 ones need no energy, **active** 主动 ones spend ATP.

simple diffusion
down a **concentration** 浓度 gradient, straight through the bilayer

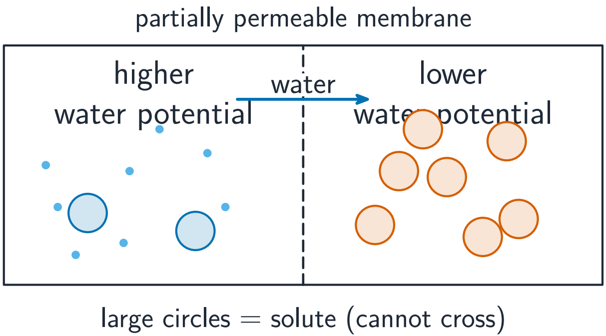
facilitated diffusion
down the gradient, but through a channel or carrier protein

osmosis
water down a **water potential** 水势 gradient

active transport
up a gradient, a pump protein spending ATP

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

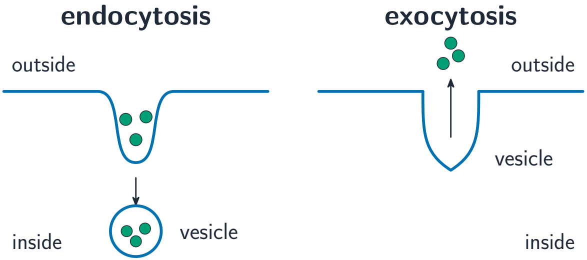
Osmosis and water potential



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

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

Bulk transport



membrane folds in,
then pinches off a vesicle

vesicle fuses, releasing
its contents outside

These move material in bulk, using ATP:

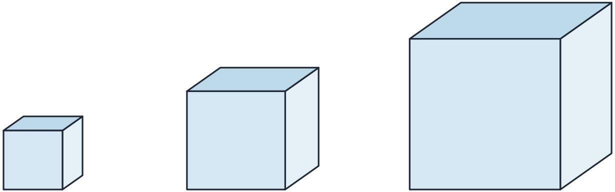
- **endocytosis** 胞吞作用 – the membrane folds in to form a **vesicle** 囊泡
- **exocytosis** 胞吐作用 – a vesicle fuses & releases its contents

3 Size and water

Surface area to volume ratio

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

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



side $L = 1$
$\text{SA} : \text{V} = 6 : 1$

side $L = 2$
$\text{SA} : \text{V} = 3 : 1$

side $L = 3$
$\text{SA} : \text{V} = 2 : 1$

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 琼脂 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.

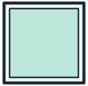
Cells in solutions

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

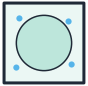
higher water potential (water enters)

lower water potential (water leaves)

plant cell

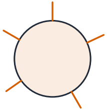


turgid



plasmolysed: contents pull away

animal cell

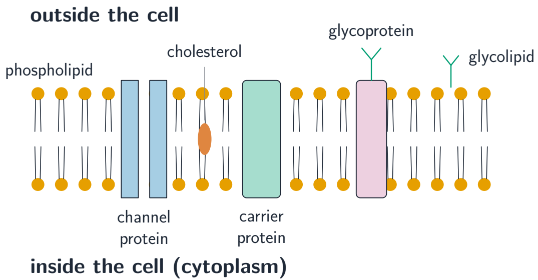


What a cell does in each solution

Higher water potential	In a solution of higher water potential – **distilled water** 蒸馏水, 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** 质壁分离.

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

What floats in the membrane



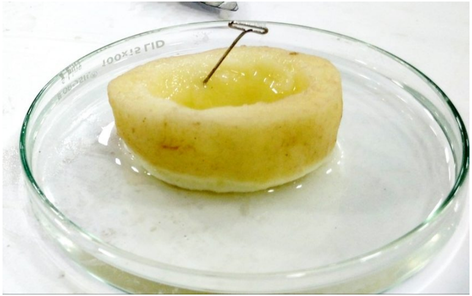
Each **phospholipid** 磷脂 has a **hydrophilic** 亲水 head and two **hydrophobic** 疏水 tails, so the bilayer forms with tails inward. **Cholesterol** 胆固醇 sits between the tails, controlling **fluidity** 流动性 and adding strength; proteins act as channels, carriers and receptors; carbohydrate chains on the outside 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** 稳定性
channel proteins 通道蛋白	a water-filled pore for facilitated diffusion of ions
carrier proteins 载体蛋白	change shape to move a specific molecule – facilitated diffusion or active transport
glycoproteins and glycolipids	carbohydrate chains on the outside – cell recognition, **antigens** 抗原, and receptors
together	they give the membrane its stability, its fluidity, and its **permeability** 通透性

> "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.

4 Recap

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

4 Water balance

turgid/plasmolysed; burst/shrink

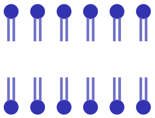
Check yourself

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