

1 · Cell biology

AQA · GCSE · Biology

Cell biology: the unit of life

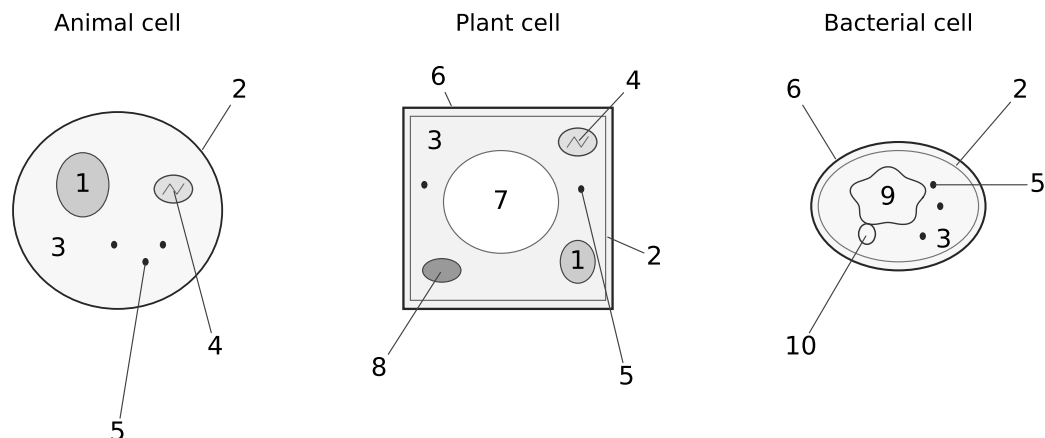
Every living thing is built from cells, and the differences between them decide what each can do. This reference covers **AQA GCSE Biology 8461, topic 4.1 Cell biology**.

How the exam treats this topic:

- Paper 1 (4.1–4.4) carries Cell biology. Required practicals: RP1 (light microscope), RP2 (antiseptics/antibiotics on agar, biology only) and RP3 (osmosis in plant tissue).
- Culturing microorganisms is **biology only**; standard-form answers for bacterial numbers are **HT only**.
- Calculations the exam demands: magnification ($\text{image} \div \text{real}$), real size from image and magnification, area by πr^2 , percentage change in mass, surface-area-to-volume ratio, bacterial division counts.

Cell structure: eukaryotes and prokaryotes

Teacher models – not to scale. Numbers match the structure key. The plant model represents a photosynthetic cell; many root cells do not have chloroplasts. The bacterial model includes a plasmid, but not every bacterium has plasmids.

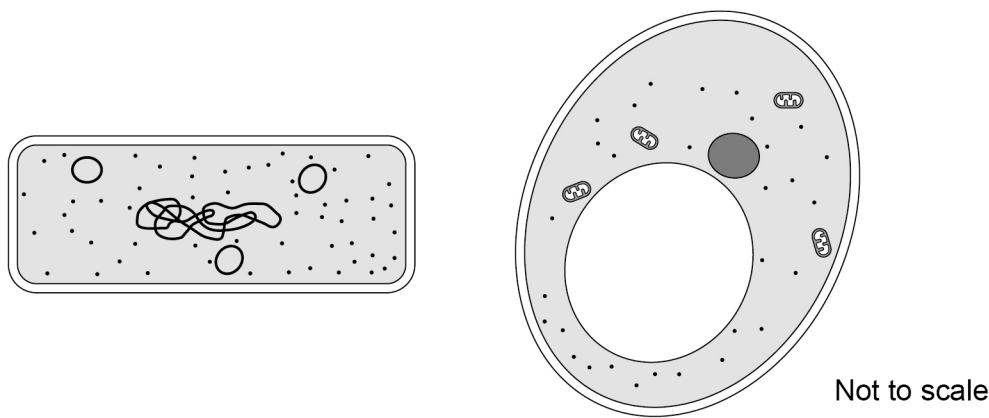


Eukaryotic cells include plant, animal and yeast cells; their genetic material is enclosed in a nucleus. **Prokaryotic** bacterial cells have no nucleus: the main DNA is a single loop and there may be plasmids. Bacteria have a membrane, cytoplasm, ribosomes and a wall; they do not have mitochondria or chloroplasts. Their

wall is not made of cellulose. Cell wall alone does not distinguish a bacterium from a yeast cell. Do not claim that all plant cells have chloroplasts or that bacteria lack ribosomes.

