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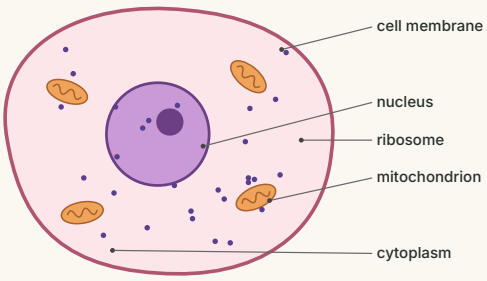
Specialist one-to-one Science, Maths & Economics tuition

AQA GCSE BIOLOGY · SPECIFICATION 4.1

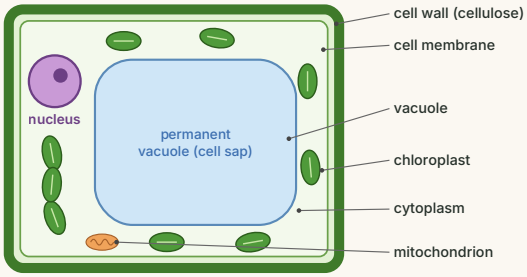
Topic 1: Cell Biology

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



ANIMAL CELL



PLANT CELL

Prepared by iBLaurel · Specialist one-to-one Science, Maths & Economics tuition
Suitable for Foundation and Higher tier · Combined Science (Trilogy) and Separate Biology

START HERE

Contents and how to use this guide

1.1 Cells: eukaryotes and prokaryotes
1.2 Microscopy and magnification
1.3 Using a light microscope (RP)
1.4 Differentiation and specialised cells
1.5 Stem cells
1.6 Chromosomes, the cell cycle and mitosis
1.7 Binary fission (Biology only)
1.8 Culturing microorganisms (RP, Biology only)
1.9 Diffusion
1.10 Osmosis (RP)
1.11 Active transport
1.12 Surface area to volume ratio
1.13 Exchange surfaces: lungs and small intestine
1.14 Exchange surfaces: leaves and gills
★ One-page memory sheet
✎ Summary questions
✓ Answers and mark scheme

How to use this guide

1. **Read** one section. Study the diagram and say the labels out loud.
2. **Learn the gold "Remember it" box** — short hooks that make facts stick.
3. **Cover and recall:** cover the page, write the key points from memory, then check and correct in a different colour.
4. **Read the green "Exam tip" and red "Common mistake" boxes** — they show where marks are won and lost.
5. Finish with the **summary questions** (no notes), then mark them with the **answers**. Re-test the ones you got wrong 2–3 days later.

THE BIG IDEA OF TOPIC 1

The **cell** is the basic unit of all life. Cells have **parts with jobs**, they become **specialised**, they **divide** to make new cells, and substances **move in and out** by diffusion, osmosis and active transport. Topic 1 is the foundation for every other Biology topic.

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
BIOLOGY ONLY	Only for Separate (Triple) Biology, not Combined Science

PART A

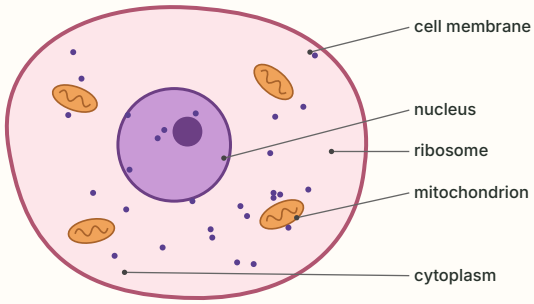
Cell Structure and Microscopy

1.1 Cells: eukaryotes and prokaryotes

AQA 4.1.1.1–4.1.1.2

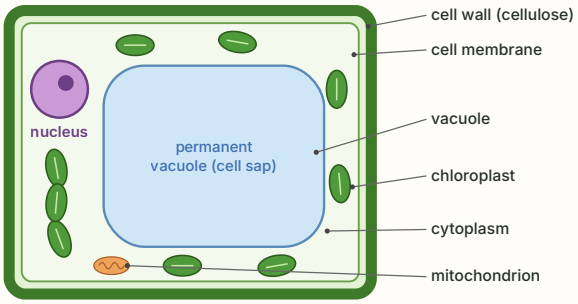
All living things are made of cells. There are two main types:

	Eukaryotic cells	Prokaryotic cells
Examples	Animal, plant (and fungi, protists)	Bacteria
Size	Bigger (about 10–100 µm)	Much smaller (about 1–10 µm)
Genetic material	Inside a **nucleus**	**No nucleus** — a single loop of DNA in the cytoplasm, plus **plasmids**
Complexity	More complex	Simpler



ANIMAL CELL

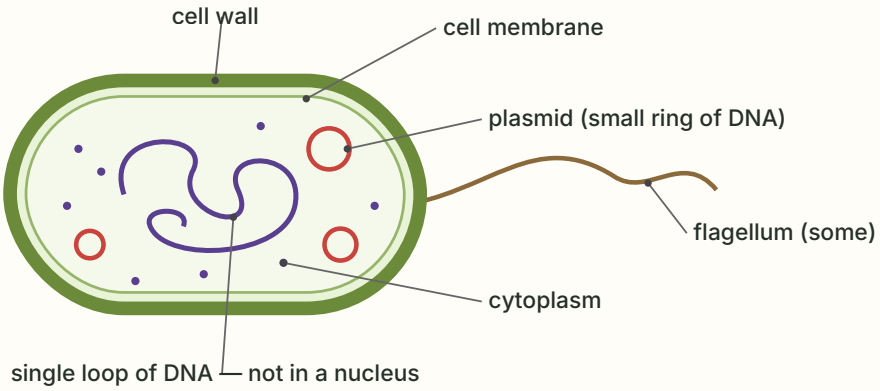
An animal cell



PLANT CELL

A plant cell

Cell part	Job — learn this line	Found in
Nucleus	Contains genetic material (DNA) that controls the cell's activities	Animal + plant
Cytoplasm	Gel where most chemical reactions happen; contains enzymes that control them	All cells
Cell membrane	Controls what goes **in and out** of the cell	All cells
Mitochondria	Where most reactions of **aerobic respiration** happen → release energy	Animal + plant
Ribosomes	Where **proteins are made** (protein synthesis)	All cells
Cell wall	Made of **cellulose** in plants; strengthens and supports the cell	Plant (+ bacteria)
Permanent vacuole	Contains **cell sap** (weak solution of sugar and salts)	Plant only
Chloroplasts	Where **photosynthesis** happens; contain green **chlorophyll** which absorbs light	Plant only



A bacterial (prokaryotic) cell

REMEMBER IT

Animal cell has **5**: **"Nice Cats Make Many Rabbits"** → **N**ucleus, **C**ytoplasm, **M**embrane, **M**itochondria, **R**ibosomes.
Plant cell adds **3 extras**: **Wall, Vacuole, Chloroplasts** ("**W**e **V**alue **C**hlorophyll").
Prokaryote = **pro**bably **no** nucleus ("**Pro = No**").

COMMON MISTAKE

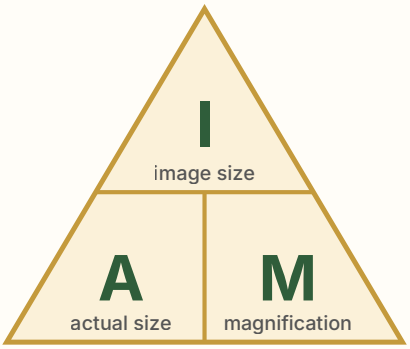
Not all plant cells have chloroplasts (e.g. root cells don't — they get no light). And bacteria DO have a cell wall, but it is **not made of cellulose**.

