Cell structure

A-Level Biology

How we study cells

Cells 细胞 are very small, so you cannot see them with your eyes alone. You use a **microscope** 显微镜 to make a bigger picture of them. The first kind you meet is the **light microscope** 光学显微镜. It shines light through a thin **specimen** 标本 (the material you look at) and uses glass lenses to enlarge the view.

Making a slide and drawing what you see

To look at living material, you make a **temporary preparation** 临时装片. You put a small, thin piece of material on a glass **slide** 载玻片, add a drop of **stain** 染色剂 (a coloured liquid that makes parts easier to see), then lower a thin **cover slip** 盖玻片 on top to flatten it and keep out air.

When you draw cells from a slide or a photograph, follow simple rules:

- use a sharp pencil and clear, single lines (no shading).
- draw only what you can really see, with the parts in the correct sizes.
- label the parts with straight lines that do not cross.

Magnification and actual size

Magnification 放大倍数 tells you how many times bigger the image is than the real object. It has no unit. You find it with one equation:

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

You can rearrange this to find any one value from the other two:

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

The top and the bottom of the fraction **must use the same unit**. Cells are tiny, so you work in small units:

- 1 mm = 1000 micrometre 微米 (µm)
- 1 µm = 1000 nanometre 纳米 (nm)
- so 1 mm = 1 000 000 nm.

Worked example. In a photomicrograph at magnification 5000, a **chloroplast** 叶绿体 measures 25 mm across. Its actual size is

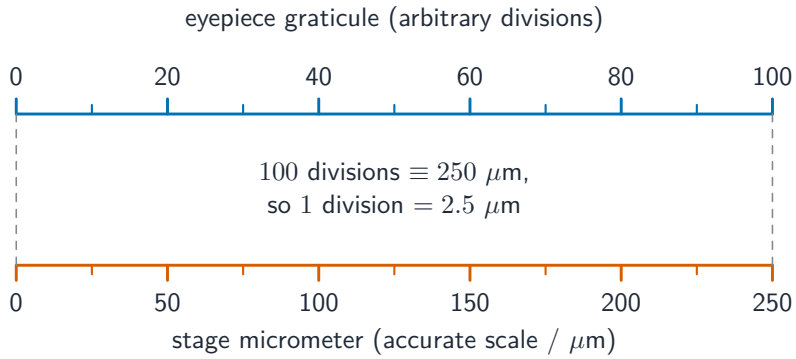
$$\frac{25 \text{ mm}}{5000} = 0.005 \text{ mm} = 5 \text{ µm}.$$

The same equation works for drawings, photomicrographs 显微照片 (photos taken through a light microscope) and **electron micrographs** 电子显微照片 (the most detailed photos, explained below). Always convert to the same unit first, then divide.

Eyepiece graticule and stage micrometer

To measure a real cell under the microscope, you use an **eyepiece graticule** 目镜测微尺—a tiny scale inside the eyepiece. Its divisions have no fixed size, so first you must **calibrate** 校准 them (work out what one division is worth).

You calibrate using a **stage micrometer** 载物台测微尺—a special slide with an accurate scale on it (often 1 mm split into 100 parts, so each part is 10 µm). You line up the two scales, count how many graticule divisions fit a known length, and divide. Once calibrated, you can swap in your specimen and measure it with the graticule.



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

Resolution and magnification

These two words are easy to mix up. The examiner gives marks for the difference.

- **Magnification** is how many times bigger the image is than the object.
- **Resolution** 分辨率 is the smallest distance between two points that still lets you see them as **two** separate points.

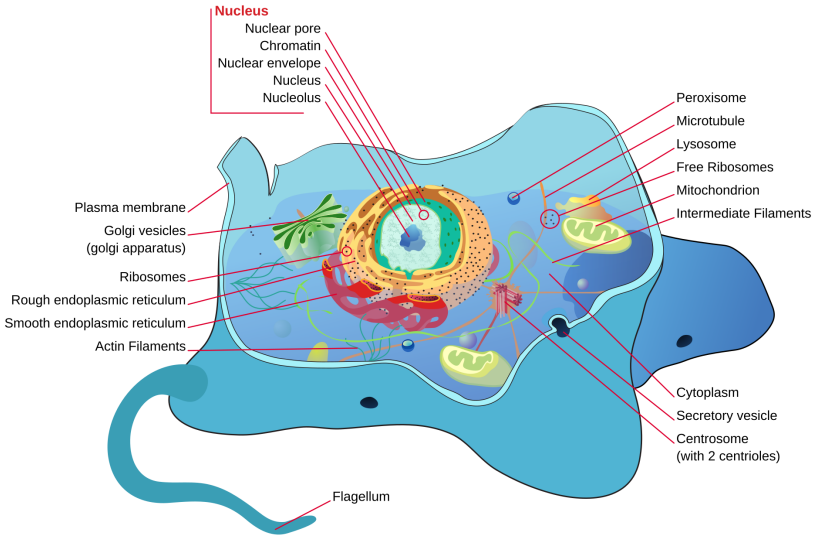
Making an image bigger does not always show more detail. Past a certain point you just get a bigger, blurry image. Resolution sets the real limit on detail.