Key	Structure	Function
1	nucleus	DNA; controls cell activities
2	cell membrane	regulates entry and exit
3	cytoplasm	site of many reactions
4	mitochondrion	aerobic respiration
5	ribosome	protein synthesis
6	cell wall	support; cellulose in plants
7	permanent vacuole	cell sap; maintains firmness
8	chloroplast	photosynthesis
9	DNA loop	bacterial genetic material
10	plasmid	small DNA ring carrying genes

Figure 10



Original 2025 Q08.1 [1]: bacteria are prokaryotic; yeast is eukaryotic. **Q08.2 [2]:** any two visible yeast features not found in bacteria include nucleus, vacuole and mitochondria. Name the structures; “more complicated” is not a labelled comparison. Do not use this not-to-scale drawing to calculate their relative real sizes.

Cell specialisation, differentiation and microscopy

Specialised cells have structures suited to their functions. Explain the feature and the resulting advantage, rather than only listing structures.

Cell	Feature	Link to function
sperm	tail; many mitochondria	swimming; energy for movement
nerve	long axon; insulation	impulses over a distance
muscle	contractile fibres; mitochondria	contraction; energy released
root hair	long projection, large surface	water and ion uptake
xylem	hollow; lignified wall	water flow; strength
phloem sieve tube	sieve plates	dissolved sugars can flow

Sheet 1.1 Q2.2 [2]: one feature plus its advantage earns the pair: a tail propels the sperm towards the egg; alternatively many mitochondria release energy through aerobic respiration for swimming. Do not replace the explanation with a second unrelated feature. **Q3.1 [4]:** mitochondria carry out aerobic respiration, releasing energy for contraction; ribosomes synthesise proteins, including the contractile fibres needed by the cell.

Differentiation means acquiring different sub-cellular structures to become specialised. Most animal cell types differentiate early; many plant cells retain this ability throughout life. Division in mature animals is mainly for repair/replacement. Differentiation changes cell type/function; division increases cell number.

■ Microscopy, scale and calculations

Magnification is how many times larger the image is than the real object. **Resolving power** concerns distinguishing close structures as separate. Enlarging a blurred image increases its size without necessarily revealing more detail. Electron microscopes have higher magnification and resolution than light microscopes, allowing finer sub-cellular detail.

$$M = \frac{I}{L}$$

Here M is magnification, I image size and L real size. Use the same length units for I and L; M has no unit. Rearranging gives $L = I/M$. Prefixes: centi = 10^{-2} , milli = 10^{-3} , micro = 10^{-6} , nano = 10^{-9} . Thus 1 cm = 10 000 μm ; 1 mm = 1000 μm = 1 000 000 nm.

Worked example: image 4.8 cm at $\times 1200$. Convert 4.8 cm = 48 000 μm .

$$L = \frac{I}{M}$$

$$L = \frac{48\,000\ \mu\text{m}}{1200} = 40\ \mu\text{m}$$

For sheet Q2.3, $2.4 \text{ mm} = 2400 \text{ }\mu\text{m}$ and $L = 2400 \text{ }\mu\text{m}/800 = \mathbf{3.0 \text{ }\mu\text{m}}$.

Original AQA 2024 Q08.3 [6]: a cylindrical structure has volume $24\,500\,000 \text{ nm}^3$ and radius 125 nm . Its image is 4 mm long. Use $\pi = 3.14$. The question provides the cylinder-length equation; find the real length before magnification.

$$L = \frac{V}{\pi r^2}$$

$$L = \frac{24\,500\,000 \text{ nm}^3}{3.14 \times (125 \text{ nm})^2} = 499.363 \dots \text{ nm}$$

Convert $I = 4 \text{ mm} = 4\,000\,000 \text{ nm}$, then:

$$M = \frac{I}{L}$$

$$M = \frac{4\,000\,000 \text{ nm}}{499.363 \dots \text{ nm}} = 8010.204 \dots \approx 8010$$

Report $\times \mathbf{8010}$, without a length unit. The official scheme rejects a magnification answer with a unit. Preserve intermediate precision and distinguish the provided radius from a diameter. Use the stated 4 mm image length rather than measuring a resized PDF.

