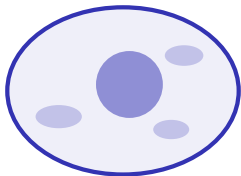


Cell Structure

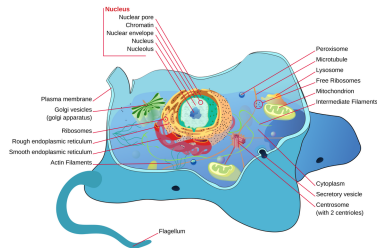
A-Level Biology ■ Topic 1

A-Level Biology



What we will cover

- 1 The light microscope
- 2 Magnification & resolution
- 3 Animal & plant cells
- 4 Organelles
- 5 Prokaryotic cells
- 6 Viruses



a eukaryotic cell



The light microscope

A **light microscope** uses visible light and glass lenses. Typical max magnification $\times 1500$; **resolution** about 200 nm. An electron microscope uses a beam of electrons: far higher resolution (TEM for internal detail, SEM for surfaces) but the specimen must be dead and in vacuum.

Magnification is how much larger the image is. Resolution is the smallest distance at which two points still look separate.

Making a slide

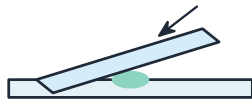
A **temporary wet mount** : specimen on a **slide** , a drop of stain, then lower the **cover slip** at an angle (no bubbles). Drawings: sharp single lines, **no shading**, parts in the right proportions, and labels on straight lines that **do not cross**. A **microscope** makes a bigger picture, because cells are far too small to see unaided.



1. specimen
on a slide



2. add a drop
of stain



3. lower the cover
slip at an angle

The rules for a biological drawing

clean continuous lines

sharp pencil, no shading, no sketchy overlapping strokes

only what you can see

draw **what is on the slide**, not what a textbook diagram shows

correct proportions

the parts in the sizes they really are relative to each other

label lines

straight, ruled, not crossing, and ending exactly on the structure

a magnification or scale

stated on the drawing

plan or high-power

a plan drawing shows **tissue outlines only**; a high-power drawing shows a few **named cells** in detail

The commonest lost mark is drawing the textbook rather than the slide. If your organelle is not visible under a light microscope, it does not belong in the drawing.

Magnification and actual size

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$

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

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

same unit top & bottom

Worked example

a chloroplast is 25 mm at $\times 5000 \Rightarrow \text{actual size} = 25/5000 = 0.005 \text{ mm} = 5 \mu\text{m}$

Measure real cells with a calibrated **eyepiece graticule** .

Rearranging the magnification equation

the equation

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$

for actual size

$$\text{actual} = \frac{\text{image}}{\text{magnification}}$$

for image size

$$\text{image} = \text{actual} \times \text{magnification}$$

the units

convert **both** lengths to the same unit first – mm, μm or nm

where it applies

drawings, **photomicrographs** (through a light microscope) and **electron micrographs** alike

measuring the image

measure with a ruler in mm, then convert to μm by multiplying by 1000

Magnification has **no units** – it is a ratio. If your answer carries a unit, a conversion has gone astray.

Resolution and the electron microscope



light microscope:
the two blur into **one**



electron microscope:
resolved as **two**

Resolution is the smallest gap at which two points still look separate.

An **electron microscope** uses a shorter **wavelength**, so it resolves far finer detail – **SEM** (surface) and **TEM** (inside).

Two electron microscopes, two kinds of picture

Scanning

A **scanning** electron microscope bounces electrons off the surface and shows it in **3D** – the outside of a pollen grain, an insect eye.

Transmission

A **transmission** electron microscope passes electrons *through* a very thin slice, showing the internal detail – the cristae inside one mitochondrion.

The cost

Both need a vacuum and a dead, prepared specimen. To look at living material you make a **temporary preparation** under a light microscope instead.

Resolution is set by the wavelength used. Electrons have a far shorter wavelength than light – that, not the lenses, is why they resolve more.

Resolution is not magnification

magnification

how many times **larger** the image is than the object

resolution

the smallest distance at which two points are still seen as **two**

why they differ

making an image bigger does not always show more detail – past a point you get a **bigger, blurry** image

what sets the limit

the **wavelength** used: light about 200 nm, electrons about 0.5 nm

the consequence

resolution sets the **real** limit on useful magnification

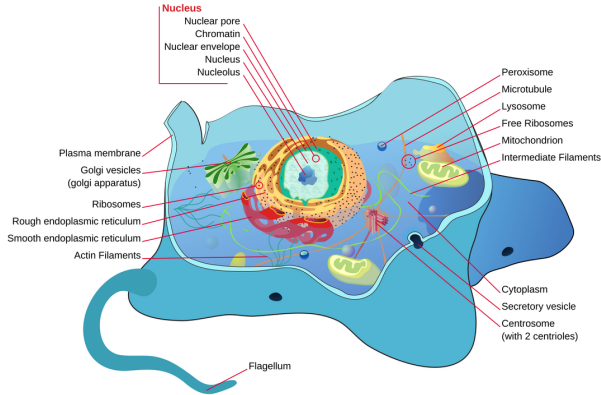
the examiner's point

these two words are easy to mix up, and **marks are given for the difference**

An electron microscope resolves more because electrons have a far shorter wavelength – not because it magnifies more. That causal link is the answer.