A light microscope has lower resolution because light has a fairly long **wavelength** 波长. An **electron microscope** 电子显微镜 uses beams of **electrons** 电子 instead of light. Electrons have a much shorter wavelength, so the resolution is far higher and you can see very small structures inside the cell. There are two kinds: **scanning** 扫描 (shows the surface in 3D) and **transmission** 透射 (passes electrons through a thin slice to show inside detail).

Eukaryotic cells and their organelles

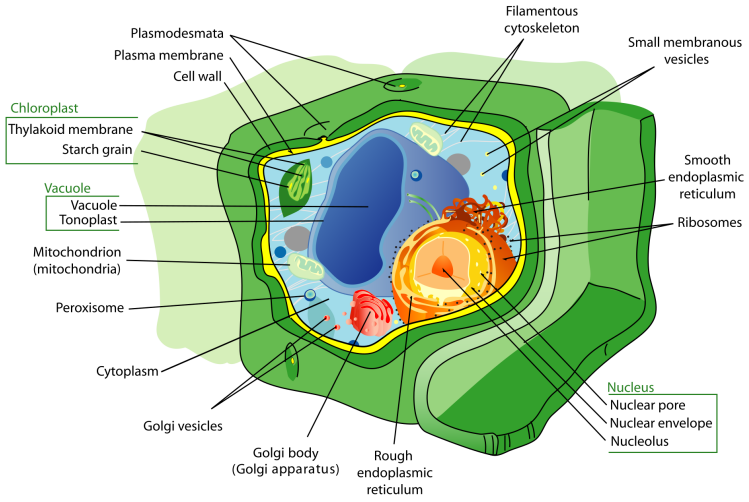
Plant and animal cells are **eukaryotic cells** 真核细胞: their DNA is kept inside a **nucleus** 细胞核. Inside the cell are many small parts called **organelles** 细胞器, each

with its own job. The jelly-like fluid around them is the **cytoplasm** 细胞质.



A generalised animal cell and its organelles 细胞器

Image: Mariana Ruiz (LadyofHats), Public domain (commons.wikimedia.org)



A plant cell also has a cell wall 细胞壁, *chloroplasts* 叶绿体 *and a large vacuole* 液泡

Image: Mariana Ruiz (LadyofHats), Public domain (commons.wikimedia.org)

In a photomicrograph or electron micrograph you identify organelles by their shape, size and position; in a drawing you show their outlines and label them.

Organelle	Structure	Function
cell surface membrane 细胞膜	thin layer around the cell	controls what enters and leaves the cell
nucleus	large, surrounded by a **nuclear envelope** 核膜 (a double membrane with holes); contains a **nucleolus** 核仁	holds the DNA; controls the cell; the nucleolus makes ribosomes
rough endoplasmic reticulum 粗面内质网 (rough ER)	sheets of membrane with ribosomes on the surface	makes and transports **proteins** 蛋白质 (for example **antibodies** 抗体)
smooth endoplasmic reticulum 滑面内质网 (smooth ER)	sheets of membrane, no ribosomes	makes **lipids** 脂质
Golgi body 高尔基体	stack of flat membrane sacs	changes and packs proteins and lipids into **vesicles** 囊泡 for **secretion** 分泌
mitochondria 线粒体	oval, with a folded inner membrane; has small circular DNA	site of **respiration** 呼吸作用—releases energy 能量 as ATP
ribosomes 核糖体	very small; 80S in the cytoplasm, 70S in chloroplasts and mitochondria	join **amino acids** 氨基酸 to **synthesise** 合成 proteins
lysosomes 溶酶体	small sacs of **enzymes** 酶	break down old organelles and waste
centrioles 中心粒 and **microtubules** 微管	small tubes made of protein	help move chromosomes and form the cell's "skeleton"
cilia 纤毛	tiny hairs on the cell surface that beat	move fluid or move the cell
microvilli 微绒毛	tiny folds of the cell surface membrane	increase surface area for **absorption** 吸收
chloroplasts (plants)	green, with stacked membranes; has small circular DNA	site of **photosynthesis** 光合作用
cell wall 细胞壁 (plants)	strong outer layer of **cellulose** 纤维素	supports and protects the cell; stops it bursting
plasmodesmata 胞间连丝 (plants)	tiny channels through the cell walls	link the cytoplasm of neighbouring cells
large permanent **vacuole** 液泡 (plants)	big sac of watery fluid, with a membrane called the **tonoplast** 液泡膜	stores water and keeps the cell firm

Cells use **ATP** made in respiration as their energy supply for every job that needs energy, such as making proteins, moving things and dividing.

