

Edexcel GCSE Combined Science — Biology

Topic 1

Key concepts in biology

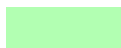
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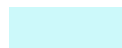
Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes



Definitions



Diagrams



Notes and warnings



Sub-topic headings

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Define Prokaryotic cell

- a cell with no nucleus; chromosomal DNA lies free in the cytoplasm (bacteria).

Define Resolution

- the smallest distance between two points still seen as two points.

Define Active site

- the part of an enzyme the substrate binds to; its shape is complementary to the substrate, which makes the enzyme **specific**.

Define Diffusion

- the net movement of particles from a higher to a lower concentration, down a concentration gradient.

Define Active transport

- the movement of substances against a concentration gradient, using energy from respiration.

Define Eukaryotic cell

- a cell whose genetic material is enclosed in a nucleus (animal, plant).

Define Magnification

- the number of times larger an image is than the actual object.

Define Enzyme

- a biological catalyst; a protein that speeds up a reaction without being used up.

Define Denatured

- the shape of the active site has changed permanently, so the substrate no longer fits.

Define Osmosis

- the net movement of water from a dilute to a concentrated solution through a partially permeable membrane.

1.1 Cells and microscopy (1.1–1.6)

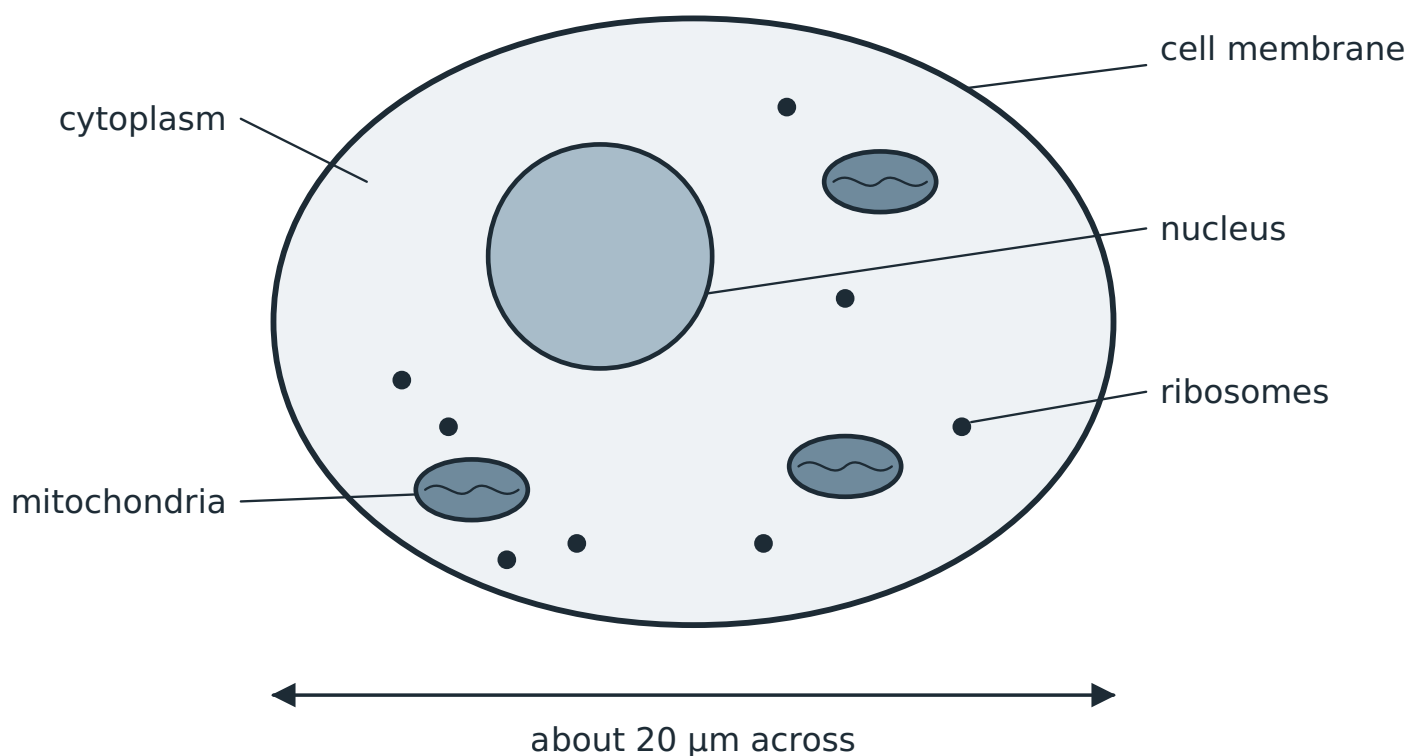
Sub-cellular structures and their functions (1.1)

