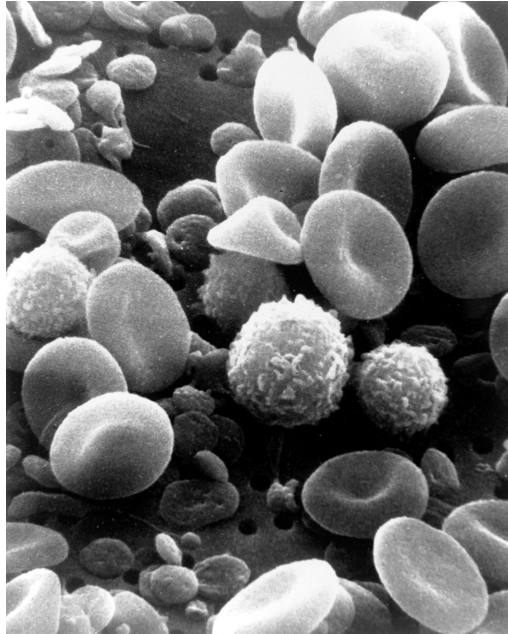


Cell membranes and transport

A-Level Biology

The cell surface membrane

Every cell is wrapped in a **cell surface membrane** 细胞膜. We describe its structure with the **fluid mosaic model** 流动镶嵌模型.



Red blood cells under a scanning electron microscope —each is wrapped in a cell surface membrane

Image: Bruce Wetzel (photographer). Harry Schaefer (photographer), Public domain (commons.wikimedia.org)

The phospholipid bilayer

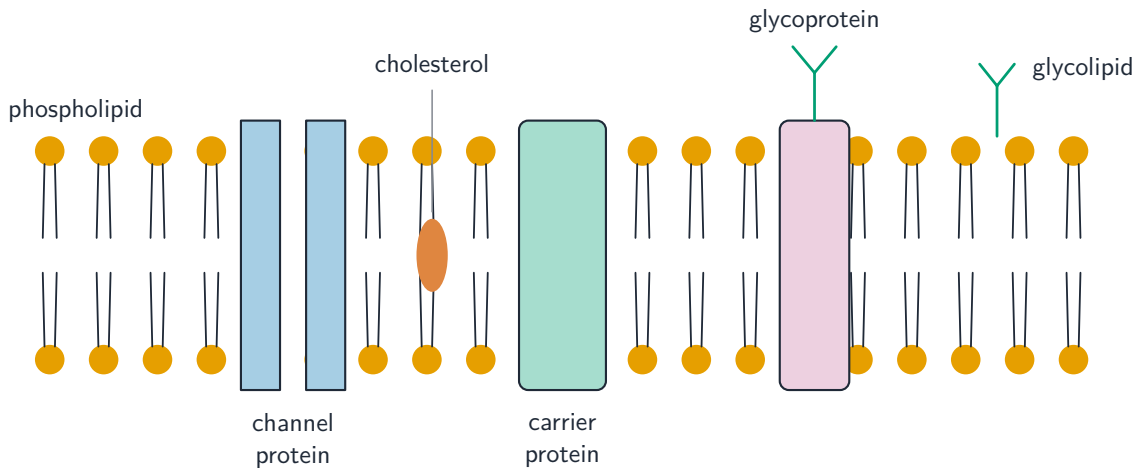
The membrane is built mainly from **phospholipids** 磷脂. Each phospholipid has a **hydrophilic** 亲水 ("water-loving") head and two **hydrophobic** 疏水 ("water-fearing") tails. There is water on both sides of the membrane, so the phospholipids line up in two layers —a **bilayer** 双层—with the heads facing the water outside and inside, and the tails hidden in the middle, away from water. This arrangement forms by itself because of those hydrophilic and hydrophobic interactions.

The model is called "fluid" because the phospholipids are not fixed: they slide past each other, so the membrane can move and bend. It is called a "mosaic" because many **proteins** 蛋白质 are dotted through it, like tiles in a picture.