1.2 Microscopy and magnification

AQA 4.1.1.5

	Light microscope	Electron microscope
Uses	Light and lenses	Electrons
Magnification	Lower (up to about ×2000)	**Much higher**
Resolution	Lower (about 200 nm)	**Much higher** — shows finer detail
Can see	Cells, nucleus	Small sub-cellular structures: **mitochondria, chloroplasts, ribosomes, plasmids** in detail
Other	Cheap, portable, can view living cells	Expensive, large; helped scientists understand sub-cellular structures

- **Magnification** = how many times bigger the image is than the real object.
- **Resolution** = the ability to tell apart two points that are close together → how much **detail** you see.



Cover the one you want to find

The magnification triangle

MATHS SKILL — MAGNIFICATION

magnification = image size ÷ real size

Rearrange: real size = image size ÷ magnification · image size = real size × magnification

Example: a cell image is 12 mm wide at ×400. Real size = 12 ÷ 400 = **0.03 mm** = 0.03 × 1000 = **30 µm**.

Always put both sizes in the same unit first. Magnification has **no units**.

Unit	Symbol	In millimetres	Convert
millimetre	mm	1 mm	÷ 1000 each step down: mm → µm → nm (multiply by 1000) µm → mm or nm → µm: divide by 1000
micrometre	µm	0.001 mm = 1×10^{-3} mm	
nanometre	nm	0.000001 mm = 1×10^{-6} mm	

STANDARD FORM

Write very small numbers as **A × 10^{n}** where A is between 1 and 10.
0.00025 mm → move the point 4 places right → **2.5×10^{-4} mm**. 3 400 000 → **3.4×10^{6}**.
Negative power = small number. Count how many places the decimal point moves.

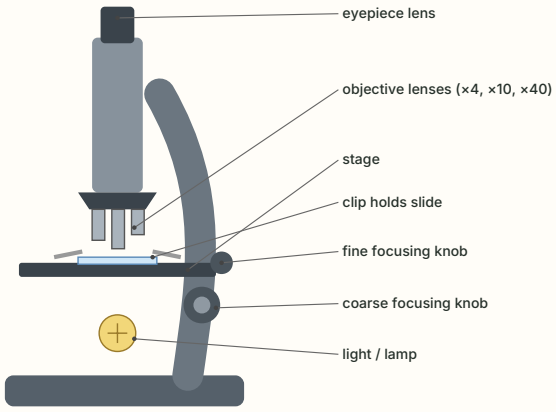
REMEMBER IT

"I AM" triangle: **I**mage on top, **A**ctual × **M**agnification on the bottom.
Electron microscope = Extra detail (higher magnification AND higher resolution).
Units ladder: **mm → µm → nm**, each step **× 1000**.

1.3 Using a light microscope

REQUIRED PRACTICAL

AQA 4.1.1.5



Parts of a light microscope

Preparing a slide (e.g. onion cells)

1. Put a drop of water on a clean slide.
2. Peel a thin layer of onion epidermis with tweezers and lay it flat on the water.
3. Add a drop of **iodine solution** (a **stain** — makes structures like the nucleus easier to see).
4. Lower a **cover slip** at an angle using a mounted needle — this **avoids air bubbles** and keeps the sample flat.

Using the microscope

1. Clip the slide on the stage.
2. Choose the **lowest-power** objective lens (e.g. ×4).
3. Use the **coarse** focusing knob to move the stage up to just below the lens (look from the side).
4. Look down the eyepiece; move the stage **down** with the coarse knob until the image is roughly in focus.
5. Use the **fine** knob to get a clear image.
6. For more detail, switch to a **higher-power** objective and refocus with the fine knob.

TOTAL MAGNIFICATION

Total magnification = eyepiece lens × objective lens. Eyepiece ×10 with objective ×40 → **×400**.

DRAWING YOUR OBSERVATIONS

Use a sharp **pencil**, draw **clear unbroken lines**, no colouring or shading, take up at least half the space, draw **in proportion**. Add a **title**, the **magnification**, and label parts with **straight lines** (ruler) that don't cross.

REMEMBER IT

Low first, then fine. Start on the lowest power, focus with coarse, finish with fine.
Stain to **see**, cover slip to **flatten** and stop bubbles.

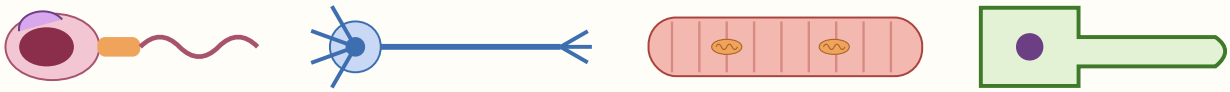
PART B

Cell Specialisation and Stem Cells

1.4 Differentiation and specialised cells

AQA 4.1.1.3–4.1.1.4

- **Differentiation** = when a cell **changes to become specialised** for its job. It gains **new sub-cellular structures** suited to that job.
- In **animals**, most cells differentiate early in life and then lose this ability. Mature animal cells mostly divide for **repair and replacement** (e.g. skin cells).
- **Plant** cells can keep differentiating all their life.
- Undifferentiated cells are called **stem cells**.



Sperm
tail to swim
many mitochondria
enzymes in head
half the genetic info

Nerve cell
long — carries impulses far
branched ends connect
to other nerve cells

Muscle cell
long — room to contract
lots of mitochondria
for energy

Root hair cell
long 'hair' → big surface
area to absorb water
and mineral ions

Specialised animal and plant cells — each structure helps the job

Cell	Job	Adaptations (how the structure helps)
Sperm cell	Get the male DNA to the egg (reproduction)	Long **tail** to swim · lots of **mitochondria** for energy · **enzymes** in the head to digest through the egg membrane · carries half the genetic information
Nerve cell	Carry electrical signals around the body	**Long** to cover more distance · **branched connections** at the ends to connect to other nerve cells
Muscle cell	Contract quickly	**Long** so there is space to contract · lots of **mitochondria** to release energy
Root hair cell	Absorb water and mineral ions from soil	Long 'hair' sticks into soil → **large surface area**
Xylem cell	Carry water and minerals up the plant	Dead, **hollow** tubes with **no end walls** · strengthened by **lignin**
Phloem cell	Carry dissolved sugars around the plant	Very few sub-cellular structures · **pores in the end walls** (sieve plates) so substances flow through

REMEMBER IT

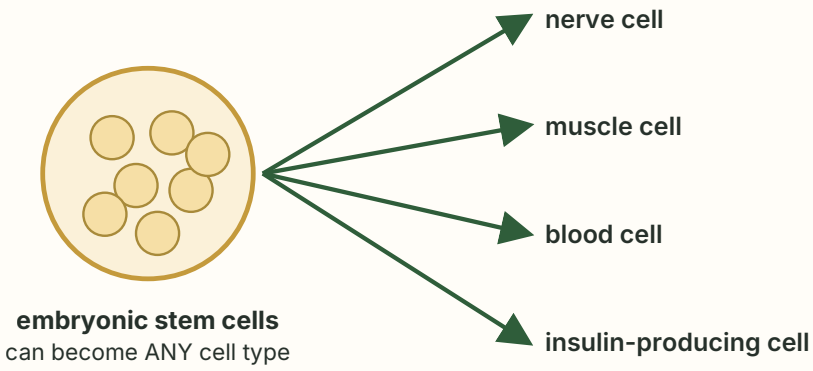
For ANY specialised cell, link **structure → function** using "**...so that...**". e.g. "It has many mitochondria **so that** it can release lots of energy for swimming."
Mitochondria lovers: **sperm and muscle** (both move!).

EXAM TIP

"Describe how a root hair cell is adapted" (2 marks): long hair-like projection (1) → large surface area to absorb water and minerals (1). One mark for the **feature**, one for **why** it helps.

1.5 Stem cells

AQA 4.1.2.3



Embryonic stem cells can differentiate into any type of cell

Type	Where found	What they can become
Embryonic stem cells	Early human embryos	**Any** type of cell
Adult stem cells	e.g. **bone marrow**	Only **some** types (e.g. blood cells)
Meristem cells (plants)	Growing tips of shoots and roots	**Any** type of plant cell, all through the plant's life

Uses in medicine:

- **Bone marrow transplants** (adult stem cells) to replace faulty blood cells, e.g. in leukaemia.
- Embryonic stem cells could replace faulty cells: e.g. **insulin-producing cells** for **diabetes**, **nerve cells** for people **paralysed** by spinal injuries.
- **Therapeutic cloning**: an embryo is made with the **same genes as the patient**. Stem cells from it are **not rejected** by the patient's body.

