

Cambridge OCR GCSE Biology A — Biology

Topic B1

Cell level systems

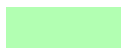
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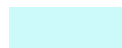
Revision notes for one topic, free to download.

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 much smaller cell with no nucleus; its genetic material is a single DNA loop, often with plasmids (bacteria).

Define Magnification

- how many times larger the image is than the real object.

Define Polymer

- a large molecule built from many repeating monomer units.

Define Complementary base pairing

- A pairs with T, G pairs with C.

Define Active site

- the part of an enzyme complementary in shape to its substrate, where the reaction occurs.

Define Cellular respiration

- the enzyme-controlled, exothermic process that supplies ATP in every living cell.

Define Photosynthesis

- the endothermic process in which light energy is used in chloroplasts to make glucose from carbon dioxide and water.

Define Eukaryotic cell

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

Define Plasmid

- a small ring of DNA in a prokaryotic cell, separate from the main DNA loop.

Define Resolution

- the smallest distance at which two points are still seen as separate.

Define Nucleotide

- the monomer of DNA: a sugar and a phosphate group with one of four bases attached.

Define Enzyme

- a protein that acts as a biological catalyst, speeding up a reaction without being used up.

Define Denatured

- describes an enzyme whose active site has changed shape, so the substrate no longer fits.

Define ATP

- the molecule that transfers energy to where it is needed in a cell.

Define Limiting factor

- the factor in shortest supply, holding back the rate of a process.

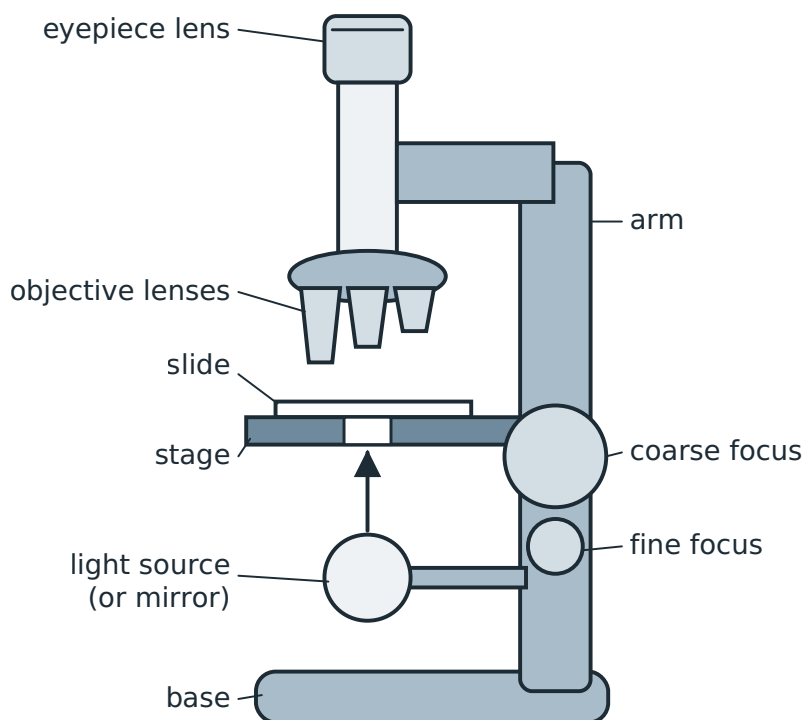
B1.1 Cell structures

Cells are the fundamental units of living organisms. They contain sub-cellular structures essential to the working of the whole cell, and microscopy is used to examine them.

Light microscopes and staining (B1.1a)

- Light from a **lamp** passes through the specimen and two sets of **lenses**: the **objective lens** above the **stage**, and the **eyepiece lens**.
- The specimen sits on a **slide** under a **cover slip**, lowered at 45° to push out air bubbles.
- **Stains** make colourless specimens visible and highlight structures or tissues: iodine for plant nuclei and starch, methylene blue for animal nuclei.
- Focus at **lowest power** first, coarse focus watched from the side, then fine focus, before changing to higher power.
- Total magnification = eyepiece × objective (×10 with ×40 gives ×400).

The light microscope and how total magnification is worked out.