What floats in the membrane

Part	Where it sits	Main roles
phospholipids	the two layers	form the basic barrier
proteins	through the membrane or on its surface	transport, support and signalling
carrier proteins 载体蛋白	span the membrane	carry specific molecules across
channel proteins 通道蛋白	span the membrane	form water-filled pores for ions to pass
cholesterol 胆固醇	between the phospholipid tails	controls fluidity 流动性 and adds strength
glycolipids 糖脂 and glycoproteins 糖蛋白	carbohydrate chains on the outer surface	cell recognition; some act as antigens 抗原

outside the cell



inside the cell (cytoplasm)

The fluid mosaic model: proteins, cholesterol and carbohydrate chains sit in a fluid phospholipid bilayer

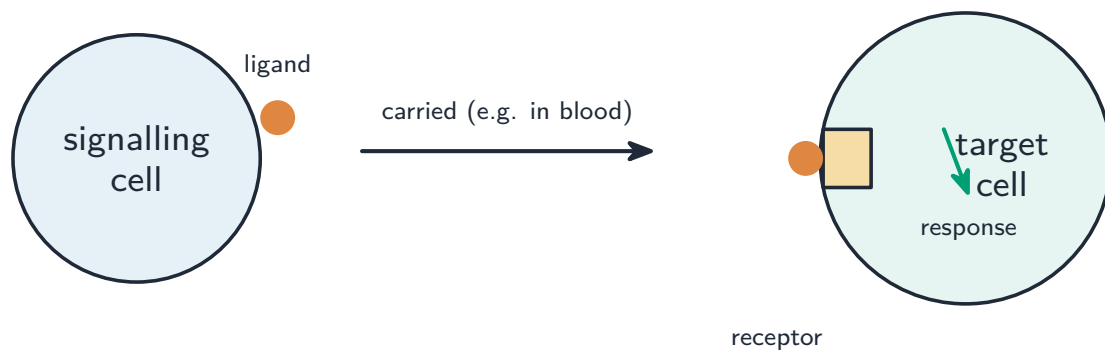
So the membrane molecules together give the membrane its **stability** 稳定性, its fluidity, its **permeability** 通透性 (control over what gets through), its transport jobs, its signalling jobs, and its cell recognition.

The membrane is **partially permeable** 半透膜: it lets some substances through easily but blocks others.

Cell signalling

Cells talk to each other by **cell signalling** 细胞信号传递. The main stages are:

1. a cell **secretes** a signal chemical called a **ligand** 配体 (for example a **hormone** 激素).
2. the ligand is carried (often in the blood) to a **target cell** 靶细胞.
3. the ligand binds to a specific **receptor** 受体 on the target cell's surface membrane. The shape of the receptor matches that ligand only. Binding then triggers a particular response inside the target cell.



The ligand fits one receptor shape only, so only cells with that receptor respond to the signal

Moving substances across the membrane

There are six processes. Some are **passive** 被动 (they need no energy 能量), and some are **active** (they use energy from ATP).

