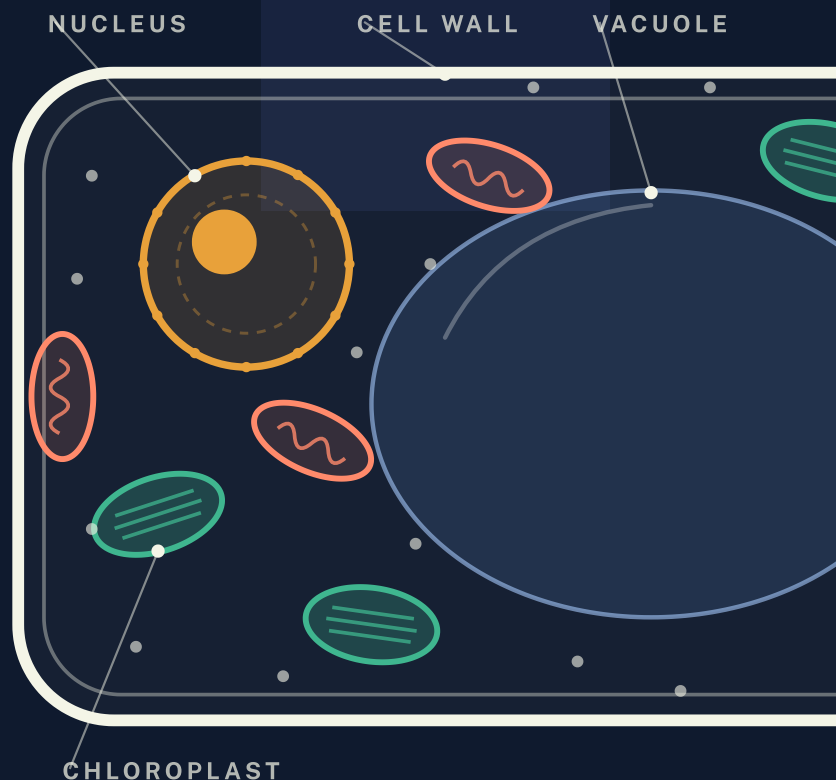


AQA GCSE BIOLOGY (8461) · PAPER 1

Biology Paper 1

Cells, organisation, infection and energy

Ten topics on two pages each: learn it, then use it. Exam questions marked in red pen, the graphs and calculations the paper really asks for, and a practice paper to finish.

**10**TOPICS, EACH ON TWO
PAGES**80**

KEY WORDS TO OWN

6

REQUIRED PRACTICALS

58MARKS IN THE PRACTICE
PAPER

Start here

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Two pages a topic

Learn it: sixty seconds of the topic, the facts with a circle to colour, key words, and a Spot it question on a sticky note.

Use it: a diagram or table, an exam question answered and marked in red pen, how it could be asked, a box to write from memory, and a quick-fire quiz.

Four steps, every time

Predict how much you'll remember. **Recall** with the page covered. **Check** in another colour and fill the circles. **Repair** the weakest part, then come back in two days.

Where it comes from

The facts follow AQA's specification (8461, version 1.0). The exam advice comes from AQA's own Paper 1 papers, mark schemes and examiners' reports (November 2021, June 2022, June 2023), plus AQA's command words list. No AQA question or mark scheme is reproduced: AQA's published marking points are used as sources and paraphrased, and every question here was written for this guide.

HT and Biology only

A red **HT** marks content the specification gives to Higher tier students only. A green **Biology only** marks content that is in GCSE Biology but not in Combined Science: Trilogy.

A four-week plan

Week 1: topics 1 to 3. **Week 2:** topics 4 to 7. **Week 3:** topics 8 to 10. **Week 4:** maths, graphs and practicals (pages 24 to 26), then the practice paper (pages 30 to 32). Come back to each topic two days later and again a week later. The tracker is on page 33.

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Know the exam

Paper 1 on one page

Paper 1	
Topics	1 to 4: Cell biology; Organisation; Infection and response; Bioenergetics
Exam	Written, 1 hour 45 minutes
Marks	100, which is 50% of the GCSE
Tiers	Foundation and Higher
Questions	Multiple choice, structured, closed short answer and open response

That is just over a minute a mark. Bring a ruler and a scientific calculator. Write in black ink, and use pencil only for drawing. Show your working: a correct answer from wrong working doesn't get full marks.

What the paper looks like

The Higher papers had seven questions in November 2021 and June 2022, and six in June 2023. Every question starts from one context, such as a plant drug, the heart, Salmonella, exercise, malaria or photosynthesis, and runs through several topics, so you'll switch topic mid-question.

At least 10% of the marks test maths, and a lot test practical skills: plotting, reading graphs, variables, controls, risk. About 60 marks need you to **use** what you know (AO2 and AO3), not just recall it (AO1, about 40).

Higher papers carry more marks for open and extended responses. Foundation papers have more multiple choice and short answers.

Paper 1 can borrow from Paper 2: AQA says cells, mitosis and meiosis, variation at fertilisation, photosynthesis, respiration and metabolism can appear in either paper. In 2023 it asked for three differences between sexual and asexual reproduction.

What the question word asks for

Word	AQA's meaning, shortened	What it looks like
Give · Name · Write	A short answer. No explanation or description.	"Pulmonary vein."
Describe	Recall facts, events or a process accurately.	First this, then this, finally this.
Explain	Make it clear, or state the reasons.	Point, because, so.
Compare	Similarities and or differences, not just one thing.	A does this, whereas B does that.
Calculate	Use the numbers in the question to work out the answer.	Formula, numbers with units, answer with unit.
Suggest	Apply what you know to a new situation.	Link a fact you know to the new context.
Evaluate	Use the information given and your own knowledge to weigh evidence for and against, then reach a judgement.	For, against, so overall.
Justify	Use evidence from the information supplied to support an answer.	Quote a figure, then say what it shows.
Predict · Estimate	A plausible outcome. An approximate value.	Read from the line, or round the numbers first.
Plot · Complete · Label	Mark data on a graph. Fill in a table or diagram. Name the parts.	Crosses, a ruler, a smooth line.
Plan · Design	Write a method. Set out how something will be done.	Variable, measurement, controls, steps, repeats.

Four marks or more: open response

These are worth four to six marks. Some are marked from a list of points. Others are marked by **levels**: two marks a level, and the examiner picks the level that best fits your whole answer. Level 3 wants relevant points, in detail, linked into a clear account. A statement that contradicts a correct one can stop you getting full marks. Plan for twenty seconds first.

Practise: worked six-mark answers are on pages 27 and 29.

Sources: AQA command words list; AQA, Our exams explained (GCSE science from summer 2018); AQA 8461 specification, papers and mark schemes (2021 to 2023). Check your own papers.

1 Inside the cell

Part one · Cell biology

Learn it

In sixty seconds

Plant and animal cells are eukaryotic: the DNA sits in a nucleus, with cytoplasm and a cell membrane around it. Plant cells add a cellulose wall, a permanent vacuole and often chloroplasts. Bacteria are prokaryotes: much smaller, no nucleus, DNA in one loop, sometimes with plasmids. Electron microscopes show more detail than light ones, and you'll need to work out a magnification.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Eukaryotic cells** (plant and animal) have a cell membrane, cytoplasm and genetic material enclosed in a **nucleus**.
- **Bacteria are prokaryotes** and much smaller. Their DNA is a single loop, not in a nucleus, and there may be small rings of DNA called **plasmids**. A cell wall surrounds the membrane.
- **Mitochondria** are where aerobic respiration takes place. **Ribosomes** make proteins. The **cell membrane** controls what goes in and out.
- Plant cells often also have **chloroplasts**, where photosynthesis happens, and a **permanent vacuole** of cell sap.
- Plant and algal cells have a **cellulose cell wall** that strengthens the cell. It doesn't stop water going in: it stops the cell bursting.
- A **specialised cell** has the sub-cellular structures its job needs. Animal examples: sperm, nerve, muscle. Plant examples: root hair, xylem, phloem.
- **Differentiation** is a cell becoming specialised. Most animal cells do it early. Many plant cells keep the ability for life. Adult animals divide cells mainly for repair and replacement.
- An **electron microscope** has much higher magnification and resolving power than a light microscope, so it shows sub-cellular structures in finer detail.
- **magnification = size of image ÷ size of real object**. Put both in the same unit before you divide, and use standard form for very big or small answers.
- 1 mm = 1000 µm and 1 µm = 1000 nm. Be ready to move between centi, milli, micro and nano.

Key words

- Eukaryote** a cell with its DNA enclosed in a nucleus. ☐
- Prokaryote** a cell with no nucleus, such as a bacterium. ☐
- Plasmid** a small ring of DNA found in bacteria. ☐
- Sub-cellular structure** a part inside a cell, such as a nucleus or ribosome. ☐
- Specialised cell** a cell adapted to do one job. ☐
- Differentiation** a cell becoming specialised. ☐
- Magnification** how many times bigger the image is than the real thing. ☐
- Resolving power** how much fine detail a microscope can show. ☐

Required practical 1. Use a thin layer of onion epidermis so you can see single cells, add iodine to stain the structures, and lower the cover slip at an angle so air bubbles don't get trapped. Focus with the focus wheel: it makes the image clear and doesn't change the magnification. Draw in pencil with continuous lines and no shading, don't overlap cells, label what you can, and add the magnification.

AQA's mark schemes refuse "mitochondria make energy", and "produce" or "create" too. Write that they're the site of aerobic respiration, or that they release energy.

Spot it Under the microscope

You see a cell with a cell wall and a nucleus, but no chloroplasts. Which cell could it be?

- (A) A palisade mesophyll cell from a leaf.
- (B) A bacterium from the soil.
- (C) A root hair cell, from underground where there's no light.

Cover this, choose, then read

C. A cell wall and a nucleus mean a plant cell. Root cells get no light, so they have no chloroplasts. Palisade cells are packed with them. A bacterium has no nucleus.

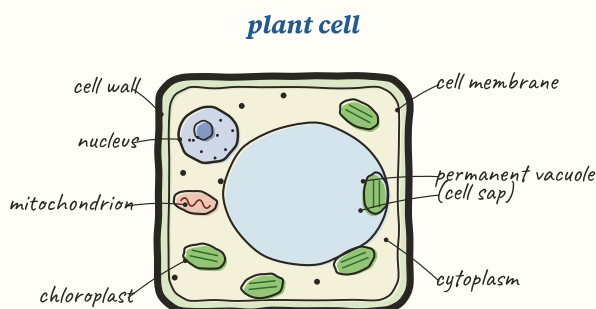
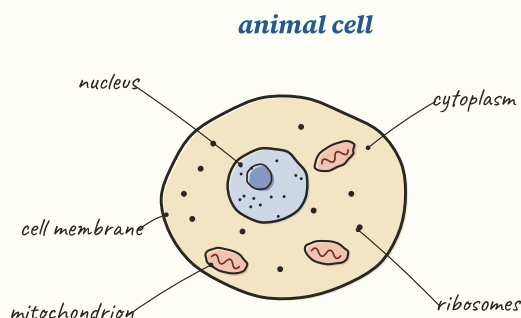
1

Part one · Cell biology

Inside the cell

Use it

Animal cell and plant cell, labelled the way you'd label them in an exam



Three kinds of cell compared

	Animal	Plant	Bacterium
Nucleus	yes	yes	no: the DNA is a single loop
Plasmids	no	no	sometimes
Cell wall	no	yes, cellulose	yes
Mitochondria	yes	yes	no
Chloroplasts	no	often	no
Permanent vacuole	no	yes	no

An image of a cell is 3.6 cm long. The magnification is $\times 1200$. Calculate the real length of the cell in micrometres (μm). [3 marks]

real size = image size $\div$ magnification ✓

3.6 cm = 36 mm, so $36 \div 1200 = 0.03 \text{ mm}$ ✓

$0.03 \text{ mm} \times 1000 = 30 \mu\text{m}$ ✓

3/3

1 for the rearranged formula. 2 for the working, in matching units. 3 for 30 μm . Unit conversion is where marks go: in 2023 many students stopped at grams when a question asked for milligrams. Do the conversion before you divide.