Magnification

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

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

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

Electron microscope

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

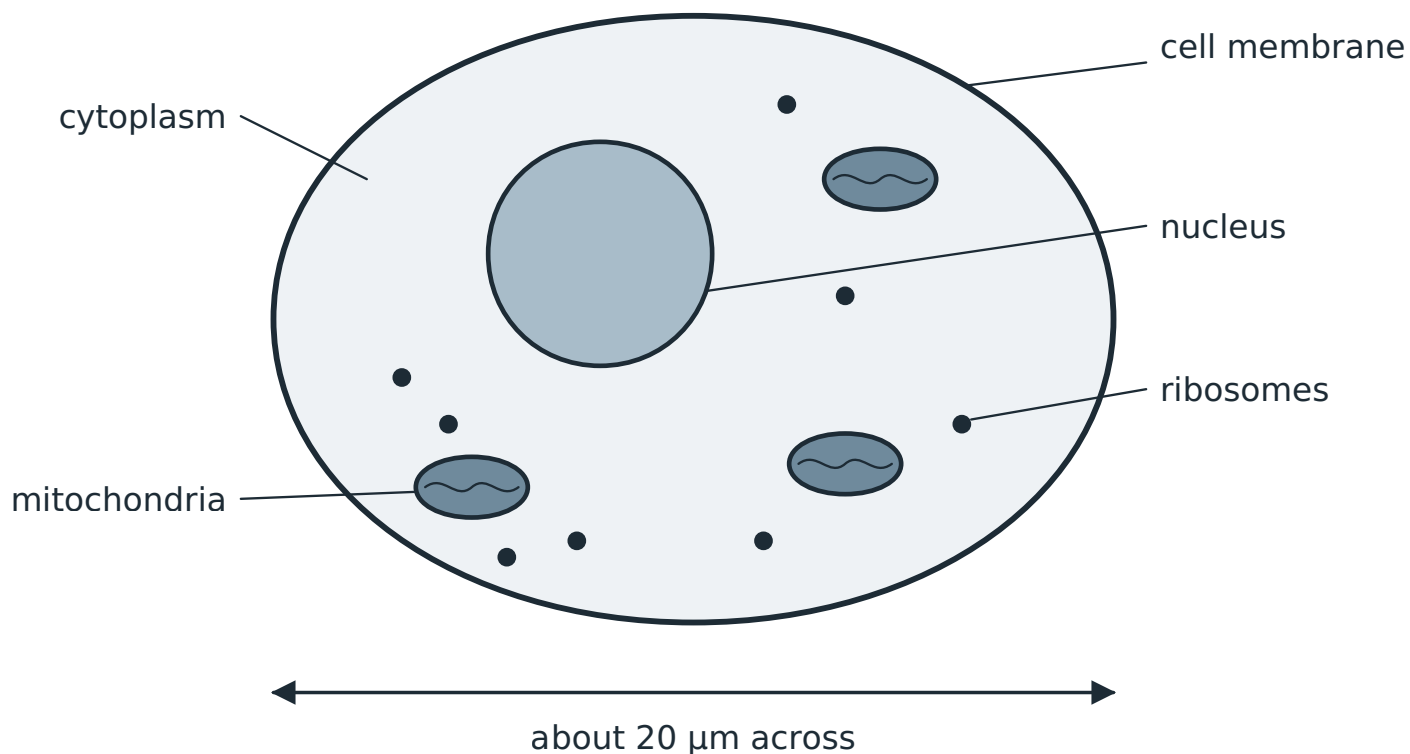
WATCH OUT

Learners commonly find it hard to think of a cell as a **3D structure**. A slide shows one thin slice through a solid object: a palisade cell is a box, not a rectangle; a red blood cell is a dented disc, not a circle. Questions on volume, surface area or diffusion distance are about the solid object.

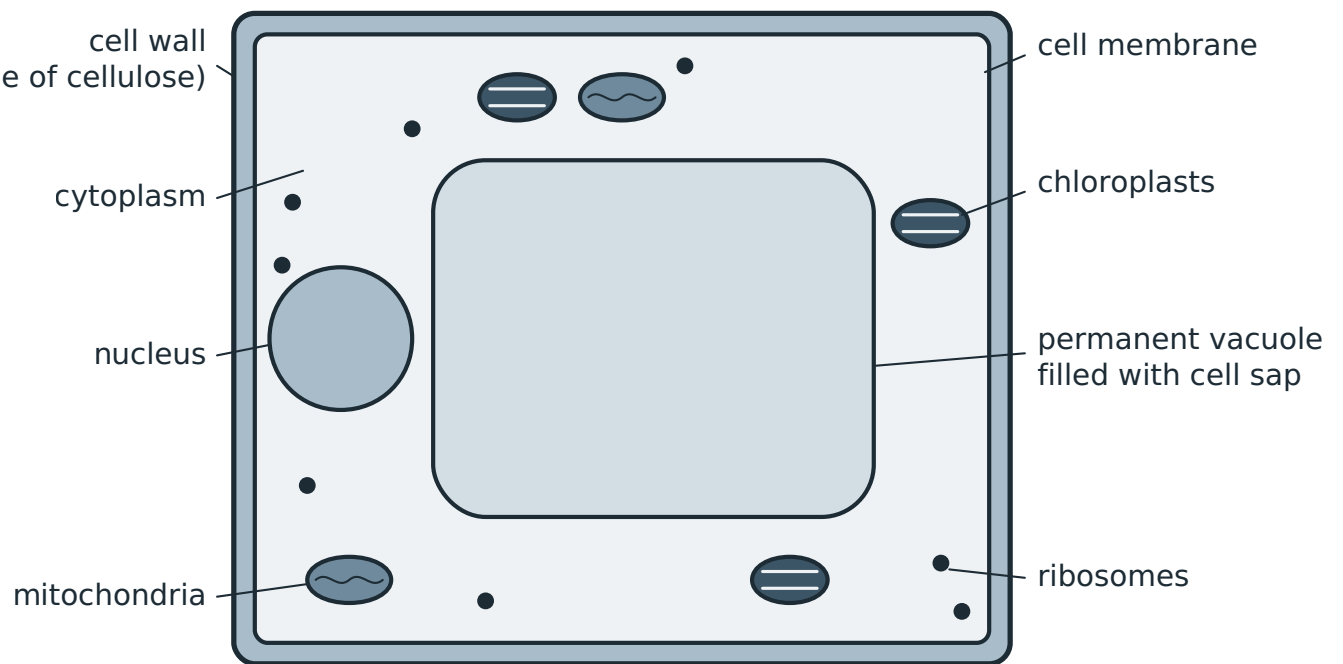
Sub-cellular structures and their functions (B1.1b)

