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Premium IB tuition — Physics, Chemistry, Maths

AQA GCSE BIOLOGY · SPECIFICATION 4.2

Topic 2: Organisation

Complete revision & exam preparation guide — key points to memorise, clear diagrams, practice questions and full answers

Key-point notes | Memory hooks | Required practicals | Maths skills | Exam questions + answers

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Suitable for Foundation and Higher tier · Combined Science (Trilogy) and Separate Biology

START HERE

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★ One-page memory sheet
✎ Summary questions
✓ Answers

How to use this guide

1. **Read** one section. Look carefully at the diagram — say the labels out loud.
2. **Learn the gold "Remember it" box.** These are short hooks that make facts stick.
3. **Cover and recall:** cover the page and write the key points from memory. Check, then fix gaps in a different colour.
4. **Read the green "Exam tip" and red "Common mistake" boxes** — they show where marks are usually won and lost.
5. At the end, do the **summary questions** without notes, then mark them with the **answers**. Re-test anything wrong after 2–3 days.

THE BIG IDEA OF TOPIC 2

Living things are **organised**: cells → tissues → organs → organ systems → organism. Every part has a **structure that fits its function**. If you can explain *how the structure helps the job*, you can answer most Topic 2 questions.

Key boxes in this guide

Box	What it means
Remember it	Memory hook, rhyme or shortcut to memorise
Exam tip	How to write the answer to get the marks
Common mistake	Errors examiners see every year
Maths skill	Calculations you must be able to do
RP	AQA Required Practical — can be asked in the written exam

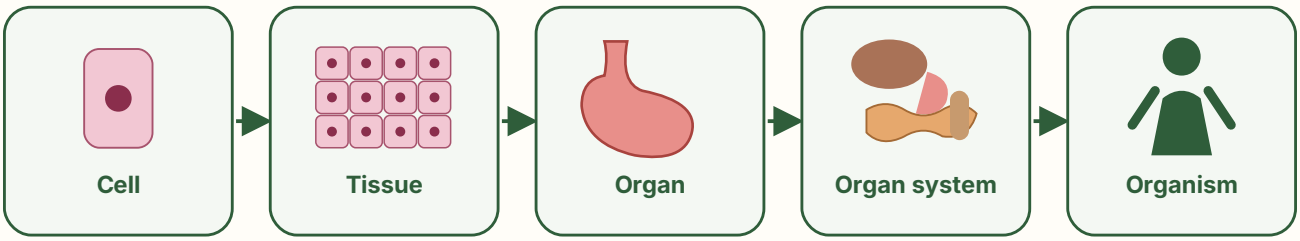
PART A

Organisation and Enzymes

2.1 Cell organisation

AQA 4.2.1

Big organisms are made of billions of cells. The cells are **organised** into levels so the body can work properly.



Levels of organisation — from smallest to biggest

- **Cells** are the basic building blocks of all living things.
- **Differentiation** = when a cell becomes **specialised** for one job. Happens as an organism develops.
- **Tissue** = a group of **similar cells** working together to do one job.
- **Organ** = a group of **different tissues** working together to do one job.
- **Organ system** = a group of **organs** working together to do one job.
- Organ systems work together to make the whole **organism**.

Animal tissue	Job
Muscular	Contracts to move things
Glandular	Makes and releases enzymes and hormones
Epithelial	Covers parts of the body (e.g. lines the gut)

Example organ — the stomach uses all three: muscular tissue churns food, glandular tissue makes digestive juice, epithelial tissue covers the inside and outside.

REMEMBER IT

"Can Tom Organise Our Office?" → **C**ell → **T**issue → **O**rgan → **O**rgan system → **O**rganism.
Tissue = **similar** cells. Organ = **different** tissues.

EXAM TIP

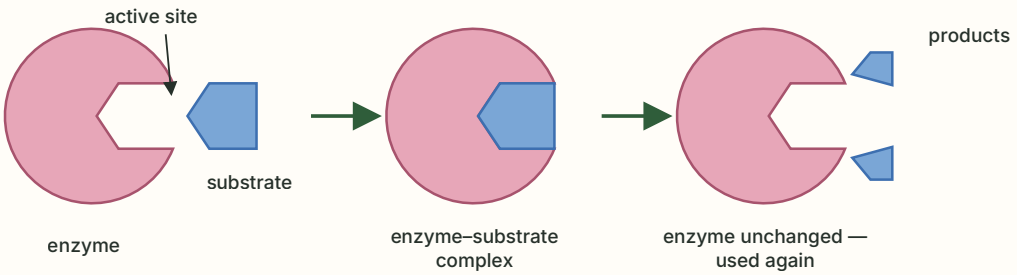
"The heart is an organ. Explain what this means." (2 marks) → It is made of **several different tissues** (1) that **work together to do a particular function** (1).

2.2 Enzymes

AQA 4.2.2.1

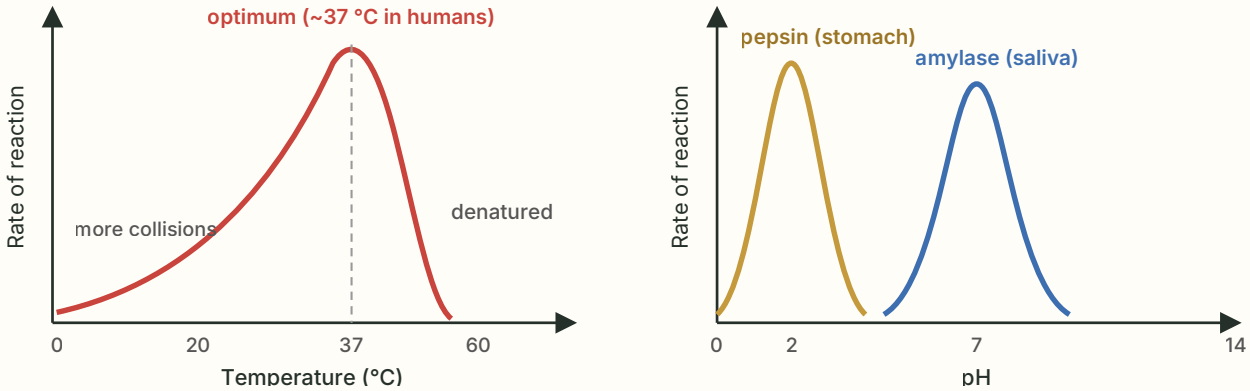
- Our cells carry out thousands of chemical reactions. These must be **controlled**.
- Heating speeds reactions, but too much heat damages cells — so we use **enzymes** instead.
- Enzymes are **biological catalysts**: they **speed up** reactions without being used up or changed.
- Enzymes are **large proteins**. Proteins are chains of **amino acids** folded into a special shape.

- Each enzyme has an **active site** with a unique shape. Only one **substrate** fits → enzymes are **specific** (one enzyme, one reaction).



Lock and key model — the substrate fits the active site like a key in a lock

- **Lock and key model**: substrate fits the active site exactly. It is a **simple model**.
- **Induced fit model** (the real picture): the active site **changes shape slightly** to grip the substrate more tightly.



Every enzyme has an optimum temperature and an optimum pH

- **Temperature:** warmer → faster at first (more collisions). Above the **optimum**, bonds holding the enzyme break.
- The active site **changes shape**, the substrate no longer fits → enzyme is **denatured**. This is permanent.
- **pH:** too acidic or too alkaline also breaks the bonds → active site changes shape → **denatured**.
- Most enzymes like about **pH 7**, but **pepsin** (stomach) works best at **pH 2**.

REMEMBER IT

Enzymes are Picky Proteins. One **shape** → one **substrate** → one **reaction**.
Denatured = deformed: active site loses its shape, substrate can't fit, and it can't be fixed.

COMMON MISTAKE

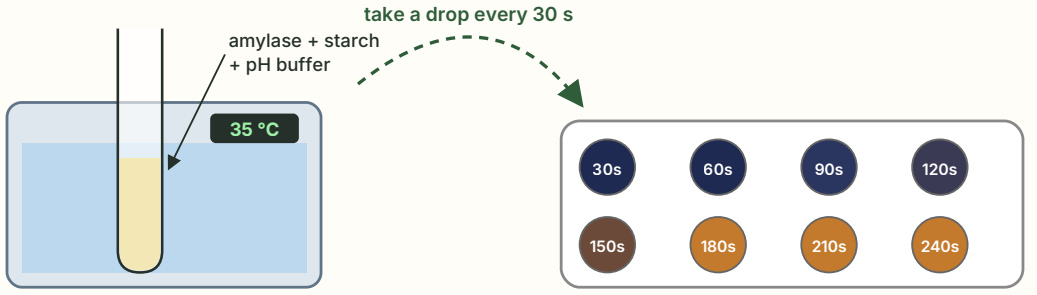
Never write "the enzyme is **killed**". Enzymes are not alive. Write: "the enzyme is **denatured** — the **active site changes shape** so the substrate **no longer fits**."