You must explain how the sub-cellular structures of eukaryotic and prokaryotic cells are related to their functions.

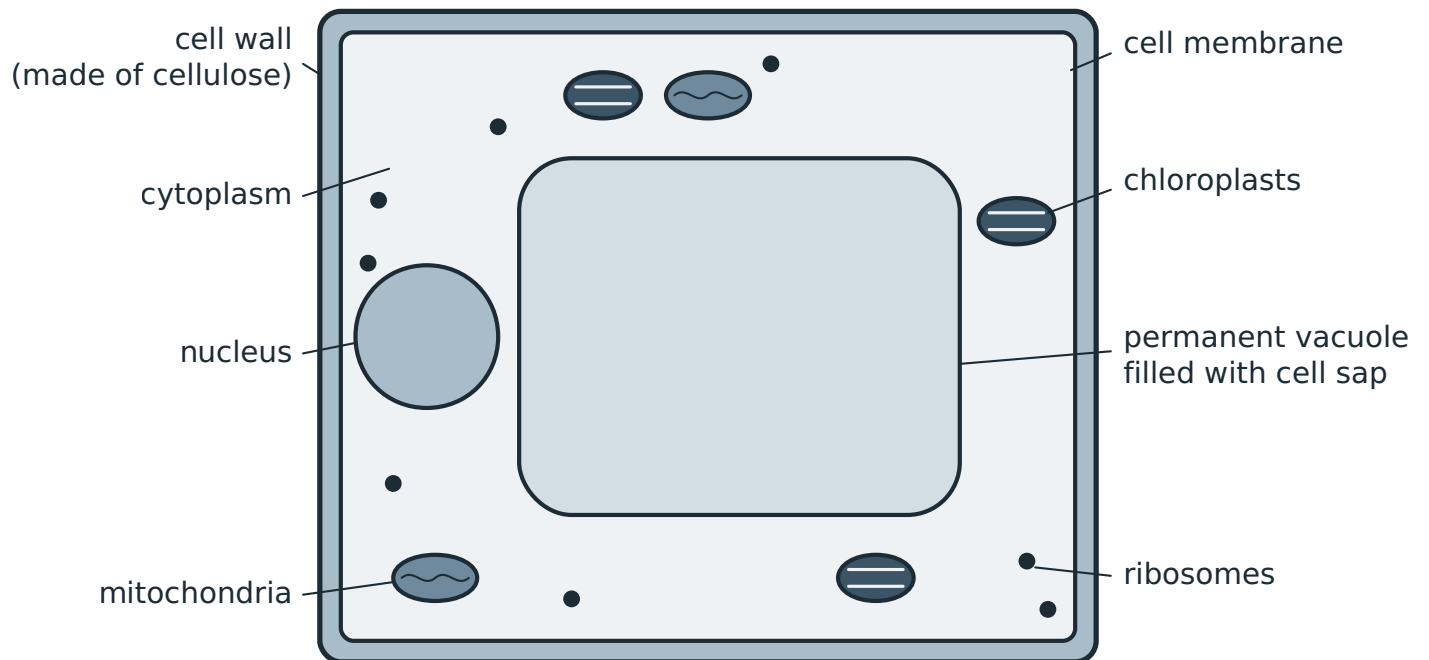
Structure	Function	Animal	Plant	Bacteria
Nucleus	Holds chromosomal DNA; controls the cell	Yes	Yes	No
Cell membrane	Controls what enters and leaves	Yes	Yes	Yes
Mitochondria	Site of aerobic respiration	Yes	Yes	No
Ribosomes	Site of protein synthesis	Yes	Yes	Yes
Cell wall	Cellulose; supports the cell	No	Yes	No
Chloroplasts	Contain chlorophyll; photosynthesis	No	Yes	No
Vacuole	Cell sap; keeps the cell turgid	No	Yes	No
Chromosomal DNA	A single free loop of DNA	No	No	Yes
Plasmid DNA	Small rings of extra genes	No	No	Yes
Flagella	Rotate to move the cell	No	No	Yes