Simple diffusion

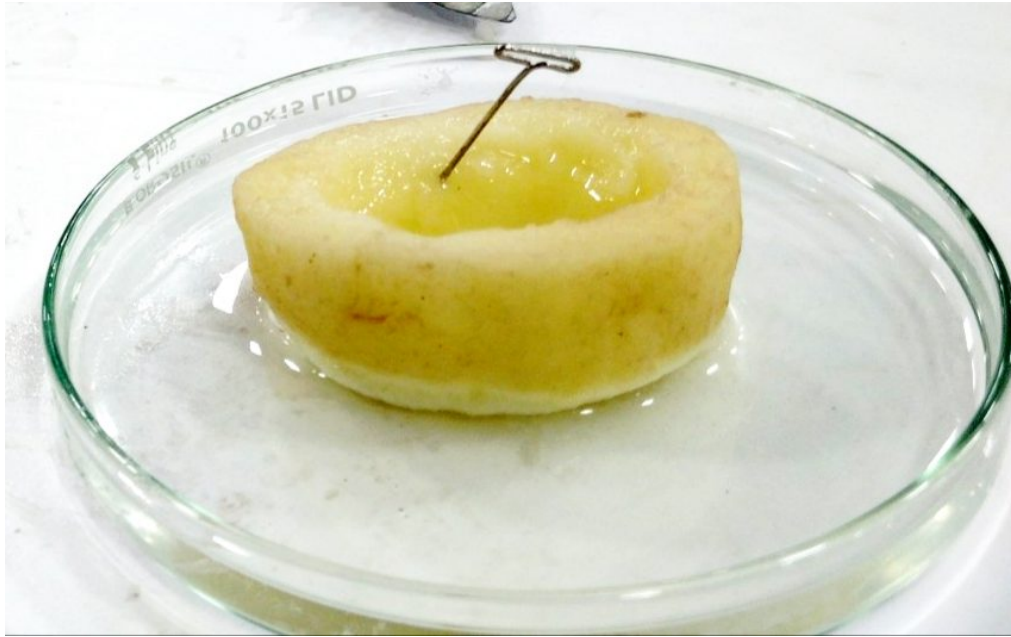
Diffusion 扩散 is the net movement of particles from where they are at a high **concentration** 浓度 to where they are at a low concentration, until they are spread evenly. **Simple diffusion** 简单扩散 is when particles pass straight through the bilayer, down the **concentration gradient** 浓度梯度. Only small or non-polar molecules can do this —such as **oxygen** 氧气 and **carbon dioxide** 二氧化碳. It is passive.

Facilitated diffusion

Charged **ions** 离子 and large polar molecules (such as **glucose** 葡萄糖) cannot cross the oily bilayer by themselves. In **facilitated diffusion** 易化扩散 they cross through channel proteins or carrier proteins, still moving down the concentration gradient. It is also passive.

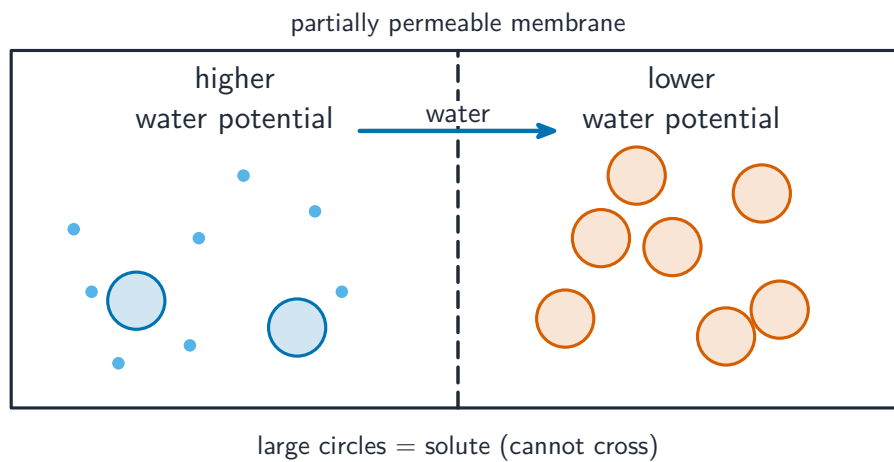
Osmosis

Osmosis 渗透 is the diffusion of water across a partially permeable membrane, from a higher **water potential** 水势 to a lower water potential. It is passive.



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

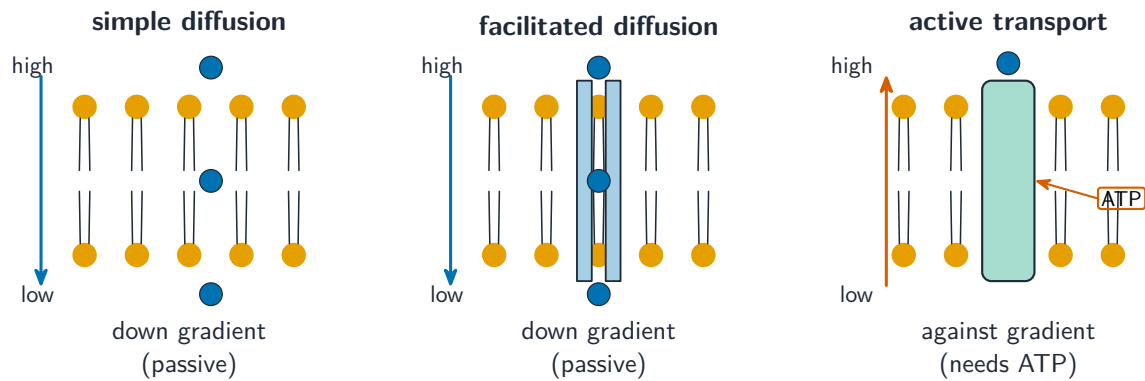
Image: Knowledge genome, CC BY-SA 4.0 (commons.wikimedia.org)