2.3 Investigating enzymes: effect of pH on amylase

AQA 4.2.2.1

REQUIRED PRACTICAL

Amylase breaks **starch → sugars (maltose)**. **Iodine** tells us if starch is still there: **blue-black = starch present**, **orange-brown = no starch**.



Continuous sampling: test a drop every 30 seconds until iodine stays orange-brown

1. Put one drop of iodine solution in each well of a spotting tile.
2. Heat a beaker of water (or use an electric water bath) to **35 °C**. Keep it constant.
3. Add 1 cm^3 amylase + 1 cm^3 **pH buffer** (e.g. pH 5) to a boiling tube. Leave in the water bath for 5 minutes to warm up.
4. Add 5 cm^3 starch solution, mix and **start the stopwatch**.
5. Every **30 seconds**, put a drop of the mixture on iodine. Record the time when the iodine **stays orange-brown**.
6. Repeat with different pH buffers (e.g. pH 4, 6, 7, 8). Repeat each pH 3 times and find a mean.

Variable	In this practical
Independent (you change)	pH of the buffer
Dependent (you measure)	Time for starch to be fully broken down
Control (keep the same)	Temperature, volume and concentration of amylase and starch

MATHS SKILL — RATE OF REACTION

Rate = 1000 ÷ time (unit s^{-1}) — used when you only measure the time taken.
Example: at pH 6 the starch was gone after 80 s → rate = 1000 ÷ 80 = **12.5 s^{-1}**.

Rate = amount changed ÷ time — used when you measure an amount.
Example: catalase made 36 cm^3 of oxygen in 60 s → rate = 36 ÷ 60 = **0.6 cm^3/s**.

EXAM TIP

Possible errors: judging the iodine colour change is **subjective**; sampling only every 30 s means the end point could be up to 30 s out. Improve by using a **colorimeter** or sampling more often. To test temperature instead of pH, keep pH constant and change the water bath temperature.

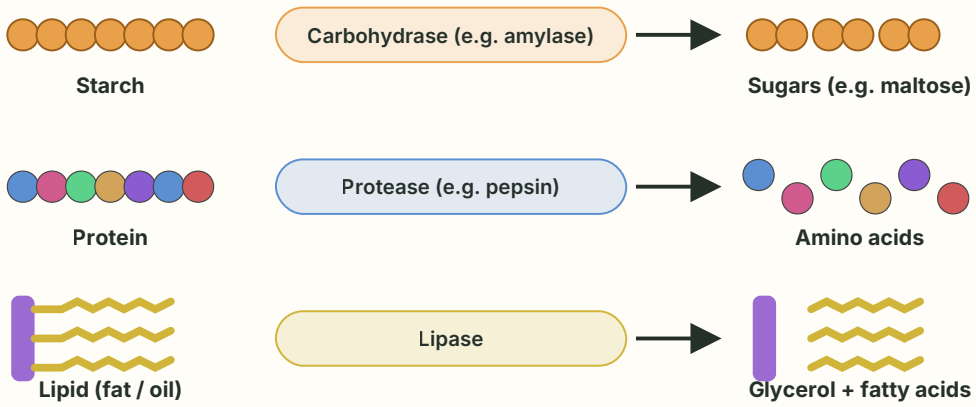
PART B

Digestion

2.4 Digestive enzymes and bile

AQA 4.2.2.1

- Starch, proteins and fats are **big molecules**. They are too big to pass through the gut wall.
- Digestive enzymes break them into **small, soluble** molecules that can be **absorbed into the blood**.
- The products are used to build new carbohydrates, proteins and lipids. Some glucose is used in **respiration**.



Three groups of digestive enzymes: big molecule → enzyme → small molecules

Enzyme	Breaks down	Into	Made in
Amylase (a carbohydrase)	Starch	Sugars (maltose)	Salivary glands, pancreas, small intestine
Protease (e.g. pepsin)	Proteins	Amino acids	Stomach, pancreas, small intestine
Lipase	Lipids (fats and oils)	Glycerol + fatty acids	Pancreas, small intestine

Bile — two jobs

- Bile is **made in the liver**, **stored in the gall bladder**, released into the **small intestine**.
- **Job 1 — neutralises stomach acid.** Bile is **alkaline**. Enzymes in the small intestine work best in alkaline conditions.
- **Job 2 — emulsifies fats.** It breaks fat into **tiny droplets** → **bigger surface area** for lipase → fat is digested **faster**.
- Bile is **not** an enzyme — it does not break chemical bonds.

REMEMBER IT

Places: Amylase = **S·P·S** (Salivary, Pancreas, Small intestine). Protease = **S·P·S** again but the first S is **Stomach**. Lipase = just **P·S**.
Products: "Starch → Sugar, Protein → Amino, Lipid → Glycerol + Fatty acids."
Bile: "**Liver Makes, Gall bladder Keeps, Small intestine Uses**" — and it does **N**eutralise + **E**mulsify (**NE**).

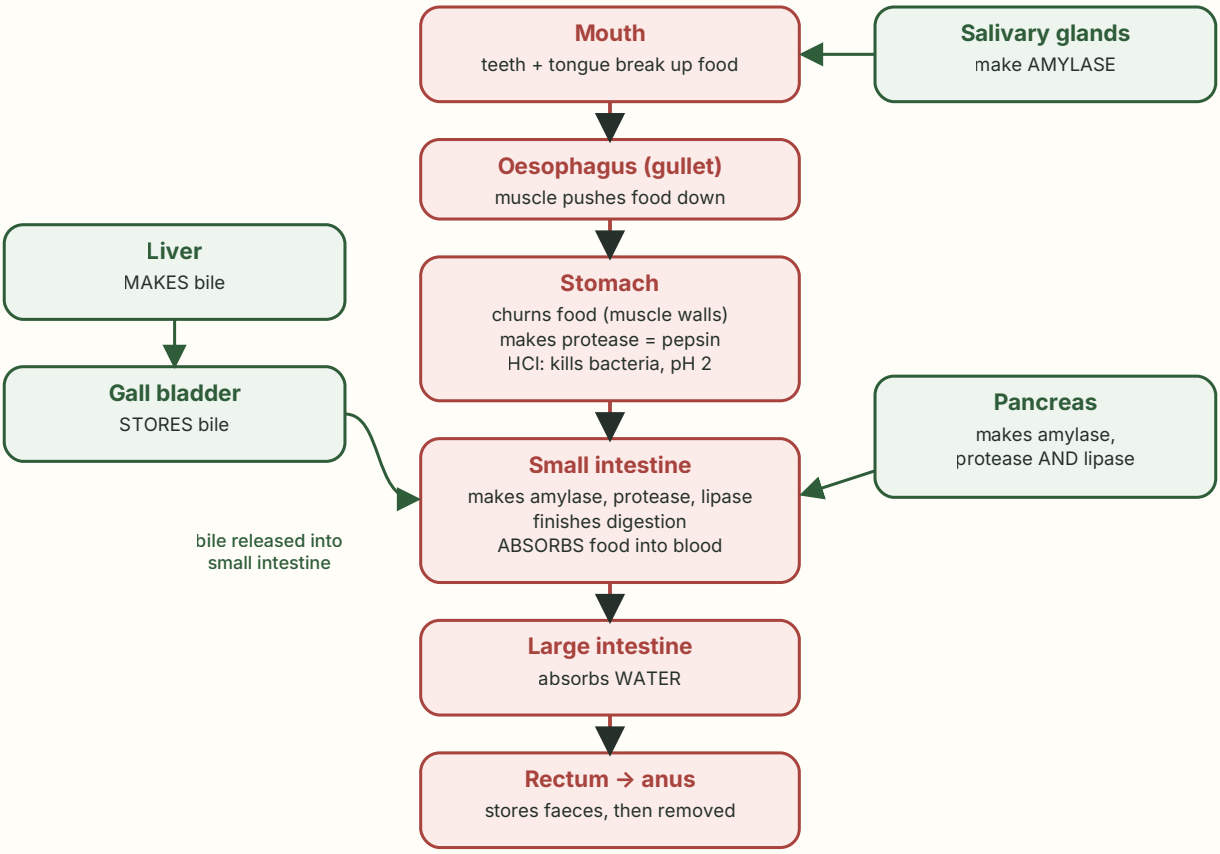
COMMON MISTAKE

Bile does **not** digest fat. It emulsifies it (increases surface area) — **lipase** digests it.

2.5 The digestive system map

AQA 4.2.2.1

Food travels down the **gut** (red boxes). **Glands** (green boxes) add juices into it. Enzymes are made by **specialised cells** in glands and in the gut lining.