Bacteria are **prokaryotic**; animal and plant cells are **eukaryotic**.

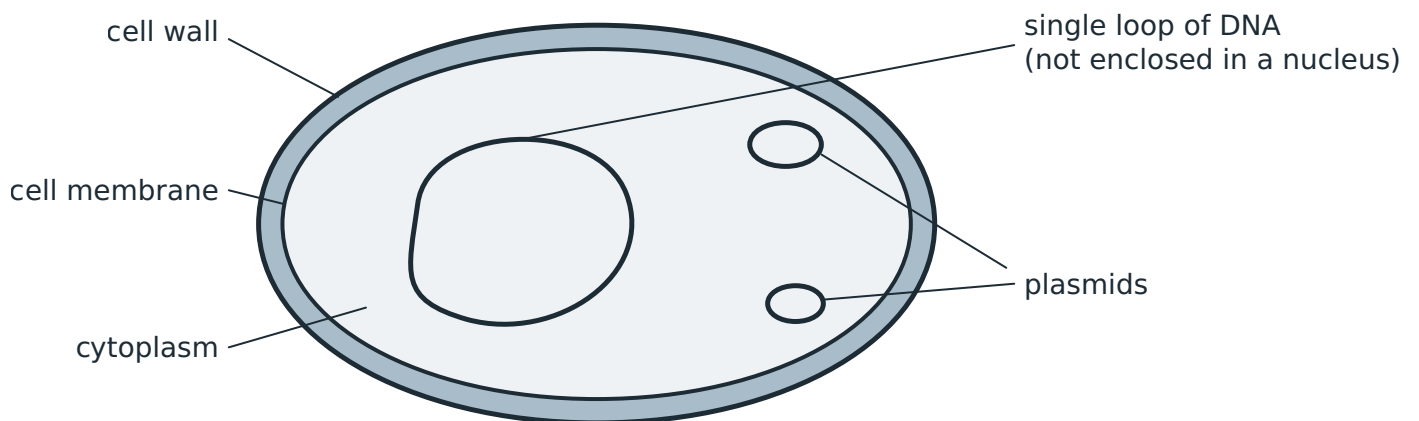
A typical animal cell



A typical plant cell



A bacterial (prokaryotic) cell



A bacterial cell is about 10× smaller across than an animal cell, so about 1000× smaller in volume. It is drawn here much larger than scale.

Specialised cells (1.2)

You must **describe how specialised cells are adapted to their function**.

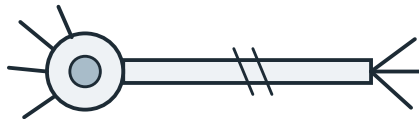
- **Sperm cells** — the **acrosome** holds enzymes that digest the egg's outer layers; the **haploid nucleus** carries one set of chromosomes, so fertilisation restores the full number; many **mitochondria** release energy to swim; the **tail** propels the cell to the egg.
- **Egg cells** — **nutrients in the cytoplasm** feed the embryo; a **haploid nucleus**; **changes in the cell membrane after fertilisation** harden it so no more sperm enter and the chromosome number stays correct.
- **Ciliated epithelial cells** — **cilia** on the top surface beat in a wave, sweeping mucus with trapped dust and microorganisms up the airways and moving an egg along the oviduct.