✓ For stem cell research	× Against / risks
Could cure diseases and help people suffering · embryos used are often unwanted ones from fertility clinics that would be destroyed anyway	**Ethical/religious**: some believe an embryo is a potential human life · stem cells grown in a lab could be **infected with a virus** → passed to the patient · should find other cures

Plants: meristem cells can make **clones** (identical copies) quickly and cheaply → used to save **rare species** from extinction, and to grow lots of crops with useful features such as **disease resistance**.

REMEMBER IT

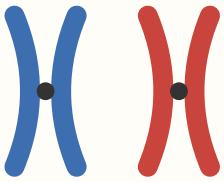
Embryonic = Everything. Adult = A few. Meristem = Many (plants, for life).
Therapeutic cloning = **"Twin cells"** — same genes, so **no rejection**.

PART C

Cell Division and Microorganisms

1.6 Chromosomes, the cell cycle and mitosis

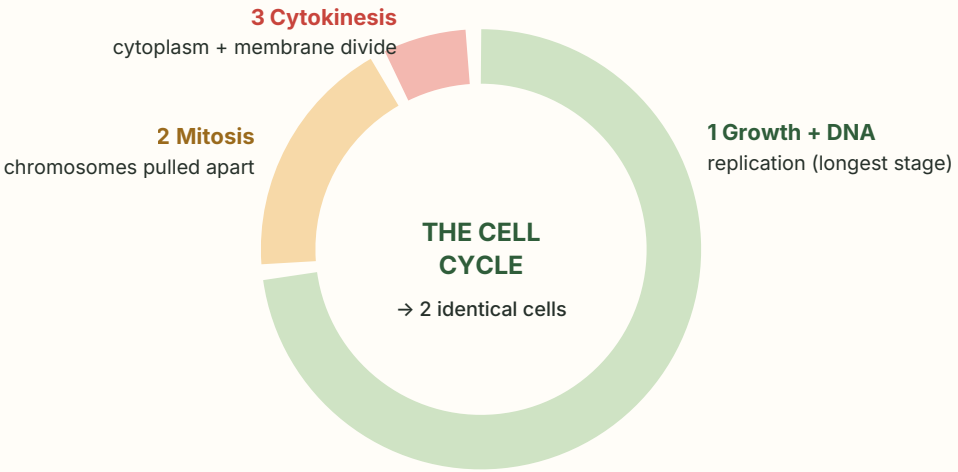
AQA 4.1.2.1–4.1.2.2



a pair of chromosomes
one from each parent

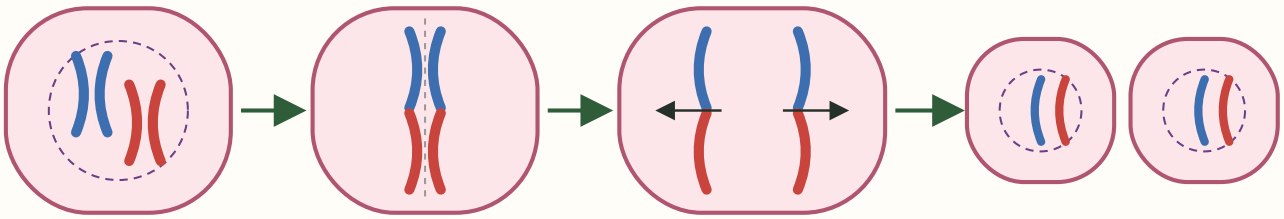
Chromosomes come in pairs

- The **nucleus** contains **chromosomes**, made of **DNA** molecules.
- Each chromosome carries a large number of **genes**. Genes control characteristics (e.g. hair colour).
- In body cells, chromosomes are found in **pairs** — one from each parent.
- Human body cells have **23 pairs** (46 chromosomes).



The cell cycle: three stages

- Body cells divide by the **cell cycle** to make new cells for **growth, development and repair**.
- **Stage 1 — growth and DNA replication:** the cell grows, makes more sub-cellular structures (ribosomes, mitochondria) and **copies its DNA** → chromosomes become X-shaped (each arm is an identical copy).
- **Stage 2 — mitosis:** chromosomes line up at the centre; cell fibres pull the arms to **opposite ends**; new membranes form round each set → two nuclei.
- **Stage 3 — cytokinesis:** the **cytoplasm and cell membrane divide**.
- Result: **two daughter cells, genetically identical** to each other and to the parent cell.



Mitosis step by step

REMEMBER IT

Cell cycle = **"Grow, Go, Split"**: **G**row + copy DNA → mitosis (chromosomes **Go** to the ends) → cytokinesis (**Split**).
Mitosis **Ma**kes **Ma**tching cells (identical). Uses: **G**rowth, **D**evelopment, **R**epair — "**GDR**".

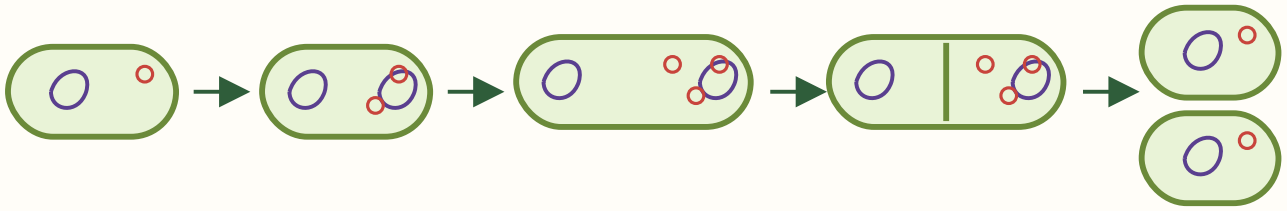
COMMON MISTAKE

Don't say mitosis makes cells with "the same chromosomes as each other" only — say **genetically identical to the parent cell**. And cytokinesis is the **last** step, after mitosis.

1.7 Binary fission BIOLOGY ONLY

AQA 4.1.1.6

- Prokaryotic cells (bacteria) divide by **binary fission** — a simple splitting in two.



Binary fission in a bacterium

- The circular DNA and plasmids are **copied**; the cell gets bigger; the DNA loops move to opposite ends; the cytoplasm divides and new cell walls form → **two daughter cells**, each with one copy of the DNA and a variable number of plasmids.
- With plenty of **nutrients** and a **warm** temperature, some bacteria divide as often as **every 20 minutes**. They stop when nutrients run out or waste builds up.

MATHS SKILL — NUMBER OF BACTERIA

Step 1: number of divisions = total time ÷ mean division time.

Step 2: bacteria at end = bacteria at start × $2^{\text{number of divisions}}$.

Example: one bacterium divides every 20 minutes. How many after 2 hours?
2 hours = 120 min → 120 ÷ 20 = **6 divisions** → 1 × 2^6 = **64 bacteria**.

Big answers may need **standard form**, e.g. 2^{24} = 16 777 216 ≈ **1.7×10^7**.