Flow map of the human digestive system — learn what each organ does

Organ	Main job — learn this line
Salivary glands	Make amylase in saliva
Stomach	Churns food; makes pepsin (protease); makes **hydrochloric acid** to **kill bacteria** and give **pH 2** for pepsin
Liver	Makes bile
Gall bladder	Stores bile
Pancreas	Makes amylase, protease and lipase → releases them into the small intestine
Small intestine	Makes all three enzymes; **absorbs** digested food into the blood
Large intestine	Absorbs **water** from undigested food
Rectum	Stores faeces before they leave through the anus

REMEMBER IT

Small intestine absorbs **food**; **large** intestine absorbs **water**.
Stomach acid has 2 jobs: Kill bacteria + Keep pH right for pepsin.

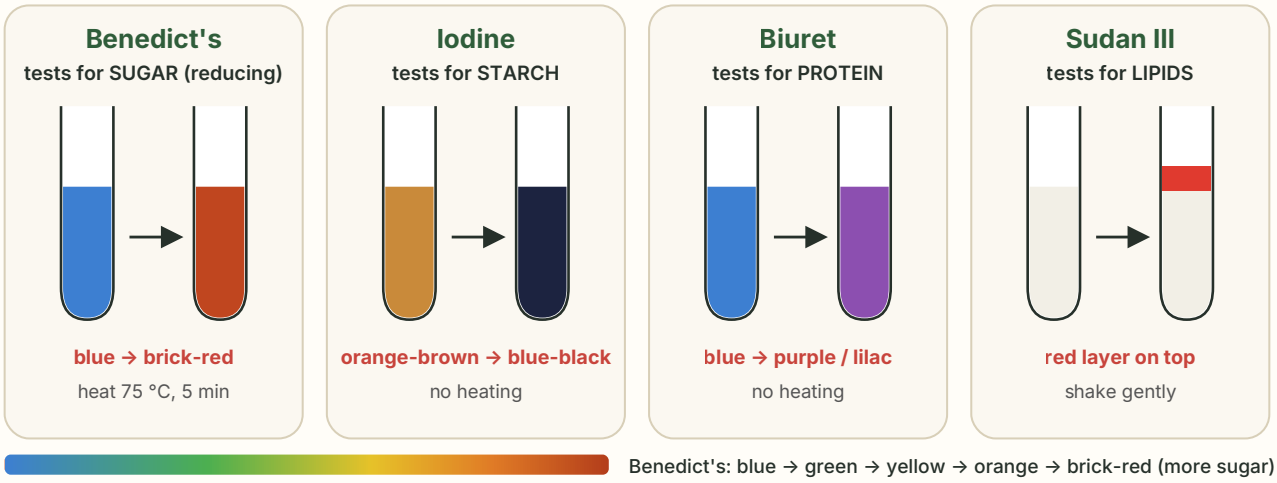
EXAM TIP

Be able to point to the liver, stomach, pancreas, gall bladder, small and large intestine on a diagram. The liver is the big organ on the upper right of the body; the pancreas sits just under the stomach.

2.6 Food tests REQUIRED PRACTICAL

AQA 4.2.2.1

First, make a food sample: grind the food with a pestle and mortar → add distilled water and stir to dissolve → filter to remove solid bits.



The four food tests — what you add and the colour change for a positive result

Testing for	Reagent	Method	Positive result
Reducing sugars	Benedict's solution	5 cm^3 sample + ~10 drops Benedict's; **water bath at 75 °C for 5 min**	Blue → green / yellow / **brick-red** (more sugar = further along)
Starch	Iodine solution	5 cm^3 sample + a few drops, shake	Orange-brown → **blue-black**
Protein	Biuret solution	2 cm^3 sample + 2 cm^3 biuret, shake	Blue → **purple** (lilac)
Lipids	Sudan III stain	5 cm^3 sample (no need to filter) + 3 drops, shake	**Red layer** forms on top

REMEMBER IT

Benedict's is the only one you heat ("Benedict's needs a bath").
Biuret for **B**eef (protein) → **purple**. **S**udan for **S**lippery fats → **red layer**. **I**odine for starch → **I**nk-black.

SAFETY + EXAM TIP

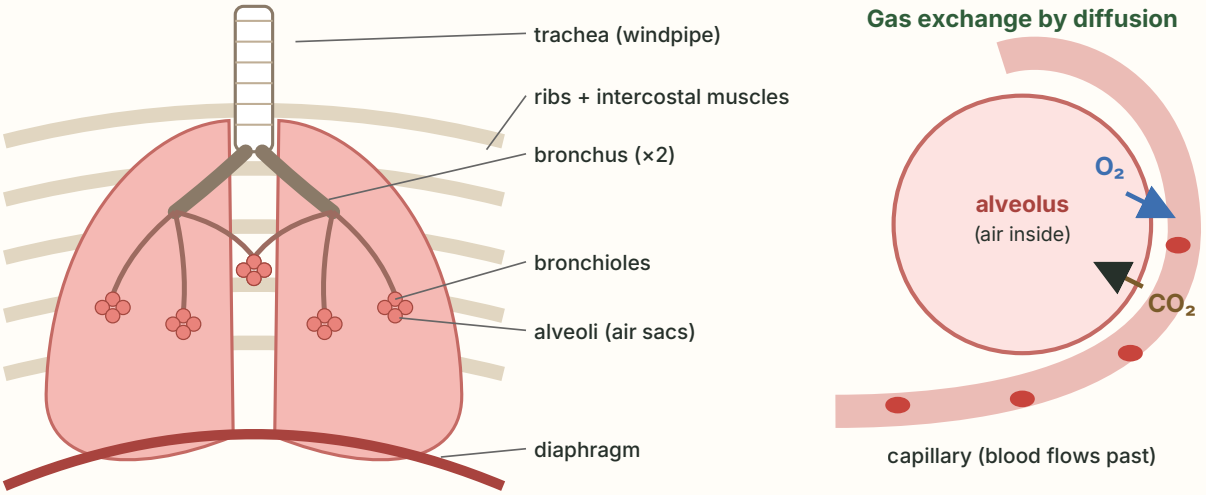
Wear eye protection; point the heated tube away from people; biuret contains an alkali (irritant); Sudan III is flammable. Benedict's gives a **rough idea** of how much sugar (colour) — it is **qualitative**, not an exact amount.

PART C

Lungs, Heart, Blood and Blood Vessels

2.7 The lungs and gas exchange

AQA 4.2.2.2



Left: the breathing system in the thorax. Right: one alveolus — where gas exchange happens

- Lungs are in the **thorax**, protected by the **ribcage**, with the **diaphragm** underneath.
- Air path: **trachea → bronchi → bronchioles → alveoli**.
- Alveoli are tiny air sacs covered by a network of **capillaries**.
- Blood arriving at the lungs has **lots of CO_2** and **little O_2**.
- **O_2 diffuses** from alveolus (high) → blood (low).
- **CO_2 diffuses** from blood (high) → alveolus (low), then is breathed out.
- At body cells it happens the other way round: O_2 into cells, CO_2 into blood.

Why alveoli are good at gas exchange: huge surface area · very thin walls (one cell thick → short diffusion distance) · moist lining · great blood supply that keeps a steep concentration gradient.

REMEMBER IT

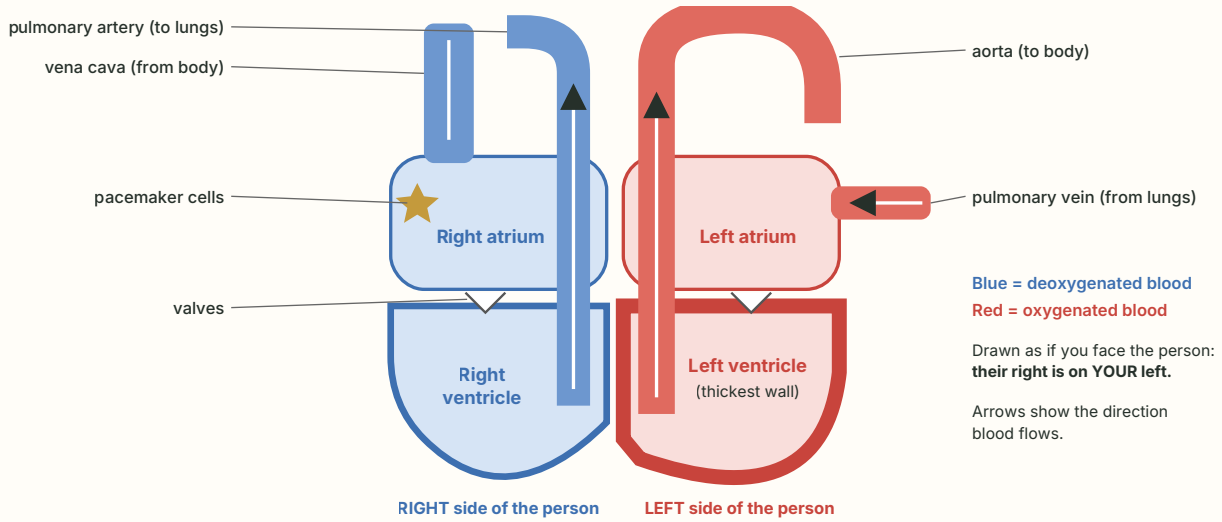
Air path: **"Tall Boys Bring Apples"** → **T**rachea → **B**ronchi → **B**ronchioles → **A**lveoli.
Alveoli adaptations: **BIG, THIN, WET, BLOOD**.