RP1: prepare/observe the selection of plant and animal cells under a light microscope, find and focus the specimen, then draw clear outlines and accurate labels. Start with low magnification to locate the specimen before moving higher. Include a magnification scale. Draw the structures actually observed; the teacher model is not proof that every organelle will be visible with the classroom microscope. A printed magnification is tied to image size. If the image is resized, that printed value changes; an embedded scale bar resized with the image retains the correspondence between bar and object.

Culturing microorganisms (biology only)

Bacteria multiply by **binary fission**. With enough nutrients and a suitable temperature they may divide as often as every 20 minutes; this is not a fixed rate for every species or condition. They can grow in nutrient broth or as colonies on agar. For a stated constant division time:

$$\text{number of divisions} = \frac{\text{elapsed time}}{\text{division time}}$$

$$\text{final population} = \text{initial population} \times 2^{\text{number of divisions}}$$

Worked example: one bacterium, 20-minute divisions, 3 hours. Elapsed time = 180 minutes; divisions = $180/20 = 9$; population = $1 \times 2^9 = 512$. Sheet 1.1 Q3.3 instead uses 2 hours: six divisions, **64** cells. Standard form 6.4×10^1 is the HT extension for this population calculation. These predictions assume the stated division rate continues; nutrient shortage or changed conditions can invalidate it.

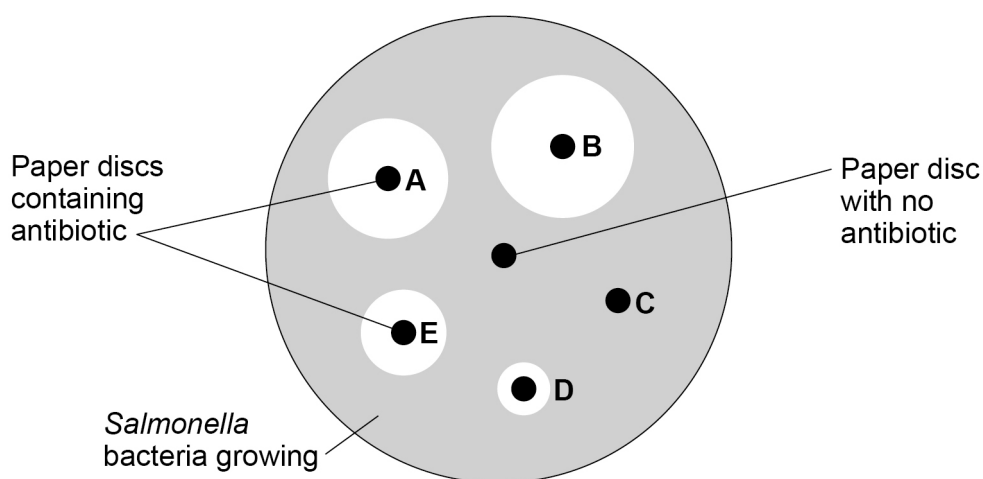
■ Aseptic technique and the reason for each action

Aseptic technique aims to prevent contamination by unwanted microorganisms. Sterilise Petri dishes and culture media before use; sterilise the inoculating loop before transfer. Briefly lifting/tilting the lid reduces contact with air, and adhesive tape secures it. Store inverted to reduce condensation dripping onto the agar. These actions have different purposes: in original 2023 Q03.3 [2], inversion alone is ignored as an aseptic answer. Name the item/action; “sterilise equipment” alone is too vague for that scheme.

Original 2023 Q03.4 [3]: 37°C is human body temperature, where the investigated *Salmonella* grows better. Schools use a maximum of 25°C to reduce growth of organisms harmful to humans. This reduces risk; it does **not** guarantee that every organism present is non-pathogenic. School work still requires aseptic precautions. Do not copy a specialist laboratory’s conditions into a school method merely because growth is faster there.

