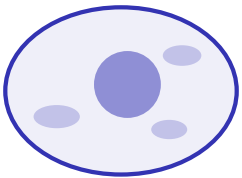
Cell Structure

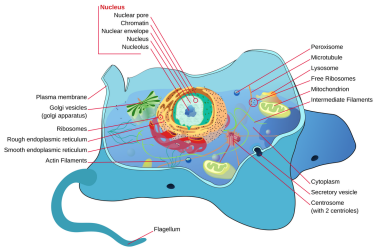
A-Level Biology ▪ Topic 1

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

1 Microscopy

The light microscope

A **light microscope** 光学显微镜 uses visible light and glass lenses. Typical max magnification $\times 1500$; **resolution** 分辨率 about $200\,\mathrm{nm}$. 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.

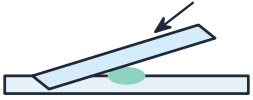
> Magnification is how much larger the image is. Resolution is the smallest distance at which two points still look separate.

Making a slide

A **temporary wet mount** 临时装片: specimen on a **slide** 载玻片, a drop of stain, then lower the **cover slip** 盖玻片 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** 显微镜 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 $25\,\text{mm}$ at $\times 5000 \Rightarrow$ actual size $= 25/5000 = 0.005\,\text{mm} = 5\,\mu\text{m}$

Measure real cells with a calibrated **eyepiece graticule** 目镜测微尺.

Rearranging the magnification equation

the equation	$\text{magnification} = \dfrac{\text{image size}}{\text{actual size}}$
for actual size	$\text{actual} = \dfrac{\text{image}}{\text{magnification}}$
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** 显微照片 (through a light microscope) and **electron micrographs** 电子显微照片 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 分辨率 is the smallest gap at which two points still look separate.

An **electron microscope** 电子显微镜 uses a shorter **wavelength** 波长, so it resolves far finer detail – **SEM** 扫描 (surface) and **TEM** 透射 (inside).

Two electron microscopes, two kinds of picture

Scanning	A **scanning** 扫描 electron microscope bounces electrons off the surface and shows it in 3D – the outside of a pollen grain, an insect eye.
Transmission	A **transmission** 透射 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** 临时装片 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.

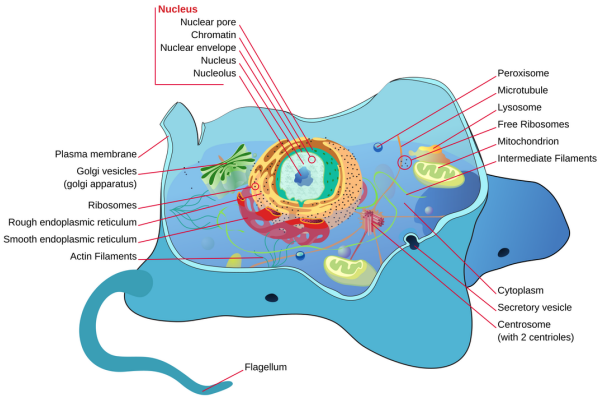
Resolution is not magnification

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.

2 Eukaryotic cells

The animal cell



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

Organelles and their jobs

nucleus
细胞核
holds DNA, controls the cell

mitochondria
线粒体
respiration → ATP

rough ER
粗面内质网
makes proteins

Golgi body
高尔基体
packs into vesicles

ribosomes
核糖体
join amino acids

lysosomes
溶酶体
break down waste

The protein production line

Nucleus	Large, surrounded by a **nuclear envelope** 核膜 – a double membrane with pores – and containing a **nucleolus** 核仁, which makes ribosomes.
Ribosomes	80S in the cytoplasm, 70S in chloroplasts and mitochondria. They join **amino acids** 氨基酸 to **synthesise** 合成 proteins.
Rough ER	**Rough endoplasmic reticulum** 粗面内质网: sheets of membrane with ribosomes on the surface, making and transporting proteins – **antibodies** 抗体, for instance.
Smooth ER	**Smooth endoplasmic reticulum** 滑面内质网: no ribosomes, and it makes **lipids** 脂质.
Golgi body	A stack of flat sacs that changes and packs proteins and lipids into **vesicles** 囊泡 for **secretion** 分泌.

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

The remaining organelles, and how they are recognised

smooth ER 滑面内质网	sheets of membrane with no ribosomes – makes **lipids** 脂质
rough ER	membrane studded with ribosomes – processes proteins
centrioles 中心粒 and microtubules 微管	small protein tubes – move chromosomes, and form the cell's "skeleton"
cilia 纤毛	tiny beating hairs on the surface – move fluid, or move the cell
microvilli 微绒毛	tiny folds of the **cell surface membrane** 细胞表面膜 – increase surface area for **absorption** 吸收
how to identify them	in a micrograph by shape, size and position; in a drawing, by outline and label

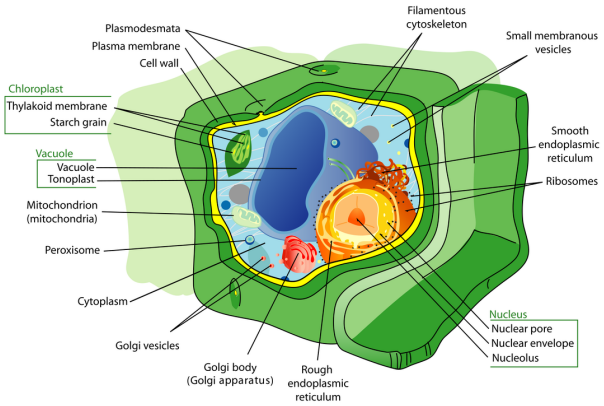
Cilia *move*, microvilli *absorb*. Both are surface projections, and telling them apart by function is the mark.