REMEMBER IT

Binary = **two**. Each division **doubles** the number: 1 → 2 → 4 → 8 → 16 …

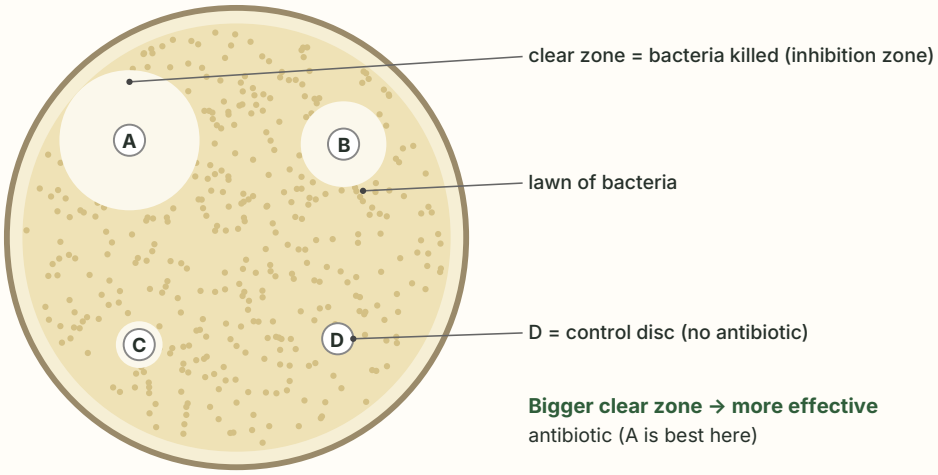
1.8 Culturing microorganisms

REQUIRED PRACTICAL · BIOLOGY ONLY · AQA 4.1.1.6

- Bacteria are grown (**cultured**) in a **culture medium** containing carbohydrates, minerals, proteins and vitamins.
- Medium can be **nutrient broth** (liquid) or **agar jelly** in a Petri dish. Bacteria grow into **colonies** on the agar.
- Spread bacteria on agar with a sterile **inoculating loop** or a sterile dropping pipette and spreader → an even '**lawn**' of bacteria.

Investigating antibiotics (the practical):

1. Put paper discs soaked in different antibiotics (or different concentrations) onto an agar plate with an even lawn of bacteria. Space them out.
2. Include a **control disc** soaked in sterile water (no antibiotic) — shows any effect is due to the antibiotic.
3. Tape the lid on and incubate at **25 °C** for about 48 hours.
4. The antibiotic diffuses into the agar. Where bacteria are killed, a clear **inhibition zone** forms. Bigger zone → **more effective** antibiotic.



Antibiotic discs on a lawn of bacteria

MATHS SKILL — AREA OF AN INHIBITION ZONE

Area = πr² (r = radius = diameter ÷ 2).
Example: clear zone diameter 16 mm → r = 8 mm → area = 3.14 × 8² = **201 mm²** (3 s.f.). Use the same formula to find the area of a colony.

Aseptic technique — to avoid contamination by unwanted microorganisms:

Step	Why
Sterilise Petri dish and agar before use (e.g. autoclave)	Kills any microorganisms already there
Pass the inoculating loop through a **hot Bunsen flame**	Kills microorganisms on the loop
Lift the lid only a little; work near a Bunsen flame	Stops microbes in the air getting in
Tape the lid on **lightly** (a few strips, not all round)	Stops microbes getting in, but lets **oxygen** in → stops harmful **anaerobic** bacteria growing
Store the dish **upside down**	Stops condensation dripping onto the agar
Incubate at **25 °C max** in schools	Harmful pathogens that grow at body temperature (37 °C) are less likely to grow

REMEMBER IT

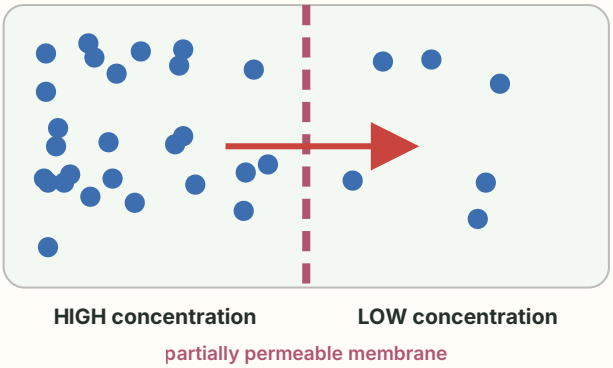
Aseptic: **"Flame, Tape, Flip, 25"** — flame the loop, tape the lid (lightly), flip the dish upside down, incubate at 25 °C.

PART D

Transport In and Out of Cells

1.9 Diffusion

AQA 4.1.3.1



Diffusion: net movement from high to low concentration

DEFINITION — LEARN WORD FOR WORD

Diffusion is the **spreading out** of the particles of any substance in a solution, or particles of a gas, resulting in a **net movement** from an area of **higher concentration** to an area of **lower concentration**.

- It is **passive** — no energy needed.
- Happens in liquids and gases because particles move about **randomly**.

Diffusion across cell membranes: only **very small** molecules can pass through, e.g. **oxygen**, **glucose**, **amino acids**, water, CO_2, urea. Big molecules like **starch** and **proteins** can't fit.

Factor	Effect on the rate of diffusion
Concentration gradient (difference in concentration)	Bigger gradient → faster
Temperature	Higher → particles have more energy, move faster → faster
Surface area of the membrane	Larger → more particles cross at once → faster

REMEMBER IT

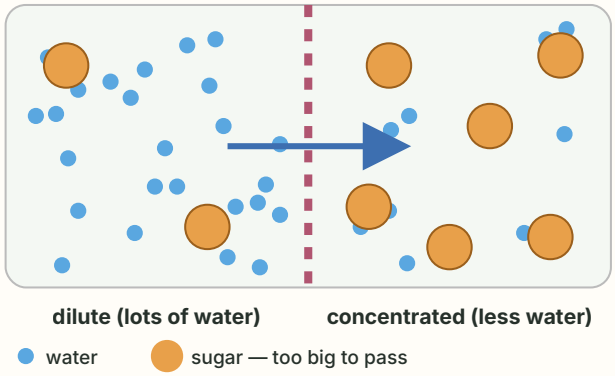
Diffusion = **"high to low, no energy, let it go"**.
Faster diffusion: **"Steep, Hot, Big"** — steep gradient, high temperature, big surface area.

EXAM TIP

Always say **"net movement"** and give the direction: **"from a higher to a lower concentration"**. Writing "particles move to where there is less" loses marks.

1.10 Osmosis REQUIRED PRACTICAL

AQA 4.1.3.2



Osmosis: water moves through a partially permeable membrane

DEFINITION — LEARN WORD FOR WORD

Osmosis is the **diffusion of water** from a **dilute solution** to a **more concentrated solution** through a **partially permeable membrane**.

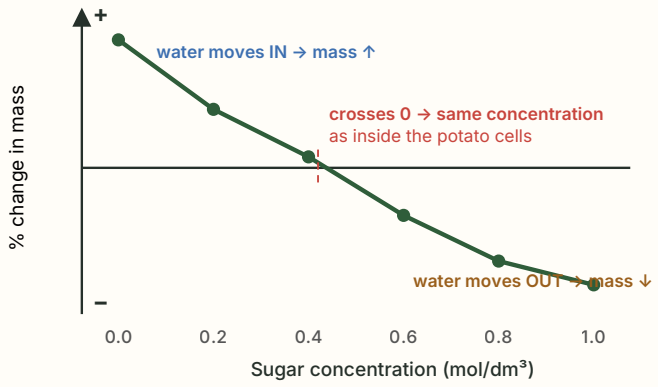
- A partially permeable membrane lets **small molecules** (water) through, but **not big ones** (e.g. sugar).
- Water molecules move both ways, but there is a **net movement** into the more concentrated solution.
- It is passive — no energy needed.

Effect on cells: cell in a more dilute solution → water moves **in** (animal cells can burst; plant cells become firm/turgid). Cell in a more concentrated solution → water moves **out** (cell shrinks).

The practical — potato cylinders in sugar solutions:

1. Make sugar (sucrose) solutions of different concentrations, e.g. 0.0, 0.2, 0.4, 0.6, 0.8, 1.0 mol/dm³ (0.0 = pure water).
2. Cut equal potato cylinders with a cork borer; trim to the same length.
3. **Dry** and **weigh** each cylinder; put one in each solution.
4. Leave for a set time (e.g. 24 hours), remove, **blot dry** with paper towel and reweigh.
5. Calculate the **% change in mass**; repeat and find means; plot a graph.