MATHS SKILL — BREATHING RATE

Breaths per minute = number of breaths ÷ number of minutes
Example: 384 breaths in 24 minutes → 384 ÷ 24 = **16 breaths per minute**.

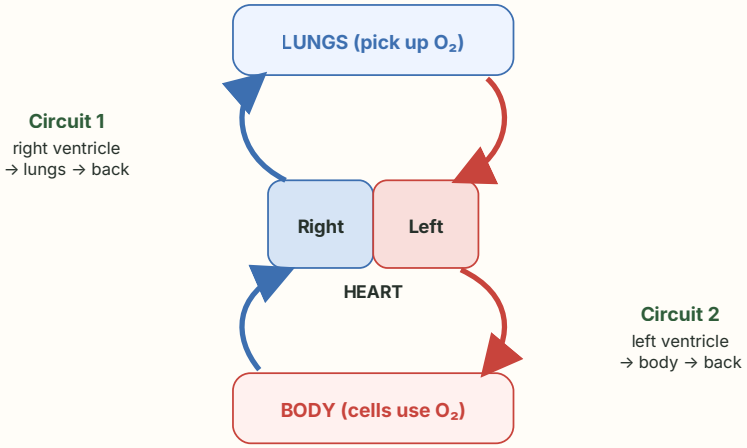
2.8 The heart and double circulation

AQA 4.2.2.2



The heart: 4 chambers, 4 main blood vessels, valves and pacemaker

- The heart is an **organ** with walls made mostly of **muscle**. It pumps blood around the body.
- Humans have a **double circulatory system**: blood goes through the heart **twice** for each full trip round the body.
- **Circuit 1:** right ventricle pumps **deoxygenated** blood to the **lungs** to collect oxygen.
- **Circuit 2:** left ventricle pumps **oxygenated** blood to the **rest of the body**.
- **Valves** stop blood flowing backwards.
- **Coronary arteries** branch off the aorta and supply the **heart muscle itself** with oxygenated blood.
- **Pacemaker:** a group of cells in the **right atrium** controls the resting heart rate by sending small **electrical impulses** that make the muscle contract. An **artificial pacemaker** (electrical device) can fix an irregular heartbeat.



Double circulation: two circuits joined at the heart

One heartbeat: blood enters the atria (from vena cava and pulmonary vein) → **atria contract** → blood pushed into ventricles → **ventricles contract** → blood forced out into the pulmonary artery and aorta → atria fill again.

REMEMBER IT

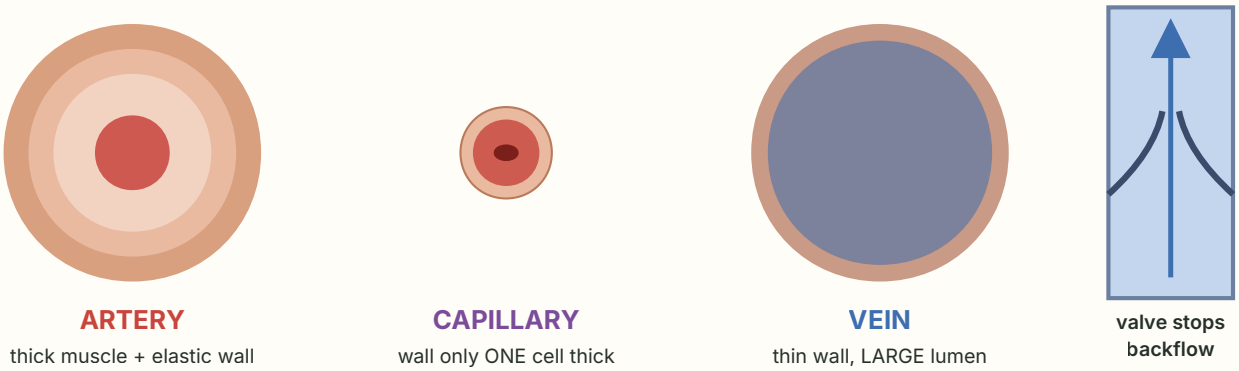
Arteries = Away from heart; **Veins = Visit** (come back).
Pulmonary = Lungs. Right side → lungs; Left side → **Long** journey to body, so the **left ventricle has the thickest wall**.
Full route: **vena cava → RA → RV → pulmonary artery → lungs → pulmonary vein → LA → LV → aorta → body**.

COMMON MISTAKE

Diagrams show the heart as if you are facing the person — so their **right side is on your left**. And the pulmonary **artery** carries **deoxygenated** blood (the only artery that does).

2.9 Blood vessels

AQA 4.2.2.2



Cross-sections of the three blood vessels, and a vein valve

	Artery	Capillary	Vein
Job	Carries blood **away** from the heart	Exchanges substances with cells	Carries blood **back to** the heart
Pressure	High	Low	Low
Wall	Thick, strong; thick layers of **muscle** and **elastic fibres** (stretch and spring back)	**One cell thick**, permeable	Thinner
Lumen	Small (narrow)	Very small	**Large** — helps blood flow at low pressure
Valves	No	No	**Yes** — stop backflow

- Arteries branch into capillaries → capillaries join up into veins.
- Capillaries carry blood close to every cell: they deliver **food and oxygen** and remove **waste like CO_2**. A thin wall gives a **short diffusion distance** → faster diffusion.

REMEMBER IT

Artery = Armour (thick, strong, high pressure). **Vein = Valves** (big lumen, low pressure). **Capillary = one Cell thick**.

MATHS SKILL — RATE OF BLOOD FLOW

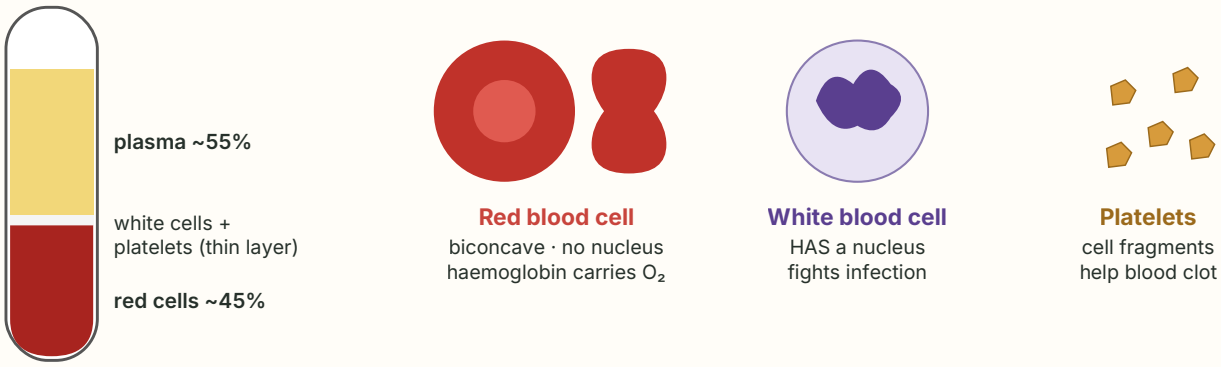
Rate of blood flow = volume of blood ÷ time

Example: 2700 ml passes through an artery in 6 minutes → 2700 ÷ 6 = **450 ml/min**.

2.10 Blood

AQA 4.2.2.3

Blood is a **tissue**. It is the body's transport system and has **four parts**.



The four parts of blood

Red blood cells carry oxygen from the lungs to all cells.

- **Biconcave disc** shape → large surface area to absorb oxygen.
- **No nucleus** → more room for haemoglobin.
- Contain red **haemoglobin**: in the lungs it joins with O_2 → **oxyhaemoglobin**; in tissues it splits and releases O_2.

Platelets are small cell fragments with no nucleus. They help blood **clot** at a wound — stopping blood loss and microorganisms getting in. Too few platelets → too much bleeding and bruising.

White blood cells defend against infection. They **do** have a nucleus.

- Some **engulf** microbes (**phagocytosis**).
- Some make **antibodies** and **antitoxins**.