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

Organelle	What it is, and what it does
chloroplasts 叶绿体	green, stacked membranes, its own circular DNA – **photosynthesis** 光合作用
cell wall 细胞壁	a strong outer layer of **cellulose** 纤维素 – supports the cell and stops it bursting
large permanent **vacuole** 液泡	a watery sac inside a membrane, the **tonoplast** 液泡膜 – stores water, keeps the cell turgid
plasmodesmata 胞间连丝	tiny channels through the walls, linking neighbouring cytoplasm

The other way round: **centrioles** 中心粒 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



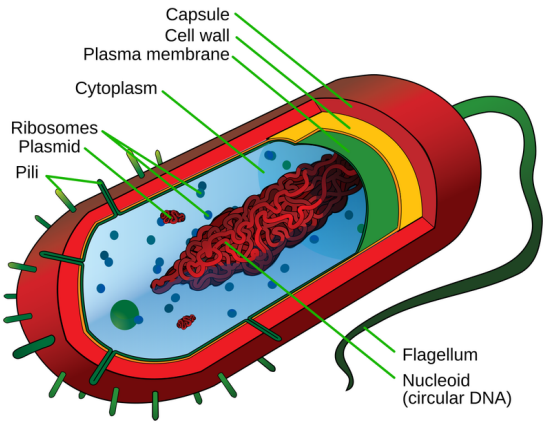
A plant cell also has:

- a **cell wall** 细胞壁 of **cellulose** 纤维素
- **chloroplasts** 叶绿体 for **photosynthesis** 光合作用
- a large permanent **vacuole** 液泡

Animal cells have none of these.

3 Prokaryotes and viruses

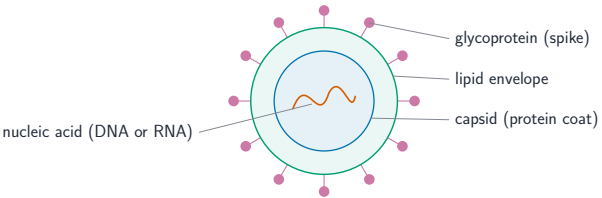
Prokaryotic cells



A **prokaryotic cell** 原核细胞 (a **bacterium** 细菌) is small (1–$5\,\mu\mathrm{m}$) & simple:

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

Viruses

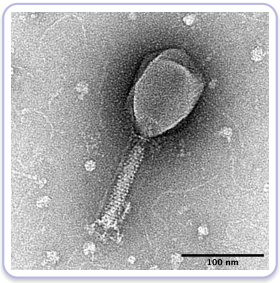


A **virus** 病毒 is **non-cellular** 非细胞:

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

It can only copy itself inside a living **host** 宿主 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

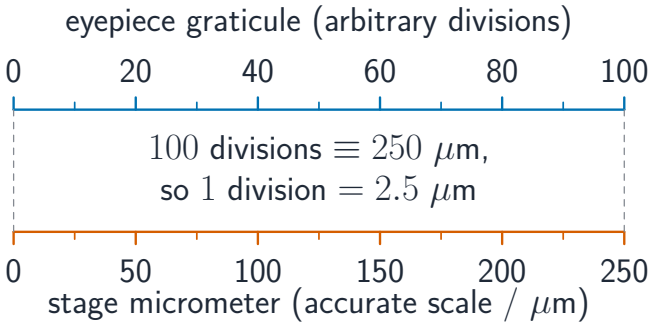
Viruses

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** 磷脂 stolen from the host membrane.
Unicellular?	The word does not apply: a bacterium is **unicellular** 单细胞的 – one cell – and a virus is not a cell at all.

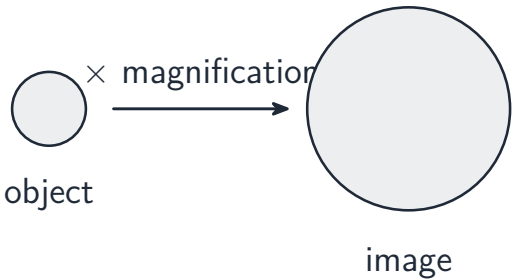
Every definition of "living" the syllabus gives is a list of processes. A virus carries out none of them outside a host.

Eyepiece graticule and stage micrometer



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

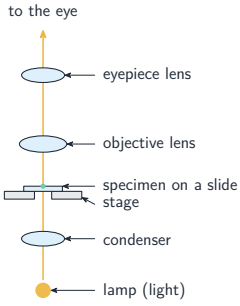
Magnification and actual size, continued



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

> 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 ÷ actual size – **convert units first** (mm ↔ μm ↔ 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 → 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.

4 Recap

Topic 1 – key takeaways

1 Microscopy

magnification = image / actual size

2 Resolution

electron microscope resolves finer detail

3 Eukaryotes

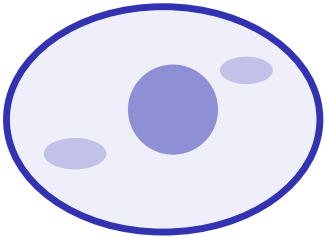
nucleus + membrane-bound organelles

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.** magnification = image size / actual size **2.** electron (shorter wavelength) **3.** mitochondria **4.** no