A-LEVEL BIOLOGY • EXERCISE SHEET

4.2 Movement into and out of cells

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS volume 体积 • distilled water 蒸馏水 • diffusion 扩散 • water potential 水势 • surface area 表面积

Objective

Build the skills to answer exam questions on **movement into and out of cells** — the transport processes, **surface area to volume ratio** 表面积体积比, and the effect of **water potential** 水势 on cells.

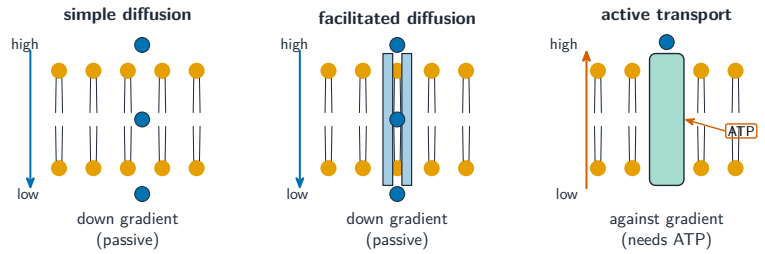
You must be able to:

- describe and explain simple diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis
- calculate surface area, volume and their ratio for simple shapes and link the ratio to diffusion
- explain water movement by water potential and its different effects on plant and animal cells

1 Worked examples

The transport processes

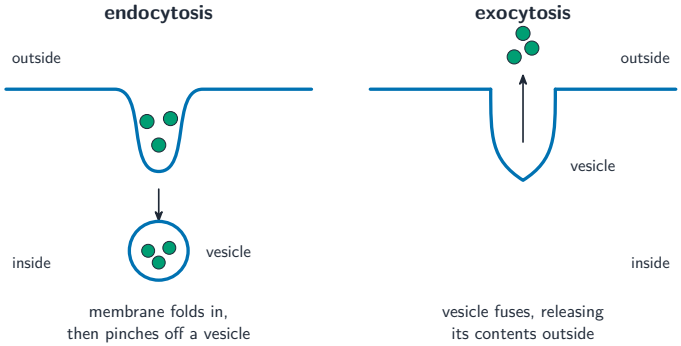
Some are **passive** 被动 (no energy, down the gradient); some are **active** (use ATP).



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

- **simple diffusion** — small/non-polar molecules (O_2, CO_2) pass straight through, down the gradient.

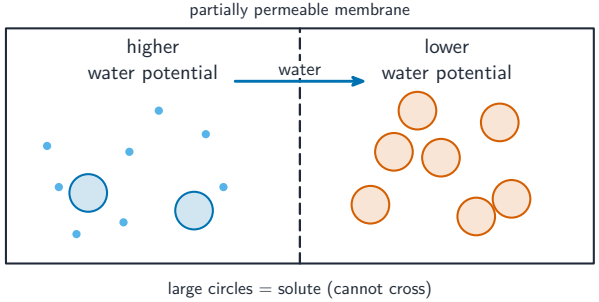
- **facilitated diffusion** 易化扩散 — ions and large polar molecules pass through channel/carrier proteins, down the gradient.
- **active transport** 主动运输 — carrier proteins pump a substance **against** the gradient, using ATP.
- **endocytosis/exocytosis** 胞吞/胞吐 — bulk transport using vesicles and ATP.



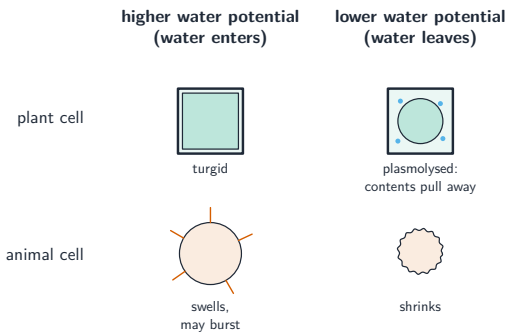
Endocytosis brings material in; exocytosis releases it

Osmosis and water potential

Osmosis 渗透 is the diffusion of water across a partially permeable membrane from **higher** to **lower** water potential. Pure water has the highest water potential (0); adding **solute** 溶质 lowers it.