The animal cell



A **eukaryotic cell** keeps its DNA in a **nucleus** ; **organelles** float in the **cytoplasm** . Every job that needs energy uses ATP made in respiration.

Organelles and their jobs

nucleus

holds DNA, controls the cell

mitochondria

respiration → ATP

rough ER

makes proteins

Golgi body

packs into vesicles

ribosomes

join amino acids

lysosomes

break down waste

The protein production line

Nucleus

Large, surrounded by a **nuclear envelope** – a double membrane with pores – and containing a **nucleolus** , which makes ribosomes.

Ribosomes

80S in the cytoplasm, 70S in chloroplasts and mitochondria. They join **amino acids** to **synthesise** proteins.

Rough ER

Rough endoplasmic reticulum : sheets of membrane with ribosomes on the surface, making and transporting proteins – **antibodies** , for instance.

Smooth ER

Smooth endoplasmic reticulum : no ribosomes, and it makes **lipids** .

Golgi body

A stack of flat sacs that changes and packs proteins and lipids into **vesicles** for **secretion** .

Lysosomes are small sacs of **enzymes** that break down old organelles and waste – the same production line, run backwards.

The remaining organelles, and how they are recognised

smooth ER

sheets of membrane with **no ribosomes** – makes **lipids**

rough ER

membrane **studded with ribosomes** – processes proteins

centrioles and micro-tubules

small protein tubes – move chromosomes, and form the cell's “skeleton”

cilia

tiny beating hairs on the surface – move fluid, or move the cell

microvilli

tiny folds of the **cell surface membrane** – increase surface area for **ab-sorption**

how to identify them

in a micrograph by **shape, size and position**; in a drawing, by outline and label

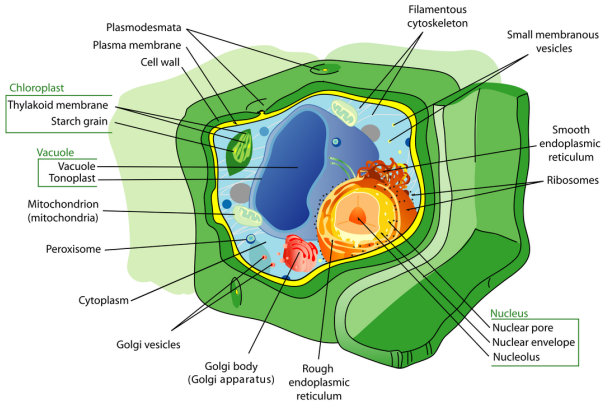
Cilia *move*, microvilli *absorb*. Both are surface projections, and telling them apart by function is the mark.

The organelles a plant cell has and an animal cell does not

Organelle	What it is, and what it does
chloroplasts	green, stacked membranes, its own circular DNA – photosynthesis
cell wall	a strong outer layer of cellulose – supports the cell and stops it bursting
large permanent vacuole	a watery sac inside a membrane, the tonoplast – stores water, keeps the cell turgid
plasmodesmata	tiny channels through the walls, linking neighbouring cytoplasm

The other way round: **centrioles** are present in animal cells and absent from most plant cells, and an animal cell is rounder and more flexible where a plant cell holds a fixed shape.

The plant cell



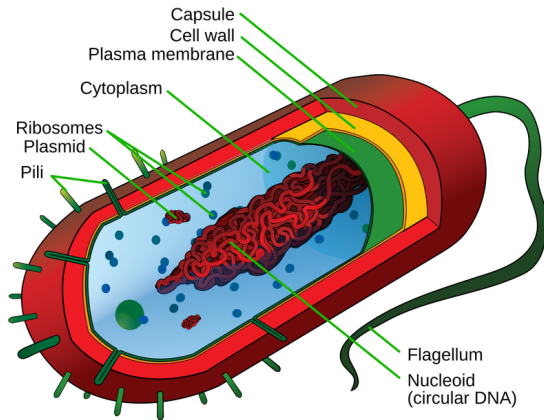
A plant cell also has:

- a **cell wall** of **cellulose**
- **chloroplasts** for **photosynthesis**
- a large permanent **vacuole**

Animal cells have none of these.



