

Cells and Cell Transport

Matthew Williams • Biology • May 9, 2026

Cells and Cell Transport

The cell is the basic unit of life. Understanding how cells are built and how substances move in and out of them connects to almost every other topic in biology — from digestion and respiration to kidney function and plant nutrition.

Cell Structure

Plant and Animal Cells

Both plant and animal cells share a set of core structures, but plant cells have additional features that support their role in photosynthesis and structural support.

Structure	Animal cell	Plant cell	Function
Cell membrane			controls what enters and leaves the cell
Cytoplasm			site of many chemical reactions
Nucleus			contains DNA; controls cell activities
Mitochondria			site of aerobic respiration; releases ATP
Cell wall			made of cellulose; gives shape and support
Large vacuole			stores cell sap; maintains turgor pressure
Chloroplasts		(in green cells)	contain chlorophyll; site of photosynthesis

Remember

The three structures found in plant cells but not animal cells are the cell wall, large permanent vacuole, and chloroplasts.

Comparison of plant and animal cell structures, with shared structures labelled in the centre

Organelle Functions

Organelle	Key function
Nucleus	carries genetic information as DNA on chromosomes; controls protein synthesis
Mitochondrion	releases energy from glucose through aerobic respiration
Chloroplast	absorbs light to drive photosynthesis; contains chlorophyll
Vacuole	in plant cells, stores water and dissolved substances; maintains firmness
Cell membrane	selectively permeable barrier; controls movement of substances
Ribosomes	site of protein synthesis (not visible without electron microscope)

Microbe Structures

Bacteria are prokaryotes — their genetic material is not enclosed in a true nucleus. A typical bacterium has:

- a **nucleoid** region containing DNA (circular, not bounded by a membrane)
- a **cell wall** (different composition from plant cell walls)
- a **cell membrane** beneath the wall
- sometimes a **capsule** (outer protective layer)
- sometimes a **flagellum** for movement

Cell Specialisation

In a multicellular organism, cells become adapted for specific functions. This is called specialisation (or differentiation). Specialised cells work together in tissues, organs, and organ systems.

Cell type	Adaptations	Function
Red blood cell	biconcave shape (large surface area); no nucleus (more space for haemoglobin); flexible membrane	carries oxygen in the blood

Root hair cell	long thin extension increases surface area; thin wall	absorbs water and mineral ions from soil
Palisade cell	packed with chloroplasts; near top of leaf for maximum light	site of most photosynthesis in the leaf
Sperm cell	long flagellum for movement; many mitochondria; acrosome to penetrate egg	delivers genetic material for fertilisation
Nerve cell (neurone)	very long axon; myelin sheath for speed	transmits electrical impulses rapidly

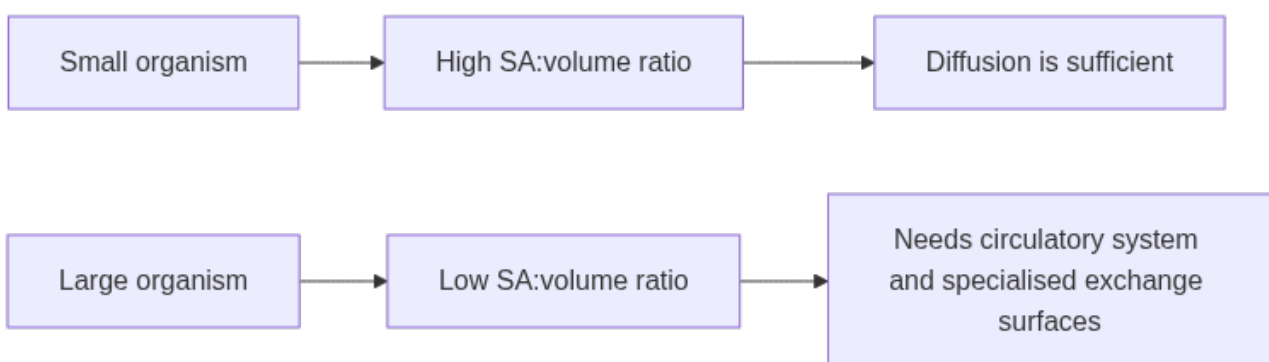
Exam Tip

When asked to explain how a cell is adapted, always link the structural feature directly to how it helps the cell carry out its function. Saying "it has many mitochondria" is incomplete — add "which release energy for..."

Surface Area to Volume Ratio

As an organism grows larger, its volume increases faster than its surface area. This matters because substances must enter and leave through the surface.

A small organism like a bacterium has a very high surface area to volume ratio, so diffusion alone supplies its needs. A large organism such as a mammal has a much lower ratio — diffusion would be far too slow to deliver oxygen and nutrients to every cell. Large organisms therefore need specialised transport systems and exchange surfaces.



Effect of size on surface area to volume ratio

Biological structures that need rapid exchange are adapted to maximise surface area: alveoli in the lungs, villi in the small intestine, and root hair cells in plant roots all achieve this.

Diffusion

Diffusion is the net movement of particles from a region of higher concentration to a region of lower concentration, due to the random motion of particles. No energy is required.

Particles spread out because they are in constant random motion and collide less often on the less-crowded side. Over time, concentrations equalise — this state is called **equilibrium**. Diffusion continues at equilibrium, but there is no net movement.