Plasma is the pale yellow liquid that carries:

- red and white cells and platelets
- digested food (glucose, amino acids)
- **CO_2** from organs to the lungs
- **urea** from the liver to the kidneys
- hormones, proteins, antibodies and antitoxins

REMEMBER IT

4 parts: **"Real Warriors Protect People"** = **R**ed cells, **W**hite cells, **P**latelets, **P**lasma.
Red cell adaptations: **"No Bad Habits"** = **N**o nucleus, **B**iconcave, **H**aemoglobin.

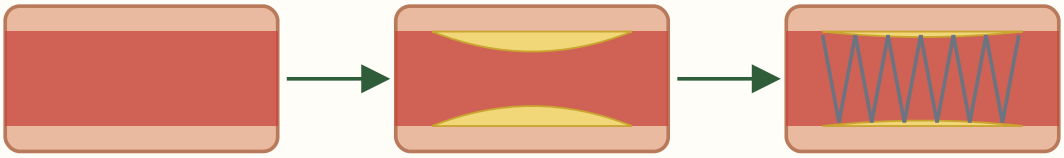
PART D

Health and Disease

2.11 Coronary heart disease: stents and statins

AQA 4.2.2.4

- **Coronary heart disease (CHD)**: **layers of fatty material build up** inside the **coronary arteries**.
- The arteries become **narrow** → **less blood flow** → **less oxygen** reaches the heart muscle → can cause a **heart attack**.



How a stent works

Stents

A stent is a small mesh **tube** put inside an artery to **hold it open**, so blood keeps reaching the heart muscle.

✓ Advantages	× Disadvantages
Lower risk of heart attack; work for a long time; quick recovery from surgery	Risk of complications in surgery (e.g. heart attack); infection; blood clot near the stent (**thrombosis**)

Statins

Statins are **drugs** that lower 'bad' (**LDL**) cholesterol in the blood → fatty material builds up **more slowly**.

✓ Advantages	× Disadvantages
Lower risk of stroke, CHD and heart attack; can raise 'good' (**HDL**) cholesterol; may help prevent other diseases	Must be taken long-term (people forget); side effects e.g. headaches, and rarely kidney failure, liver damage, memory loss; take time to work

REMEMBER IT

Stent = Scaffold (needs surgery, works straight away). **Statin = Swallow** (a tablet, works slowly).

EXAM TIP

"Evaluate" questions want **both sides** and a **conclusion**, e.g. "Stents act fast, but surgery carries risk; statins avoid surgery but must be taken for life. Best choice depends on how badly the artery is blocked."

2.12 Heart failure, faulty valves and artificial blood

AQA 4.2.2.4

Problem / treatment	Key points	Downsides
Heart failure → transplant	A **donor heart** (or heart and lungs) from someone who has died.	Must wait for a donor; risk of **rejection**; drugs needed for life
Artificial heart	A **mechanical** pump. Usually **temporary** — keeps a person alive until a donor heart is found, or lets the heart rest and recover. Sometimes permanent. Made of metal/plastic → **less likely to be rejected**.	Surgery → bleeding, infection; parts can wear out or the motor fail; blood does not flow smoothly → **clots, strokes**; needs blood-thinning drugs
Faulty valves	Damaged by heart attack, infection or old age. Valve may **stiffen** (won't open fully) or **leak** (blood flows backwards) → blood circulates less well.	
Replacement valve	**Biological** = from humans or other mammals (pigs, cows). **Mechanical** = man-made. Less drastic than a heart transplant.	Still major surgery; blood clots
Artificial blood	A **salt solution (saline)** that tops up blood **volume** after big blood loss, so the heart can keep pumping the remaining red cells. Gives the body time to make new red cells.	Air bubbles are dangerous; may still need a transfusion

REMEMBER IT

Valve faults: **Stiff or Leaky**. Valve swaps: **Bio** (animal/human) or **Mech** (machine).

2.13 Health and disease

AQA 4.2.2.5

- **Health** = a state of **physical and mental wellbeing**.
- Diseases are a major cause of ill health.

	Communicable	Non-communicable
Meaning	Can **spread** between people, or between animals and people	**Cannot spread** between people
Caused by	Pathogens: bacteria, viruses, fungi, protists	Often lifestyle, genes, environment
How long	Often short	Usually long-lasting, get worse slowly
Examples	Measles, malaria, flu	Asthma, cancer, coronary heart disease

Diseases can interact — one can lead to another:

- Weak **immune system** → more likely to catch communicable diseases (e.g. flu).
- Some **viruses** can trigger **cancer**: hepatitis → liver cancer; **HPV** → cervical cancer.
- Immune reactions to a pathogen can trigger **allergies** (e.g. skin rashes) or make **asthma** worse.
- Serious physical illness can lead to **mental health** problems such as **depression**.

Other things that affect health: diet (balanced or poor) · stress · life situation (access to medicine, healthy food, condoms to prevent STIs).

> REMEMBER IT
> **Communicable = Catching** (pathogen, spreads). **Non-communicable = Not catching**.

2.14 Risk factors for non-communicable diseases

AQA 4.2.2.6

- A **risk factor** is something linked to an **increased chance** of getting a disease. It does **not guarantee** you will get it.
- Risk factors can be **lifestyle** (e.g. exercise, diet, smoking), **substances in the environment** (e.g. air pollution) or **substances in the body** (e.g. asbestos fibres).
- Many diseases are caused by **several risk factors interacting**.

Risk factor	Disease it can directly cause
Smoking	Cardiovascular disease, lung disease, lung cancer (damages artery walls and lung lining)
Obesity	Type 2 diabetes (body becomes less sensitive to insulin)
Too much alcohol	Liver disease; brain damage (nerve cells damaged)
Smoking / alcohol when pregnant	Health problems for the unborn baby
Carcinogens (e.g. ionising radiation, X-rays)	Cancer

> CORRELATION IS NOT CAUSATION
> Scientists find risk factors by looking for **correlations** in data. A link does not prove one thing causes the other. E.g. lack of exercise and a high-fat diet are linked to heart disease, but it is the **high blood pressure** and **high 'bad' cholesterol** they lead to that actually cause it.

Patterns: locally — your own choices; nationally — people in **deprived areas** are more likely to smoke, eat poorly and not exercise, so CVD, obesity and type 2 diabetes are higher there; globally — richer countries have more non-communicable disease (more high-fat food).

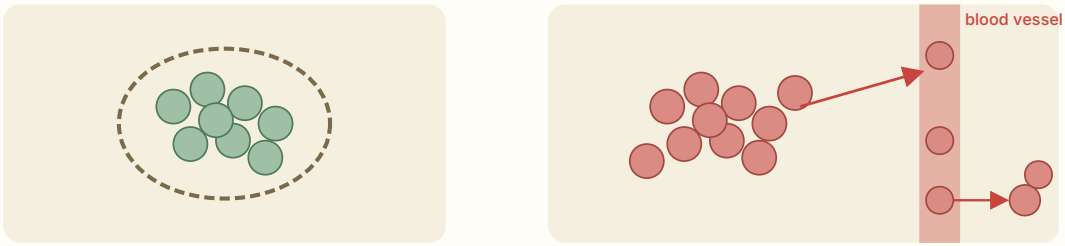
Costs: Human — millions of deaths a year, lower quality of life, shorter life, effects on family. **Financial** — huge cost to the NHS for research and treatment; families may need to adapt their home or lose income; fewer people working harms the **economy**.

> REMEMBER IT
> Big 4 lifestyle risk factors: **"SODA"** = **S**moking, **O**besity, **D**iet/exercise, **A**lcohol. Costs: **Human + Money** at **Local, National, Global** level.

2.15 Cancer

AQA 4.2.2.7

- Cancer is caused by changes in cells that lead to **uncontrolled growth and division**. This forms a **tumour** (a mass of cells).



BENIGN — stays in one place
(inside a membrane) · not cancer

MALIGNANT — spreads (cancer)
cells travel in blood → secondary tumours

Benign tumours stay put; malignant tumours spread through the blood

- **Benign**: grows until no more room; stays in one place (usually in a membrane); does **not invade** other tissues; not normally dangerous; **not cancer**.
- **Malignant**: grows and spreads into nearby tissue; cells **break off** and travel in the **blood**; invade other tissues and form **secondary tumours**. These **are cancers** and can be fatal.

Lifestyle risk factors:

- **Smoking** — lung, mouth, bowel, stomach, cervical cancer
- **Obesity** — bowel, liver, kidney cancer
- **UV exposure** (sun, sunbeds) — skin cancer
- **Viral infection** — hepatitis B and C → liver cancer; HPV → cervical cancer

Genetic risk factors: inherited faulty genes, e.g. **BRCA** gene mutations → higher chance of breast and ovarian cancer.

Survival rates have improved thanks to better treatments, earlier diagnosis and more screening.

> **REMEMBER IT**
> **Benign = Be-nice** (stays home). **Malignant = Moves** (spreads to make secondary tumours).