Specialised cells and how they are adapted



Sperm cell

tail to swim; many mitochondria for energy; enzymes in the head to digest into the egg



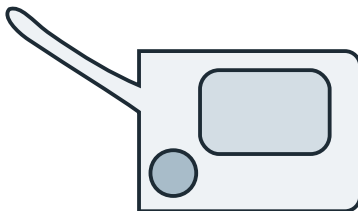
Nerve cell

long and thin to carry electrical impulses a long way; branched ends join other cells



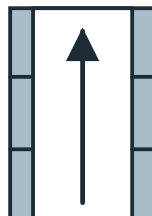
Muscle cell

contracts and relaxes; many mitochondria to release the energy needed to contract



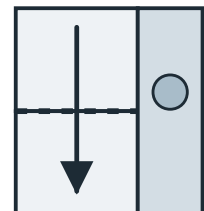
Root hair cell

long, thin hair gives a large surface area to absorb water and mineral ions from the soil



Xylem vessel

hollow dead cells joined end to end, no end walls — carries water; lignin strengthens walls



Phloem cell

sieve plates with pores let cell sap flow; companion cells supply the energy needed

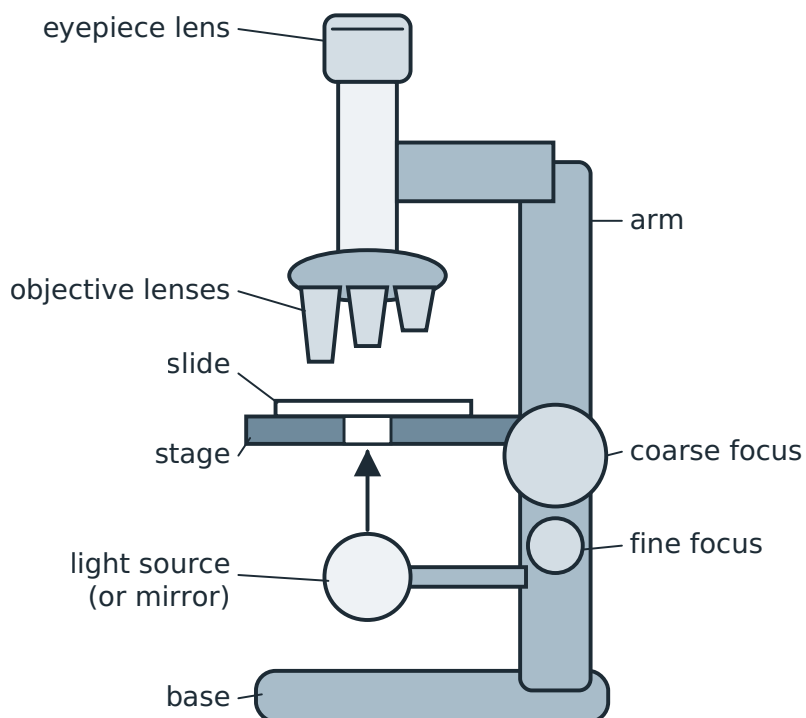
Microscope technology (1.3)

You must **explain how changes in microscope technology, including electron microscopy, have enabled us to see cell structures and organelles with more clarity and detail than in the past and increased our understanding of the role of sub-cellular structures**.