Structure	Found in	Function
Nucleus	Eukaryotes only	Holds the genetic material as chromosomes ; controls the cell
DNA loop	Prokaryotes	Single circular strand of genetic material, free in the cytoplasm
Plasmid	Prokaryotes	Extra ring of DNA carrying additional genes, e.g. antibiotic resistance
Mitochondria	Eukaryotes	Contain the enzymes for cellular respiration
Chloroplasts	Plant and algal cells	Contain chlorophyll , which absorbs light for photosynthesis
Cell membrane	All cells	Contains receptor molecules ; a selective barrier to molecules
Ribosomes	All cells	Site of protein synthesis
Cell wall / vacuole	Plants (bacteria have a wall too)	Support and rigidity

The sub-cellular structures of a typical animal cell.

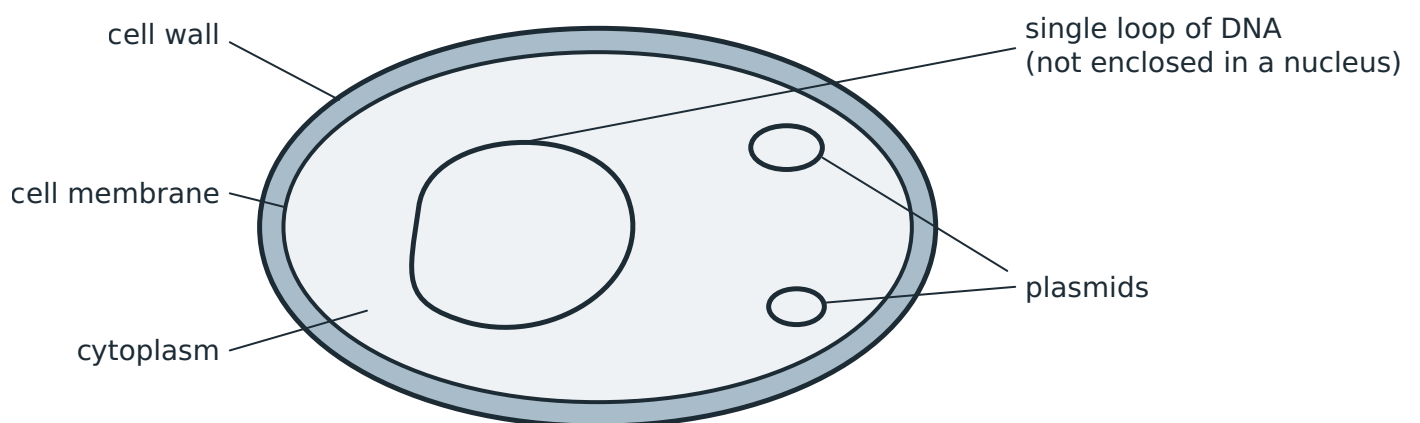


The sub-cellular structures of a typical plant cell.



Feature	Prokaryotic cell	Eukaryotic cell
Size	About 0.1–5 μm	About 10–100 μm
Nucleus	Absent — single DNA loop in cytoplasm	Present — DNA as chromosomes
Plasmids	Often present	Absent
Mitochondria / chloroplasts	Absent	Mitochondria in all; chloroplasts in plants
Cell wall	Present, not cellulose	Cellulose in plants; none in animals

A prokaryotic cell, with its single loop of DNA and its plasmids.



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

Electron microscopy (B1.1c)

- Electron microscopes use a beam of electrons, whose much shorter wavelength gives far **greater resolution** as well as greater magnification.
- The **increased resolution in a transmission electron microscope (TEM)** revealed the internal structure of mitochondria and chloroplasts, ribosomes, and the true structure of the cell membrane.
- Light microscope: about $\times 2000$, resolving 200 nm; TEM: over $\times 1\,000\,000$, resolving below 1 nm — **HT ONLY** best compared in standard form.
- Limitation: specimens must be dead and in a vacuum, so living processes such as cytoplasmic streaming need a light microscope.