What moves by diffusion in living systems

- Oxygen from the alveoli into the blood
- Carbon dioxide from the blood into the alveoli
- Glucose from the gut into the bloodstream
- Carbon dioxide out of cells during respiration
- Oxygen into cells for respiration

Factors affecting the rate of diffusion

Factor	Effect on rate	Reason
Concentration gradient	steeper gradient 'faster	more particles move from the concentrated side
Temperature	higher temperature 'faster	particles have more kinetic energy
Surface area	larger surface area 'faster	more area through which diffusion can occur
Diffusion distance	shorter distance 'faster	particles reach the other side sooner
Particle size	smaller particles 'faster	small particles move more quickly

Osmosis

Osmosis is the movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane.

Water potential describes how freely water molecules can move. Pure water has the highest water potential. Adding a solute (such as sugar or salt) lowers the water potential of a solution, because solute particles interfere with the movement of water molecules. A dilute solution has higher water potential than a concentrated solution.

A **partially permeable membrane** allows water molecules to pass through but prevents most larger molecules from crossing. The cell membrane acts as a partially permeable membrane.

Effects on plant cells

Condition	Result	Explanation
Placed in pure water or dilute solution	cell becomes turgid	water enters by osmosis; vacuole expands; membrane presses against cell wall
Placed in solution with same concentration as cell contents	no net water movement	water potential is equal on both sides
Placed in concentrated solution	cell becomes flaccid then plasmolysed	water leaves by osmosis; vacuole shrinks; membrane pulls away from cell wall

Turgid plant cells provide support to soft tissues such as leaves and young stems. Plasmolysis causes wilting and is normally fatal if prolonged.

Effects on animal cells

Animal cells have no cell wall to resist pressure, so the effects are more extreme.

Condition	Result
Placed in pure water or very dilute solution	swells and may lyse (burst)
Placed in solution with same concentration as cell contents	remains normal
Placed in concentrated solution	shrinks and crenates (shrivels)

Tonicity

Solution type	Solute concentration	Water movement	Effect on animal cell	Effect on plant cell
Hypotonic	lower than cell	into cell	swells / lyses	turgid
Isotonic	same as cell	no net movement	normal	slightly flaccid
Hypertonic	higher than cell	out of cell	crenates	plasmolysed

Potato cylinder experiment

Potato cylinders are cut to equal length and mass, then placed in solutions of different salt or sugar concentrations. After a set time, the cylinders are re-weighed. Cylinders in dilute solutions gain mass (water entered); cylinders in concentrated solutions lose mass (water left). The concentration at which mass does not change is equal to the solute concentration inside the potato cells.

Exam Tip

Exam questions often give a table or graph from this experiment and ask you to: (1) identify the internal concentration of the potato, (2) explain the results in terms of water potential, or (3) calculate percentage change in mass. Always use "water potential" in your explanation — not just "concentration."

Active Transport

Active transport is the movement of substances from a region of lower concentration to a region of higher concentration — against the concentration gradient. This requires energy in the form of ATP, released by respiration.

Because active transport works against the natural direction of diffusion, carrier proteins in the cell membrane use ATP to move substances across. Any condition that reduces respiration (low oxygen, poisons that block respiration) will also slow active transport.

Examples of active transport in living systems

- **Root hair cells** absorb mineral ions (nitrates, phosphates, magnesium) from the soil even when the concentration inside the root is already higher than in the soil.
- **Small intestine** absorbs glucose and amino acids into the blood even when blood glucose is already high.

Comparing the Three Transport Processes

Feature	Diffusion	Osmosis	Active transport
Substance moved	any dissolved particles or gases	water only	specific molecules or ions
Direction	high 'low concentration	high 'low water potential	low 'high concentration
Energy required	no	no	yes (ATP from respiration)

Membrane required	not always	yes (partially permeable)	yes (carrier proteins)
Example	O ₂ into cells, CO ₂ out	water into root cells	mineral ions into root hairs

Core idea

Diffusion and osmosis are passive — they follow concentration gradients without energy. Active transport moves substances against gradients and requires ATP.

PRACTICE — CELLS AND CELL TRANSPORT

Cell wall

A rigid outer layer found in plant cells, made of cellulose, that provides support and prevents the cell from bursting.

Chloroplast

An organelle found in plant cells that contains chlorophyll and is the site of photosynthesis.

Mitochondrion

An organelle found in all eukaryotic cells that releases energy through aerobic respiration.

Diffusion

The net movement of particles from a region of higher concentration to lower concentration, requiring no energy.

Osmosis

The movement of water from higher water potential to lower water potential through a partially permeable membrane.

Water potential

A measure of how freely water molecules can move; pure water has the highest water potential.

Turgid

Describes a plant cell that has taken in water by osmosis; the vacuole is full and the membrane presses against the cell wall.

Plasmolysis

The shrinking of a plant cell's membrane away from the cell wall when water is lost to a hypertonic solution.

Active transport

The movement of substances against a concentration gradient using energy from ATP.

Partially permeable membrane

A membrane that allows water and small molecules to pass through but not larger molecules.

Hypotonic

Describes a solution with a lower solute concentration than the cell; water moves into the cell.

Hypertonic

Describes a solution with a higher solute concentration than the cell; water moves out of the cell.

Study Vault