■ RP2: controls, measurements and conclusions

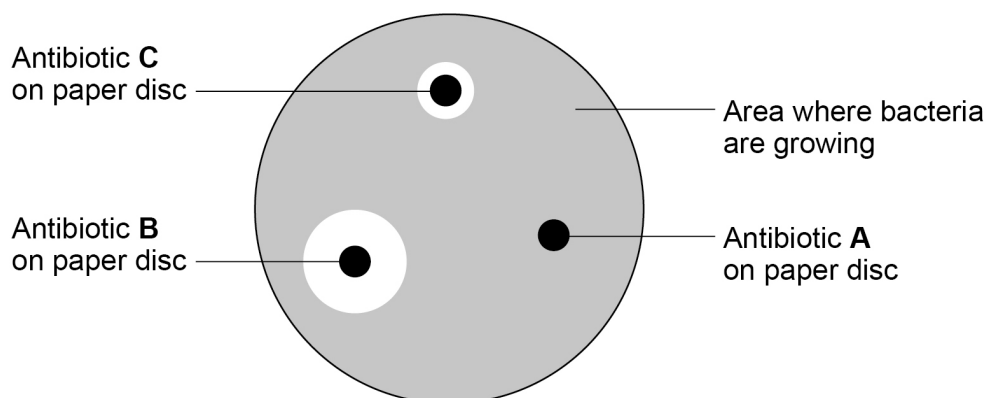
Figure 4



Original Q03.5 [1]: the disc with no antibiotic is a **control**, allowing comparison to check that inhibition is due to the antibiotic rather than the paper disc. It is not a “control variable”. **Q03.6–Q03.7 [1 + 1]:** A and B have the largest zones of inhibition for the tested bacterium. Measure each diameter/radius, or calculate each area, to

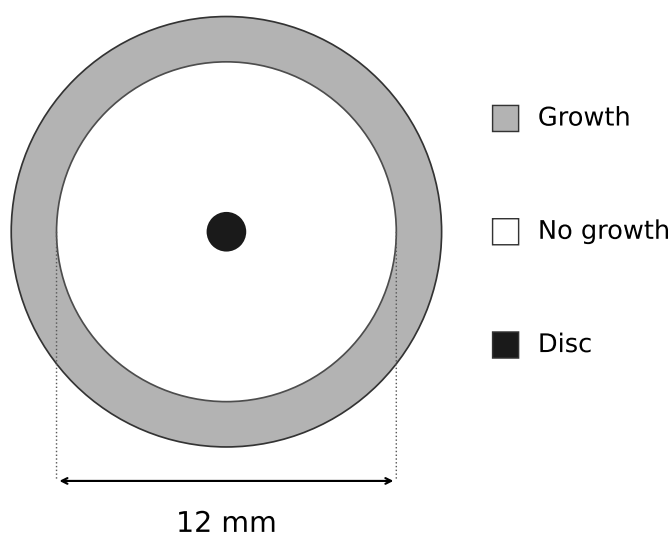
compare quantitatively. In a fair investigation keep bacterial type, agar, disc size, amounts/concentrations, incubation time and temperature consistent as appropriate; repeat measurements/cultures and compare means. A zone is evidence about the tested organism under the tested conditions, not proof of identical effects in every infection.

Figure 5



Original 2024 Q06.2 [2]: the claim that this bacterium is resistant to C is contradicted by a zone of inhibition. If it were resistant in this test, growth would reach the disc edge and no zone would appear. A **small** zone is still a zone; it is not the same as no inhibition. Describe bacteria being killed or their growth being prevented, rather than only saying “white area”.

Teacher schematic for the worksheet’s stated diameter – not measured exam data.



Sheet 1.1 Q3.2(c) [2]: diameter 12 mm, so radius is half the diameter.

$$r = \frac{d}{2} = \frac{12 \text{ mm}}{2} = 6 \text{ mm}$$

$$A = \pi r^2$$

$$A = \pi \times (6 \text{ mm})^2 = 113.097 \dots \text{ mm}^2 \approx 113 \text{ mm}^2$$

Using 12 mm as the radius gives four times the correct area. The question supplies the clear-zone diameter and does not ask for an annular area excluding the disc. If a different question asks for an area excluding the disc, use its stated dimensions and subtract the disc area. Measure several diameters for an irregular zone where appropriate; use a consistent measurement rule across samples.