Independent	Dependent	Control variables
Sugar concentration	Change in mass of the potato	Volume of solution, temperature, time, type of potato, size of cylinders



Typical results — where the line crosses 0 is the concentration inside the potato cells

MATHS SKILL — % CHANGE IN MASS

% change = (final mass – initial mass) ÷ initial mass × 100

Example: 2.50 g → 2.80 g. Change = 0.30 g → 0.30 ÷ 2.50 × 100 = **+12%** (gained water).

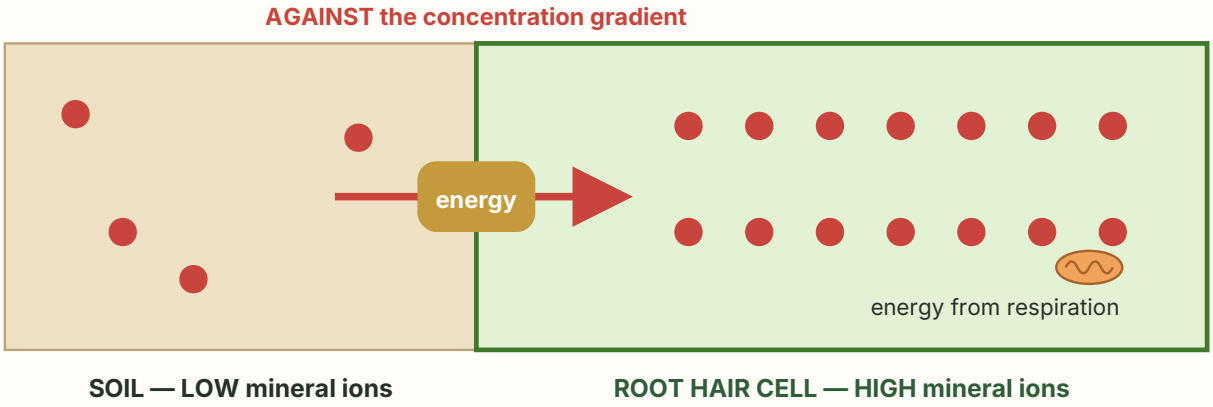
We use **% change** because the cylinders may not start at exactly the same mass.

EXAM TIP — ERRORS

Not drying the cylinders properly adds extra water → mass too high. Water evaporating from the beakers changes the concentration. Use repeats and calculate a **mean**.

1.11 Active transport

AQA 4.1.3.3



Active transport in a root hair cell: mineral ions move from LOW to HIGH concentration

DEFINITION — LEARN IT

Active transport moves substances from a **more dilute** solution to a **more concentrated** solution (**against** a concentration gradient). This needs **energy from respiration**.

In plants — root hair cells

- The concentration of mineral ions is usually **higher in the root hair cells** than in the soil.
- So diffusion can't take them in — active transport is used.
- Plants need mineral ions for healthy growth (e.g. nitrates).

In animals — the gut

- Sometimes there is a **lower** concentration of sugar (glucose) in the gut than in the blood.
- Active transport moves glucose into the blood **against the gradient**.
- Glucose is then taken to cells for **respiration**.

	Diffusion	Osmosis	Active transport
What moves	Any small particles	Water only	Particles (e.g. mineral ions, glucose)
Direction	High → low concentration	Dilute → concentrated solution	**Low → high** concentration
Energy?	No (passive)	No (passive)	**Yes — from respiration**
Membrane?	Not needed	Partially permeable	Needs a membrane with carrier proteins

REMEMBER IT

Active = Against + energy. Like pushing a ball **uphill** — it needs energy. Diffusion and osmosis roll **downhill** for free.

COMMON MISTAKE

Cells that do lots of active transport have **lots of mitochondria** — to release the energy needed. Mention this in “explain the adaptation” questions.

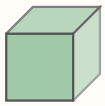
PART E

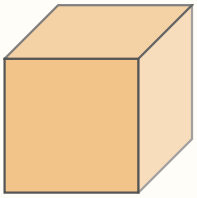
Exchange Surfaces

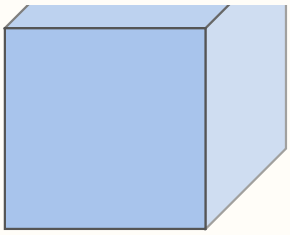
1.12 Surface area to volume ratio

AQA 4.1.3.1

- Organisms must exchange substances with their environment: **oxygen and CO_2** (gas exchange), **dissolved food and minerals**, and **waste** (e.g. urea from cells into the blood, for removal by the kidneys).
- How easy this is depends on the **surface area to volume ratio (SA:V)**.







	1 cm cube	2 cm cube	3 cm cube
Surface area	6 cm²	24 cm²	54 cm²
Volume	1 cm³	8 cm³	27 cm³
SA : V	**6 : 1**	**3 : 1**	**2 : 1**

Bigger organism → SMALLER surface area : volume ratio

As an object gets bigger, its surface area to volume ratio gets smaller

MATHS SKILL — WORKING OUT SA:V

Surface area of a block = add up the area of all 6 faces (each face = length × width).
Volume = length × width × height.
Example: block 2 cm × 2 cm × 4 cm. SA = (2×2)×2 + (2×4)×4 = 8 + 32 = **40 cm²**. V = 2×2×4 = **16 cm³**. SA:V = 40 : 16 = **2.5 : 1** (divide both by the volume).

Single-celled organisms have a **large SA:V**. Substances can diffuse **directly** into and out of the cell across the membrane fast enough to supply the whole volume.

Multicellular organisms have a **small SA:V**. Diffusion through the outer surface is too slow, so they need **specialised exchange surfaces** and a **transport system** (e.g. blood).

Features of a good exchange surface:

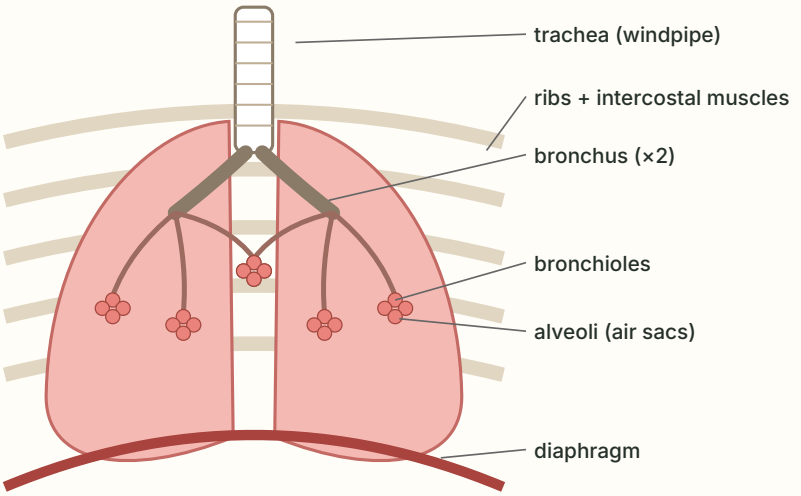
- **Large surface area** — lots of substance can cross at once.
- **Thin membrane** — short diffusion distance.
- **Efficient blood supply** (animals) — keeps a steep concentration gradient.
- **Ventilated** (for gas exchange in animals) — also keeps the gradient steep.

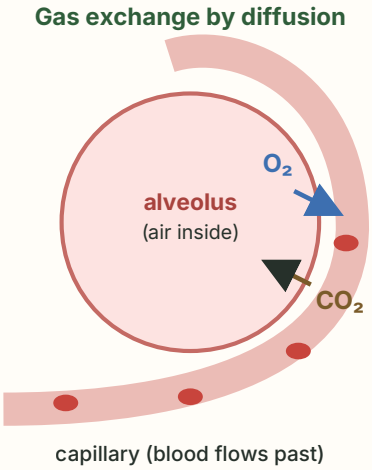
REMEMBER IT

Good exchange surface = **"Big, Thin, Blood, Breathe"**.
Small things, big ratio; big things need help.