PART E

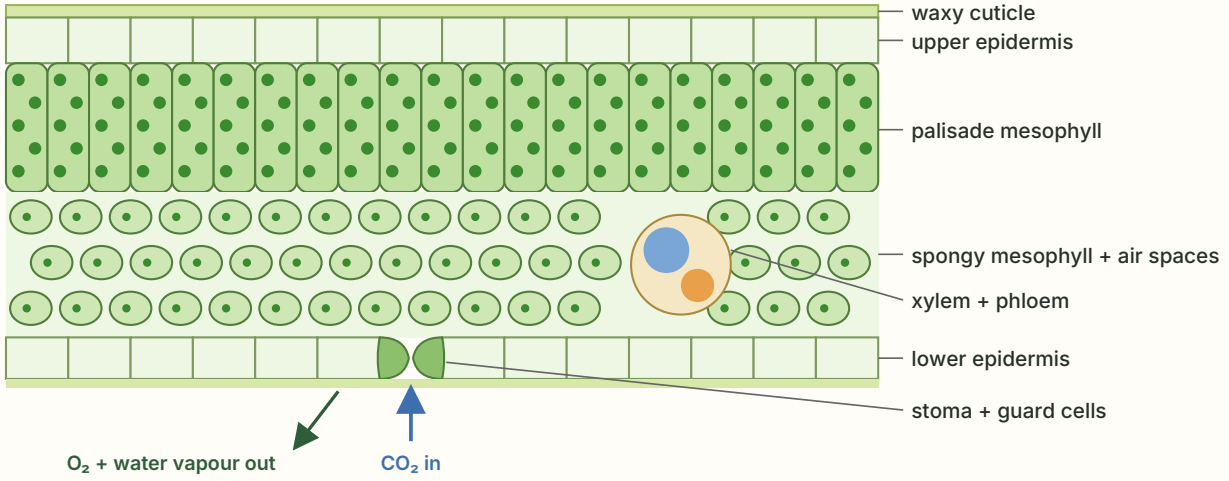
Plant Organisation and Transport

2.16 Plant tissues and the leaf

AQA 4.2.3.1

Plants have organs too: **stems, roots and leaves**. They work together as organ systems to **transport substances** around the plant.

Plant tissue	Job
Epidermal	Covers the whole plant
Palisade mesophyll	Where **most photosynthesis** happens
Spongy mesophyll	Has big **air spaces** so gases diffuse in and out of cells
Xylem and phloem	Transport water, mineral ions and food (sugars)
Meristem	Found at **growing tips** of shoots and roots; can **differentiate** into many types of plant cell → lets the plant grow



Cross-section of a leaf — the leaf is an organ made of several tissues

How leaf structure fits its function:

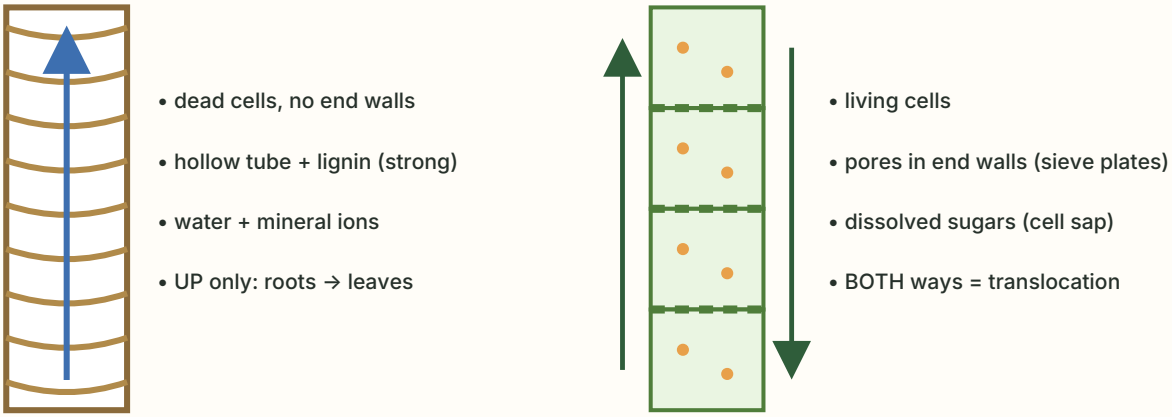
- **Waxy cuticle** → reduces water loss by evaporation.
- **Upper epidermis is transparent** → light passes through to the palisade layer.
- **Palisade cells** are packed with **chloroplasts** and are near the top → get the most light.
- **Xylem and phloem** form vascular bundles → bring water and minerals in, take glucose away, and help **support** the leaf.
- **Lower epidermis has stomata** → CO_2 diffuses in; opened and closed by **guard cells**.
- **Air spaces** in spongy mesophyll → increase the rate of gas diffusion.

REMEMBER IT

Leaf layers, top to bottom: **"Can Ugly Plants Survive Lovely Summers?"** → **C**uticle, **U**pper epidermis, **P**alisade, **S**pongy, **L**ower epidermis, **S**tomata.

2.17 Xylem, phloem and transpiration

AQA 4.2.3.2



Xylem carries water up; phloem carries sugars both ways

Phloem — moves food

- Columns of **elongated living cells** with small **pores in the end walls** so cell sap can flow.
- Carries **dissolved sugars** made in the leaves to the rest of the plant — for **immediate use** (e.g. growing regions) or for **storage**.
- Moves in **both directions**. This is called **translocation**.

Xylem — moves water

- **Dead cells** joined end to end, **no end walls**, hollow in the middle.
- Strengthened with **lignin**.
- Carries **water and mineral ions** from the roots up to the stem and leaves.
- Water moving roots → xylem → leaves is the **transpiration stream**.

Transpiration

- **Transpiration** = **loss of water** from a plant, mostly from the **leaves**, by **evaporation and diffusion**.
- This creates a slight shortage of water in the leaf → more water is pulled up the **xylem** → more water is taken in at the **roots** → a constant transpiration stream.
- Transpiration is a **side-effect** of photosynthesis: leaves need stomata open for gas exchange, and water vapour escapes through them by diffusion.

REMEMBER IT

Phloem = Food, Flows both ways (translocation, living cells).
Xylem = water, eXits upwards only (dead, hollow, lignin).

COMMON MISTAKE

Don't mix up the words: **transpiration** = water in xylem; **translocation** = sugars in phloem.

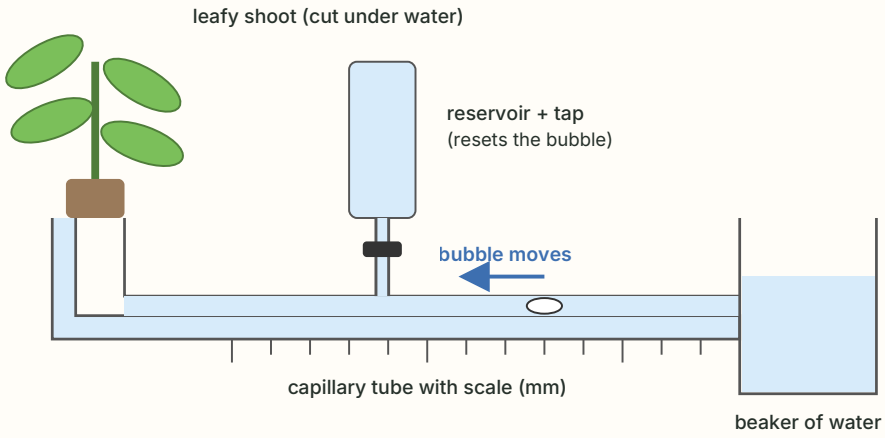
2.18 Transpiration rate and stomata

AQA 4.2.3.2

Factor	Effect on transpiration rate	Why
Light intensity ↑	Faster	Stomata open wider in light (for photosynthesis); they close in the dark so little water escapes
Temperature ↑	Faster	Water particles have more energy to evaporate and diffuse out
Air flow (wind) ↑	Faster	Water vapour is swept away → low concentration outside → steep gradient → faster diffusion
Humidity ↑	**Slower**	Air already full of water → small concentration difference → slower diffusion

REMEMBER IT

Think of **washing on a line**: it dries fastest when it is **bright, warm, windy and dry**. A plant loses water fastest in the same weather.
Factors: **"LiTHA"** = **Li**ght, **T**emperature, **H**umidity, **A**ir flow.



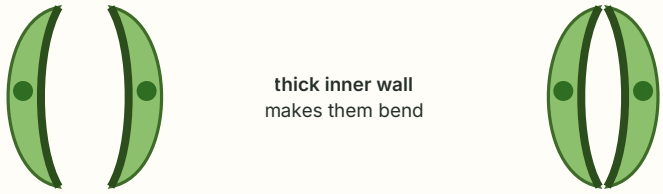
A potometer measures water uptake

Measuring the rate — potometer

- Water **uptake** is used to estimate water **loss** (they are almost equal).
- Record the start position of the air bubble, start a stopwatch, measure how far it moves in a set time.
- Keep other conditions constant (e.g. temperature, humidity). Use the tap/reservoir to reset the bubble.