It could be asked as

- Label a plant, animal or bacterial cell and say what each part does.
- Describe differences between a bacterial cell and a eukaryotic cell (not size).
- Explain how a specialised cell's structure suits its job.
- Calculate magnification, real size or image size, including a unit conversion.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

1.1 Which part of a cell is the site of aerobic respiration?

1.2 Name two parts found in plant cells but not in animal cells.

1.3 Give two ways a bacterial cell differs from a plant cell, apart from size.

1.4 A cell is 0.05 mm wide and its image is 25 mm. What is the magnification?

2 Mitosis and stem cells

Part one · Cell biology

Learn it

In sixty seconds

Before a cell divides it grows and copies its DNA. In mitosis one set of chromosomes is pulled to each end and the nucleus divides. Then the cytoplasm and membrane divide, leaving two identical cells. Stem cells haven't differentiated yet, so they can still become other types of cell.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Chromosomes** are made of DNA molecules in the nucleus. Each carries a large number of **genes**. In body cells they normally come in pairs.
- The **cell cycle** has three overall stages: growth and copying, then mitosis, then the cytoplasm and membranes dividing.
- Before dividing, the cell **grows** and makes more sub-cellular structures, such as ribosomes and mitochondria. The DNA **replicates**, giving two copies of each chromosome.
- In **mitosis** one set of chromosomes is pulled to each end of the cell and the nucleus divides.
- Finally the cytoplasm and cell membranes divide, forming **two identical cells**. Each has the same set of chromosomes.
- Mitosis matters for growth and development of multicellular organisms. In mature animals it's mainly for **repair and replacement**.
- A **stem cell** is undifferentiated. It can make many more cells of its type, and some can differentiate into other cell types. Becoming specialised is called **differentiation**.
- Embryonic stem cells can be cloned and made into most human cell types. Adult **bone marrow** stem cells make many types, including blood cells. Plant **meristems** make any plant cell type, for life.
- **Therapeutic cloning** makes an embryo with the patient's genes, so the stem cells aren't rejected. Risks: viral infection can be passed on. Some people object on ethical or religious grounds.
- Meristem cells can clone plants quickly and cheaply: rare species, or crops with a useful feature such as disease resistance.

Key words

- Chromosome** a long molecule of DNA carrying many genes. ☐
- Gene** a section of DNA that carries instructions for a feature. ☐
- Cell cycle** the stages a cell goes through to divide. ☐
- Mitosis** the stage where the nucleus divides to make two identical nuclei. ☐
- Replicate** make an exact copy. ☐
- Stem cell** an undifferentiated cell that can become other cell types. ☐
- Meristem** plant tissue at the growing tips where stem cells are found. ☐
- Therapeutic cloning** making an embryo with the patient's genes to get matching stem cells. ☐

You need the three overall stages of the cell cycle, not the names of the phases inside mitosis. Stem cell treatment may help conditions such as diabetes and paralysis, so be ready to weigh the benefits, the risks and the ethics. Bacteria divide by **binary fission**, as often as every 20 minutes with enough nutrients. AQA's mark scheme refuses "mitosis" as the name.

If the question says DNA, examiners ignore "chromosomes" and "genetic material", and DNA "multiplying" or "reproducing" earns nothing. Say it's replicated. In 2023 they also wanted "one set of chromosomes pulled to each end": "chromosomes pull apart" and "DNA halves" weren't enough.

Spot it The rare orchid

A grower wants hundreds of identical copies of a rare plant, quickly and cheaply. She needs a part of the plant that can become any type of cell. What should she use?

- (A) Meristem tissue from a shoot tip.
- (B) Cells from the surface of a leaf.
- (C) Cells from a root hair of a mature plant.

Cover this, choose, then read

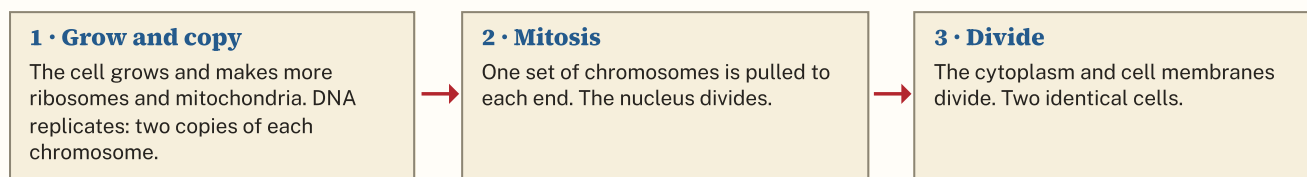
A. Meristems can become any type of plant cell throughout life. They're used to clone plants quickly and cheaply, and to protect rare species.

2 Part one · Cell biology

Mitosis and stem cells

Use it

The cell cycle in three steps, and where stem cells come from



Stem cells from	Can become	Use or issue
Human embryos	Most types of human cell, once cloned and made to differentiate.	Therapeutic cloning gives matching cells that aren't rejected. Some people object on ethical or religious grounds.
Adult bone marrow	Many types of cell, including blood cells.	Viral infection could be passed on.
Plant meristems	Any type of plant cell, for the plant's whole life.	Clone rare species. Clone crops with a useful feature, such as disease resistance.

Same idea, from Paper 2: sexual and asexual reproduction

	Sexual reproduction	Asexual reproduction
Parents	Two	One
Gametes	Two gametes join (fertilisation)	None
Offspring	Mixed genetic material, so genetic variation	No mixing: genetically identical
Cell division	Involves meiosis	Involves mitosis

Describe what happens to a cell's DNA and chromosomes between the start of the cell cycle and the formation of two new cells. [4 marks]

The DNA is replicated, so there are two copies of each chromosome ✓. One set of chromosomes is pulled to each end of the cell ✓ and the nucleus divides. The cytoplasm and cell membrane then divide ✓, forming two new cells that each have an identical set of chromosomes ✓.

4/4

Four marks, four steps: DNA copied, one set to each end, cytoplasm and membrane divide, identical sets. "Describe" only asks what happens, in order.

It could be asked as

- Describe the stages of the cell cycle, including mitosis.
- Explain why mitosis matters in a growing organism or when a cut heals.
- Evaluate the use of stem cells in medicine: a benefit, a risk and an ethical issue.
- Where are stem cells found in plants, and why do farmers like them?

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

- 2.1** Where in a cell are chromosomes found?
-
- 2.3** How many cells does one round of mitosis, with the cytoplasm dividing, produce from one cell?
-
- 2.5** What is the name for stem cells becoming specialised cells?
-

- 2.2** What happens to the DNA before a cell divides?
-
- 2.4** Name the plant tissue where stem cells are found.
-

3 Diffusion, osmosis and active transport

Learn it

In sixty seconds

Diffusion moves particles from a higher to a lower concentration, with no energy needed. Osmosis is diffusion of water from a dilute solution to a concentrated one through a partially permeable membrane. Active transport goes against the gradient and uses energy from respiration. Big organisms need exchange surfaces because their surface area to volume ratio is small.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Diffusion:** the net movement of particles from an area of higher concentration to an area of lower concentration. It moves oxygen and carbon dioxide in gas exchange, and the waste product **urea** from cells into the blood plasma.
- Diffusion is faster with a bigger **concentration gradient**, a higher **temperature** and a larger **surface area** of membrane.
- **Osmosis:** the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.
- **Active transport:** from a dilute to a more concentrated solution, against the concentration gradient. It needs **energy from respiration**.
- Active transport takes mineral ions into root hair cells from dilute soil water, and sugar from the gut into the blood.
- A single-celled organism has a large **surface area to volume ratio**, so enough molecules cross its surface to meet its needs.
- Larger organisms have a smaller ratio. Diffusion distances get too long, so they need **exchange surfaces** and a transport system.
- A good exchange surface has a large surface area, a thin membrane (short diffusion path), a good blood supply (animals) and, for gas exchange, ventilation.
- **Small intestine:** villi give a large surface area, thin walls and a rich blood supply. **Lungs:** millions of alveoli. **Gills:** many thin filaments, with water flowing over them. **Roots:** root hair cells. **Leaves:** flat and thin, with stomata.

Key words

- Diffusion** net movement from high to low concentration. No energy needed. ☐
- Concentration gradient** the difference in concentration between two places. ☐
- Osmosis** diffusion of water through a partially permeable membrane. ☐
- Partially permeable** lets some substances through but not others. ☐
- Active transport** moving substances against a gradient, using energy. ☐
- Surface area to volume ratio** surface area divided by volume. ☐
- Exchange surface** a surface where substances pass in or out. ☐
- Ventilated** having air moved in and out, as the lungs are. ☐

Required practical 3. Weigh pieces of plant tissue before and after a range of salt or sugar concentrations. Dry the surface first, or the liquid on it adds mass. An antibiotic that damages a bacterial cell wall makes the cell burst: water rushes in by osmosis and the weakened wall can't hold the pressure. A healthy plant cell takes in water too, but its wall holds it together.

Be careful with direction. "Water moves from high concentration to low concentration" is marked wrong unless you say you mean water, because examiners assume you mean the solute. The safe version: water moves from a dilute solution to a more concentrated one.

Spot it The potato chip

A potato chip of mass 4.0 g is left in a strong sugar solution. An hour later its mass is lower. Why?

- (A) Sugar left the chip by diffusion, down its concentration gradient.
- (B) Water left the chip by osmosis, into the more concentrated solution.
- (C) Water left the chip by active transport, using energy from respiration.

Cover this, choose, then read

B. The solution outside is more concentrated than the cell contents, so water moves out by osmosis through the partially permeable membrane. Osmosis needs no energy.

3 Part one · Cell biology

Diffusion, osmosis and active transport

Use it

Three ways across a membrane, and why size matters

	Diffusion	Osmosis	Active transport
What moves	Particles of a gas or solute	Water only	Ions, sugars and other substances
Direction	High to low concentration	Dilute to concentrated solution	Low to high concentration
Membrane	Cell membrane	Partially permeable membrane	Cell membrane
Energy from respiration?	No	No	Yes
Example	Oxygen into a cell. Urea out of a cell.	Water into root hair cells.	Ions into root hair cells. Sugar from gut to blood.

Surface area to volume ratio of a cube: the bigger it is, the smaller the ratio

Side	Surface area ($6 \times \text{side}^2$)	Volume (side^3)	Ratio SA : V
1 cm	6 cm ²	1 cm ³	6:1
2 cm	24 cm ²	8 cm ³	3:1
3 cm	54 cm ²	27 cm ³	2:1

A chip is left in a concentrated sugar solution and loses mass. Explain why.

[3 marks]

Water leaves the chip by osmosis ✓. It moves from a high concentration to a low concentration ✗ through the cell membrane ✗.

1/3

A student's answer, 1 out of 3. Osmosis earns the first mark. "High to low concentration" needs "water" or "dilute to concentrated", and "cell membrane" needs "partially permeable". Full marks: water leaves by osmosis, because the outside solution is more concentrated than the cell contents, through a partially permeable membrane.

It could be asked as

- Explain the difference between diffusion, osmosis and active transport.
- Explain why a large animal needs a transport system but a single-celled organism doesn't.
- Describe how the lungs, small intestine or a root hair cell is adapted for exchange.
- Calculate a percentage change in mass, and plot or read a graph of the results.

Cover both pages and write your sixty seconds from memory

predict ___ / 9 got ___ / 9

Quick-fire. Answers are on page 33

3.1 Which of the three processes needs energy from respiration?

3.3 Why does a single-celled organism not need a transport system?

3.2 Name three things that make diffusion faster.

3.4 Name the waste product that diffuses from cells into the blood plasma.

4 Enzymes and digestion

Part two · Organisation

*Learn it***In sixty seconds**

Digestive enzymes turn food into small, soluble molecules that can be absorbed into the blood. An enzyme speeds up one reaction because of the shape of its active site. Amylase breaks down starch, proteases break down proteins and lipases break down fats. Bile, made in the liver, neutralises stomach acid and emulsifies fat.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- A **tissue** is a group of cells with a similar structure and function. Tissues make **organs**, and organs work together as **organ systems**.
- **Enzymes** catalyse specific reactions in living organisms because of the shape of their **active site**. The “lock and key” idea is a simplified model: the substrate fits the active site and binds to it.
- Enzymes are proteins. A low temperature slows the reaction. Each enzyme has an **optimum** temperature and pH. Above the optimum, or at the wrong pH, the active site changes shape and the enzyme is **denatured**.
- **Carbohydrases** break down carbohydrates to simple sugars. **Amylase** is a carbohydrase that breaks down starch.
- **Proteases** break down proteins to amino acids. **Lipases** break down lipids (fats) to glycerol and fatty acids.
- Amylase is made in the salivary glands, pancreas and small intestine. Proteases: stomach, pancreas, small intestine. Lipases: pancreas and small intestine. AQA ignores “mouth” and marks “large intestine” wrong.
- **Bile** is made in the liver and stored in the gall bladder. It's alkaline, so it neutralises hydrochloric acid from the stomach.
- Bile also **emulsifies** fat into small droplets. The bigger surface area helps lipase break the fat down faster.
- The products of digestion are used to build new carbohydrates, lipids and proteins. Some glucose is used in respiration.
- **Food tests:** Benedict's reagent for sugars, iodine for starch, Biuret reagent for protein.