1.13 Exchange surfaces: lungs and small intestine

AQA 4.1.3.1

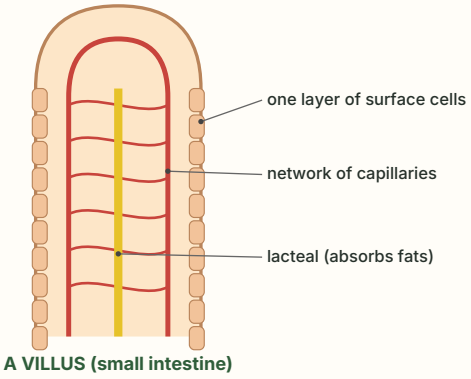




Gas exchange in the alveoli

- The lungs transfer **oxygen into the blood** and remove **CO_2** from it. This happens in millions of tiny air sacs called **alveoli**.
- Blood arriving at the alveoli has just come from the body: **low O_2, high CO_2** → O_2 diffuses **into** the blood, CO_2 diffuses **out** into the air.

Alveoli are adapted to maximise diffusion: enormous surface area (about 75 m² in humans) · moist lining for gases to dissolve · **very thin walls** (short distance) · **good blood supply**.



A villus

The small intestine — villi

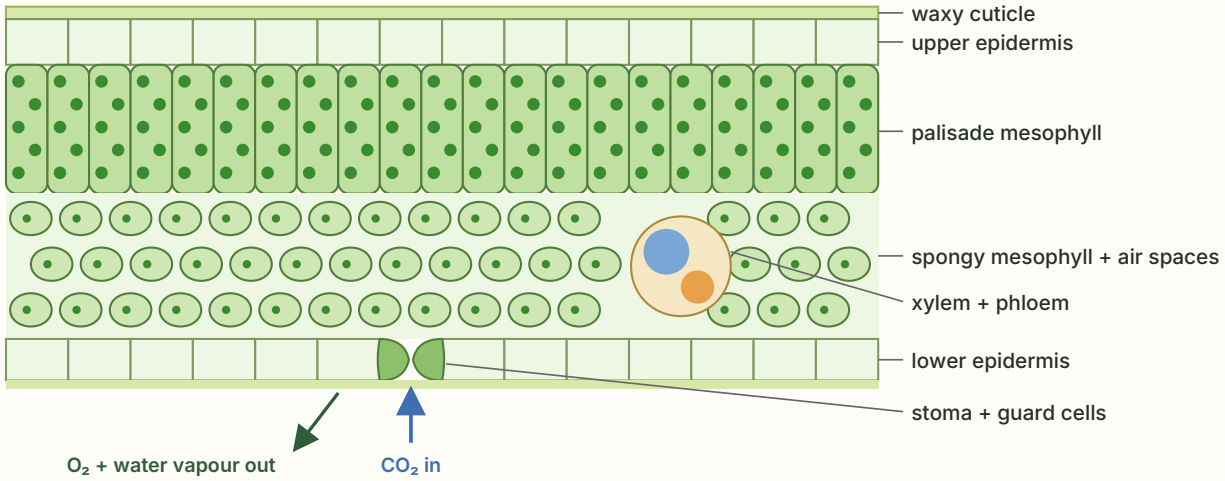
- The inside of the small intestine is covered in millions of finger-like projections called **villi**.
- They **increase the surface area** massively, so digested food is absorbed into the blood much faster.
- Each villus has a **single layer of surface cells** (short distance) and a **very good blood supply** (network of capillaries) to keep the gradient steep.
- The surface cells have tiny **microvilli** → even more surface area.
- Absorption happens by **diffusion** and **active transport**.

REMEMBER IT

Alveoli = **Air** sacs (lungs). Villi = **Vital food** absorbers (gut). Both are **Big, Thin, Blood**.

1.14 Exchange surfaces: leaves and gills

AQA 4.1.3.1



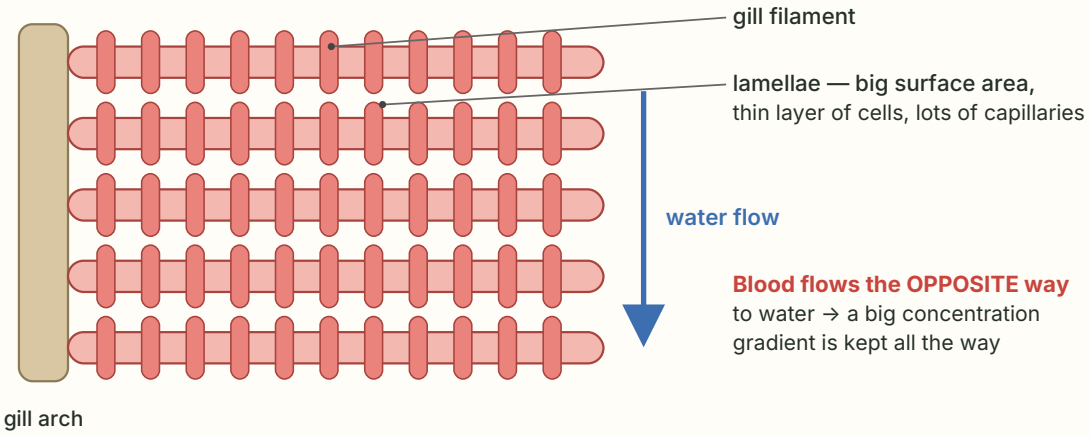
Gas exchange in a leaf: CO_2 diffuses in, O_2 and water vapour diffuse out through stomata

Leaves

- CO_2 diffuses **into the air spaces** in the leaf, then into the cells for **photosynthesis**.
- The underneath of the leaf has small holes called **stomata** (opened and closed by **guard cells**).
- O_2 (made in photosynthesis) and **water vapour** diffuse out through the stomata. Water lost this way is replaced from the xylem.
- **Flattened shape** → large surface area for exchange.
- **Air spaces** in the spongy layer → gases reach cells easily; large internal surface area.
- Guard cells close stomata when the plant is short of water.

Fish gills

- Water (with O_2) enters the mouth and passes out through the **gills**.
- O_2 diffuses from the water into the blood; CO_2 diffuses from the blood into the water.
- Each gill is made of thin plates called **gill filaments** → big surface area.
- Filaments are covered in tiny **lamellae** → even bigger surface area.
- Lamellae have **lots of capillaries** and a **thin surface layer** of cells → short diffusion distance.
- Blood flows in the **opposite direction** to water → a big concentration gradient is kept along the whole gill.



Fish gills: filaments covered in lamellae

REMEMBER IT

Gills: Filaments → Lamellae → Lots of capillaries → Opposite flow.
Leaves: **Flat, Spaces, Stomata**.

EXAM TIP

For any exchange surface, use the same 3-point answer: **(1) large surface area** because..., **(2) short diffusion distance** because..., **(3) steep concentration gradient** kept by... Then give the specific structure for each.