Water crosses to the lower water potential; the solute is too big to cross the partially permeable membrane

Active transport

Active transport 主动运输 moves a substance **against** its concentration gradient — from low to high concentration. This needs carrier proteins and energy from ATP.

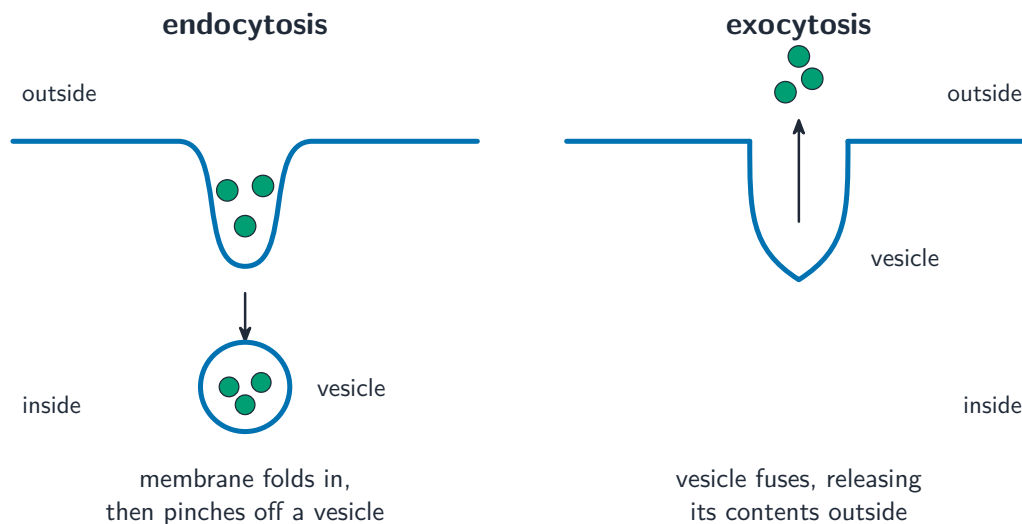


Diffusion and facilitated diffusion are passive (down the gradient); active transport goes against it and needs ATP

Endocytosis and exocytosis

These move large amounts of material in bulk, using ATP.

- in **endocytosis** 胞吞作用, the membrane folds inwards around material and pinches off a **vesicle** 囊泡 to bring it into the cell.
- in **exocytosis** 胞吐作用, a vesicle fuses with the membrane and releases its contents outside the cell.



Endocytosis brings material in by forming a vesicle; exocytosis fuses a vesicle to release its contents

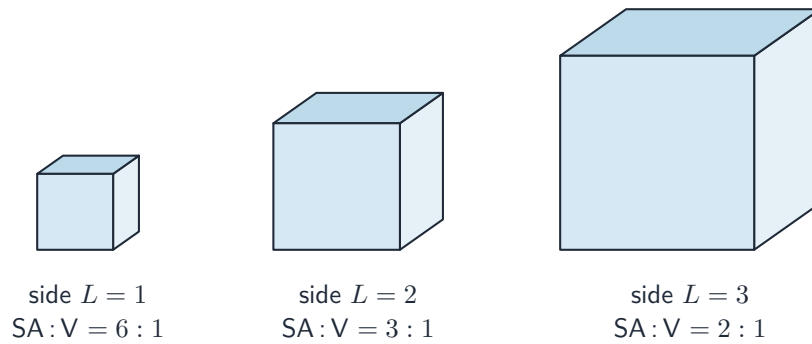
Surface area to volume ratio

A cell takes in and removes substances across its surface. As an object gets bigger, its **volume** 体积 grows faster than its **surface area** 表面积. So the surface area to volume ratio gets **smaller** as size increases.