	Light microscope	Electron microscope
Uses	A beam of light	A beam of electrons
Maximum magnification	About ×1500	About ×2 000 000
Resolution	About 200 nm	About 0.2 nm
Can see	Nucleus, cell wall, chloroplasts, vacuole	Also ribosomes, plasmids, inside mitochondria

Higher magnification **and** resolution let scientists see organelles light microscopes could not separate, work out their structure and so their role — for example that ribosomes are the site of protein synthesis. Understanding of the cell has advanced with the technology.

The light microscope



Magnification

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

$$\text{so: real size} = \frac{\text{size of image}}{\text{magnification}}$$

$$1 \text{ mm} = 1000 \mu\text{m}; 1 \mu\text{m} = 1000 \text{ nm}$$

Electron microscope

has much higher magnification and resolving power than a light microscope, so far more detail of sub-cellular structures can be seen.

Number, size and scale (1.4–1.5)

You must **demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used**, and of the relationship between quantitative units in relation to cells.

Prefix	Symbol	Multiplier	Typical use
milli	mm	10^{-3}	A small organism
micro	μm	10^{-6}	Cells and organelles (animal cell $\approx 10\text{--}30\ \mu\text{m}$)
nano	nm	10^{-9}	Ribosomes ($\approx 20\ \text{nm}$), resolution
pico	pm	10^{-12}	Atoms and molecules

HIGHER TIER

Learn: **1 mm = 1000 μm , 1 μm = 1000 nm, 1 nm = 1000 pm**, so 1 mm = 1 000 000 μm .

HT ONLY Calculations with numbers written in standard form (1.5e). Write numbers as $A \times 10^n$ with $1 \leq A < 10$, e.g. $0.000\ 02\ \text{m} = 2 \times 10^{-5}\ \text{m} = 20\ \mu\text{m}$. To multiply, multiply the front numbers and **add** the powers; to divide, **subtract** them.

Estimations are used when an exact value is not needed or not obtainable — how many cells cross a field of view, or checking an answer is sensible. Round to one significant figure first.

WATCH OUT

Magnification has no unit — " $\times 600\ \mu\text{m}$ " loses the mark. Magnification is not resolution: magnifying a blurred image just gives a bigger blur.