Key words

- | | |
|--|--------------------------|
| Enzyme a biological catalyst that speeds up a specific reaction. | ☐ |
| Active site the part of an enzyme where the substrate fits. | ☐ |
| Substrate the substance an enzyme acts on. | ☐ |
| Denatured the active site has changed shape, so the enzyme stops working. | ☐ |
| Carbohydrase an enzyme that breaks down carbohydrates. | ☐ |
| Emulsify break fat into small droplets. | ☐ |
| Bile alkaline liquid made in the liver. Stored in the gall bladder. | ☐ |
| Catalyst speeds up a reaction without being used up. | ☐ |

Required practical 5. Mix amylase and starch at each pH, test a drop with iodine every 30 seconds until it stops turning blue-black, and keep the temperature steady in a water bath. The time taken is what you measure, and the rate is $1 \div \text{time}$.

Examiners want “a group of similar cells with a similar function” for a tissue. “A group of cells working together” gets no mark. And enzymes aren't alive, so they're denatured, never “killed”. Bile isn't an enzyme: it emulsifies fat, and lipase breaks it down.

Spot it The wrong pH

Amylase works best at around neutral pH. A student mixes it with starch at pH 2, and ten minutes later the starch is still there. Why?

- (A) The amylase was used up before it reached the starch.
- (B) Amylase only breaks down protein, so the starch stayed.
- (C) The acid changed the shape of the active site, so the starch no longer fitted.

Cover this, choose, then read

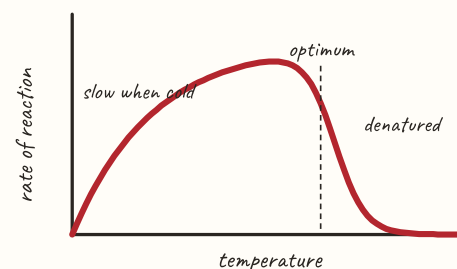
C. A pH far from the optimum changes the shape of the active site, so the substrate can't fit and the enzyme is denatured. Amylase breaks down starch, not protein.

4 Enzymes and digestion

Part two · Organisation

Use it**Enzymes: where they're made, what temperature does to them, and how to test the food**

Enzyme	Breaks down	To make	Made in
Amylase	Starch	Simple sugars	Salivary glands, pancreas, small intestine
Proteases	Proteins	Amino acids	Stomach, pancreas, small intestine
Lipases	Lipids (fats)	Glycerol and fatty acids	Pancreas, small intestine

**Food tests**

Test for	Reagent	Method	Positive result
Sugars	Benedict's	Heat with the food in a water bath.	Blue goes green, yellow, orange or brick red.
Starch	Iodine	Add a few drops.	Orange-brown goes blue-black.
Protein	Biuret	Add to the food solution.	Blue goes purple.

Explain why the rate of an enzyme-controlled reaction falls at a high temperature.

[4 marks]

Heat kills the enzyme **X**, so the substrate can no longer fit **✓**. The reaction stops **✓**.

2/4

A student's answer, 2 out of 4. Enzymes aren't alive, so "kills" earns nothing, and "stops" should be "slows down or stops". The marks it misses: the active site changes shape, and the enzyme is denatured. Full marks: the shape of the active site changes, the substrate no longer fits, the enzyme is denatured, so the rate falls.

It could be asked as

- Describe how bile helps the digestion of fat.
- Name the enzymes that break down starch, protein and fat, and the products.
- Describe how you'd test a food for starch, sugar and protein.
- Use the lock and key model to explain why an enzyme only works on one substrate.
- Explain the results of an enzyme experiment done at 5 °C, at 37 °C and at 80 °C.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33**4.1** Which enzyme breaks down starch?**4.2** Name the products when lipase breaks down fat.**4.3** Where is bile made, and where is it stored?**4.4** What colour does iodine turn if starch is present?

5 The heart and blood

Part two · Organisation

*Learn it***In sixty seconds**

The right ventricle pumps blood to the lungs. The left ventricle pumps it around the rest of the body. Arteries carry blood away from the heart, veins carry it back, and capillaries swap substances with cells. In coronary heart disease, fatty material narrows the coronary arteries that feed the heart muscle.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Double circulation:** the right ventricle pumps blood to the lungs for gas exchange. The left ventricle pumps blood around the rest of the body.
- Name these vessels: **aorta**, **vena cava**, **pulmonary artery**, **pulmonary vein** and the **coronary arteries**, which supply the heart muscle itself.
- A group of cells in the right atrium act as a **pacemaker** and control the resting heart rate. Artificial pacemakers correct irregular rhythms.
- The lungs: trachea, bronchi, **alveoli** and the capillary network around the alveoli. Alveoli give a large surface area, thin walls and a rich blood supply.
- **Arteries** have thicker walls with more muscle and elastic tissue, a narrower lumen and no valves. **Veins** have thinner walls, a wider lumen and valves. **Capillaries** are one cell thick.
- **Blood** is a tissue. **Plasma** carries red blood cells (a biconcave disc, no nucleus, full of haemoglobin to carry oxygen), white blood cells (defence) and platelets (clotting).
- In **coronary heart disease** fatty material builds up inside the coronary arteries and narrows them. Less blood reaches the heart muscle, so it gets less oxygen.
- **Stents** keep the coronary arteries open. **Statins** lower blood cholesterol, which slows the build-up of fatty material. They don't remove what's already there.
- Faulty valves (not opening fully, or leaking) can be replaced with biological or mechanical valves.
- In heart failure, a donor heart, or heart and lungs, can be transplanted. Artificial hearts keep patients alive while they wait, or let the heart rest.

Key words

Atrium	an upper chamber of the heart that receives blood.	☐
Ventricle	a lower chamber of the heart that pumps blood out.	☐
Artery	a vessel carrying blood away from the heart.	☐
Vein	a vessel carrying blood back to the heart.	☐
Capillary	a tiny vessel where substances are exchanged.	☐
Plasma	the liquid part of blood.	☐
Stent	a tube that holds an artery open.	☐
Statin	a drug that lowers blood cholesterol.	☐

Evaluate treatments by weighing benefits and risks: a drug (statins), a mechanical device (a stent or mechanical valve) or a transplant. The table on the next page gives the points. Blood flow rate = volume of blood ÷ time.

The coronary arteries feed the heart muscle itself, not the lungs or the body. Examiners saw that muddle a lot, and it kept students out of the top level. And a stent holds an artery open. It doesn't "unblock" it or take the fat away.

Spot it The thicker wall

The wall of the left ventricle is thicker than the wall of the right ventricle. Why?

- (A) It pumps blood around the whole body, so it needs more force.
- (B) It pumps blood to the lungs, which are a long way from the heart.
- (C) It holds more blood than the right ventricle, so its wall must be stronger.

Cover this, choose, then read

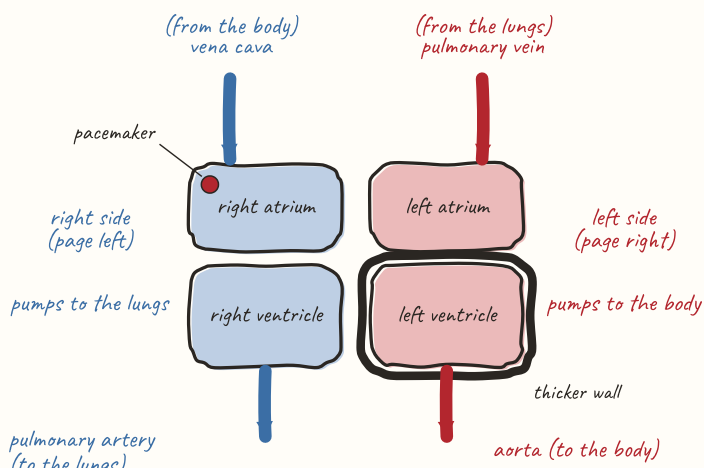
A. The left ventricle pumps blood around the rest of the body, so its muscular wall is thicker. The right ventricle only pumps blood to the lungs.

5 The heart and blood

Part two · Organisation

Use it

The double circulatory system, drawn so no vessels cross



Atria receive blood. **Ventricles** pump it out.

Right side: deoxygenated blood comes in from the body and goes to the lungs.

Left side: oxygenated blood comes in from the lungs and goes to the body.

Treating heart disease

Treatment	What it does	A drawback
Statins (drug)	Lower blood cholesterol, which slows the build-up of fatty material.	Taken for years. Can have side effects.
Stent (device)	Holds a coronary artery open, so blood flow is restored.	Needs surgery, which carries risk.
Bypass	Diverts blood around the blockage. AQA mark schemes credit it.	Major surgery.
Transplant or artificial heart	A donor heart replaces a failed one. An artificial heart keeps a patient alive while they wait.	Needs a donor. The body may reject it.

Compare the structure of an artery with the structure of a vein.

[3 marks]

An artery has thicker walls, with more muscle and more elastic tissue ✓, whereas a vein's walls are thinner ✓. An artery has a narrower lumen and no valves ✓, but a vein has a wide lumen and valves.

3/3

Any three of: thicker muscle, thicker elastic tissue, narrower lumen, no valves. Comparative words (thicker, narrower) score. "Cell walls" and "size of vessel" earned nothing in 2023.

It could be asked as

- Describe the path of blood through the heart and lungs.
- Compare arteries, veins and capillaries, or relate their structure to function.
- Explain what happens in coronary heart disease and how it can be treated.
- Evaluate statins, a stent or a transplant for a patient with heart disease.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

5.1 Which chamber pumps blood to the lungs?

5.2 Name the vessel that brings oxygenated blood from the lungs to the heart.

5.3 What do the coronary arteries supply?

5.4 What is the job of platelets?

5.5 Where is the heart's natural pacemaker?

6 Risk factors and cancer

Part two · Organisation

Learn it

In sixty seconds

A risk factor is linked to a higher rate of a disease. For some, a causal mechanism has been proven, and for others it hasn't. Diet, stress and life situations affect health too. Cancer starts with changes in cells that lead to uncontrolled growth and division. A benign tumour stays where it is. A malignant tumour invades and spreads.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Health** is the state of physical and mental well-being. Diet, stress and life situations can all affect it.
- Diseases can **interact**: a weak immune system means more infections; viruses living in cells can trigger some cancers; immune reactions can trigger allergies; severe physical illness can lead to depression.
- A **risk factor** is linked to a higher rate of a disease. It can be a lifestyle choice, or a substance in the body or environment.
- A **causal mechanism** has been proven for some risk factors but not for others. A link isn't proof of cause.
- Diet, smoking and exercise affect **cardiovascular disease**. Obesity is a risk factor for **Type 2 diabetes**.
- Alcohol affects the **liver** and brain function. Smoking affects lung disease and lung cancer. Smoking and alcohol both affect **unborn babies**.
- **Carcinogens**, including ionising radiation, are risk factors for cancer. Some cancers also have genetic risk factors.
- **Cancer** is caused by changes in cells that lead to uncontrolled growth and division.
- **Benign tumours** are growths of abnormal cells contained in one area, usually within a membrane. They don't invade other parts of the body.
- **Malignant tumour** cells are cancers. They invade neighbouring tissues and spread in the blood to form secondary tumours.

Key words

- Communicable** can be passed on, caused by a pathogen. ☐
- Non-communicable** can't be passed on, such as heart disease. ☐
- Risk factor** something linked to a higher chance of a disease. ☐
- Correlation** a link between two variables. ☐
- Causal mechanism** a proven way in which one thing causes another. ☐
- Carcinogen** something that can cause cancer. ☐
- Benign** a tumour that stays in one place. ☐
- Malignant** a tumour that invades and spreads. ☐

Be ready to discuss the cost of these diseases to an individual, a local community, a nation or the world, in human and financial terms. Many diseases have several causes working together, so be wary of blaming one.

A correlation shows a link, not a cause. Write "is linked to" unless a mechanism is given. And read the stem of a data question twice: in 2023 many students misread figures given as a percentage of another group. Under 100% means fewer cases, not more.

Spot it The scatter graph

A scatter diagram shows that countries with more smokers also have more lung cancer. What can you say?

- (A) It proves smoking causes lung cancer.
- (B) It shows that lung cancer makes people smoke.
- (C) It shows a correlation that supports smoking as a risk factor, but doesn't prove cause on its own.