Cell division: chromosomes, mitosis and the cell cycle

The nucleus contains **chromosomes** made of DNA. Each carries many **genes**, sections of DNA; body-cell chromosomes normally occur in pairs. For human body cells, 23 pairs means 46 chromosomes, not 23 chromosomes. This paired arrangement is different from the two copies produced when DNA replicates.

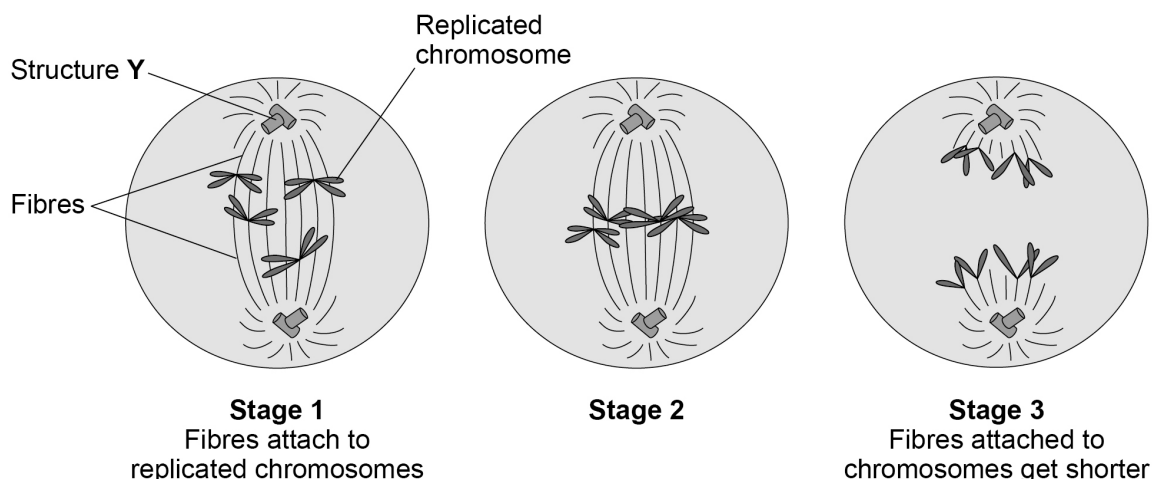
Overall stage	What happens
Preparation	Growth; more ribosomes/mitochondria; DNA copied
Mitosis	One chromosome set to each end; nucleus divides
Final division	Cytoplasm/membrane divide; two identical cells

Growth and DNA replication both prepare the cell for division; do not present replication as a separate stage before growth. Replication makes two copies of each chromosome. **Mitosis** distributes the copied genetic material: it does not halve the chromosome set in each daughter cell. The three overall stages above are sufficient here; the named phases within mitosis are not required.

Original 2024 Q08.1 [1]: DNA replication is already given. Another preparatory change is cell growth or an increase in ribosomes/mitochondria. Repeating DNA replication does not answer “one other change”.

Original 2023 Q05.6 [3] / sheet 1.2 Q3.1: after DNA replication, one set of chromosomes is pulled to each end of the cell (1); the nucleus divides (1); cytoplasm or cell membrane divides to form two cells (1). Keep these three points distinct. DNA copying is preparation; it does not replace one of these division points.

Figure 9



Original Figure 9 shows some stages within division, not the three overall cell-cycle stages in the table. Its stage numbers belong to that figure.

Original 2024 Q08.4 [2]: drug X prevents fibres attaching to replicated chromosomes. Therefore chromosomes cannot be pulled to each end (1), so the nucleus cannot divide / two genetically identical cells cannot form (1). “The cell cannot divide” simply repeats the question; describe the mechanism. **Q08.5 [1]:** stopping division stops tumour growth/spread. Mitosis also supports normal growth, development and repair. Blocking division in living hair-follicle cells can cause hair loss; slowing division in repair tissue can delay healing. The dead hair shaft is not dividing.

Stem cells

A **stem cell** is undifferentiated: it can make more cells of its own type and can differentiate into other cell types. Division increases cell number; differentiation provides specialised structures/functions.

