Microscopy

4.1.1.5 · Cell biology · revision notes

How light and electron microscopes compare, how the electron microscope improved our understanding of cells, and how to use magnification = size of image ÷ size of real object. It includes the microscopy required practical: preparing a slide, using a light microscope and drawing cells with a magnification or scale.

Key facts

- magnification = size of image ÷ size of real object
- total magnification = eyepiece lens × objective lens
- Resolution: the ability to distinguish between two points that are close together
- Electron microscope: much higher magnification and resolution; shows ribosomes and fine detail; specimens dead
- real size = size of image ÷ magnification
- 1 cm = 10 mm; 1 mm = 1000 µm; 1 µm = 1000 nm
- Light microscope: up to about ×2000; can view living cells in colour; cheap
- A stain (e.g. iodine solution) makes cell structures easier to see

Notes

Light and electron microscopes

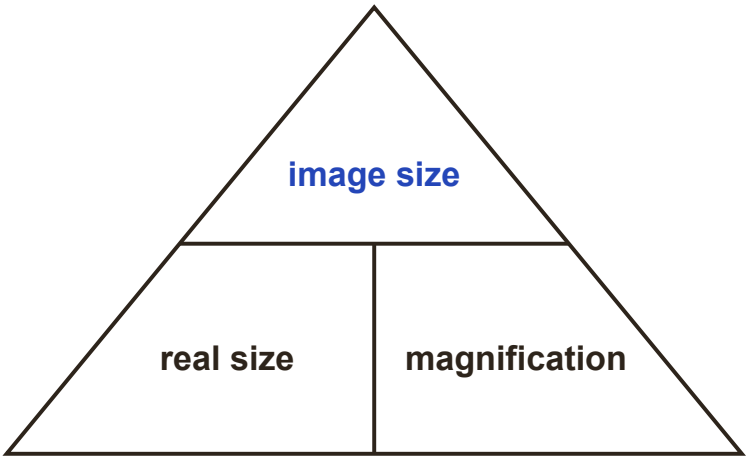
- A **light microscope** uses light and glass lenses. It magnifies up to about ×2000 and shows detail down to about 0.2 µm. It is cheap and can show living cells in colour.
- An **electron microscope** uses a beam of electrons. It has a much higher **magnification** (up to about ×2 000 000) and a much higher **resolving power** (detail smaller than 1 nm).
- **Resolution** is the ability to distinguish between two points that are close together. Higher resolution means more detail can be seen.
- Electron microscopes are large and expensive, and specimens must be dead because they are viewed in a vacuum.

How microscopy developed

- Light microscopes were first used in the 1600s and showed that living things are made of cells. Better light microscopes later showed structures such as the nucleus and chloroplasts.
- Electron microscopes were developed in the 1930s, so cells could be studied in much finer detail.
- Electron microscopes revealed structures too small to see with a light microscope, such as ribosomes, and the internal structure of mitochondria and chloroplasts. This helped biologists understand how these structures work.

Magnification calculations

- magnification = size of image ÷ size of real object
- Rearranged: real size = image size ÷ magnification, and image size = magnification × real size.

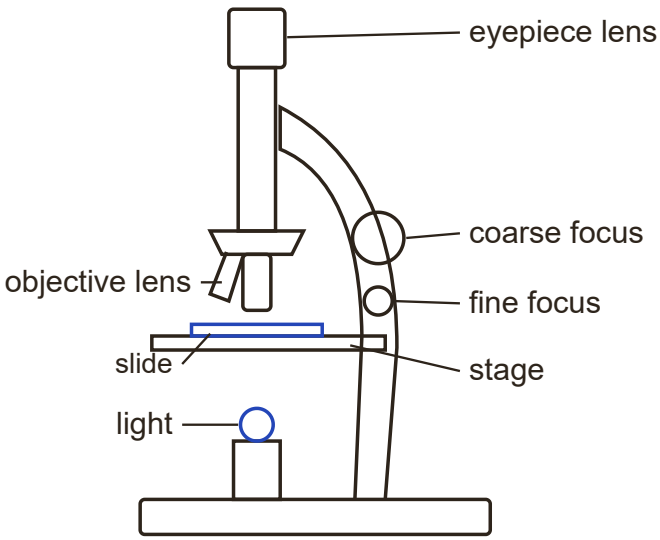


Cover the one you want: magnification = image ÷ real size; real size = image ÷ magnification; image = magnification × real size.

- Both sizes must be in the same unit (1 cm = 10 mm, 1 mm = 1000 µm, 1 µm = 1000 nm). Magnification has no unit: write it as, e.g., ×400.
- Total magnification of a light microscope = eyepiece lens magnification × objective lens magnification.