Cover this, choose, then read

C. A scatter diagram shows a correlation. It supports a link but can't prove cause on its own: a causal mechanism is needed, and many diseases have several risk factors.

6 Risk factors and cancer

Part two · Organisation

Use it

Risk factors and what they affect

Risk factor	Linked to
Poor diet, smoking, lack of exercise	Cardiovascular disease
Obesity	Type 2 diabetes
Alcohol	Damage to the liver and to brain function
Smoking	Lung disease and lung cancer
Smoking and alcohol in pregnancy	Effects on the unborn baby
Carcinogens, including ionising radiation	Cancer

Two kinds of tumour

	Benign tumour	Malignant tumour
Where	Stays in one area, usually inside a membrane	Invades neighbouring tissues
Spread	Doesn't spread to other parts of the body	Spreads in the blood and forms secondary tumours
Is it cancer?	No	Yes

Describe the differences between a benign tumour and a malignant tumour.

[3 marks]

A benign tumour stays in one area, usually inside a membrane ✓, and doesn't invade other parts of the body. A malignant tumour is a cancer. Its cells invade neighbouring tissues ✓ and spread in the blood, forming secondary tumours ✓.

3/3

1 benign stays put. 2 malignant invades neighbouring tissue. 3 it spreads in the blood and forms secondary tumours. "Differences" means both sides.

It could be asked as

- Describe how smoking, alcohol or obesity affects health.
- Explain why a link between a risk factor and a disease doesn't prove a cause.
- Describe the differences between benign and malignant tumours.
- Interpret a graph, table or scatter diagram about disease and risk factors.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

6.1 What is a risk factor?

6.2 Name a risk factor for Type 2 diabetes.

6.3 Which kind of tumour spreads to other parts of the body?

7 Water and sugar in plants

Part two · Organisation

*Learn it***In sixty seconds**

Root hair cells take in water by osmosis and mineral ions by active transport. Xylem carries water and ions up to the leaves in the transpiration stream. Phloem carries dissolved sugars from the leaves to wherever the plant needs them: that's translocation. Stomata and guard cells control gas exchange and water loss.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Plant tissues:** epidermal, palisade mesophyll, spongy mesophyll, xylem and phloem, and **meristem** at the growing tips of shoots and roots.
- **Palisade mesophyll** cells are packed with chloroplasts for photosynthesis. **Spongy mesophyll** has air spaces for gases to diffuse through.
- **Root hair cells** are adapted for efficient uptake of water by osmosis and mineral ions by active transport.
- **Xylem** transports water and mineral ions from the roots to the stems and leaves. It's dead, hollow tubes strengthened by lignin.
- **Phloem** transports dissolved sugars, such as sucrose, from the leaves to the rest of the plant, for use or storage, in both directions. This is **translocation**.
- Phloem is tubes of elongated cells. Cell sap moves from one cell to the next through pores in the end walls.
- **Transpiration:** water moves up the xylem and evaporates from the leaves, mostly through the stomata. That flow is the transpiration stream.
- **Stomata** and their **guard cells** control gas exchange and water loss. They're wide open in bright light, to let carbon dioxide in, and nearly shut in the dark, to save water.
- Transpiration is faster with higher temperature, lower humidity, more air movement and higher light intensity.
- Measure the rate of transpiration by the **uptake of water**: rate = volume of water taken up ÷ time.

Key words

Epidermis the outer layer of cells covering the leaf.	☐
Palisade mesophyll leaf tissue with many chloroplasts. Most photosynthesis.	☐
Xylem tubes that carry water and mineral ions upwards.	☐
Phloem tubes that carry dissolved sugars.	☐
Translocation movement of sugars in the phloem.	☐
Transpiration loss of water vapour from the leaf, drawing water up.	☐
Stomata pores in the leaf. One pore is a stoma.	☐
Guard cells a pair of cells that open and close a stoma.	☐

You may be given stomata counts or a potometer. Expect to find a mean, plot a graph and calculate a rate. Explain how each factor changes the rate: don't just say that it does.

Don't write that phloem only takes food down. It carries dissolved sugars up and down, to wherever they're needed. Name the sugar: "food" isn't enough, and phloem doesn't carry ions. Transpiration needs no energy of its own.

Spot it The hot, windy day

On a hot, dry, windy day a plant loses water quickly. If its stomata close, what does that cost the plant?

- (A) Nothing: closing stomata only saves water.
- (B) Less carbon dioxide gets in, so photosynthesis falls.
- (C) Water uptake by osmosis stops.

Cover this, choose, then read

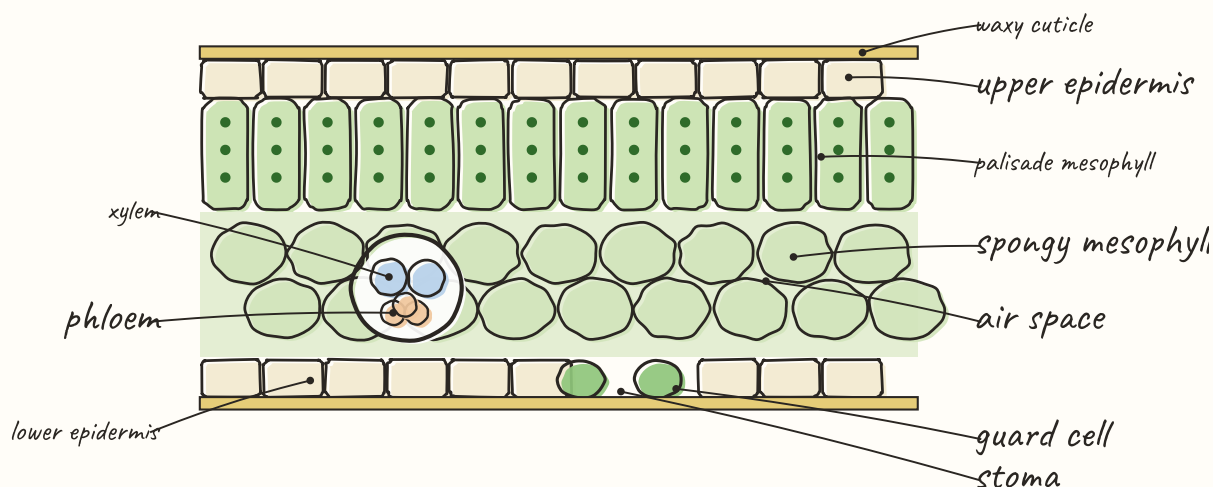
B. Stomata control gas exchange and water loss. Closing them saves water but cuts the carbon dioxide entering the leaf, so photosynthesis is reduced.

7 Part two · Organisation

Water and sugar in plants

Use it

A section through a leaf, and the two flows in a plant



Transpiration stream and translocation compared

	Transpiration stream	Translocation
Tissue	Xylem	Phloem
Carries	Water and mineral ions	Dissolved sugars, such as sucrose
Direction	Upwards	Up and down, to where it's needed
Cells	Dead, hollow tubes	Living cells with pores in the end walls
Energy	None needed	Needed (AQA's 2022 mark scheme allows this point)

Explain how a root hair cell is adapted to its function.

[3 marks]

A root hair cell has a long, thin extension that gives it a large surface area ✓, so water is taken in quickly by osmosis ✓. It has mitochondria that release energy by respiration ✓ for the active transport of mineral ions from the soil.

3/3

1 large surface area. 2 water in by osmosis. 3 mitochondria and energy for active transport of ions. Name the feature, then say what it lets the cell do.

It could be asked as

- Label a leaf section and describe the job of each tissue.
- Explain how temperature, humidity, air movement or light changes the rate of transpiration.
- Describe two differences between the transpiration stream and translocation.
- Explain why the stomata are open at midday and nearly closed at midnight.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

7.1 Which tissue carries water up a plant?

7.2 What is the movement of sugars in the phloem called?

7.3 What do guard cells control?

7.4 Why does a windy day increase transpiration?

8 Pathogens, defence and medicines

Learn it

In sixty seconds

Pathogens are viruses, bacteria, protists and fungi. Your skin, nose, trachea and bronchi, and stomach are non-specific defences. White blood cells do the rest by phagocytosis, antibody production and antitoxin production. A vaccine uses dead or inactive pathogen so antibodies are made fast next time. Antibiotics kill bacteria, not viruses.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **Pathogens** may be viruses, bacteria, protists or fungi. They infect plants or animals and spread by direct contact, by water or by air.
- Bacteria and viruses reproduce rapidly in the body. Bacteria **release toxins** that damage tissues. Viruses live and reproduce **inside cells**, damaging them.
- A **vector** is an organism that passes a pathogen from one host to another, as mosquitoes do for malaria.
- **Non-specific defences**: the skin, the nose, the trachea and bronchi, and the stomach.
- **White blood cells** defend you by phagocytosis, antibody production and antitoxin production.
- **Vaccination**: dead or inactive pathogen carries antigens that make white blood cells produce specific antibodies. Memory cells stay behind, so if the same pathogen returns the right antibodies are made quickly and in large numbers.
- If a large proportion of the population is immunised, the **spread of a pathogen** is reduced.
- **Antibiotics** such as penicillin kill bacteria inside the body. A specific antibiotic is needed for specific bacteria. They can't kill viruses, and **resistant** strains are a worry. **Painkillers** treat symptoms but don't kill pathogens.
- **Testing a new drug** for toxicity, efficacy and dose: preclinical tests on cells, tissues and animals, then clinical trials with very low doses first. Double blind trials use a placebo. Results are peer reviewed.

Key words

Pathogen	a microorganism that causes disease.	☐
Toxin	a poison released by bacteria.	☐
Vector	an organism that passes a pathogen on.	☐
Phagocytosis	a white blood cell engulfing and digesting a pathogen.	☐
Antibody	a protein made by white blood cells that binds to one antigen.	☐
Antigen	a molecule on a pathogen that triggers antibody production.	☐
Placebo	a dummy treatment containing no drug.	☐
Peer review	checking of results by other scientists before publication.	☐

HT **Biology only** **Monoclonal antibodies.** A mouse lymphocyte and a tumour cell make a hybridoma, which is cloned into many identical cells making one antibody, then collected and purified. Uses: pregnancy tests, measuring hormones, finding molecules in cells, carrying drugs to cancer cells. A test strip's control area shows the test has worked. **Drugs and spread.** Digitalis comes from foxgloves, aspirin from willow, penicillin from *Penicillium* mould. Trials use healthy volunteers and patients, and find the optimum dose. Spread is reduced by hygiene, vaccination, vector control (nets) and removing infected plants.

Resistant, never immune: resistant bacteria survive the antibiotic, and "the bacteria are immune" loses the mark. A mosquito is a vector, not a "carrier". And bacteria release or produce toxins: "toxins" on its own didn't score in 2023.

Spot it The cough

A child has a cold caused by a virus. A parent asks for antibiotics. What's the right answer?

- (A) No. Antibiotics can't kill viruses. Painkillers might ease the symptoms.
- (B) Yes. A short course of antibiotics will kill the virus.
- (C) Yes, if the doctor picks a stronger antibiotic.

Cover this, choose, then read

A. Antibiotics kill bacteria, not viruses. Painkillers only treat symptoms. A vaccine prevents a disease when it's given before infection.

8 Pathogens, defence and medicines

Part three · Infection and response

Use it

Seven diseases from the specification, and what protects plants

Disease	Pathogen	How it spreads	Key points
Measles	Virus	Droplets from sneezes and coughs	Fever and red skin rash. Most young children are vaccinated.
HIV	Virus	Sexual contact, or body fluids such as shared needles	Attacks immune cells. Antiretroviral drugs control it. Late stage is AIDS.
Tobacco mosaic virus	Virus (plants)	Not given in the specification	Mosaic discolouration on leaves, so less photosynthesis.
Salmonella	Bacterium	Eaten in food, or food prepared unhygienically	Fever, cramps, vomiting, diarrhoea. UK poultry are vaccinated.
Gonorrhoea	Bacterium	Sexual contact	Thick yellow or green discharge. Penicillin no longer works on many strains. Condoms reduce spread.
Rose black spot	Fungus (plants)	Water or wind	Purple or black spots, yellow leaves. Fungicide, or remove and destroy leaves.
Malaria	Protist	Mosquitoes (the vector)	Recurring fever. Stop mosquitoes breeding. Use nets.