Source	Differentiation potential
Embryo	Most human cell types
Adult bone marrow	Many types, including blood cells; narrower range
Plant meristem	Any plant cell type throughout plant life

Original 2025 Q07.1 [1]: embryonic stem cells can differentiate into liver cells, giving the relevant property for liver treatment. “Can divide” alone does not explain production of the required specialised cells. The question explicitly says donor cells can be rejected: do not transfer the patient-matched therapeutic-cloning claim to all donated stem cells.

Therapeutic cloning: an embryo with the patient’s genes provides matching stem cells, which the syllabus describes as not rejected. This is an immune-compatibility

benefit, not a guarantee against every risk. Stem-cell treatment has potential uses in diabetes and paralysis; possible viral transfer remains a risk. Details of the cloning technique are outside this specification.

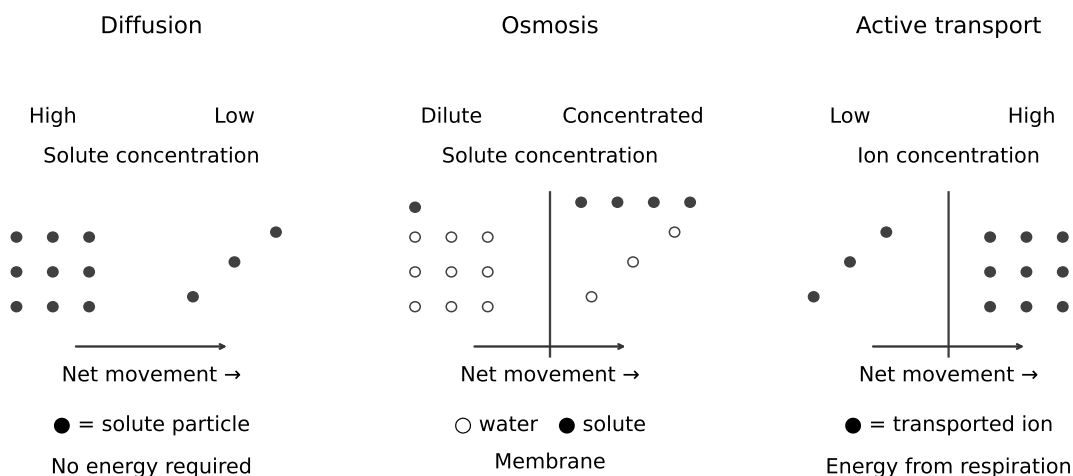
Original 2025 Q07.2 [1]: an ethical objection needs a reason: embryo destruction, inability of an embryo to consent, or conflict with specified personal/religious beliefs. “Religion” alone is insufficient in this scheme. Viral transfer is a biological risk, not an ethical explanation.

Teacher comparison model, not an official six-mark scheme: embryonic cells have a wider differentiation range; bone-marrow cells have a narrower range including blood cells. Using embryos raises objections about embryo destruction; adult marrow avoids that particular objection. Both sources still require safety assessment. A benefit should be linked to a possible treatment and a risk/objection should be explained, then weighed in context; do not claim the source alone guarantees a cure.

Original 2023 Q01.2 [1]: the plant stem-cell tissue is **meristem**. Meristem cells retain differentiation potential throughout life. Cloning can preserve rare plants and rapidly/economically produce identical crops with useful traits such as disease resistance. These are separate purposes: preserving a rare species does not automatically make it disease-resistant.

Transport in cells

Teacher particle models: filled circles represent solute particles (transported ions in the third panel); open circles represent water. The arrows show **net movement**, not the motion of every particle. The osmosis panel’s concentration labels refer to **solute**, and water crosses a partially permeable membrane. Active transport moves the named substance against its own concentration gradient.



Process	Net direction	Energy from respiration
Diffusion	Substance: high $\rightarrow$ low concentration	Not required
Osmosis	Water: dilute $\rightarrow$ concentrated solution	Not required
Active transport	Substance: low $\rightarrow$ high concentration	Required