Required practical: looking at cells

- Place a thin layer of tissue (e.g. onion epidermis) on a slide, so light can pass through it. Add a drop of stain (e.g. iodine solution) to make structures such as the nucleus easier to see.
- Lower a coverslip at an angle to avoid trapping air bubbles.
- Start with the lowest-power objective lens. Focus with the coarse focus, then the fine focus. Then switch to a higher power and refocus using only the fine focus.



A light microscope. Focus with the lowest-power objective lens first.

- Draw with a sharp pencil: clear continuous lines, no shading, ruled label lines, and a magnification or scale bar.

How to answer each type of question

Calculate the real size of a cell

2 to 3 marks | Grade 5

1. Write the equation, rearranged: real size = image size ÷ magnification.
2. Convert the image size into the unit the answer needs (usually μm).
3. Substitute and calculate, and give the unit.

Example. A student draws a cheek cell. The drawing of the cell is 45 mm wide. The magnification of the drawing is ×750.
Calculate the real width of the cheek cell in micrometres (μm).

Model answer.

real size = image size ÷ magnification	(1)
45 mm = 45 000 μm	(1)
45 000 ÷ 750 = 60 μm	(1)

Describe how to prepare and view a slide

4 marks | Grade 5

1. Describe the sample: a thin layer on a slide.
2. Add a stain, then a coverslip lowered at an angle.
3. Describe focusing: lowest power first, coarse then fine focus, then a higher power.

Example. Describe how a student could prepare a slide of onion cells and view the cells with a light microscope.

Model answer.

Any four from:

peel a thin layer of onion epidermis and place it flat on a slide	(1)
add a drop of iodine solution / a stain	(1)
lower a coverslip at an angle to avoid air bubbles	(1)
start with the lowest-power objective lens	(1)
focus with the coarse focus, then the fine focus	(1)
then switch to a higher power and refocus with the fine focus	(1)

Explain the advantage of electron microscopes

2 to 3 marks | Grade 5

1. Use the words 'resolution' (or 'resolving power') and 'magnification'.
2. Say what the higher resolution lets you see: smaller structures, in more detail.
3. Link to the structure in the question.

Example. Scientists could not see ribosomes until the electron microscope was developed. Explain why.

Model answer. Ribosomes are too small to be seen with a light microscope (1). Electron microscopes have a much higher resolution / resolving power (1) and a higher magnification, so they can show much smaller structures in detail (1).

Calculate the magnification, in standard form

2 to 3 marks | Grade 7

1. Put the image size and real size in the same unit.
2. Divide the image size by the real size.
3. Write the answer in standard form if asked. Magnification has no unit.

Example. A mitochondrion is 2 μm long. In an electron micrograph, the image of the mitochondrion is 50 mm long.
Calculate the magnification of the micrograph. Give your answer in standard form.

Model answer.

50 mm = 50 000 μm (1)

50 000 ÷ 2 = 25 000 (1)

2.5×10^4 (1)

Don’t lose marks

- Forgetting to convert mm to μm before dividing, giving an answer 1000 times too big or too small.
- Putting a unit on magnification, or leaving the unit off a size.
- Confusing resolution with magnification. Resolution is about telling two close points apart, not about size.
- Using the coarse focus on high power, which can crush the slide. On high power use only the fine focus.
- Shading a drawing, using sketchy lines, or drawing label lines that do not touch the structure.

More tips

Memory tricks

- 'I AM': Image size = Actual size × Magnification. Cover the quantity you want to find.
- Convert everything to µm before you divide: it avoids most slips.
- Sense check: the real size of a cell should usually come out between about 1 µm and 100 µm.
- Magnification is about size; resolution is about detail. Magnifying a blurred image does not show more detail.

Exam technique

- Write the equation first: it is often worth a mark and helps you rearrange it correctly.
- Show the unit conversion as a separate line, e.g. 45 mm = 45 000 µm.
- If the question asks for standard form or a number of significant figures, do it in your final answer.
- In 'explain' questions about electron microscopes, use the words 'resolution' and 'magnification'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State what magnification means

How many times bigger the image is than the real object.

Grade 4

Calculate the total magnification of a microscope

Multiply the eyepiece lens magnification by the objective lens magnification, e.g. ×10 and ×40 give ×400.

Grade 4

Compare light and electron microscopes

Electron microscopes have much higher magnification and resolution; light microscopes can show living cells in colour.

Grade 5

Use magnification = image size ÷ real size

Rearrange the equation to find the magnification, the image size or the real size.

Grade 5

Prepare a slide and focus a microscope

Thin sample, stain, coverslip; start on the lowest power and focus with the coarse, then the fine, focus.

Grade 5

Convert units in magnification calculations

Put the image size and the real size in the same unit, usually µm, before dividing.

Grade 5

Explain how electron microscopes improved understanding

Their much higher resolution revealed small sub-cellular structures, such as ribosomes, and the detail inside mitochondria and chloroplasts.

Grade 8

Give real sizes in standard form

e.g. a real size of 0.000012 m is 1.2×10^{-5} m.

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