MATHS SKILL

Bubble moves 45 mm in 15 min → rate = 45 ÷ 15 = **3 mm/min**.



OPEN — guard cells TURGID
lots of water, light (day)

CLOSED — guard cells FLACCID
short of water, dark (night)

Guard cells control the size of the stoma

- Guard cells are **kidney-shaped** and open and close the stomata.
- Lots of water → guard cells fill up and become **turgid** → stoma **opens** → gases exchanged for photosynthesis.
- Short of water → guard cells become **flaccid** → stoma **closes** → less water vapour escapes.
- **Thin outer walls** and **thick inner walls** make them bend to open and close.
- They are **sensitive to light** and close at night — saving water without losing photosynthesis.
- More stomata on the **underside** of leaves: it is **shaded and cooler**, so less water is lost.

REMEMBER IT
Turgid = open (plump with water). **Flaccid = closed** (floppy).

★ LAST-MINUTE

One-page memory sheet

Topic	Must-know facts
Organisation	Cell → tissue (similar cells) → organ (different tissues) → organ system → organism. Differentiation = cells become specialised.
Enzymes	Biological catalysts; proteins; active site; specific (lock and key / induced fit). High temp or wrong pH → active site changes shape → **denatured**.
Rate formulas	Rate = 1000 ÷ time · Rate = change ÷ time · Breaths/min = breaths ÷ minutes · Blood flow = volume ÷ time
Digestive enzymes	Amylase: starch → sugars (salivary, pancreas, SI). Protease: protein → amino acids (stomach, pancreas, SI). Lipase: lipid → glycerol + fatty acids (pancreas, SI).
Bile	Made in liver, stored in gall bladder, used in small intestine. Alkaline → neutralises acid. Emulsifies fat → bigger surface area for lipase.
Stomach acid	HCl: kills bacteria + pH 2 for pepsin.
Food tests	Benedict's (heat 75 °C) sugar: blue → brick-red · Iodine starch: orange → blue-black · Biuret protein: blue → purple · Sudan III lipid: red top layer
Lungs	Trachea → bronchi → bronchioles → alveoli. O_2 diffuses into blood, CO_2 out. Alveoli: big area, thin wall, moist, good blood supply.
Heart	Double circulation. Right side → lungs (deoxygenated). Left side → body (oxygenated, thickest wall). Valves stop backflow. Pacemaker cells in right atrium. Coronary arteries feed heart muscle.
Vessels	Artery: away, high pressure, thick muscle + elastic. Vein: back, big lumen, valves. Capillary: one cell thick, exchange.
Blood	Red cells (biconcave, no nucleus, haemoglobin) · white cells (phagocytosis, antibodies, antitoxins) · platelets (clotting) · plasma (carries CO_2, urea, glucose, hormones…)
CHD	Fatty build-up in coronary arteries → less O_2 to heart. Stents = hold artery open (surgery). Statins = lower LDL cholesterol (long-term drug).
Other treatments	Transplant, artificial heart (temporary, not rejected, clots), valve replacement (biological or mechanical), artificial blood = saline.
Disease	Health = physical + mental wellbeing. Communicable spreads (pathogens); non-communicable doesn't. Diseases interact (HPV → cervical cancer).
Risk factors	Increase chance, don't guarantee. Smoking, obesity, alcohol, carcinogens. Correlation ≠ causation. Human + financial costs.
Cancer	Uncontrolled cell division → tumour. Benign stays; malignant spreads in blood → secondary tumours. BRCA genes.
Plant tissues	Epidermis, palisade (most photosynthesis), spongy (air spaces), xylem, phloem, meristem (growing tips, differentiates).
Transport	Xylem: dead, lignin, water up (transpiration stream). Phloem: living, end-wall pores, sugars both ways (translocation).
Transpiration	Faster with more light, heat, wind; slower with more humidity. Potometer measures uptake. Guard cells: turgid = open, flaccid = closed.

PRACTICE

Summary questions

Try every question **without notes**. Answers start on page 24. Tick each one you get fully right; redo the rest in 2–3 days.

Section A — Quick recall (1–2 marks each)

1. What is a tissue?
2. Explain what is meant by an organ system.
3. What is differentiation?
4. Name the three tissues in the stomach and give the job of each.
5. Why can enzymes be described as biological catalysts?
6. Why does an enzyme usually only catalyse one reaction?
7. What does ‘denatured’ mean?
8. How is the induced fit model different from the lock and key model?
9. What is the optimum pH of pepsin? Why does this suit it?
10. List the three places amylase is made.
11. What does lipase break lipids into?
12. Where is bile made and where is it stored?
13. Give the two reasons the stomach makes hydrochloric acid.
14. Which part of the gut absorbs most water?
15. Name the reagent used to test for lipids and its positive result.
16. Which food test needs heating, and how?
17. Name the tubes that split off the trachea.
18. Explain why the circulatory system is called ‘double’.
19. Name the four chambers of the heart.
20. How is resting heart rate controlled?
21. What is the function of the coronary arteries?
22. Why do red blood cells have no nucleus?
23. What do platelets do?
24. Name two waste products carried in plasma and where they go.
25. What is the difference between biological and mechanical replacement valves?
26. What is a non-communicable disease? Give an example.
27. What is a risk factor?
28. Which type of tumour is cancerous?
29. What is meristem tissue and where is it found?
30. What is translocation?

31. What is transpiration?
32. Name the cells that open and close stomata.

Section B — Exam-style questions

33. Explain why a protease from the stomach stops working when it moves into the small intestine. [3 marks]
34. Bile is a product of the liver. Describe and explain its role in digestion. [4 marks]
35. A student investigated the effect of pH on amylase. Describe a method she could use. Include the variables she should control. [6 marks]
36. Describe how the alveoli are adapted for gas exchange. [4 marks]
37. Explain why the wall of the left ventricle is thicker than the wall of the right ventricle. [2 marks]
38. Describe how veins are adapted to carry blood back to the heart. [2 marks]
39. Explain how the structure of capillaries helps them do their job. [3 marks]
40. Outline three ways in which red blood cells are adapted to carry oxygen. [3 marks]
41. A patient has coronary heart disease. Evaluate the use of stents and statins to treat them. [6 marks]
42. Suggest one disadvantage of treating heart failure with an artificial heart. [1 mark]
43. Smoking is linked with lung cancer. Explain why scientists say smoking is a 'risk factor' and why correlation alone does not prove cause. [3 marks]
44. Explain the difference between a benign and a malignant tumour. [3 marks]
45. Describe the structure of xylem. [3 marks]
46. Explain how low light intensity affects the rate of transpiration. [3 marks]
47. Explain why a plant on a hot, windy day loses water faster than on a cool, still, humid day. [4 marks]

Section C — Maths skills

48. Amylase took 150 seconds to break down all the starch at pH 4. Calculate the rate using rate = 1000 ÷ time. Give your answer to 2 significant figures. [2 marks]
49. Catalase released 27 cm^3 of oxygen in 45 seconds. Calculate the rate in cm^3/s. [1 mark]
50. During a 15 minute run, a student took 510 breaths. Calculate the mean breathing rate. [1 mark]
51. 1960 ml of blood passed through an artery in 3.5 minutes. Calculate the rate of blood flow in ml/min. [1 mark]
52. In a potometer the bubble moved 36 mm in 12 minutes. Calculate the rate of water uptake. Suggest why this is only an estimate of transpiration. [2 marks]

ANSWERS

Answers and mark scheme

Section A — Quick recall

1. **What is a tissue?**
   A group of similar cells that work together to carry out a particular function.
2. **Explain what is meant by an organ system.**
   A group of organs working together to carry out a particular function (e.g. the digestive system).
3. **What is differentiation?**
   The process by which a cell becomes specialised for a particular job.
4. **Name the three tissues in the stomach and give the job of each.**
   Muscular — churns food; glandular — makes digestive juices; epithelial — covers the inside and outside.
5. **Why can enzymes be described as biological catalysts?**
   They are made by living things and speed up reactions without being used up or changed.
6. **Why does an enzyme usually only catalyse one reaction?**
   Its active site has a unique shape; only one substrate fits into it.
7. **What does 'denatured' mean?**
   The bonds holding the enzyme together break, so the active site changes shape and the substrate no longer fits. It is permanent.
8. **How is the induced fit model different from the lock and key model?**
   In induced fit, the active site changes shape slightly as the substrate binds, giving a tighter fit.
9. **What is the optimum pH of pepsin? Why does this suit it?**
   About pH 2 — it works in the stomach, which is acidic due to hydrochloric acid.
10. **List the three places amylase is made.**
    Salivary glands, pancreas, small intestine.
11. **What does lipase break lipids into?**
    Glycerol and fatty acids.
12. **Where is bile made and where is it stored?**
    Made in the liver; stored in the gall bladder.
13. **Give the two reasons the stomach makes hydrochloric acid.**
    To kill bacteria; to give the right (acidic, pH 2) conditions for pepsin.
14. **Which part of the gut absorbs most water?**
    The large intestine.
15. **Name the reagent used to test for lipids and its positive result.**
    Sudan III stain — a bright red layer forms on top.
16. **Which food test needs heating, and how?**
    Benedict's test — in a water bath at about 75 °C for 5 minutes.
17. **Name the tubes that split off the trachea.**
    The bronchi (one bronchus to each lung).
18. **Explain why the circulatory system is called 'double'.**
    There are two circuits: right ventricle → lungs → heart, and left ventricle → body → heart. Blood passes through the heart twice per circuit of the body.