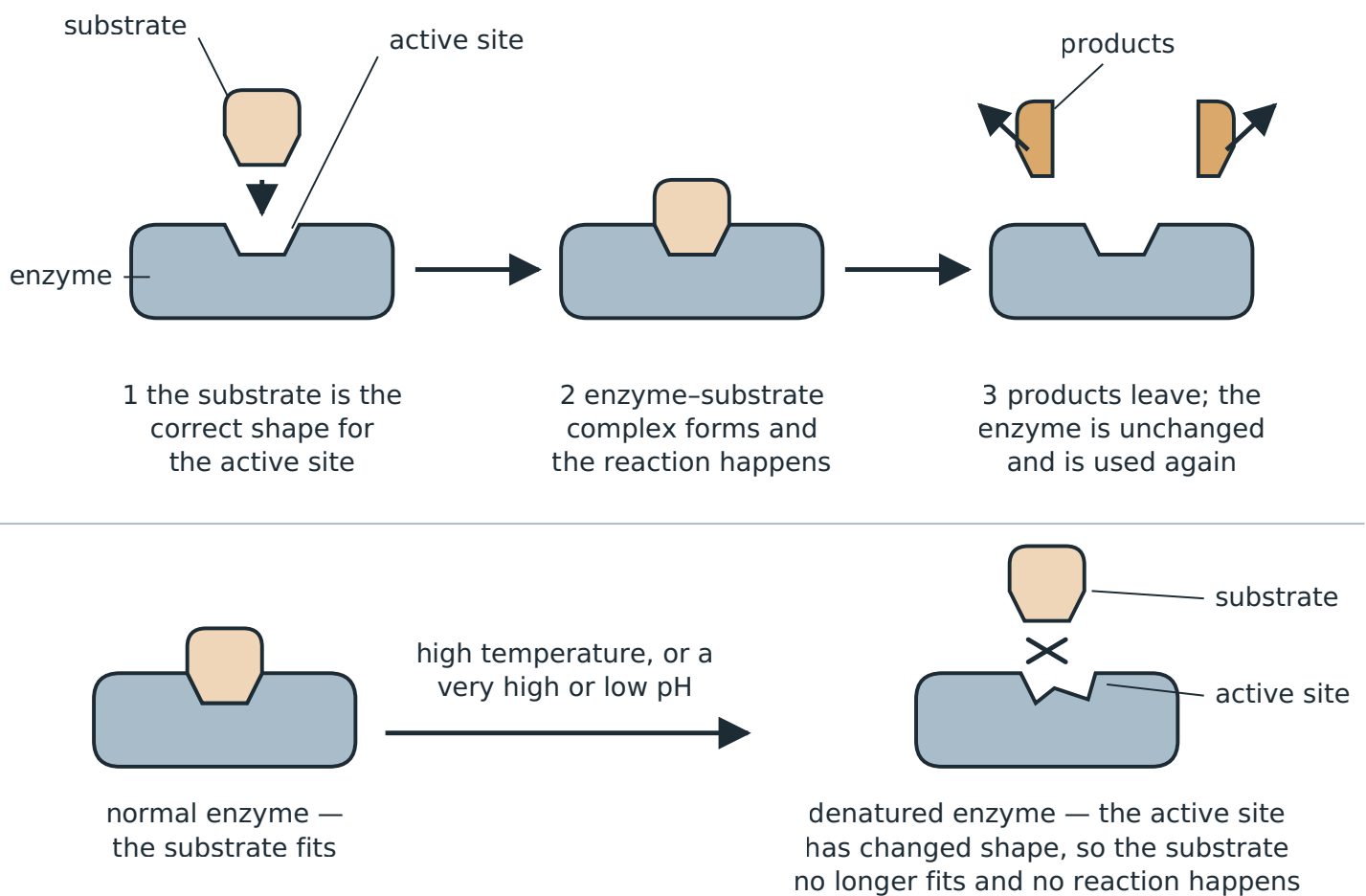
1.2 Enzymes (1.7–1.12)

The mechanism of enzyme action (1.7)

You must **explain the mechanism of enzyme action including the active site and enzyme specificity**.

- Enzymes are **biological catalysts** — proteins that speed up reactions without being used up.
- Each has an **active site** whose shape is **complementary** to its substrate.
- The substrate binds to form an **enzyme–substrate complex**; products form and leave, and the enzyme is used again.
- Only a substrate of the right shape fits, so an enzyme is **specific** — one enzyme, one reaction: the **lock-and-key** model.

The lock-and-key model of enzyme action



ANALOGY

Enzyme action. The active site is a lock and the substrate its key. Only the correctly shaped key turns that lock, and the lock is not used up, so it opens again and again. Unlike a lock, though, a real active site can be destroyed by heat or extreme pH.