Water moves to the lower water potential; the solute cannot cross

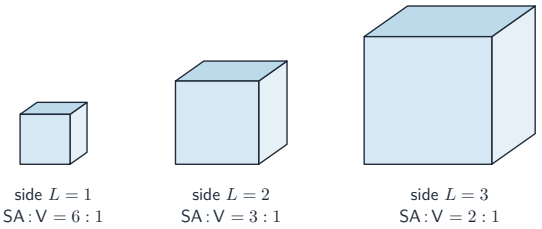


Plant cell: turgid or plasmolysed. Animal cell: may burst (haemolysis) or shrink

■ Surface area to volume ratio

As a cell grows, its volume rises faster than its surface area, so the ratio **falls**. For a cube of side L:

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



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

A small ratio means slow exchange by diffusion — so large organisms need transport systems.

2 Practice

2.1 State whether each process is passive or active: simple diffusion · active transport · osmosis · exocytosis. [2]

2.2 A cube-shaped block has side 2 cm. Calculate its surface area, its volume, and its surface area to volume ratio. [3]

3 Exam-style questions

3.1 Glucose enters a cell through a carrier protein, moving down its concentration gradient, without using ATP. This is: [1]

- **A** active transport
- **B** facilitated diffusion
- **C** osmosis
- **D** simple diffusion

3.2 A red blood cell is placed in distilled water. What happens, and why? [1]

- **A** it shrinks, because water leaves by osmosis
- **B** it bursts, because water enters by osmosis
- **C** nothing, because the cell wall protects it
- **D** it becomes turgid, because water enters by osmosis

3.3 Agar blocks of different sizes are soaked in dye to model diffusion into cells.

(a) Explain why the smallest block becomes fully coloured fastest. [3]

(b) Explain why large organisms cannot rely on diffusion alone to supply their cells. [2]

3.4 Pieces of potato are placed in sucrose solutions of different water potentials and their change in mass is measured.

(a) Explain how the results can be used to estimate the water potential of the potato tissue. [2]

(b) A plant cell is placed in a solution of lower water potential than its contents. Describe and name what happens to the cell. [3]

3.5 Cubes of agar containing a pH indicator were cut to three sizes and placed in dilute hydrochloric acid. The time for the acid to reach the centre of each cube was recorded.

Cube side / mm	**Surface area / mm^2**	**Volume / mm^3**	**SA : V**	**Time / s**
2	24	8		40
4	96	64		150
8	384	512		590

(a) Complete the SA : V column, and describe the relationship between SA : V and the time taken. [3]

(b) Explain the results in terms of the process by which the acid enters the agar. [3]

(c) Explain how this model helps to explain why large active animals need a specialised gas exchange surface **and** a transport system. [3]

(d) State **two** ways in which the agar model is **not** a good model of a real cell. [2]

Solutions

2.1 simple diffusion — passive; active transport — active; osmosis — passive; exocytosis — active.

2.2 surface area $= 6 \times 2^2 = 24$ cm^2; volume $= 2^3 = 8$ cm^3; ratio $= 24 : 8 = 3 : 1$.

3.1 B. Through a protein and down the gradient with no ATP = facilitated diffusion.

3.2 B. Distilled water has a higher water potential, so water enters by osmosis and the cell, having no wall, bursts (haemolysis).

3.3 (a) the smallest block has the largest surface area to volume ratio; so dye diffuses across a relatively larger surface for the volume inside; and the diffusion distance to the centre is shorter.
(b) large organisms have a small surface area to volume ratio, so diffusion across the surface is too slow to supply all the inner cells — they need a transport system.

3.4 (a) find the solution that gives no change in mass; its water potential equals that of the potato tissue.
(b) water leaves the cell by osmosis; the contents shrink and the membrane pulls away from the cell wall; this is plasmolysis.

3.5 (a) SA : V = 3 : 1, 1.5 : 1 and 0.75 : 1. As SA : V falls, the time rises; halving the ratio roughly quadruples the time, so the relationship is not simply proportional.
(b) The acid enters by **diffusion** down its concentration gradient; the rate of entry depends on surface area, while the amount that must be supplied depends on volume; in the large cube each unit of volume is served by less surface **and** the distance to the centre is greater, so it takes far longer.
(c) A large animal has a small SA : V, so its body surface cannot supply enough oxygen for its volume of respiring tissue; the distance from surface to inner cells is also far too great for diffusion alone; a specialised exchange surface supplies the area, and a transport system covers the distance quickly.
(d) The agar is not alive — there is no cell surface membrane, so nothing is selectively permeable and there is no active transport; it does not consume the acid as a respiring cell consumes oxygen, so no steep internal gradient is maintained.