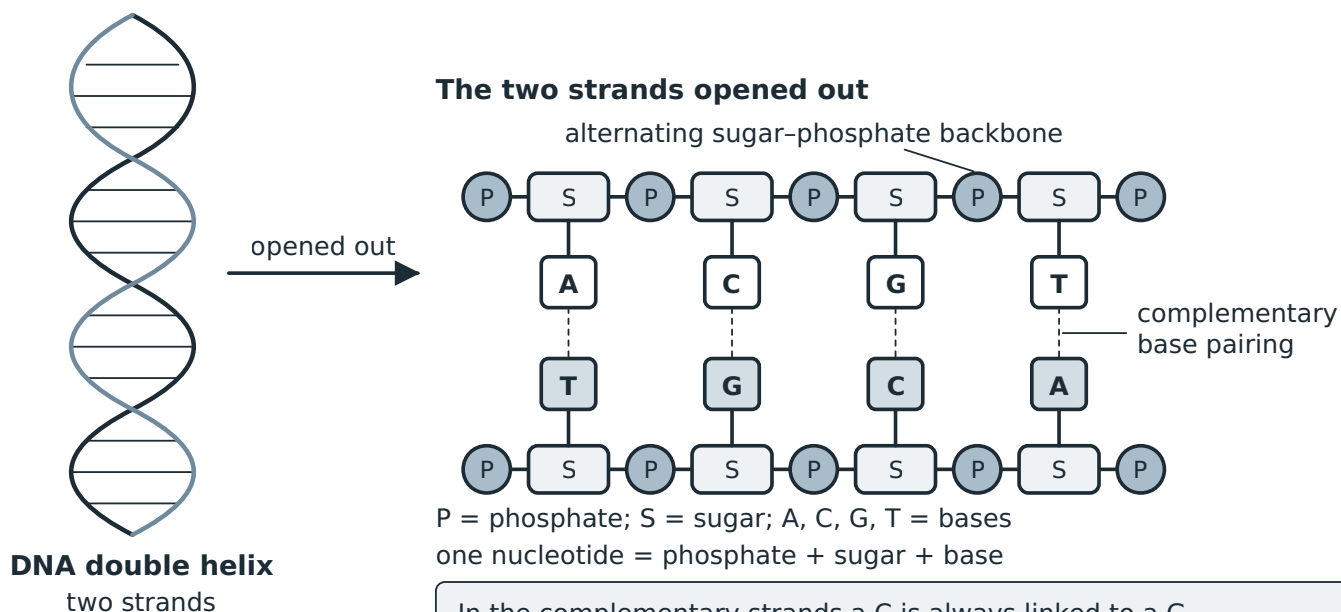
B1.2 What happens in cells (and what do cells need)?

Life processes depend on biological molecules whose structure is related to their function. Inside every cell is genetic material used as a code to make proteins, and enzymes are important proteins in biology.

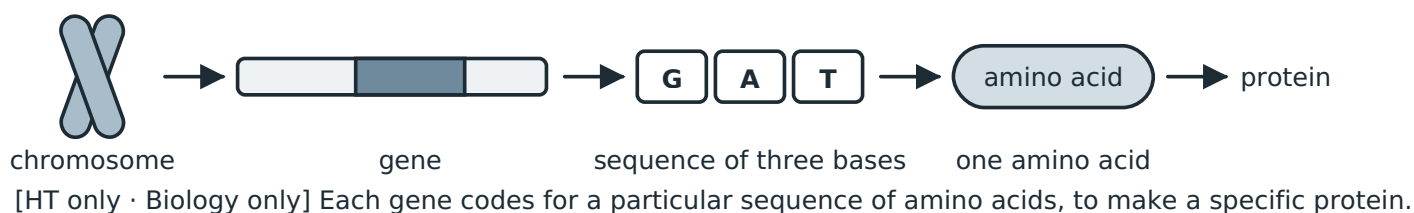
The structure of DNA (B1.2a–c)

- DNA is a **polymer** — a very long chain of repeating units (B1.2a) — made of **two strands forming a double helix** (B1.2b).
- **BIOLOGY ONLY** DNA is made from **four different nucleotides**, each a **common sugar** and a **phosphate group** with **one of four bases** attached to the sugar (B1.2c).
- **BIOLOGY ONLY** The bases pair by **complementary base pairing**: **A–T** and **G–C**, so the two strands are complementary — which is what allows accurate copying (B1.2c).
- Sugars and phosphates form the backbone of each strand; the paired bases form the rungs.

The structure of DNA, from the double helix down to the base sequence that codes for a protein.



In the complementary strands a C is always linked to a G on the opposite strand, and a T to an A.



WATCH OUT

Learners commonly think **DNA is made of protein or of sugar**. It is neither — DNA is a nucleic acid, a polymer of nucleotides. It *contains* a sugar in each nucleotide and it *codes for* proteins, but it is not itself either.