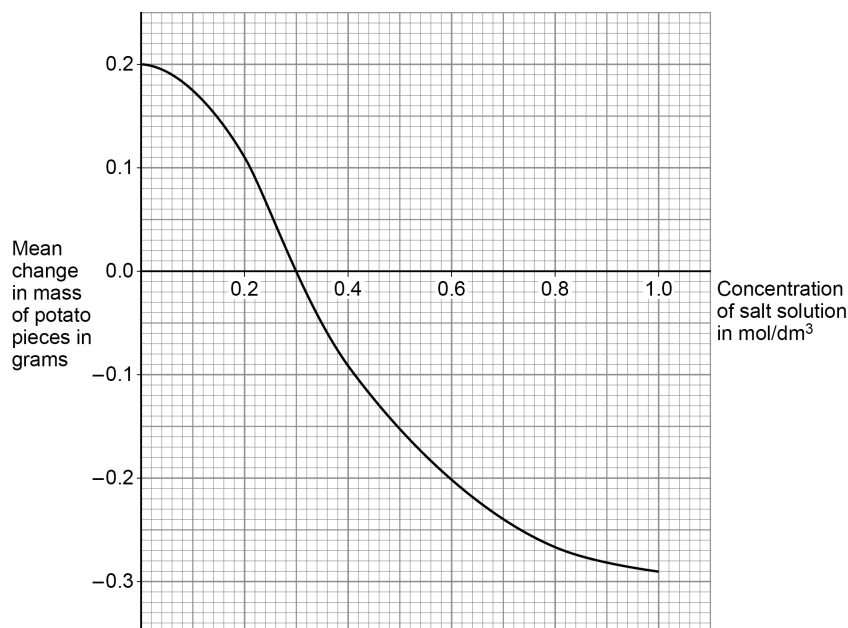
Diffusion is the net movement of particles from higher to lower concentration. Particles still move both ways; the overall transfer is down the gradient. Examples: oxygen/carbon dioxide in gas exchange and urea from cells to blood plasma. Original 2025 Q06.1 [1] needs the net high-to-low direction; sheet Q2.1 [2] also identifies particles in a gas or solution.

Rate: a steeper concentration gradient gives greater net movement; higher temperature increases particle motion; greater membrane surface area allows more transfer at once. A thin exchange barrier shortens the diffusion path. Blood flow and ventilation help maintain gradients rather than supplying energy for diffusion.

Active transport: root hairs can absorb a mineral ion when its concentration is lower in the soil than in the cell. It moves low $\rightarrow$ high for that ion, using energy from respiration. Glucose uptake from gut to blood is another example. Original 2025 Q03.3 [1]: energy requirement, movement against a gradient, or transport of ions/glucose rather than water distinguishes it from osmosis.

Osmosis: net water movement from a dilute solution to a more concentrated solution through a partially permeable membrane. Original 2025 Q03.2: potato cell solution is more concentrated than distilled water, so net water entry increases mass. With more concentrated solution outside, water leaves and mass falls. At no mass change, there is **no net water movement**, not an absence of molecular movement.

Figure 4



Original Figure 4: the vertical axis is **mean change in mass in grams**, not percentage. Its zero crossing is approximately 0.30 mol/dm³, an estimate of the matching external concentration under these conditions. Original Q05.2 [3]: at 0.6 mol/dm³ mass decreases because water leaves; the cell solution is less concentrated than outside; water moves by osmosis. Q05.3 [2]: 1.0 mol/dm³ gives a steeper concentration gradient and more water loss than 0.6 mol/dm³. The graph does not give an exact universal concentration for all potatoes.

■ Percentage change and RP3

Known initial and final masses must be distinguished. Subtract initial from final, then divide by the **initial** mass. Percentage change permits comparison when starting masses differ; preserve a negative sign for loss.

$$\Delta m = m_{\text{final}} - m_{\text{initial}}$$

$$p = \frac{\Delta m}{m_{\text{initial}}} \times 100\%$$

Teacher example: initial mass 2.5 g, final mass 2.9 g.

$$\Delta m = 2.9 \text{ g} - 2.5 \text{ g} = +0.4 \text{ g}$$

$$p = \frac{+0.4 \text{ g}}{2.5 \text{ g}} \times 100\% = +16\%$$

Sheet Q2.2: the 3.0 g piece loses 0.45 g, so the signed change is -0.45 g.

$$p = \frac{-0.45 \text{ g}}{3.0 \text{ g}} \times 100\% = -15\%$$

RP3 sequence: cut equal-sized peeled pieces from the same potato; blot consistently and record initial masses; immerse in measured concentrations with equal solution volume, time and temperature; remove, blot and record final masses; calculate change/percentage change; repeat at each concentration, calculate means and plot the appropriate dependent variable. The original 2024 graph requires **mean mass change in grams**; a percentage-change graph needs that additional calculation and a different vertical-axis label.