For a cube of side L :

$$\text{surface area} = 6L^2, \quad \text{volume} = L^3, \quad \text{ratio} = \frac{6}{L}.$$

A large L gives a small ratio. This is why small cells (and thin, flat shapes) exchange materials quickly, while large cells cannot rely on diffusion alone.



a bigger cube (or cell) has a **smaller** surface area : volume ratio

As a cube (or cell) grows, its surface area : volume ratio gets smaller

Worked example. Compare the surface area : volume ratio of a cube-shaped cell of side 4 with one of side 10.

For side 4: surface area = $6 \times 4^2 = 96$ and volume = $4^3 = 64$, so the ratio is $96 : 64 = 1.5 : 1$. For side 10: surface area = $6 \times 10^2 = 600$ and volume = $10^3 = 1000$, so the ratio is $600 : 1000 = 0.6 : 1$. The larger cell has the smaller ratio, so it exchanges materials across its surface more slowly for its size—which is why large organisms need specialised exchange surfaces such as lungs and gills.

You can show this with **agar** 琼脂 blocks of different sizes soaked in dye or acid: the smallest block, with the largest surface area to volume ratio, changes colour all the way through fastest. Diffusion across non-living materials can also be studied with **dialysis tubing** 透析袋 (Visking tubing).

Water potential and living cells

Water potential measures how likely water is to leave a solution. Pure water has the highest water potential. Adding a **solute** 溶质 (a dissolved substance) lowers it. Water always moves by osmosis from a higher to a lower water potential.

To estimate the water potential of plant tissue, you place pieces in sucrose solutions of different water potentials. The solution that causes **no change** in mass or length has about the same water potential as the tissue.

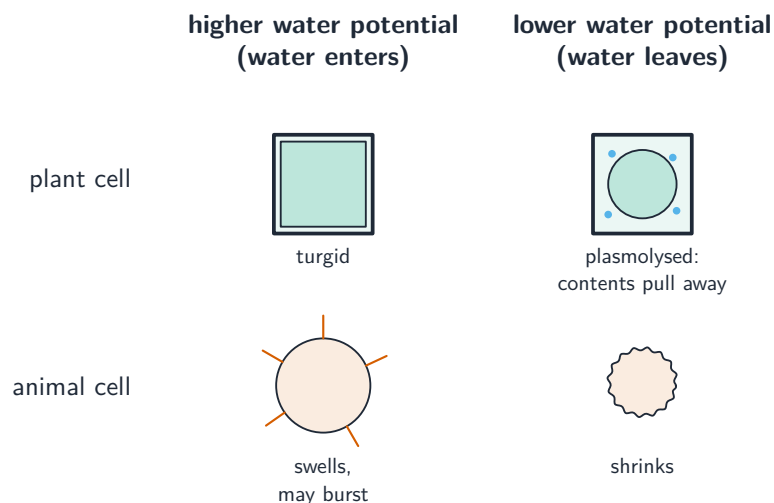
Effect on plant cells

- in a solution of **higher** water potential (for example **distilled water** 蒸馏水), water enters the cell. The cell swells and becomes **turgid** 膨胀, but the strong cell wall stops it bursting.
- in a solution of **lower** water potential, water leaves. The cell contents shrink and the membrane pulls away from the cell wall —this is **plasmolysis** 质壁分离.

Effect on animal cells

Animal cells have no cell wall to protect them.

- in a solution of higher water potential, water enters and the cell may burst. In a red blood cell this bursting is called **haemolysis** 溶血.
- in a solution of lower water potential, water leaves and the cell shrinks.



A plant cell becomes turgid or plasmolysed; an animal cell may burst (haemolysis) or shrink

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.