HT ONLY BIOLOGY ONLY Protein synthesis (B1.2d–e)

HT ONLY BIOLOGY ONLY A simple description of protein synthesis (B1.2d):

1. The DNA molecule **unzips around the gene** being used.
2. The base sequence is **copied to mRNA in the nucleus** — **transcription**.
3. The mRNA passes to a ribosome, where the **nucleotide sequence is translated in the cytoplasm** — **translation**.
4. **tRNA carries the amino acids** to the ribosome in the order specified.
5. The code is a **triplet code**: each group of three bases determines the next amino acid, so the base order sets the **amino acid order in the protein**.

HT ONLY BIOLOGY ONLY Because the base sequence sets the amino acid sequence, and that sequence makes the chain fold into a particular shape, **the structure of DNA determines the proteins made**

(B1.2e). Change one base and an amino acid may change; change an amino acid and the folded shape changes; change an enzyme's **active site** and it stops working.

ANALOGY

Transcription and translation — the non-lending library. DNA is a reference book that may never leave the library (the nucleus). To use one recipe you photocopy a single page — the mRNA — and carry it to the kitchen (the ribosome), where tRNA fetches the ingredients (amino acids) in the written order. The photocopy is disposable; the master is never at risk.

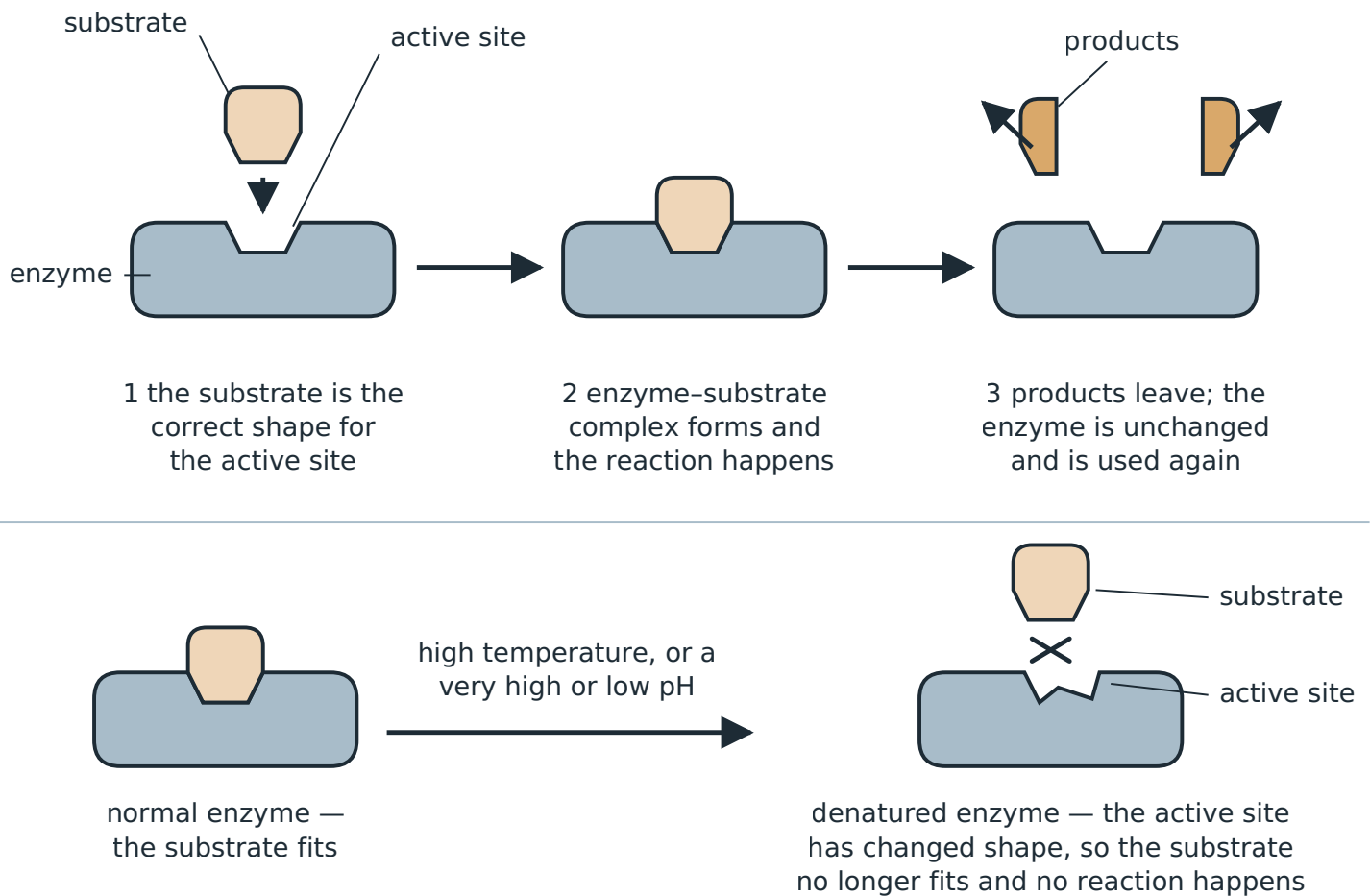
Investigating enzymatic reactions (B1.2f)

Rate is measured either as the product made per unit time, or by timing how long a reaction takes to reach an end point.