Comparing plant and animal cells

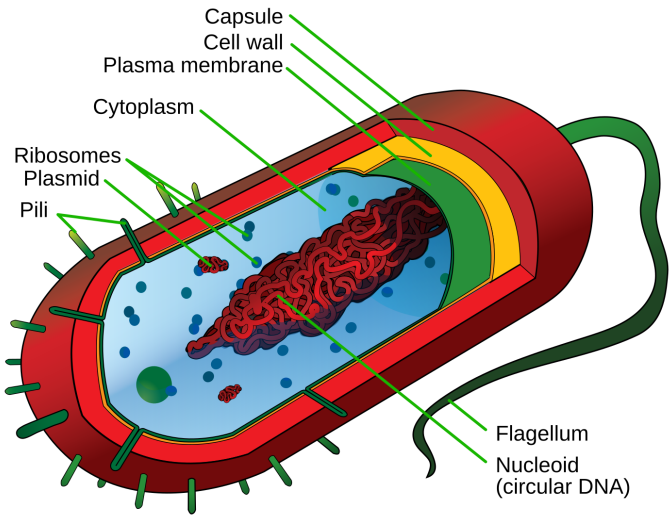
Feature	Plant cell	Animal cell
cell wall	present (cellulose)	absent
chloroplasts	present	absent
large permanent vacuole	present	absent (only small, temporary ones)
centrioles	absent in most	present
shape	fixed and regular	rounder and more flexible

Both have a cell surface membrane, cytoplasm, a nucleus, mitochondria, ribosomes, ER and a Golgi body.

Prokaryotic cells (bacteria)

A **prokaryotic cell** 原核细胞, such as a **bacterium** 细菌, is much smaller and simpler than a eukaryotic cell. Its key features are:

- **unicellular** 单细胞—it is a single cell.
- generally 1–5 µm across.
- a cell wall made of **peptidoglycan** 肽聚糖 (not cellulose).
- circular DNA lying free in the cytoplasm —there is **no nucleus**.
- 70S ribosomes (smaller than the 80S ones in the cytoplasm of eukaryotes).
- **no organelles surrounded by a double membrane** —so no nucleus, no mitochondria and no chloroplasts.



A prokaryotic cell: the circular DNA (nucleoid 拟核) lies free, with no nucleus and no double-membrane organelles

Image: Mariana Ruiz (LadyofHats), Public domain (commons.wikimedia.org)

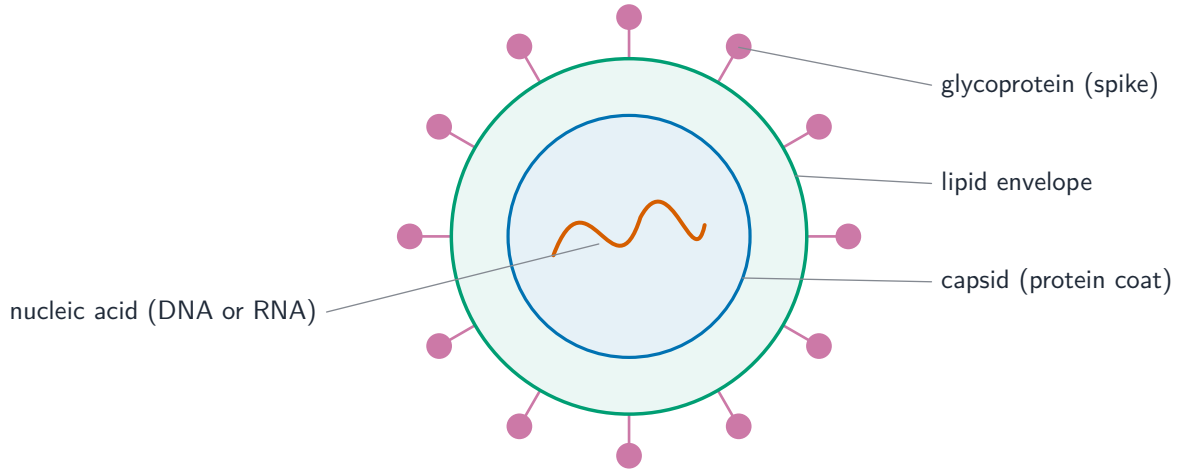
Comparing prokaryotic and eukaryotic cells

Feature	Prokaryotic cell	Eukaryotic cell
size	about 1–5 µm	about 10–100 µm
DNA	circular, free in cytoplasm	linear, inside a nucleus
nucleus	none	present
double-membrane organelles	none	mitochondria (and chloroplasts in plants)
ribosomes	70S	80S (with 70S inside mitochondria and chloroplasts)
cell wall	peptidoglycan	cellulose (plants) or none (animals)

Viruses

All **viruses** 病毒 are **non-cellular** 非细胞—they are not made of cells at all. Each virus is built from just two or three parts:

- a core of **nucleic acid** 核酸, which is **either DNA or RNA** (never both).
- a protein coat around the core called a **capsid** 衣壳.
- in some viruses, an outer **envelope** 包膜 made of **phospholipids** 磷脂.



A generalised virus: nucleic acid 核酸 *inside a protein capsid* 衣壳*, with a lipid envelope* 包膜 *in some viruses*

A virus has no cytoplasm, no organelles and no ribosomes. It cannot respire or make its own proteins. It can only copy itself inside a living **host** 宿主 cell, so it sits at the edge of what we call ”living”.