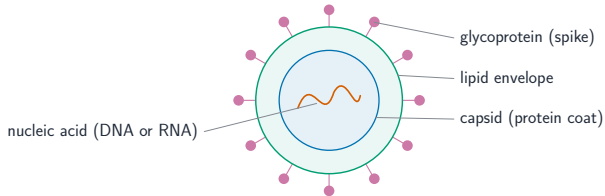
Prokaryotic cells



A **prokaryotic cell** (a **bacterium**) is small ($1\text{--}5\ \mu\text{m}$) & simple:

- circular DNA free in the cytoplasm – **no nucleus**
- 70S ribosomes; **peptidoglycan** wall
- no double-membrane organelles

Viruses

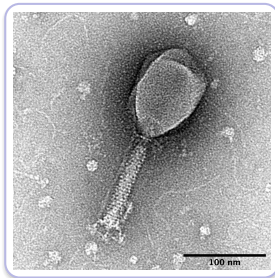


A **virus** is **non-cellular** :

- a core of **nucleic acid** – DNA *or* RNA
- a protein **capsid** ; some have a lipid **envelope**

It can only copy itself inside a living **host** cell.

Viruses, continued



A real virus, magnified hugely. The rounded head is the protein capsid wrapped around the nucleic acid core; the tail injects that nucleic acid into a bacterium. Note the scale bar – the whole virus is about 100 nm, far smaller than any cell

What a virus is, and is not

Not a cell

No cytoplasm, no organelles, no ribosomes – so a virus cannot respire, grow or reproduce on its own.

What it has

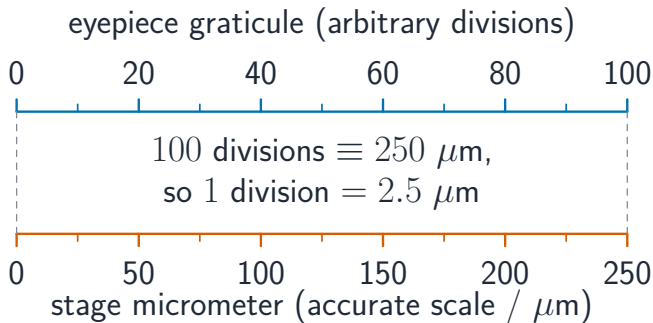
A nucleic acid core (DNA or RNA), a protein coat, and in some viruses an outer envelope of **phospholipids** stolen from the host membrane.

Unicellular?

The word does not apply: a bacterium is **unicellular** – one cell – and a virus is not a cell at all.

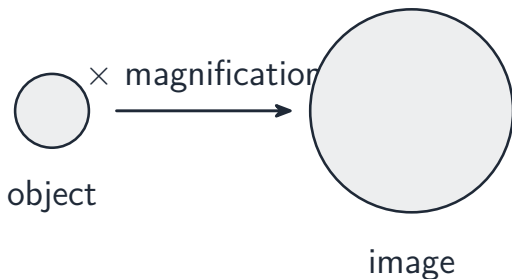
Every definition of “living” the syllabus gives is a list of processes. A virus carries out none of them outside a host.

Eyepiece graticule and stage micrometer



Calibrate the graticule by lining it up with the stage micrometer's known scale

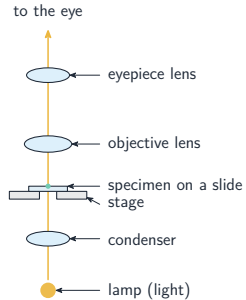
Magnification and actual size, continued



$$\text{magnification} = \frac{\text{image}}{\text{actual}}$$

Magnification = image size ÷ actual size

How we study cells



A light microscope: light passes up through the specimen, then two lenses (the objective and the eyepiece) magnify it

Exam tips

- Magnification = image size $\div$ actual size – **convert units first** (mm $\leftrightarrow$ μ m $\leftrightarrow$ nm), then rearrange for whichever is unknown.
- Distinguish **magnification** (how many times larger) from **resolution** (smallest distance still seen as two points); electron microscopes resolve more because electrons have a shorter wavelength.
- Give each organelle a **structure + function** pair (e.g. mitochondrion: folded inner membrane $\rightarrow$ aerobic respiration).
- State the **prokaryote vs eukaryote** differences exactly: no nucleus, smaller (70S) ribosomes, no membrane-bound organelles, circular DNA.
- Viruses are **non-living** – describe them only by capsid, genetic material and (sometimes) an envelope.



Topic 1 – key takeaways

1

Microscopy

magnification = $\text{image} / \text{actual size}$

2

Resolution

electron microscope resolves finer detail

3

Eukaryotes

nucleus + membrane-bound organelles

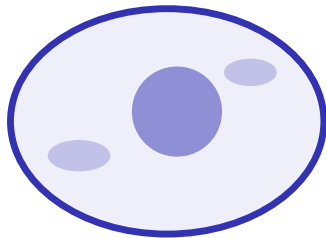
4

Prokaryotes

no nucleus; viruses are non-cellular

Check yourself

- 1 Write the magnification equation.
- 2 Which microscope has higher resolution, and why?
- 3 Name the organelle where respiration makes ATP.
- 4 Does a prokaryote have a nucleus?



Answers 1. $\text{magnification} = \text{image size} / \text{actual size}$ 2. electron (shorter wavelength)
3. mitochondria 4. no