Plant disease, ion deficiency and defences Biology only

What to know

Pathogens and pests	Tobacco mosaic virus (a virus), rose black spot (a fungus) and aphids (insects). HT Signs: stunted growth, spots, decay, growths, malformed leaves, discolouration, pests. Identify with a manual, a laboratory or monoclonal antibody test kits.
Ion deficiency	Nitrate ions make proteins: a lack gives stunted growth. Magnesium ions make chlorophyll: a lack gives chlorosis.
Defences	Physical: cellulose walls, waxy cuticle, dead layers such as bark. Chemical: antibacterial chemicals, poisons. Mechanical: thorns, hairs, leaves that curl or droop, mimicry.

A town vaccinates most of its children against measles. Explain how this protects the whole town, including children who haven't been vaccinated.

[4 marks]

The vaccine's dead or inactive virus makes white blood cells produce antibodies ✓. If a vaccinated child meets measles, the right antibodies are made quickly ✓, so far fewer people are infected and passing the virus on ✓. An unvaccinated child is then much less likely to meet it ✓.

4/4

Two halves: *how the vaccine protects one person* (marks 1 and 2), then *why fewer infected people protects everyone* (marks 3 and 4). In 2023, under 6% of students made that kind of link in a vaccination question, and vague "the body makes antibodies" earned little.

It could be asked as

- Describe how the body defends itself against pathogens.
- Explain how vaccination prevents illness, and why it protects people who aren't vaccinated.
- Explain why antibiotics treat bacterial disease but not viral disease.
- Describe how a new drug is tested before it's used.

Cover both pages and write your sixty seconds from memory

predict ___ / 9 got ___ / 9

Quick-fire. Answers are on page 33

8.1 Name the four types of pathogen.

8.2 Name three ways white blood cells defend the body.

8.3 What word describes an organism, such as a mosquito, that passes a pathogen on?

8.4 What does a memory cell let the body do?

9 Photosynthesis

Part four · Bioenergetics

Learn it

In sixty seconds

Photosynthesis is an endothermic reaction: light transfers energy from the environment to the chloroplasts. Carbon dioxide and water make glucose and oxygen. Temperature, light intensity, carbon dioxide concentration and the amount of chlorophyll all affect the rate. The glucose is used for respiration, stored as starch, made into fat or oil, made into cellulose for cell walls, or turned into amino acids for proteins.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- **carbon dioxide + water** → **glucose + oxygen**, using light. As symbols: $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$. AQA has asked students to complete this one.
- Photosynthesis is **endothermic**. Energy is transferred from the environment to the chloroplasts by light.
- Four factors affect the rate: **temperature**, **light intensity**, **carbon dioxide concentration** and the amount of **chlorophyll**.
- On a graph with one limiting factor, the rate rises then **levels off**. A straight rising section is a linear relationship ($y = mx + c$). If it starts at the origin, the rate is proportional.
- **HT** The factors **interact**, and any one of them may be the limiting factor. You may need to read graphs with two or three factors.
- **HT** **Inverse square law**: light intensity $\propto 1 \div \text{distance}^2$. Double the distance from the lamp and the intensity falls to a quarter.
- **HT** Greenhouse growers weigh the cost of extra heat, light or carbon dioxide against the extra growth, to keep a profit.
- Glucose is used for **respiration**, made into insoluble **starch** for storage, made into fat or oil, or made into **cellulose** for cell walls.
- Glucose also makes **amino acids** for proteins, together with nitrate ions absorbed from the soil.
- Chlorophyll absorbs mostly blue and red light and reflects green, so green leaves photosynthesise fastest in blue or red light and slowest in green.

Key words

- Photosynthesis** making glucose from carbon dioxide and water, using light. ☐
- Chlorophyll** the green substance that absorbs light. ☐
- Endothermic** takes in energy from the surroundings. ☐
- Limiting factor** the factor in shortest supply that holds the rate down. ☐
- Starch** an insoluble carbohydrate used for storage. ☐
- Cellulose** made from glucose. Strengthens cell walls. ☐
- Nitrate ions** taken from the soil. Used to make proteins. ☐
- Inverse square law** intensity falls with the square of the distance. ☐

Required practical 6. The specification uses pondweed: change the light intensity and measure the oxygen given off. A version AQA used in 2023 uses leaf discs: air is removed so the discs sink, sodium hydrogencarbonate solution supplies carbon dioxide, oxygen collects in the discs and makes them rise, and the time to rise is the measure. A coloured filter over the lamp changes the colour of the light.

Sodium hydrogencarbonate provides, or releases, carbon dioxide for photosynthesis. "It contains carbon dioxide" and "it provides water" didn't score in 2023. And light isn't a raw material: it's the energy source.

Spot it The flat line

The rate of photosynthesis rises as the light gets brighter, then stops rising even though the lamp is brighter still. What's going on?

- (A) The chlorophyll has been used up.
- (B) The light is too bright, so photosynthesis has stopped.
- (C) Another factor, such as carbon dioxide or temperature, is now limiting the rate.

Cover this, choose, then read

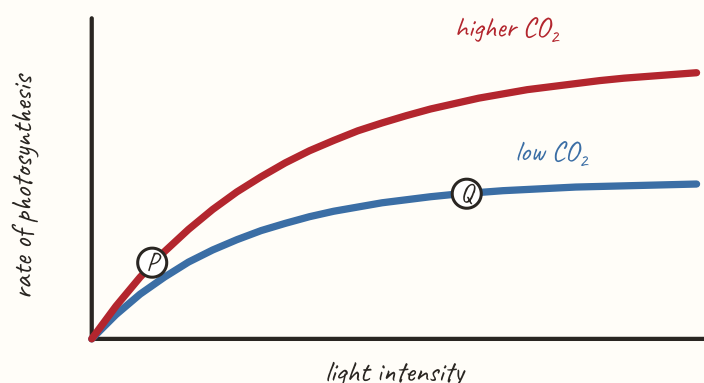
C. Once light isn't the limiting factor, something else holds the rate back. More light changes nothing until that factor improves.

9 Photosynthesis

Part four · Bioenergetics

Use it

Reading a limiting factor graph. At P light is limiting. At Q something else is.



At P the line is still rising. Light is the limiting factor, so more light means more photosynthesis.

At Q the line is flat. Light isn't limiting any more. Something else is: carbon dioxide, temperature or chlorophyll.

HT The red line levels off higher because there is more carbon dioxide. That shows carbon dioxide was the limiting factor on the blue line.

Distance and light intensity **HT**

Distance from lamp	10 cm	20 cm	30 cm
Relative intensity (100 at 10 cm)	100	25	11.1

Pondweed gives off 12 cm³ of oxygen in 4 minutes. Calculate the rate of photosynthesis.

[2 marks]

rate = volume ÷ time ✓

= 12 ÷ 4 = 3 ✗

1/2

A student's answer, 1 out of 2. The method is right, but the answer has no unit. A rate needs "per" in its unit. Full marks: 12 cm³ ÷ 4 min = 3 cm³ per minute.

It could be asked as

- Write the equation for photosynthesis in words or symbols, or complete it.
- Explain why the rate of photosynthesis levels off on a graph.
- Describe how you'd investigate the effect of light intensity, or colour, on photosynthesis.
- Explain how a grower could raise the yield of a greenhouse crop, and whether it's worth the cost.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

9.1 Name the two raw materials for photosynthesis.

9.2 Name the products of photosynthesis.

9.3 Name three factors that affect the rate of photosynthesis.

9.4 Which two substances does a plant use to make amino acids?

10 Part four · Bioenergetics Respiration and metabolism

Learn it

In sixty seconds

Respiration is exothermic and goes on all the time in living cells. Aerobic respiration uses oxygen. Anaerobic respiration doesn't, and transfers much less energy: in muscles it makes lactic acid, in plant and yeast cells ethanol and carbon dioxide. Metabolism is the sum of all the reactions in a cell or in the body.

Facts to know

Try it, then colour the circle: ● knew it ● shaky ○ missed

- ☐ Respiration is **exothermic** and goes on continuously in living cells. The energy transferred supplies all the energy needed for living processes.
- ☐ Organisms need energy for building larger molecules, for **movement** and for keeping warm.
- ☐ **Aerobic:** glucose + oxygen → carbon dioxide + water, or $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.
- ☐ **Anaerobic in muscles:** glucose → lactic acid. The oxidation of glucose is incomplete, so much less energy is transferred.
- ☐ **Anaerobic in plant and yeast cells:** glucose → ethanol + carbon dioxide. In yeast this is fermentation, used for bread and alcoholic drinks.
- ☐ In exercise, **heart rate, breathing rate and breath volume** increase, so muscles get more oxygenated blood.
- ☐ If too little oxygen arrives, muscles respire anaerobically. Lactic acid builds up and creates an **oxygen debt**. Long, hard exercise leads to muscle **fatigue**.
- ☐ **HT** Blood carries lactic acid to the liver, which converts it back to glucose. **Oxygen debt** is the extra oxygen needed afterwards to react with the lactic acid and remove it from cells.
- ☐ **Metabolism** is the sum of all the reactions in a cell or the body. Energy from respiration drives the enzyme-controlled reactions that build new molecules.
- ☐ Metabolism includes making starch, glycogen and cellulose from glucose; lipids from glycerol and three fatty acids; and proteins from amino acids. Excess protein is broken down to **urea**.

Key words

- Aerobic** using oxygen. ☐
- Anaerobic** without oxygen. ☐
- Exothermic** transfers energy to the surroundings. ☐
- Lactic acid** made in muscles by anaerobic respiration. ☐
- Fermentation** anaerobic respiration in yeast. ☐
- Oxygen debt** **HT** the extra oxygen needed after hard exercise. ☐
- Fatigue** muscles tire and stop contracting efficiently. ☐
- Metabolism** all the reactions in a cell or the body. ☐

Two effects of anaerobic respiration, each with its reason: **lactic acid builds up**, which causes fatigue; and, **HT** **breathing and heart rate stay high afterwards**, to supply the oxygen that breaks the lactic acid down. Less energy is released, so muscles contract less. Small organisms lose heat faster, because their surface area to volume ratio is large, so they respire more to keep warm.

"Energy is produced, made or created" is marked wrong: respiration releases or transfers energy, and it doesn't need energy to start. Plants respire too, all the time. "No oxygen is carried" fails: say less. And "pain, aches and stitch" aren't enough: say lactic acid builds up and causes fatigue.

Spot it The bubbling yeast

Yeast is added to sugar solution with no oxygen. Bubbles of gas appear. Which gas, and which process?

- ☐ (A) Oxygen, from aerobic respiration.
- ☐ (B) Carbon dioxide, from anaerobic respiration, also called fermentation.
- ☐ (C) Lactic acid, from anaerobic respiration.

Cover this, choose, then read

B. In yeast, anaerobic respiration makes ethanol and carbon dioxide. That's fermentation. Lactic acid is made in muscles, not in yeast.

10 Part four · Bioenergetics Respiration and metabolism

Use it

Respiration compared, and photosynthesis alongside it

	Aerobic	Anaerobic in muscles	Anaerobic in yeast
Oxygen needed?	Yes	No	No
Glucose goes to	Carbon dioxide and water	Lactic acid	Ethanol and carbon dioxide
Energy transferred	Much more	Much less (glucose only partly oxidised)	Much less

Photosynthesis and respiration are opposites

	Photosynthesis	Aerobic respiration
Uses	Carbon dioxide and water, with light	Glucose and oxygen
Makes	Glucose and oxygen	Carbon dioxide and water
Energy	Endothermic: takes energy in from light	Exothermic: transfers energy out
Where	In chloroplasts, in plants and algae	In living cells, all the time

Compare aerobic respiration with anaerobic respiration in muscles.

[4 marks]

Aerobic respiration needs oxygen, but anaerobic respiration doesn't ✓. Aerobic respiration makes carbon dioxide and water ✓, whereas anaerobic respiration in muscles makes lactic acid ✓. Anaerobic respiration produces less energy ✗.

3/4

A student's answer, 3 out of 4. Three comparisons are clear. The last loses its mark because respiration doesn't "produce" energy. Full marks: anaerobic respiration releases (transfers) much less energy, because the glucose is only partly oxidised. Use "whereas" or "but" so both sides are in each sentence.

It could be asked as

- Write the equation for aerobic respiration, or for anaerobic respiration in muscles or yeast.
- Explain two effects of anaerobic respiration on the body.
- Compare aerobic and anaerobic respiration.
- Explain why red blood cells bursting makes a person tired.