Enzymes and enzyme action (B1.2g)

- Enzymes are proteins acting as **biological catalysts**: they speed up reactions without being used up, so each molecule works repeatedly.
- They control **metabolism**, the sum of a cell's chemical reactions — both **breakdown** (e.g. digestion) and **synthesis** (e.g. making glycogen).
- **Enzyme specificity — the lock and key hypothesis**: the **active site** is complementary in shape to one substrate only; the substrate fits, reacts, and the products leave the unchanged active site.

The lock and key model of enzyme action, and what happens when the enzyme is denatured.



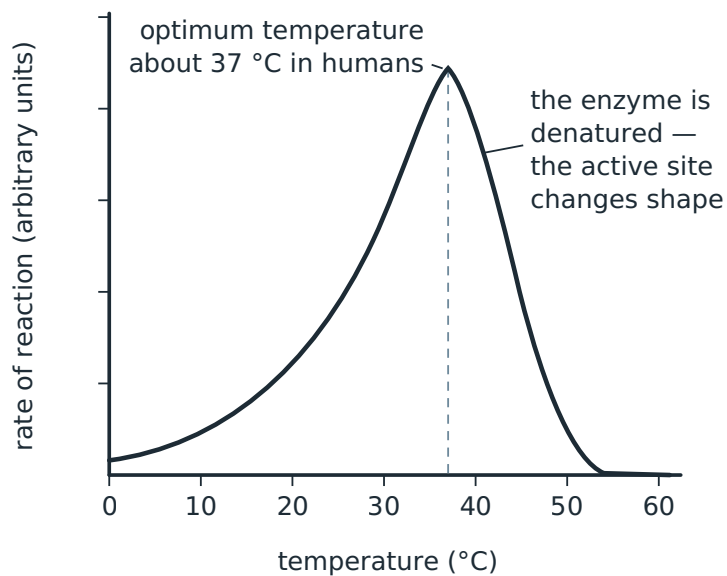
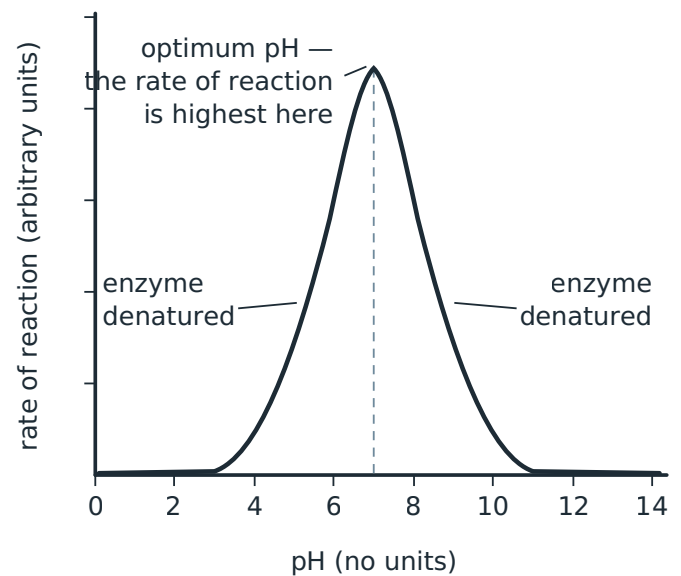
ANALOGY

Enzymes — lock and key. The substrate is a key and the active site a lock: only the right key fits, so one enzyme catalyses one reaction. Overheating or the wrong pH bends the lock out of shape — and unlike a bent key, denaturing cannot be undone.

Factors affecting the rate of enzyme-controlled reactions

- **Temperature** — rate rises with kinetic energy up to an **optimum**; above it the active site changes shape, the enzyme is **denatured** and the rate falls steeply to zero.
- **pH** — each enzyme has an optimum pH (stomach protease about pH 2, salivary amylase about pH 7); either side the active site distorts, and far from it the enzyme denatures.
- **Substrate concentration** — rate rises, then **plateaus** once every active site is occupied.
- **Enzyme concentration** — rate rises while substrate remains available.

The effect of temperature and of pH on the rate of an enzyme-controlled reaction.



WATCH OUT

Learners commonly assume **all enzymes have an optimum temperature of 37 °C**. Enzymes have a **range** of optima: hot-spring bacteria work above 70 °C, cold-water fish enzymes far lower, washing-powder enzymes at 40 °C. "Optimum" means best for *that* enzyme.

B1.3 Respiration

Metabolic processes such as respiration are controlled by enzymes. Organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life.

WATCH OUT

Ventilation is not respiration. Breathing moves air in and out of the lungs; respiration is a chemical reaction inside every cell — plants respire without lungs. Watch the wording too: molecules are **broken down** in respiration, not "broken up".