Original 2025 Q03.1 [6], evaluation: recording before/after mass and using several concentrations are strengths. “Cubes” alone does not specify equal size. Blot before weighing to remove surface liquid; specify equal dimensions, time, temperature and volume to control competing effects; repeat at each concentration and calculate means to reduce random variation; use percentage change if starting masses differ. A high-level answer includes a strength, explained improvements and a supported judgement, not an unlinked checklist. More concentrations improve the detail of the response curve but do not replace repeats.

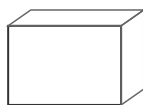
One workable teacher setup: 1 cm peeled cubes; $0.0\text{--}1.0$ mol/dm³ salt solutions in 0.2 steps; equal 30 mL volumes fully covering the cubes; 20 minutes at 20°C; three pieces per concentration. These are stated design choices, not values supplied by the original method.

Original 2024 Q05.1 [6], planning: a logical method must produce the displayed mean mass-change graph: before/after weighing, stated concentrations, controlled time/size/temperature, consistent blotting, repeats and means. “Evaluate” examines an existing method; “plan” supplies a reproducible sequence. A list of control-variable names alone is not either complete answer.

■ Surface area, volume and exchange

Teacher cubes: drawn side lengths are proportional; use the stated dimensions, not a ruler on a resized PDF. For a cube, six square faces give surface area; three dimensions give volume.

Side length: 2 mm

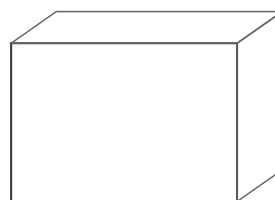


Surface area = 24 mm²

Volume = 8 mm³

SA:V = 3:1

Side length: 4 mm



Surface area = 96 mm²

Volume = 64 mm³

SA:V = 1.5:1

$$SA = 6a^2 \quad V = a^3 \quad R = \frac{SA}{V}$$

For side length a = 2 mm:

$$SA = 6(2 \text{ mm})^2 = 24 \text{ mm}^2$$

$$V = (2 \text{ mm})^3 = 8 \text{ mm}^3$$

$$R = \frac{24 \text{ mm}^2}{8 \text{ mm}^3} = 3 \text{ mm}^{-1}$$

For a = 4 mm, SA = 96 mm² and V = 64 mm³, so R = 1.5 mm⁻¹. The classroom shorthand SA:V is 3:1 versus 1.5:1 when numerical values use matching millimetre units. Doubling length multiplies area by four and volume by eight, halving SA per unit volume. The larger cube has **more total surface area**, but a **smaller ratio**.

A small single-celled organism can exchange enough through its cell surface. Large multicellular organisms have less surface area per unit volume and longer internal diffusion paths, so specialised exchange surfaces and transport systems meet demand. The cell surface is still an exchange surface: “no specialised organ” does not mean “no exchange”.

Adaptation	Effect
Large area	More exchange at once
Thin barrier	Short diffusion path
Blood supply	Maintains gradients; carries substances
Ventilation	Replaces air/water; maintains gas gradients

Examples: lungs and small intestine in mammals, fish gills, plant roots and leaves. Sheet Q3.3: numerous alveoli provide area; thin walls shorten the path; capillaries maintain gradients. Halving working alveoli reduces gas-exchange area and oxygen transfer rate; supply may fail to meet demand, prompting faster breathing. This does not mean each breath contains half the oxygen.

Checklist before you call this topic done

- Label animal, plant and bacterial cells; match every structure to its function.
- Specialised cells: one structural feature linked to one function each.
- Magnification, real size and image size – convert units before dividing.
- Aseptic technique whys; binary-fission counts; πr^2 zones (RP2).
- Cell cycle stages and where mitosis occurs; stem cell sources with benefits and risks.
- Diffusion, osmosis, active transport: direction, energy, examples; the three rate factors.
- SA:V calculations; four exchange-surface features; percentage change in mass (RP3).