Cover both pages and write your sixty seconds from memory

predict ___ / 10 got ___ / 10

Quick-fire. Answers are on page 33

10.1 Is respiration endothermic or exothermic?

10.2 Name the product of anaerobic respiration in muscles.

10.3 Name the two products of anaerobic respiration in yeast.

10.4 Why does breathing rate rise during exercise?

Skills

The maths you need

Set every calculation out the same way: write the formula, put the numbers in with their units, calculate, then write the unit. Check it's sensible. Examiners give marks for each step, so show them all.

Magnification

Image 45 mm, real size 0.15 mm.
magnification = image ÷ real = $45 \div 0.15$

$$= \times 300$$

Rearranged: real size = image ÷ magnification. $36 \text{ mm} \div 1200 = 0.03 \text{ mm}$, which is $30 \text{ }\mu\text{m}$.

Changing units first

A plant extract holds 0.85 g of a chemical per 100 g of plant. How many mg in 400 g?

$$0.85 \div 100 \times 400 = 3.4 \text{ g, then } \times 1000$$

$$= 3400 \text{ mg}$$

In 2023 many students stopped at grams. Read the unit the question asks for.

Percentage change

A potato chip goes from 4.0 g to 3.4 g.
change ÷ original × 100 = $(3.4 - 4.0) \div 4.0 \times 100$

$$= -15\%$$

A negative answer is a loss. Always divide by the starting value.

Rate

Pondweed gives off 24 cm^3 of oxygen in 6 minutes.
rate = amount ÷ time = $24 \div 6$

$$= 4 \text{ cm}^3 \text{ per minute}$$

Transpiration, enzyme and blood flow rates work the same way. Write the unit with "per".

Mean, ignoring an anomaly

Five repeats: 12, 14, 13, 25, 13.
25 is far from the rest, so leave it out: $(12 + 14 + 13 + 13) \div 4$

$$= 13$$

Say why you left it out: it looks like a measuring error. Median is the middle value, mode the most common.

Cells dividing

A bacterium divides every 20 minutes. In 2 hours: $120 \div 20 = 6$ divisions, so $2^6 = 64$ bacteria.

A cell divides every 45 minutes. Divisions in 6 hours: $360 \div 45 = 8$, so $2^8 = 256$ cells.

$$64 \text{ bacteria} \cdot 256 \text{ cells}$$

Biology only Start with 100 bacteria: $100 \times 64 = 6400$. **HT**
Write it as 6.4×10^3 .

Area of a clear zone

A zone of inhibition is 12 mm across, so its radius is 6 mm.
area = $\pi r^2 = 3.14 \times 6 \times 6$

$$= 113 \text{ mm}^2$$

Halve the diameter first. Use the π the question gives, not your calculator's button, and don't subtract the disc. Required practical 2.

Standard form on a calculator

Surface area $3.2 \times 10^{-3} \text{ m}^2$, volume $1.6 \times 10^{-5} \text{ m}^3$.
ratio = surface area ÷ volume

$$= 200 : 1$$

Use the $\times 10^x$ or EXP key, and don't type " $\times 10$ " by hand. Estimate first: $3 \div 1.6$ is about 2, and $10^{-3} \div 10^{-5}$ is 100.

Rate from a curve

Draw a tangent where you want the rate. Read two points on it: (2 min, 6 cm^3) and (10 min, 14 cm^3).

$$\text{gradient} = (14 - 6) \div (10 - 2)$$

$$= 1 \text{ cm}^3 \text{ per minute}$$

Subtract both readings. The tangent doesn't start at zero. AQA's 2021 paper marked this at four marks.

Size and rounding

A plant cell $100 \text{ }\mu\text{m}$ wide and a bacterium $1 \text{ }\mu\text{m}$ wide differ by 100 times. 73.77... to 2 significant figures is 74.

0.03612 to 2 significant figures

$$\text{two orders of magnitude} \cdot 0.036$$

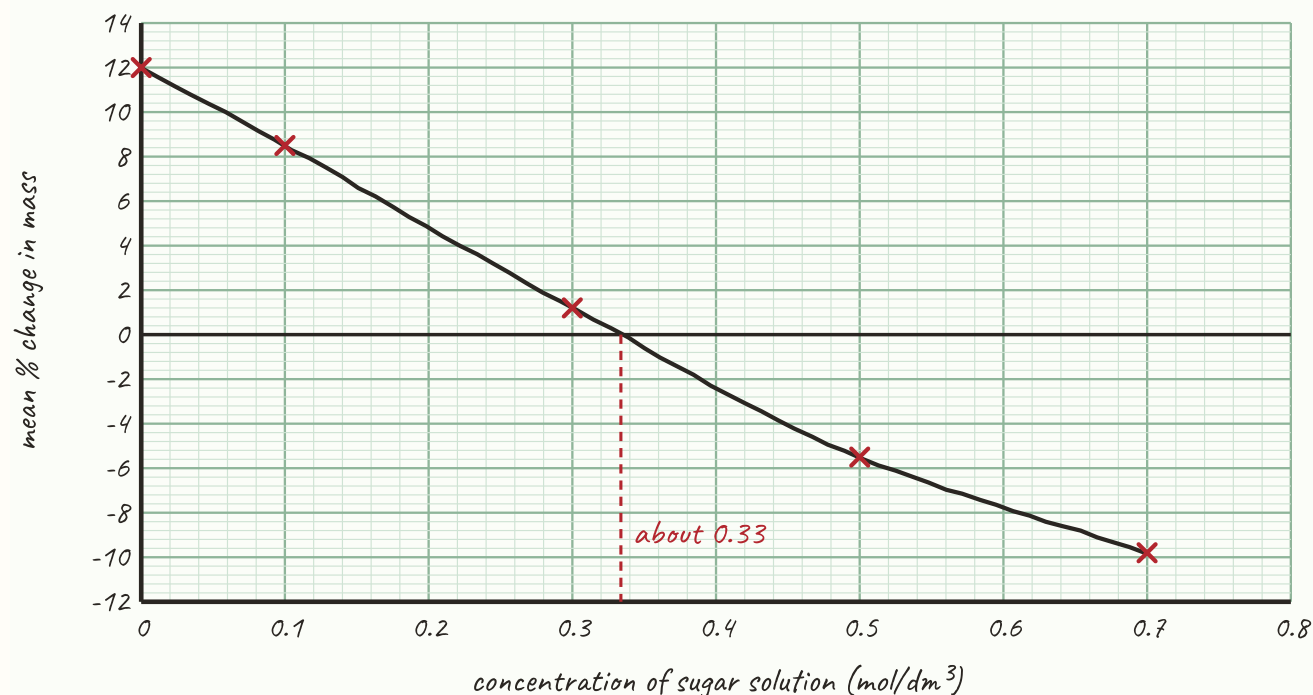
Each order of magnitude is a factor of ten. Compare standard form by the power first: 10^{-3} is bigger than 10^{-4} .

Skills

Graphs and data

Plotted the way an examiner wants it. The sugar concentrations are made up for practice.

Concentration (mol/dm ³)	0	0.1	0.3	0.5	0.7
Mean % change in mass	+12	+8.5	+1.2	-5.5	-9.8



Plotting

- Independent variable on the x-axis. Label both axes with the quantity and the unit.
- A scale that fills more than half the grid, in even steps. Not 3s, not 7s.
- Mark each point with a small cross. A big blob or a tiny dot is hard to judge.
- Check the x-values. They're often not evenly spaced, so don't space them evenly.
- Draw one smooth line of best fit with a sharp pencil, within half a small square of the points: a curve if they curve, a straight line if they don't. Not dot to dot.

Reading

Rule construction lines from the axes. Here the line crosses zero at about 0.33: no net movement of water, so the cell contents have that concentration. Read to the nearest half small square.

Describing a trend

Say what happens to one variable as the other changes, and quote numbers from both ends: "as concentration rises from 0.0 to 0.7, the mean change falls from +12.0% to -9.8%." Don't just list the figures, and don't write "going down the table" or "getting fatter": use the names and the numbers. Use "correlation" or "proportional" only if you're sure.

Percentages of a control

When results are given as a percentage of another group, 100% means no difference. 63% means 37% fewer cases.

Samples and charts

A bigger, random sample is more reliable. Use a bar chart for categories and a line graph for continuous data. A scatter diagram shows a correlation, not a cause.

Straight sections

A straight line through the origin, such as the start of a light intensity graph, means the rate is proportional ($y = mx + c$ with $c = 0$). A flat section means another factor is limiting. To find the rate at one moment on a curve, draw a tangent, then $\text{gradient} = \text{change in } y \div \text{change in } x$. Subtract both readings: the tangent doesn't start at zero.

Skills

The six required practicals

Practical skills are marked on every paper, so expect to be asked how you'd run, plan or improve these. The aim is as the specification words it. The rest is what AQA's papers have asked about each one.

Practical	The aim	What gets asked
1 Microscopy	Observe, draw and label plant and animal cells, with a magnification scale. Thin layer of onion epidermis, iodine stain, cover slip lowered at an angle. Use the focus wheel to make the image clear: it doesn't change the magnification.	Why thin (see single cells), why iodine (stain the structures), why the angle (no air bubbles). Risk assessment: iodine irritates (wash skin or wear gloves); a sharp knife cuts (cut away from you, on a board). Drawing: continuous lines, no shading, no overlap, labels, magnification.
2 Antibiotics on bacteria Biology only	Investigate antiseptics or antibiotics on bacterial growth using agar plates and zones of inhibition.	Aseptic technique: disinfect surfaces, sterilise the dish and agar before use, flame the inoculating loop, work near a flame, tilt the lid when adding discs, secure the lid with adhesive tape and store the dish upside down. A disc with no antibiotic is the control. Bigger clear zone, more effective: compare areas (πr^2). 25 °C in schools because 37 °C is body temperature and favours human pathogens.
3 Osmosis	Investigate a range of salt or sugar concentrations on the mass of plant tissue.	Independent variable: concentration. Dry the surface before weighing, or liquid adds mass. Percentage change. Plot it: where the line crosses zero is the concentration of the cell contents.
4 Food tests	Use qualitative reagents on carbohydrates, lipids and proteins.	Benedict's (heat) for sugars. Iodine for starch. Biuret for protein (it turns purple).
5 pH and amylase	Effect of pH on the rate of reaction of amylase. Continuous sampling.	Iodine every 30 seconds, until it stays orange-brown. Water bath for temperature. Time taken is the measure. Rate = $1 \div \text{time}$.
6 Light and photosynthesis	Effect of light intensity on the rate of photosynthesis with an aquatic organism such as pondweed.	Vary the lamp distance. Count bubbles or measure oxygen. Leaf-disc version: remove the air so discs sink, sodium hydrogencarbonate supplies carbon dioxide, oxygen makes them rise, time to rise is the measure.

Words for a fair test

Word	Meaning	Example
Independent variable	The one thing you change.	pH, lamp distance, sugar concentration
Dependent variable	What you measure.	Time for starch to go, time for discs to rise, change in mass
Control variable	Everything you keep the same.	Temperature, volumes, size of the potato piece
A control	A comparison that shows what happened without the factor. It's not a control variable.	A disc with no antibiotic
Repeatable · reproducible	Same person gets similar results again · different people with different kit do.	Repeat three times and find a mean
Accurate · precise	Close to the true value · closely clustered.	A result can be precise but not accurate

Errors. Random error makes results vary unpredictably, so take more measurements and use a mean. Systematic error shifts every result by the same amount. Look at anomalous results: if they come from a poor measurement, ignore them.

Growing bacteria (**Biology only**). They multiply by binary fission as often as every 20 minutes if they have nutrients and a suitable temperature, in nutrient broth or on an agar plate.

Skills

Plan an investigation: the six-mark question

AQA marks these on levels. Level 3 is a method that would lead to a **valid** outcome (it measures what it claims to, with other variables controlled), with the key steps in a logical order. Level 2 has most steps but wouldn't quite give a valid result, or the order is shaky. Level 1 has a few relevant steps with no links.

In 2023, the main thing holding students back was using one athlete. One person can't give a valid result. Some forgot to measure the heart rate before the exercise.

The recipe

1. **Change one thing.** Say what you'll change and the range: at least five values.
2. **Measure one thing.** Say what you'll measure, with the unit, the equipment, and how often.
3. **Keep the rest the same.** Name three variables and how you'll hold each one.
4. **Write the method in order.** Numbered steps someone else could follow.
5. **Repeat.** Repeat each value and find a mean, or use a large group.
6. **Stay safe.** One hazard, and what you'll do about it.
7. **Say what you'll do with the results.** A table, a graph, and what pattern would answer the question.

Plan an investigation to find out how pH affects the time amylase takes to digest starch.