Respiration as a universal process (B1.3a–b)

- Cellular respiration is a **universal chemical process occurring continuously in all living cells**, supplying ATP (B1.3a). ATP transfers the energy released to where it is needed: muscle contraction, active transport, building large molecules, keeping body temperature constant.
- Respiration is **exothermic** (B1.3b) — it transfers energy to the surroundings, which is why germinating peas in a vacuum flask warm up.

Aerobic and anaerobic respiration compared (B1.3c)

glucose + oxygen → carbon dioxide + water (aerobic)
glucose → lactic acid (anaerobic, animals)
glucose → ethanol + carbon dioxide (anaerobic, plants and fungi — fermentation)

	Aerobic	Anaerobic
Conditions	Oxygen available	Little or no oxygen
Substrate	Glucose	Glucose
Products	Carbon dioxide and water	Animals: lactic acid. Plants/fungi: ethanol + carbon dioxide
Breakdown of glucose	Complete	Incomplete — products still contain energy
Relative yield of ATP	Large (about 19× more per glucose)	Small

Anaerobic respiration lets muscles keep working during hard exercise, but lactic acid builds up and must be broken down afterwards. Fermentation in yeast is used in brewing and baking.

Synthesis and breakdown of biological molecules (B1.3d–f)

Cells build large molecules from small ones and break them down again, using the terms **monomer** and **polymer**.

- **Sugars (B1.3d)** — glucose and other simple sugars are the monomers of the carbohydrate polymers starch (plant store), glycogen (animal store) and cellulose (cell walls); breaking them down releases glucose for respiration.
- **Amino acids (B1.3e)** — the monomers of proteins. The **order** in which the 20 amino acids are joined sets the folded shape and so the function: enzymes, antibodies, hormones, muscle fibres. Dietary protein is broken to amino acids and reassembled in a different order.
- **Fatty acids and glycerol (B1.3f)** — a lipid is made from **one glycerol and three fatty acids**; lipids are a concentrated energy store, used for insulation and in membranes.

B1.4 Photosynthesis

Green plants and algae trap light from the Sun to fix carbon dioxide with hydrogen from water, making organic compounds.

Producers, the process, and energy (B1.4a–c)

- Photosynthetic organisms are the **main producers of food and therefore of biomass** for life on Earth; nearly every food chain begins with them (B1.4a).
- **carbon dioxide + water → glucose + oxygen**, in the presence of light and chlorophyll (B1.4b).
- The reaction happens **in the chloroplasts**, where chlorophyll absorbs light, and is a **two-stage process**: light energy first splits water, releasing oxygen and providing hydrogen; that hydrogen is then used to **fix carbon dioxide** into glucose (B1.4b).
- Photosynthesis is **endothermic** (B1.4c) — energy is transferred *from* the surroundings, the opposite of respiration; compare a chemical icepack, which takes in energy and cools.

WATCH OUT

Learners often think **plants do not respire**. Plants respire in every cell, day and night; in daylight photosynthesis is faster, so the plant releases oxygen overall and the respiration is hidden, but it never stops.

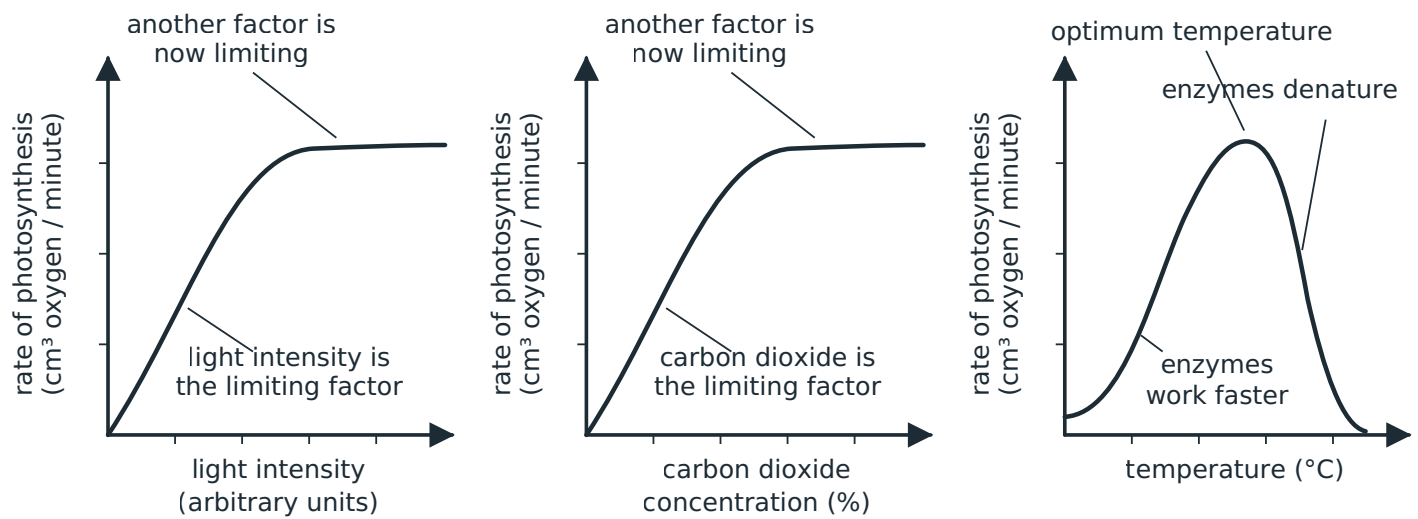
Rate of photosynthesis and limiting factors (B1.4e)

Rate is affected by **temperature**, **light intensity** and **carbon dioxide concentration**; whichever is in shortest supply is the **limiting factor**. (B1.4d is the separate outcome on **describing experiments to investigate photosynthesis** — see the PAG box below.)