★ LAST-MINUTE

One-page memory sheet

Topic	Must-know facts
Eukaryotes v prokaryotes	Eukaryotes (animal, plant) have a nucleus. Prokaryotes (bacteria) are smaller, no nucleus — single DNA loop + plasmids.
Cell parts	Nucleus (DNA) · cytoplasm (reactions, enzymes) · membrane (controls in/out) · mitochondria (aerobic respiration) · ribosomes (make proteins). Plants also: cellulose wall, permanent vacuole (cell sap), chloroplasts (photosynthesis).
Microscopes	Electron = higher magnification + higher resolution → sees mitochondria, ribosomes, plasmids. Resolution = ability to distinguish two close points.
Maths	Magnification = image ÷ real · total mag = eyepiece × objective · mm → µm → nm (× 1000) · bacteria = start × 2^n · area = πr^2 · % change = change ÷ initial × 100 · SA:V
RP microscope	Thin onion layer, water, iodine stain, cover slip at angle (no bubbles). Lowest objective first, coarse then fine focus. Pencil drawing, labels, magnification.
Differentiation	Cell becomes specialised. Animals: early in life. Plants: all their life.
Specialised cells	Sperm (tail, mitochondria, enzymes) · nerve (long, branched) · muscle (long, mitochondria) · root hair (large SA) · xylem (hollow, lignin) · phloem (sieve plates).
Stem cells	Embryonic → any cell. Adult (bone marrow) → some. Meristem (plants) → any, for life. Therapeutic cloning = same genes → no rejection. Issues: ethics, viral infection.
Cell cycle	23 pairs of chromosomes. 1 grow + copy DNA → 2 mitosis (pulled apart) → 3 cytokinesis. 2 identical cells. For growth, development, repair.
Binary fission	Bacteria split in two; as often as every 20 min. Bio only.
Culturing	Agar / broth. Aseptic: sterilise, flame loop, tape lid lightly, upside down, 25 °C. Bigger inhibition zone = better antibiotic. Control disc.
Diffusion	Net movement high → low concentration, passive. Faster: steep gradient, higher temperature, bigger surface area.
Osmosis	Water, dilute → concentrated, through partially permeable membrane. RP: potato cylinders, % change in mass; crosses 0 = same concentration as cells.
Active transport	Low → high (against gradient), needs energy from respiration. Root hairs (minerals), gut (glucose).
SA:V	Bigger organism → smaller ratio → needs exchange surfaces + transport system.
Exchange surfaces	Large SA, thin, good blood supply, ventilated. Alveoli · villi (microvilli, capillaries) · leaves (stomata, air spaces, flat) · gills (filaments, lamellae, opposite flow).

PRACTICE

Summary questions

Try every question **without notes**. Tick each one you get fully right; redo the rest in 2–3 days. Answers are in the next section.

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

1. Give two differences between a prokaryotic cell and a eukaryotic cell.
2. Name three sub-cellular structures found in both animal and plant cells.
3. What is the function of the ribosomes?
4. What is the function of the mitochondria?
5. What is the cell wall of a plant made from, and what does it do?
6. What does the permanent vacuole contain?
7. Where is the genetic material found in a bacterial cell?
8. What is meant by ‘resolution’?
9. Give two advantages of an electron microscope over a light microscope.
10. Write down the formula for magnification.
11. How many micrometres are in one millimetre?
12. Why is a stain such as iodine added to a slide?
13. Why should the cover slip be lowered at an angle?
14. Which objective lens should you start with when using a microscope?
15. What is differentiation?
16. Give two ways a sperm cell is adapted to its function.
17. Why do muscle cells contain lots of mitochondria?
18. What is a stem cell?
19. Where are adult stem cells found in humans, and what can they become?
20. Where are stem cells found in plants?
21. Why are stem cells from therapeutic cloning not rejected?
22. How many chromosomes are in a normal human body cell?
23. Name the three stages of the cell cycle in order.
24. What is binary fission?
25. Why should Petri dishes be stored upside down?
26. Why are cultures incubated at 25 °C in schools?
27. Define diffusion.
28. Give three factors that affect the rate of diffusion.
29. Define osmosis.
30. Why is active transport needed in root hair cells?

31. Where does the energy for active transport come from?
32. Why do multicellular organisms need exchange surfaces?

Section B — Exam-style questions

33. Describe how the structure of a palisade (plant) cell differs from an animal cell, and explain why. [3 marks]
34. Explain why an electron microscope allowed scientists to learn more about sub-cellular structures than a light microscope. [2 marks]
35. Describe how to prepare a slide of onion cells and observe them using a light microscope. [6 marks]
36. Explain how a nerve cell is adapted to its function. [2 marks]
37. Explain why xylem cells are adapted for transporting water. [3 marks]
38. Evaluate the use of embryonic stem cells to treat diseases such as diabetes. [6 marks]
39. Describe what happens during the cell cycle. [4 marks]
40. Explain why mitosis is important for multicellular organisms. [2 marks]
41. A student investigated the effect of four antibiotics on bacteria. Describe how she should make sure her results are valid and not contaminated. [4 marks]
42. Explain the results of an osmosis practical where a potato cylinder in pure water gained mass, and one in 1.0 mol/dm³ sugar solution lost mass. [4 marks]
43. Compare active transport with diffusion. [3 marks]
44. Explain why root hair cells contain many mitochondria. [2 marks]
45. Describe how the small intestine is adapted for absorbing digested food. [4 marks]
46. Explain how fish gills are adapted for efficient gas exchange. [4 marks]

Section C — Maths skills

47. An image of a cell is 6 mm long. The magnification is ×200. Calculate the real length of the cell in µm. [2 marks]
48. A mitochondrion is 0.0025 mm long. Write this in standard form. [1 mark]
49. A microscope has a ×10 eyepiece and a ×40 objective lens. What is the total magnification? [1 mark]
50. A cell is 50 µm wide. Its image in a drawing is 25 mm wide. Calculate the magnification. [2 marks]
51. A bacterium divides every 30 minutes. Starting with one bacterium, how many will there be after 3 hours? [2 marks]
52. An inhibition zone has a diameter of 20 mm. Calculate its area. Use π = 3.14. [2 marks]
53. A potato cylinder had a mass of 4.00 g at the start and 3.40 g at the end. Calculate the percentage change in mass. [2 marks]
54. A cube-shaped cell has sides of 3 µm. Calculate its surface area to volume ratio. [2 marks]

ANSWERS

Answers and mark scheme

Section A — Quick recall

1. **Give two differences between a prokaryotic cell and a eukaryotic cell.**
   Prokaryotic cells are smaller; have no nucleus (DNA is a single loop in the cytoplasm); have plasmids.
2. **Name three sub-cellular structures found in both animal and plant cells.**
   Any three: nucleus, cytoplasm, cell membrane, mitochondria, ribosomes.
3. **What is the function of the ribosomes?**
   Protein synthesis (where proteins are made).
4. **What is the function of the mitochondria?**
   Where most of the reactions of aerobic respiration take place (releasing energy).
5. **What is the cell wall of a plant made from, and what does it do?**
   Cellulose; it strengthens and supports the cell.
6. **What does the permanent vacuole contain?**
   Cell sap — a weak solution of sugar and salts.
7. **Where is the genetic material found in a bacterial cell?**
   In a single loop of DNA floating in the cytoplasm, plus small rings called plasmids.
8. **What is meant by 'resolution'?**
   The ability to distinguish between two points that are close together.
9. **Give two advantages of an electron microscope over a light microscope.**
   Higher magnification; higher resolution (can see smaller structures in detail).
10. **Write down the formula for magnification.**
    Magnification = image size ÷ real size.
11. **How many micrometres are in one millimetre?**
    1000 µm.
12. **Why is a stain such as iodine added to a slide?**
    To make structures (e.g. the nucleus) easier to see.
13. **Why should the cover slip be lowered at an angle?**
    To avoid trapping air bubbles.
14. **Which objective lens should you start with when using a microscope?**
    The lowest-power objective lens.
15. **What is differentiation?**
    The process by which a cell changes to become specialised for its job.
16. **Give two ways a sperm cell is adapted to its function.**
    Tail to swim; lots of mitochondria for energy; enzymes in the head to digest the egg membrane (any two).
17. **Why do muscle cells contain lots of mitochondria?**
    To release lots of energy (by respiration) for contraction.
18. **What is a stem cell?**
    An undifferentiated cell that can differentiate into different types of cell.
19. **Where are adult stem cells found in humans, and what can they become?**
    Bone marrow; only certain types of cell, e.g. blood cells.