19. **Name the four chambers of the heart.**
    Right atrium, right ventricle, left atrium, left ventricle.
20. **How is resting heart rate controlled?**
    By a group of pacemaker cells in the right atrium wall that send electrical impulses to make the heart muscle contract.
21. **What is the function of the coronary arteries?**
    To supply the heart muscle with oxygenated blood.
22. **Why do red blood cells have no nucleus?**
    To give more room for haemoglobin, so they can carry more oxygen.
23. **What do platelets do?**
    Help the blood clot at a wound, stopping blood loss and microorganisms getting in.
24. **Name two waste products carried in plasma and where they go.**
    CO_2 from organs to the lungs; urea from the liver to the kidneys.
25. **What is the difference between biological and mechanical replacement valves?**
    Biological valves come from humans or other mammals (e.g. pigs, cows); mechanical valves are man-made.
26. **What is a non-communicable disease? Give an example.**
    A disease that cannot spread between people or animals, e.g. cancer, asthma, CHD.
27. **What is a risk factor?**
    Something linked to an increased chance of developing a disease (it does not guarantee you get it).
28. **Which type of tumour is cancerous?**
    Malignant.
29. **What is meristem tissue and where is it found?**
    Tissue that can differentiate into many types of plant cell; found at the growing tips of shoots and roots.
30. **What is translocation?**
    The movement of dissolved sugars through the phloem, in both directions.
31. **What is transpiration?**
    The loss of water from a plant (mostly the leaves) by evaporation and diffusion.
32. **Name the cells that open and close stomata.**
    Guard cells.

Section B — Exam-style questions

33. **Explain why a protease from the stomach stops working when it moves into the small intestine.** [3]
    - The small intestine is **alkaline** (bile neutralises the acid) (1)
    - The pH is far from pepsin's optimum (pH 2), so the bonds holding the enzyme break (1)
    - The **active site changes shape** so the substrate no longer fits — the enzyme is denatured (1)
34. **Bile is a product of the liver. Describe and explain its role in digestion.** [4]
    - Bile is alkaline (1) so it neutralises hydrochloric acid from the stomach (1) giving alkaline conditions where small-intestine enzymes work best
    - It emulsifies fat into tiny droplets (1) which gives a larger surface area for lipase, so fats are digested faster (1)

35. **A student investigated the effect of pH on amylase. Describe a method she could use. Include the variables she should control.** [6]
    - Drop of iodine in each well of a spotting tile
    - Water bath at constant temperature (e.g. 35 °C)
    - Add amylase + buffer of known pH to a tube; let it warm up
    - Add starch, mix and start a stopwatch
    - Every 30 s place a drop on iodine; record time when iodine stays orange-brown
    - Repeat at other pH values (and repeat each pH for a mean)
    - Control: temperature, volumes and concentrations of amylase and starch
    - *Level marking: 5–6 marks for a clear, logical method a person could follow with controls named.*
36. **Describe how the alveoli are adapted for gas exchange.** [4]
    - Large surface area (1)
    - Thin walls / one cell thick → short diffusion distance (1)
    - Moist lining so gases dissolve (1)
    - Good blood supply (network of capillaries) keeps a steep concentration gradient (1)
37. **Explain why the wall of the left ventricle is thicker than the wall of the right ventricle.** [2]
    - The left ventricle pumps blood to the whole body / further (1)
    - so it must contract more strongly / at higher pressure — more muscle needed (1). (The right ventricle only pumps to the nearby lungs.)
38. **Describe how veins are adapted to carry blood back to the heart.** [2]
    - Large lumen helps blood flow despite low pressure (1)
    - Valves keep blood flowing in the right direction / stop backflow (1)
39. **Explain how the structure of capillaries helps them do their job.** [3]
    - Walls are one cell thick (1) → short diffusion distance, so faster diffusion (1)
    - Walls are permeable and capillaries are close to every cell, so substances (O_2, glucose, CO_2) can be exchanged (1)
40. **Outline three ways in which red blood cells are adapted to carry oxygen.** [3]
    - Biconcave disc shape → large surface area to absorb oxygen (1)
    - No nucleus → more room for haemoglobin (1)
    - Contain haemoglobin, which binds to oxygen to form oxyhaemoglobin (1)
41. **A patient has coronary heart disease. Evaluate the use of stents and statins to treat them.** [6]
    - CHD = fatty build-up narrows coronary arteries → less oxygen to heart muscle
    - Stents: hold artery open; work immediately and for a long time; quick recovery — but surgery risk (heart attack, infection, thrombosis)
    - Statins: lower LDL cholesterol, slow fatty build-up, raise HDL, no surgery — but must be taken for life, side effects, take time to work
    - Conclusion: e.g. stent better for a severe blockage needing quick action; statins better to prevent further build-up; often used together
    - *Level marking: advantages and disadvantages of both + a justified conclusion for 5–6 marks.*

42. **Suggest one disadvantage of treating heart failure with an artificial heart.** [1]
    - Any one: risk of bleeding/infection from surgery; parts can wear out or motor fail; blood clots → stroke; need blood-thinning drugs

43. **Smoking is linked with lung cancer. Explain why scientists say smoking is a 'risk factor' and why correlation alone does not prove cause.** [3]
    - Smoking increases the chance of lung cancer but does not guarantee it (1)
    - A correlation shows two things are linked (1)
    - but another factor could cause both, so more evidence (e.g. a mechanism — damage to lung cells) is needed to show cause (1)

44. **Explain the difference between a benign and a malignant tumour.** [3]
    - Benign tumours stay in one place / within a membrane and do not invade other tissues (1)
    - Malignant tumours invade neighbouring tissue (1)
    - and cells break off, travel in the blood and form secondary tumours (1)

45. **Describe the structure of xylem.** [3]
    - Dead cells joined end to end (1)
    - No end walls — a hollow tube (1)
    - Strengthened with lignin (1)

46. **Explain how low light intensity affects the rate of transpiration.** [3]
    - Low light → transpiration rate decreases (1)
    - Stomata begin to close as it gets darker (1)
    - because photosynthesis cannot happen so CO_2 is not needed; less water vapour diffuses out (1)

47. **Explain why a plant on a hot, windy day loses water faster than on a cool, still, humid day.** [4]
    - Higher temperature → water particles have more energy to evaporate and diffuse (1)
    - Wind sweeps away water vapour (1) keeping a low concentration outside the leaf → steeper concentration gradient (1)
    - Humid air has less concentration difference so diffusion is slower on the humid day (1)

Section C — Maths skills

48. **Amylase took 150 seconds to break down all the starch at pH 4. Calculate the rate using rate = 1000 ÷ time. Give your answer to 2 significant figures.** [2]
    1000 ÷ 150 = 6.666… = **6.7 s^{-1}**

49. **Catalase released 27 cm^3 of oxygen in 45 seconds. Calculate the rate in cm^3/s.** [1]
    27 ÷ 45 = **0.6 cm^3/s**

50. **During a 15 minute run, a student took 510 breaths. Calculate the mean breathing rate.** [1]
    510 ÷ 15 = **34 breaths per minute**

51. **1960 ml of blood passed through an artery in 3.5 minutes. Calculate the rate of blood flow in ml/**

    1960 ÷ 3.5 = **560 ml/min**

52. **In a potometer the bubble moved 36 mm in 12 minutes. Calculate the rate of water uptake. Suggest why this is only an estimate of transpiration.** [2]
    36 ÷ 12 = **3 mm/min** (1). Some water taken up is used by the plant (e.g. in photosynthesis / to keep cells turgid), so uptake is not exactly equal to water lost (1).

FINAL EXAM ADVICE

Use the **key words** examiners look for: *active site, denatured, specific, emulsify, neutralise, diffusion, concentration gradient, surface area, one cell thick, oxyhaemoglobin, translocation, transpiration, turgid, flaccid*. Show every step in calculations and include **units**.

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