[6 marks]

1. Use five pH buffers, for example pH 3, 5, 7, 9 and 11 ✓.
2. Put 5 cm³ of starch solution and 2 cm³ of one buffer in a test tube. Stand it in a water bath at 30 °C, and keep the volumes and concentrations of starch and amylase the same each time ✓.
3. Add 1 cm³ of amylase, start a stopwatch, and mix ✓.
4. Every 30 seconds, take a drop of the mixture and add it to iodine solution on a spotting tile ✓.
5. When the iodine stays orange-brown there is no starch left. Record the time taken ✓.
6. Repeat three times at each pH and work out a mean time ✓.
7. Wear eye protection. Plot mean time against pH. The shortest time shows the optimum pH.

Level 3

1 independent variable and range. 2 controls: temperature, volumes, concentrations. 3 and 4 the method, in order, with iodine every 30 seconds. 5 the measurement, taken from the colour change. 6 repeats and a mean. Step 7 is a bonus. The volumes and 30 °C are example values: any sensible ones work.

A different shape: compare three mouthwashes on bacteria

Spread the same bacterium over three agar plates, using aseptic technique. On each plate put a disc soaked in one mouthwash (same volume, same size of disc), plus a disc soaked in water as the control. Tape the lid on, store the plates upside down and incubate at 25 °C for the same time. Measure the diameter of each clear zone (or work out its area with πr^2), repeat three times, and compare the means. Keep the bacterium, volumes, incubation time and temperature the same. Use a group or several repeats: examiners marked down plans that relied on one subject.

Your turn

Plan one of these in six minutes, then check it against the recipe: **(a)** the effect of light colour on photosynthesis in leaf discs; **(b)** the effect of temperature on how fast an enzyme digests starch; **(c)** the effect of antiseptic strength on bacterial growth.

Skills

What AQA's examiners saw students get wrong

These come from AQA's Reports on the Examination for the Higher paper (November 2021, June 2023) and the “do not accept” lines in its mark schemes and specimen. They're paraphrased. The struck-through words are what students wrote. The green words are what earns the mark.

Biased reports. Many reasons were given. ~~Not peer reviewed~~ and ~~no double blind trial~~ scored nothing. Only one idea counted: someone gains or loses money.

Enzyme sites. ~~Mouth~~ and ~~large intestine~~ for where amylase is made. Salivary glands, pancreas, small intestine.

Tissue. ~~A group of cells working together~~ earned nothing. A group of similar cells with a similar function.

Stem cells in a root. Not ~~root hairs~~ or ~~xylem~~. Meristem.

Where drugs come from. Students swapped them. Aspirin comes from willow. Foxgloves give digitalis.

Units. Many stopped at grams when the question asked for milligrams. Convert, and show every step. A wrong conversion factor still kept the later mark.

Drug trials. ~~Efficiency~~. Toxicity and side effects are one point, not two. Efficacy. Toxicity. Dose.

Artery and vein. ~~Cell walls~~ and ~~size of vessel~~ scored nothing. Thicker muscle, thicker elastic tissue, narrower lumen, no valves. Use comparatives.

Graphs. Blobs for points, wrongly spaced x-values, dot-to-dot lines, feathery lines. Small crosses. Check the x-values. A smooth curve within half a small square.

Coronary arteries. Students said they take blood ~~to the lungs~~ or ~~around the body~~. They supply the heart muscle. “Heart attack” alone only reached Level 1.

Statins and stents. ~~Break down the deposits~~. ~~Unblock the artery~~. Statins lower cholesterol and slow the build-up. A stent holds the artery open.

Salmonella symptoms. Just ~~toxins~~. Bacteria release or produce toxins.

Vaccination. Memory cells called antibodies. Antibodies said to make white blood cells. Specific antibodies, made quickly and in large numbers on the second exposure.

Aseptic technique. ~~Sterilise equipment~~ and ~~flame equipment~~ were too vague. Flame the inoculating loop. Sterilise the dish and agar before use. Tilt the lid. Tape it.

37 °C and 25 °C. Only 1% got all three marks. 37 °C is body temperature. 25 °C avoids growing bacteria harmful to humans.

A control. ~~Control variable~~ for the disc with no antibiotic. It's a control: it shows the antibiotic caused the clear zone.

Resistance. ~~The bacteria become immune~~. The bacteria are resistant.

Osmosis. ~~Water moves from high concentration to low concentration~~. Antibiotic said to enter by osmosis. Water moves from dilute to concentrated. Water enters the damaged cell and bursts it.

Anaerobic respiration. ~~Pain, aches, stitch~~. Oxygen debt named but not repaid. Lactic acid causes fatigue. Less energy means weaker contractions. **HT** Breathing stays fast to repay the oxygen debt.

Energy. ~~Produced, made or created~~ lost the mark in 2021, 2022 and 2023. So did ~~respiration needs energy~~. Released, or transferred.

Designing a test. ~~One athlete~~. No heart rate measured before. A group, at least two exercises, before and after, a mean.

Monoclonal antibodies. The ~~lymphocyte~~ cloned. ~~Divides by mitosis~~ scored nothing. The hybridoma is cloned. All cells make the same antibody. It's collected and purified.

Malaria. ~~Carrier~~ and ~~communicable disease~~. A vector.

Burst red blood cells. ~~No oxygen is carried~~. Less oxygen is carried, so less respiration, so less energy is released.

Cell wall. ~~Stops water going in~~. Students used it to explain why a plant cell doesn't burst, then got the job backwards. It strengthens the cell, so the cell doesn't burst.

Binary fission. ~~Mitosis~~ for how bacteria divide (specimen mark scheme). Binary fission.

Mitosis and DNA. DNA ~~multiplying~~. In 2023, ~~chromosomes pull apart~~ and ~~DNA halves~~ were too vague. DNA is replicated. One set of chromosomes is pulled to each end.

Leaf discs. Sodium hydrogencarbonate ~~contains~~ carbon dioxide, or ~~provides water~~. It releases carbon dioxide, which is used in photosynthesis.

Skills

Two six-mark answers, marked

Plan for twenty seconds, then write linked sentences. The red ticks show where the points are. Both answers were written for this guide to meet the top-level description.

Explain why a person with a partly blocked coronary artery gets tired and short of breath when they run. [6 marks]

Fatty material has narrowed the coronary artery, so less blood reaches the heart muscle ✓. Less oxygen and glucose arrive ✓, so the heart muscle does less aerobic respiration and releases less energy ✓. The heart then contracts less strongly and pumps less blood to the rest of the body ✓. The body's muscles get less oxygen too, so they respire anaerobically ✓, and lactic acid builds up and causes fatigue ✓. Less carbon dioxide is removed, so breathing speeds up and the person feels short of breath. **HT** Breathing stays fast afterwards to supply the oxygen that breaks the lactic acid down.

Level 3

The "so" chain. Each sentence hands a result to the next: blocked artery, less blood, less oxygen and glucose, less respiration, less energy, weaker contraction, anaerobic respiration, lactic acid, fatigue. A Level 1 answer just says "less blood, heart attack".

Evaluate whether a student should choose the sausage roll or the pasty for a regular lunch. Use the data and your own knowledge. [6 marks]

per 100 g (invented data)	Energy	Protein	Saturated fat	Sugar	Fibre
Sausage roll	1150 kJ	9.5 g	7.0 g	1.5 g	1.2 g
Bean and vegetable pasty	790 kJ	5.5 g	1.8 g	4.0 g	4.5 g

The sausage roll has nearly twice the protein of the pasty, which the body needs for growth ✓. But it has almost four times the saturated fat and more energy, so eating it often could lead to obesity, a risk factor for Type 2 diabetes ✓, and the fat could build up in the coronary arteries and cause coronary heart disease ✓. The pasty has nearly four times the fibre, which helps digestion ✓, though it has more sugar, which also adds energy ✓. **Overall**, the pasty is the better choice for most days, and the sausage roll is fine now and then ✓.

Level 3

Data, then knowledge. Quote the table, then use what you know: saturated fat leads to obesity and Type 2 diabetes and to coronary heart disease, fibre helps digestion, protein is for growth. Level 3 needs a judgement that those reasons support.

The coronary artery question at three levels

Level 1 (1 to 2 marks). "The artery is blocked so less blood gets to the heart and they have a heart attack. They get tired." Points are stated, but nothing links them.

Level 2 (3 to 4 marks). "Less blood reaches the heart muscle, so it gets less oxygen. So there is less respiration and less energy, and the person gets tired." Linked, but it stops at the heart and says nothing about lactic acid or the rest of the body.

Level 3 (5 to 6 marks). The answer above: the whole chain, with the effect on the body as well as the heart.

Your turn

Cover the answers. Write one in six minutes, then mark yourself: did every sentence do something, and did the last one reach a judgement? Do the other one two days later.

Practice

Practice paper, part one

58 marks over three pages, about 61 minutes. Written for this guide, with invented data. Mark it on pages 33–34.

1 Tick one box for each question. [1 mark each] *[4]*

1.1 Which part of an animal cell contains the genetic material?

☐ A cell membrane

☐ B mitochondrion

☐ C nucleus

☐ D ribosome

1.3 Which enzyme breaks down fats?

☐ A amylase

☐ B lipase

☐ C protease

☐ D carbohydrase

1.2 Which process moves water from a dilute solution to a concentrated one through a partially permeable membrane?

☐ A active transport

☐ B diffusion

☐ C osmosis

☐ D translocation

1.4 Which blood vessel carries blood from the heart to the lungs?

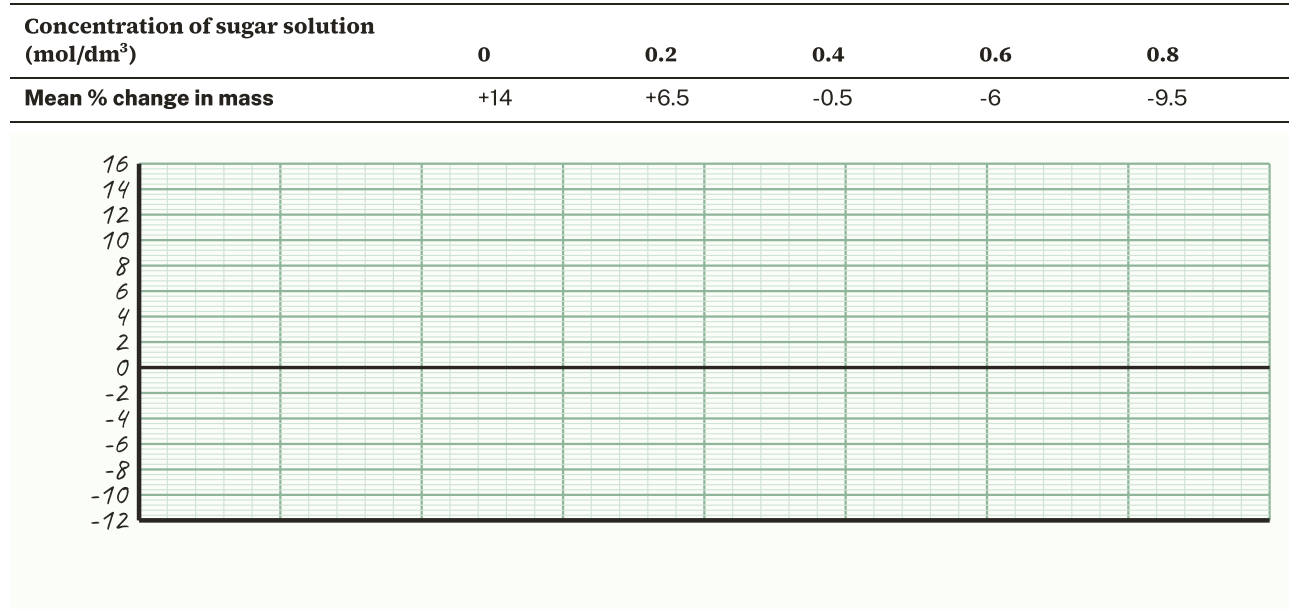
☐ A aorta

☐ B pulmonary vein

☐ C vena cava

☐ D pulmonary artery

2.1 A student put pieces of potato in sugar solutions and found the mean percentage change in mass. Complete the graph: label the x-axis and choose a scale for it, plot the data and draw a line of best fit. *[4]*



2.2 Use your graph to find the concentration of sugar solution that is the same as the concentration inside the potato cells. *[1]*

2.3 A potato piece went from 3.0 g to 3.3 g. Calculate the percentage increase in mass. *[2]*

2.4 Explain why potato pieces in the strongest solution lost mass. *[3]*

Practice

Practice paper, part two

- 3.1** A drawing of a cell is 4.5 cm long. The magnification is $\times 300$. Calculate the real length of the cell in micrometres (μm). [3]