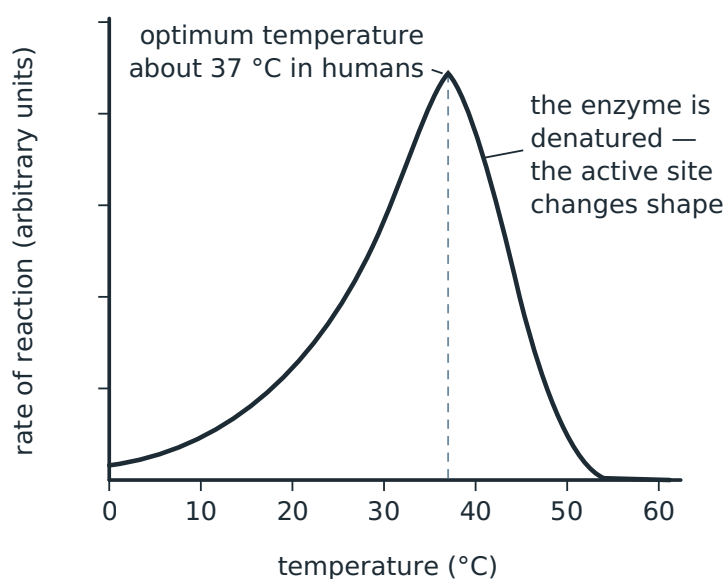
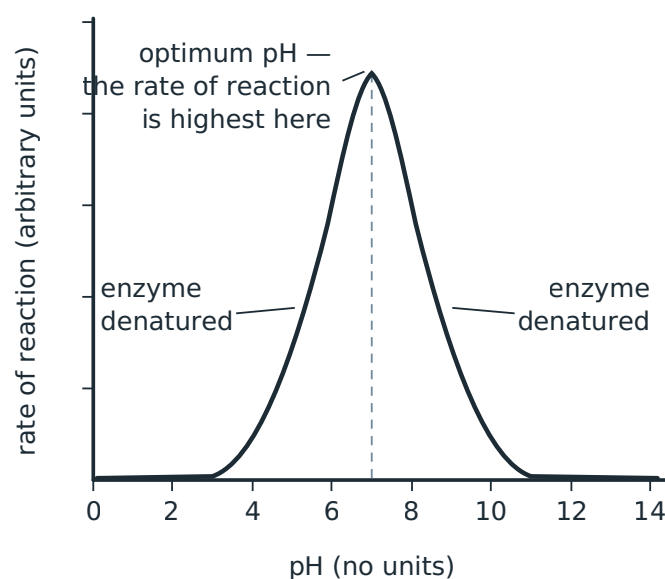
Denaturing (1.8)

You must **explain how enzymes can be denatured due to changes in the shape of the active site**. High temperature or extreme pH breaks the bonds holding the protein in its folded shape, so the **active site changes shape**, the substrate no longer fits and no enzyme-substrate complex forms. Denaturing is **permanent**: the rate falls to zero and does not recover on cooling.

Effects of temperature, substrate concentration and pH (1.9)

- **Temperature** — molecules gain kinetic energy and collide more often, so the rate rises to the **optimum** (about 37 °C for human enzymes). Above it the enzyme denatures and the rate falls to zero: an asymmetric peak.
- **pH** — each enzyme has an **optimum pH** (about 7 for salivary amylase, about 2 in the stomach). Either side the active site changes shape and the rate falls; far from it the enzyme denatures: a symmetrical peak.
- **Substrate concentration** — more substrate means more collisions with active sites, so the rate rises, then **levels off** when every active site is occupied and enzyme concentration limits it.

The effect of temperature and pH on enzyme activity



Rate calculations for enzyme activity (1.11)

Enzymes as biological catalysts (1.12)

You must **explain the importance of enzymes as biological catalysts in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol.**

- **Synthesis** — enzymes join small molecules into large ones: sugars into **carbohydrates** (starch, glycogen, cellulose), amino acids into **proteins**, fatty acids and glycerol into **lipids**. Without enzymes these reactions are far too slow at body temperature, and a cell cannot heat itself up.
- **Breakdown** — enzymes split large insoluble molecules into small soluble ones that can be absorbed: carbohydrates → **sugars**, proteins → **amino acids**, lipids → **fatty acids and glycerol**.

Enzyme group	Substrate	Products
Carbohydrases , e.g. amylase	Carbohydrates — amylase acts on starch	Sugars (amylase → maltose, then glucose)
Proteases	Proteins	Amino acids
Lipases	Lipids (fats and oils)	Fatty acids and glycerol

NOTE

Bile is not an enzyme: it is alkaline, so it neutralises stomach acid, and it **emulsifies** fats into small droplets, increasing the surface area for lipase so fat is digested faster. Digestion in the alimentary canal is not a numbered statement in Topic 1 — Edexcel lists it only as a **suggested practical**.