20. **Where are stem cells found in plants?**
    In the meristems — the growing tips of roots and shoots.
21. **Why are stem cells from therapeutic cloning not rejected?**
    The embryo has the same genes as the patient, so the immune system does not see the cells as foreign.
22. **How many chromosomes are in a normal human body cell?**
    46 (23 pairs).
23. **Name the three stages of the cell cycle in order.**
    Growth and DNA replication → mitosis → cytokinesis.
24. **What is binary fission?**
    The way prokaryotic cells (bacteria) divide — splitting into two daughter cells.
25. **Why should Petri dishes be stored upside down?**
    So condensation does not drip onto the agar.
26. **Why are cultures incubated at 25 °C in schools?**
    Harmful pathogens that grow at body temperature (37 °C) are less likely to grow.
27. **Define diffusion.**
    The spreading out of particles resulting in a net movement from an area of higher concentration to an area of lower concentration.
28. **Give three factors that affect the rate of diffusion.**
    Concentration gradient; temperature; surface area of the membrane.
29. **Define osmosis.**
    The diffusion of water from a dilute solution to a more concentrated solution through a partially permeable membrane.
30. **Why is active transport needed in root hair cells?**
    Mineral ion concentration is higher inside the cell than in the soil, so ions must be moved against the gradient.
31. **Where does the energy for active transport come from?**
    Respiration.
32. **Why do multicellular organisms need exchange surfaces?**
    They have a small surface area to volume ratio, so diffusion through their outer surface is too slow to supply all their cells.

Section B — Exam-style questions

33. **Describe how the structure of a palisade (plant) cell differs from an animal cell, and explain why.** [3]
    - Plant cell has a cellulose cell wall — supports/strengthens the cell (1)
    - Has a permanent vacuole containing cell sap (1)
    - Has chloroplasts with chlorophyll for photosynthesis — palisade cells are near the top of the leaf to absorb light (1)
34. **Explain why an electron microscope allowed scientists to learn more about sub-cellular structures than a light microscope.** [2]
    - Electron microscopes have higher magnification and higher resolution (1)
    - so smaller structures such as mitochondria, ribosomes and plasmids can be seen in detail (1)

35. **Describe how to prepare a slide of onion cells and observe them using a light microscope.** [6]
    - Drop of water on a slide; thin layer of onion epidermis peeled with tweezers onto it
    - Add a drop of iodine to stain
    - Lower a cover slip at an angle with a mounted needle to avoid air bubbles
    - Clip slide on stage, start with lowest-power objective
    - Use coarse focus to move stage up near the lens (looking from the side), then focus down while looking through the eyepiece
    - Use fine focus for a clear image; switch to higher power for more detail and refocus
    - *Level marking: 5–6 marks for a clear, logical method a person could follow.*
36. **Explain how a nerve cell is adapted to its function.** [2]
    - Long, so impulses can be carried a long distance around the body (1)
    - Branched connections at the ends to connect with other nerve cells / form a network (1)
37. **Explain why xylem cells are adapted for transporting water.** [3]
    - Hollow in the centre / no cytoplasm — water flows through easily (1)
    - No end walls — form a continuous tube (1)
    - Strengthened with lignin — supports the plant and stops collapse (1)
38. **Evaluate the use of embryonic stem cells to treat diseases such as diabetes.** [6]
    - **For:** can become any cell type, e.g. insulin-producing cells; could cure diabetes or paralysis; therapeutic cloning — same genes so no rejection; embryos often unwanted ones from fertility clinics
    - **Against:** ethical/religious objections — embryo is a potential life; risk of viral infection passed to patient; treatment still experimental; expensive
    - **Conclusion** with a reason, e.g. benefits to many patients may outweigh concerns if strict rules are followed
    - *Level marking: balanced points on both sides plus a justified conclusion for 5–6 marks.*
39. **Describe what happens during the cell cycle.** [4]
    - Cell grows and increases the number of sub-cellular structures, e.g. ribosomes and mitochondria (1)
    - DNA is replicated/copied to form X-shaped chromosomes (1)
    - Mitosis: chromosomes line up and one set is pulled to each end; nuclei form (1)
    - Cytokinesis: cytoplasm and cell membrane divide → two identical daughter cells (1)
40. **Explain why mitosis is important for multicellular organisms.** [2]
    - Produces new cells for growth and development (1)
    - Repairs damaged tissue / replaces cells, with cells genetically identical to the parent (1)
41. **A student investigated the effect of four antibiotics on bacteria. Describe how she should make sure her results are valid and not contaminated.** [4]
    - Sterilise Petri dish and agar before use (1)
    - Pass the inoculating loop through a flame (1)
    - Tape the lid lightly / don’t seal fully so anaerobic bacteria don’t grow; store upside down (1)
    - Use a control disc soaked in sterile water; keep disc size and antibiotic concentration the same; incubate at 25 °C (1)

42. **Explain the results of an osmosis practical where a potato cylinder in pure water gained mass, and one in 1.0 mol/dm³ sugar solution lost mass.** [4]
    - In pure water, the solution outside was more dilute than inside the potato cells (1) so water moved into the cells by osmosis → mass increased (1)
    - In 1.0 mol/dm³ the solution outside was more concentrated than inside (1) so water moved out of the cells by osmosis → mass decreased (1)
43. **Compare active transport with diffusion.** [3]
    - Diffusion: high → low concentration; active transport: low → high / against the gradient (1)
    - Diffusion is passive / needs no energy; active transport needs energy from respiration (1)
    - Both move substances across membranes / both involve particles (1)
44. **Explain why root hair cells contain many mitochondria.** [2]
    - They take in mineral ions by active transport (1)
    - which needs energy released by respiration in the mitochondria (1)
45. **Describe how the small intestine is adapted for absorbing digested food.** [4]
    - Covered in villi → very large surface area (1)
    - Villi have microvilli → even more surface area (1)
    - Single layer of surface cells → short diffusion distance (1)
    - Very good blood supply / network of capillaries → keeps a steep concentration gradient (1)
46. **Explain how fish gills are adapted for efficient gas exchange.** [4]
    - Gill filaments covered in lamellae → large surface area (1)
    - Lamellae have a thin surface layer of cells → short diffusion distance (1)
    - Lots of blood capillaries to carry O_2 away (1)
    - Blood flows in the opposite direction to water → large concentration gradient maintained along the gill (1)

Section C — Maths skills

47. **An image of a cell is 6 mm long. The magnification is ×200. Calculate the real length of the cell in µm.** [2]
    6 ÷ 200 = 0.03 mm (1) → 0.03 × 1000 = **30 µm** (1)
48. **A mitochondrion is 0.0025 mm long. Write this in standard form.** [1]
    2.5×10^{-3} mm
49. **A microscope has a ×10 eyepiece and a ×40 objective lens. What is the total magnification?** [1]
    10 × 40 = **×400**
50. **A cell is 50 µm wide. Its image in a drawing is 25 mm wide. Calculate the magnification.** [2]
    25 mm = 25 000 µm (1) → 25 000 ÷ 50 = **×500** (1)
51. **A bacterium divides every 30 minutes. Starting with one bacterium, how many will there be after 3 hours?** [2]
    180 ÷ 30 = 6 divisions (1) → 1×2^6 = **64 bacteria** (1)
52. **An inhibition zone has a diameter of 20 mm. Calculate its area. Use π = 3.14.** [2]
    r = 10 mm (1) → 3.14×10^2 = **314 mm²** (1)
53. **A potato cylinder had a mass of 4.00 g at the start and 3.40 g at the end. Calculate the percentage change in mass.** [2]
    Change = 3.40 − 4.00 = −0.60 g (1) → −0.60 ÷ 4.00 × 100 = **−15%** (1)

54. **A cube-shaped cell has sides of 3 µm. Calculate its surface area to volume ratio.** [2]

SA = 6 × 3 × 3 = 54 µm²; V = 3 × 3 × 3 = 27 µm³ (1) → 54 : 27 = **2 : 1** (1)

FINAL EXAM ADVICE

Use the **key words** examiners look for: *eukaryotic, prokaryotic, plasmid, resolution, magnification, differentiation, stem cell, mitosis, cytokinesis, genetically identical, net movement, concentration gradient, partially permeable, against the gradient, energy from respiration, surface area to volume ratio*. Show every step in calculations, convert units first and always include **units**.

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