- 3.2** A bacterium divides every 20 minutes. How many bacteria will there be after 2 hours, starting with one? [2]

--

- 3.3** Give one difference between a plant cell and a bacterial cell. Don't refer to size. [1]

--

- 4.1** Describe how bile helps the digestion of fat. [3]

- 4.2** A patient has a blocked coronary artery. Explain how a stent helps. [2]

- 4.3** Explain how statins reduce the risk of coronary heart disease. [2]

- 5.1** Three paper discs are on an agar plate covered in bacteria. Disc A has antibiotic X and a clear zone of radius 12 mm. Disc B has antibiotic Y and a clear zone of radius 5 mm. Disc C has no antibiotic and no clear zone. What was the purpose of disc C? [1]

--

- 5.2** Which antibiotic is more effective? How do you know? [2]

- 5.3** Calculate the area of the clear zone around disc A. Use $\text{area} = \pi r^2$, with $\pi = 3.14$. [2]

- 5.4** School students incubate the plate at 25 °C. Explain why not 37 °C. [2]

- 6** A gardener's tomato plants have stunted growth and yellow leaves. Stunted growth can come from a lack of nitrate ions, and yellow leaves from a lack of magnesium ions. Explain how each deficiency causes its sign. [6]

Practice

Practice paper, part three

- 7.1** A student moved a lamp away from some pondweed and counted the oxygen given off. Name the independent variable and the dependent variable. [2]

- 7.2** At 10 cm the pondweed gave off 36 cm³ of oxygen in 6 minutes. Calculate the rate of photosynthesis. [2]

- 7.3** Explain why the rate fell as the lamp moved further away. [2]

- 7.4** Complete the symbol equation for photosynthesis. $6\text{CO}_2 + 6 \text{ ----- } \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ ----- }$ [1]

- 7.5** **HT** The lamp was moved from 10 cm to 20 cm. By what factor did the light intensity change? [1]

--

- 8.1** Write the word equation for anaerobic respiration in muscles. [1]

--

- 8.2** Explain why a runner's heart rate rises during a race. [3]

- 9** A town started a measles vaccination programme. The table shows what happened. Evaluate the case for the programme. Use the data and your own knowledge. (The data is invented for practice.) [6]

Year	Children vaccinated (%)	Measles cases per 100 000 people
2014	62	41
2016	71	27
2018	83	9
2020	91	2

Answers

Quick-fire answers

1 Inside the cell

- 1.1** Mitochondria.
- 1.2** Any two of: cell wall, permanent vacuole, chloroplasts.
- 1.3** Any two of: no nucleus (DNA is a single loop), has plasmids, no mitochondria, no chloroplasts, no permanent vacuole.
- 1.4** $\times 500$ ($25 \div 0.05$).

4 Enzymes

- 4.1** Amylase.
- 4.2** Glycerol and fatty acids.
- 4.3** Made in the liver, stored in the gall bladder.
- 4.4** Blue-black.

7 Plants

- 7.1** Xylem.
- 7.2** Translocation.
- 7.3** The opening and closing of the stomata.
- 7.4** Moving air carries away water vapour, keeping a steep concentration gradient.

10 Respiration

- 10.1** Exothermic.
- 10.2** Lactic acid.
- 10.3** Ethanol and carbon dioxide.
- 10.4** More oxygen is needed for aerobic respiration, and carbon dioxide must be removed.

2 Mitosis

- 2.1** In the nucleus.
- 2.2** It replicates: two copies of each chromosome.
- 2.3** Two, genetically identical.
- 2.4** Meristem.
- 2.5** Differentiation.

5 Heart and blood

- 5.1** Right ventricle.
- 5.2** Pulmonary vein.
- 5.3** The heart muscle itself.
- 5.4** They help the blood to clot.
- 5.5** In the right atrium.

8 Infection

- 8.1** Viruses, bacteria, protists and fungi.
- 8.2** Phagocytosis, antibody production, antitoxin production.
- 8.3** A vector.
- 8.4** Make the right antibodies quickly, and in large numbers, if the pathogen returns.

3 Transport

- 3.1** Active transport.
- 3.2** Bigger concentration gradient, higher temperature, larger surface area.
- 3.3** Large surface area to volume ratio, so enough substances diffuse in and out.
- 3.4** Urea.

6 Risk and cancer

- 6.1** Something linked to an increased rate of a disease.
- 6.2** Obesity.
- 6.3** Malignant.

9 Photosynthesis

- 9.1** Carbon dioxide and water.
- 9.2** Glucose and oxygen.
- 9.3** Any three of: temperature, light intensity, carbon dioxide concentration, amount of chlorophyll.
- 9.4** Glucose and nitrate ions.

Your tracker

Colour a circle when you've done it. Come back to each topic two days later and a week later.

Topic	Learn it	Use it	Recall box	Quick-fire	2 days later	1 week later
1 Inside the cell	☐	☐	☐	☐	☐	☐
2 Mitosis	☐	☐	☐	☐	☐	☐
3 Transport	☐	☐	☐	☐	☐	☐
4 Enzymes	☐	☐	☐	☐	☐	☐
5 Heart and blood	☐	☐	☐	☐	☐	☐
6 Risk and cancer	☐	☐	☐	☐	☐	☐
7 Plants	☐	☐	☐	☐	☐	☐
8 Infection	☐	☐	☐	☐	☐	☐
9 Photosynthesis	☐	☐	☐	☐	☐	☐
10 Respiration	☐	☐	☐	☐	☐	☐

Answers

Practice paper: marks and answers

1 1.1 C, nucleus; 1.2 C, osmosis; 1.3 B, lipase; 1.4 D, pulmonary artery. [4]

2.1 x-axis labelled, with the unit, and a scale that fills more than half the grid [1]; all points plotted as crosses, allowing 3 or 4 correct for 1 [2]; smooth line of best fit [1]. Four marks in total.

2.2 The concentration where the line crosses 0% change: about 0.38 mol/dm³ (accept 0.36 to 0.40). [1]

2.3 $0.3 \div 3.0 \times 100$ [1] = 10% [1].

2.4 Water moves out of the potato by osmosis [1]; the solution outside is more concentrated than the cell contents (cell contents more dilute) [1]; through a partially permeable membrane [1].

3.1 $4.5 \text{ cm} = 45 \text{ mm}$ [1]; $45 \div 300 = 0.15 \text{ mm}$ [1]; $\times 1000 = 150 \mu\text{m}$ [1].

3.2 $120 \div 20 = 6$ divisions [1]; $2^6 = 64$ bacteria [1].

3.3 Any one: bacteria have no nucleus (DNA is a single loop), have plasmids, no chloroplasts or mitochondria or permanent vacuole. [1]

4.1 Bile emulsifies fat into small droplets [1]; this gives a bigger surface area [1]; so lipase breaks the fat down faster. Also: it is alkaline and neutralises stomach acid [1]. Any three.

4.2 A stent holds the coronary artery open [1], so blood flow to the heart muscle is restored [1]. (Do not accept unblocks or removes the fat.)

4.3 Statins lower blood cholesterol [1], which slows the build-up of fatty material in the coronary arteries [1].

5.1 It's a control: it shows the clear zones are caused by the antibiotics, not the disc. [1]

5.2 Antibiotic X [1], because its clear zone is larger (radius 12 mm against 5 mm) so more bacteria were killed [1].

5.3 $3.14 \times 12 \times 12$ [1] = 452 mm² (accept 452.16) [1].

5.4 37 °C is body temperature, which suits human pathogens [1]; 25 °C reduces the growth of bacteria that are harmful to humans [1].

6 Level 3 (5 to 6): both explained with links: **nitrate** makes amino acids and so proteins, so with too little the plant can't build new cells and growth is stunted; **magnesium** makes chlorophyll, so leaves turn yellow (chlorosis), photosynthesis falls, and less glucose is made for respiration, energy and cellulose. Level 2 (3 to 4): both covered, some linking. Level 1 (1 to 2): no links.

7.1 Independent: distance of the lamp from the pondweed [1]. Dependent: volume of oxygen given off (or number of bubbles) in the set time [1].

7.2 $36 \div 6$ [1] = 6 cm³ per minute [1].

7.3 Light intensity falls as the lamp moves away [1]; less light means slower photosynthesis, because light is the limiting factor [1].

7.4 H₂O and O₂, in that order. [1]

7.5 **HT** It fell to one quarter ($\frac{1}{4}$) of the intensity at 10 cm. [1]

8.1 glucose → lactic acid. [1]

8.2 The muscles respire faster and need more oxygen and glucose [1]; the heart beats faster to deliver more oxygenated blood [1] and to carry carbon dioxide away [1].

9 Level 3 (5 to 6): a judgement backed by linked reasons using the data and your own knowledge. For example: vaccinated children rose from 62% to 91% while cases fell from 41 to 2 per 100 000; vaccines make white blood cells produce antibodies, so vaccinated people don't get ill; fewer infected people means less spread, which protects the unvaccinated too; the data shows a link, not proof, and no vaccine is risk-free, but the benefit is large. Level 2 (3 to 4): data used, some linked reasons. Level 1 (1 to 2): simple points, no links.

Lost marks? Go here

Question	Go to	Pages
1, 3.3	Topics 1, 3, 4 and 5	4–5, 8–9, 10–11, 12–13
2.1, 2.2	Graphs and data	25
2.3 to 2.4, 5.1 to 5.4	Topics 3 and 8, the practicals	8–9, 18–19, 26
3.1, 3.2, 5.3, 7.2	The maths page	24
4.1 to 4.3, 8.2	Topics 4, 5 and 10	10–11, 12–13, 22–23
6, 9	Topics 8 and 9, six-mark pages	19, 20–21, 29
7.1 to 7.5	Topic 9	20–21

Mark with a different colour and add up. Your teacher may accept other correct wording.

More from Empower Educators

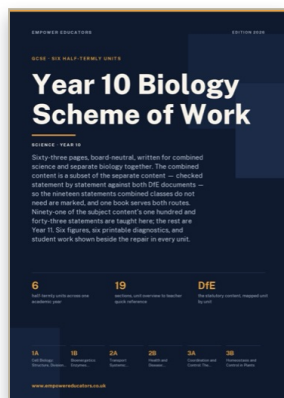
The Biology range

If this guide was useful, here is the rest of the Biology shelf. Everything shown is on the site now.



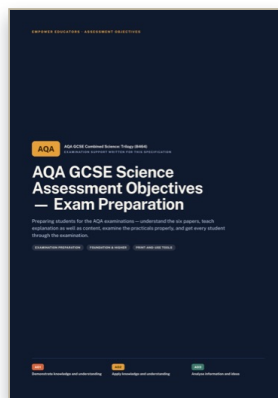
The Science playbook

The science department's playbook, with Biology inside it.



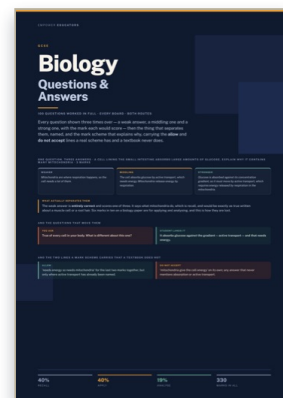
Schemes of work

Year 10 to Year 11. One sequence table a year, unit by unit and in teaching order.



Science exam board playbooks

The science department's books, one for each board, with Biology inside them.



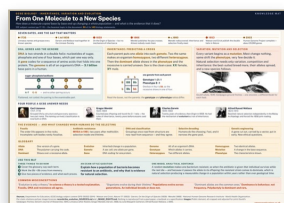
GCSE questions and answers

A hundred questions, each answered three times: weak, middling and strong.



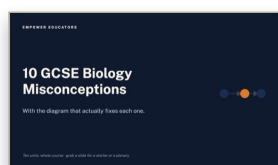
Knowledge organisers

Year 10 to Year 11. A4, printable, one per unit.



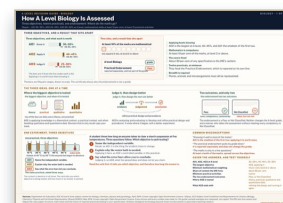
GCSE knowledge mats

One landscape sheet a topic, from inheritance to ecosystems.



GCSE PowerPoints

Ten misconceptions, one to a slide, each fixed with its own diagram. Editable.



A Level revision guide

The core ideas beside a figure, worked examples and the misconceptions that cost marks.

See the whole Biology range

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Details and previews for every resource.