- **Light intensity** — rate rises, then plateaus when something else becomes limiting; in darkness it is zero.
- **Carbon dioxide concentration** — the same shape: rising, then a plateau.
- **Temperature** — rate rises as the controlling enzymes work faster, up to an optimum, then falls sharply as they **denature**, making this a **peaked curve** unlike the other two.

On a graph a **rising section** means that factor is limiting, a **plateau** that another factor now is (BM1.4iv).

How light intensity, carbon dioxide concentration and temperature each affect the rate of photosynthesis.



HIGHER TIER

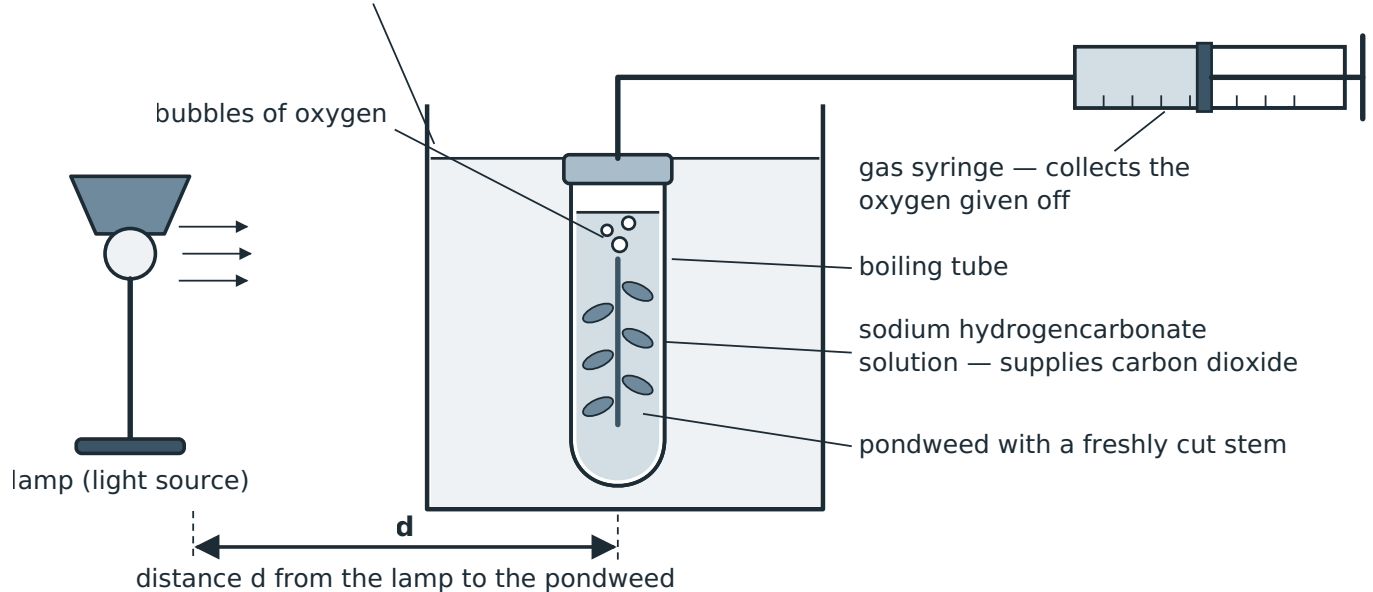
HT ONLY Interaction of limiting factors (B1.4f)

HT ONLY You must explain how the three factors **interact**:

- Only **one** factor is limiting at any moment; increasing any other has **no effect** until the limiting one is raised.
- Plot rate against light intensity at two carbon dioxide concentrations: the curves overlap in the steep region (light limiting for both) and separate at the plateau, the higher CO₂ line levelling off higher.
- Temperature behaves differently — pushing past the optimum makes the rate **fall** as enzymes denature, whereas extra light or CO₂ simply has no further effect.
- Growers therefore raise light, carbon dioxide and temperature together in a greenhouse, each until the cost outweighs the extra yield.

Apparatus for measuring the rate of photosynthesis in pondweed at different light intensities.

large beaker of water — a heat shield: it absorbs heat from the lamp so the temperature stays constant



independent variable — distance d of the lamp from the pondweed (this changes the light intensity)

dependent variable — volume of oxygen collected in one minute (or bubbles counted per minute)

control variables — temperature (kept constant by the water bath), carbon dioxide concentration, the same piece of pondweed, the same time for each reading