1.3 Transport in and out of cells (1.15–1.17)

Diffusion, osmosis and active transport (1.15)

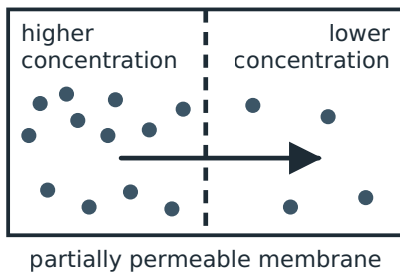
You must explain how substances are transported into and out of cells, including by diffusion, osmosis and active transport.

	Diffusion	Osmosis	Active transport
What moves	Any small dissolved or gaseous particle	Water only	Dissolved substances
Direction	High → low, down the gradient	Dilute → concentrated solution	Low → high, against the gradient
Needs	Nothing — occurs in air and liquids	A partially permeable membrane	Carrier proteins
Energy from respiration	No — passive	No — passive	Yes
Example	Oxygen in, carbon dioxide out	Water into a root hair cell	Mineral ions into root hairs

All three go faster with a **steeper concentration gradient**, a **higher temperature** and a **larger surface area**.

Diffusion, osmosis and active transport compared

Diffusion

**Moves:**

any substance in solution, or a gas — e.g. oxygen, carbon dioxide, urea

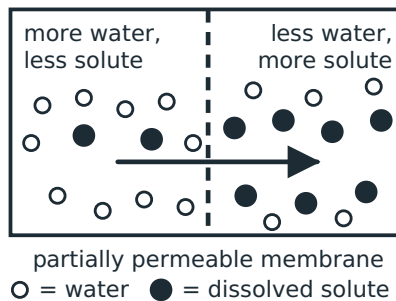
Direction:

down the concentration gradient, from a higher to a lower concentration

Energy from respiration:

not needed — it is passive

Osmosis

**Moves:**

water only, through a partially permeable membrane

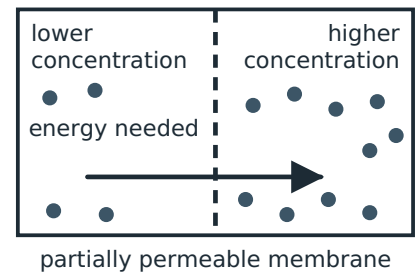
Direction:

from a dilute solution to a more concentrated solution

Energy from respiration:

not needed — it is passive

Active transport

**Moves:**

dissolved substances — mineral ions into root hair cells, sugar from the gut into the blood

Direction:

against the concentration gradient, from a lower to a higher concentration

Energy from respiration:

yes — energy is needed

ANALOGY

Diffusion. Open a perfume bottle in the corner of a room and the smell spreads until it is even everywhere — particles move randomly from crowded regions to empty ones, needing no energy.

ANALOGY

Active transport. Diffusion is water running downhill; active transport is pumping it uphill, and a pump works only while powered. That is why root hair cells, absorbing mineral ions against the gradient, are packed with mitochondria.

ANALOGY

Osmosis. Two rooms, one crowded and one empty, are joined by a door only children fit through. The children (water molecules) wander both ways, but more cross into the crowded room, diluting it. The adults (solute molecules) cannot pass.

Surface area : volume ratio

As an organism gets bigger its volume grows faster than its surface area, so the ratio falls and diffusion alone becomes too slow — hence exchange surfaces and a transport system in large organisms. (The calculation is formally statement 8.2, in Topic 8.)

Percentage gain and loss of mass in osmosis (1.17)

Use of mathematics in Topic 1

HIGHER TIER

- Number, size and scale and the relationship between units (2a, 2h); estimations (1d)
- Rate calculations (1a, 1c); **HT ONLY** standard form (1b); means (2b); graphs and charts (2c, 4a–4d)
- Percentage gain and loss of mass (1c); scatter diagrams to identify a correlation (2g)