

Microscopy and measuring cells

Revision notes · Light and electron microscopes, estimation, units from milli to pico, and the core practical on using a microscope.

For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Microscopy and measuring cells **Spec 1.3-1.6**

Changes in microscope technology **Spec 1.3**

Early light microscopes could show cells, but not much detail inside them. Two ideas matter here.

Magnification is how many times bigger the image is than the real object. **Resolution** (resolving power) is how well a microscope can show two points that are close together as separate points.

Light and electron microscopes compared		
	Light microscope	Electron microscope
Uses	Light and glass lenses	A beam of electrons
Magnification	Lower	Much higher
Resolution	Lower	Much higher
What can be seen	Cells, nucleus, and some larger structures such as chloroplasts	Fine detail, such as the internal structure of mitochondria and chloroplasts, and ribosomes

Because electron microscopes have a higher magnification and **higher resolution**, we can see **sub-cellular structures** in much more detail and with more clarity than in the past. This has increased our understanding of what each structure does, because we can now see how its structure is related to its function.

Exam tip: For a full answer to 'explain how electron microscopes have increased understanding', say three things: higher magnification and resolution, so more detail can be seen, which helps us understand the role of sub-cellular structures.

Number, size and scale: estimations **Spec 1.4**

Biology deals with very big and very small numbers, from the number of cells in a body to the size of a ribosome. You need to understand number, size and scale so you can compare sizes sensibly.

An **estimation** is an approximate answer, usually found by rounding numbers to one significant figure. Estimations should be used:

- to check that the answer to a calculation is sensible, for example that a cell is not 5 metres long
- when an exact value is not needed, or is impossible or too slow to find, for example estimating the number of cells in a sample by counting a few areas and scaling up
- to make quick comparisons between sizes, for example roughly how many times bigger one cell is than another

Maths skill: To check a calculation, round first: $59 \text{ mm} \div 410$ is roughly $60 \div 400 = 0.15 \text{ mm}$. If your answer is nowhere near that, look for a slip with units.

Units: milli, micro, nano and pico Spec 1.5

Cells are far too small to measure in metres, so we use smaller units. Each unit below is 1000 times smaller than the one before it.

Units used for cells			
Prefix	Symbol	Power of ten	Unit of length
milli	m	10^{-3}	millimetre (mm)
micro	μ	10^{-6}	micrometre (μm)
nano	n	10^{-9}	nanometre (nm)
pico	p	10^{-12}	picometre (pm)

To go to a smaller unit, **multiply by 1000**: mm to μm , μm to nm, nm to pm. To go to a larger unit, **divide by 1000**. So 1 mm = 1000 μm , 1 μm = 1000 nm and 1 nm = 1000 pm.

Higher tier

Standard form

Higher tier

Standard form writes a number as a number between 1 and 10 multiplied by a power of ten. For example, 0.000 045 m is 4.5×10^{-5} m, and 3 200 000 is 3.2×10^6 . A negative power means a small number. You must be able to do calculations with numbers written in standard form.

Higher tier

Calculating with standard form

A cell is 2.5×10^{-5} m long. It is viewed at a magnification of $\times 400$. Calculate the length of the image in mm.

1. image size = real size $\times$ magnification
2. $2.5 \times 10^{-5} \times 400 = 1.0 \times 10^{-2}$ m
3. 1.0×10^{-2} m = 0.01 m
4. 0.01 m $\times$ 1000 = 10 mm

Answer: 10 mm

Maths skill: Convert to one unit before you calculate. Mixing mm and μm in one calculation is the most common way to lose marks.

Core practical: using a microscope Spec 1.6

In this core practical you investigate biological specimens with a light microscope, calculate magnification and make a labelled scientific drawing. A common specimen is onion epidermis, which is a thin, single layer of plant cells.

Core practical: Prepare a slide, focus from low power to high power using the fine focus, draw only what you see, then calculate the magnification from your drawing.

Method

1. Put a drop of water or stain (for example iodine solution) on a clean slide.
2. Peel a thin layer of epidermis from the onion and lay it flat on the drop with forceps.

3. Lower a coverslip on at an angle using a mounted needle, so air bubbles are not trapped.
4. Clip the slide on the stage. Select the lowest power objective lens and use the coarse focus to bring the cells into focus, then the fine focus to make them sharp.
5. Move to a higher power objective lens and focus again with the fine focus only.
6. Draw what you see and label it.

Scientific drawings

- use a sharp pencil and make clear, continuous lines, with no shading or colouring
- draw large, filling most of the space, and only draw what you can see
- label with straight lines drawn with a ruler that touch the structure they name, and do not cross the labelling lines
- give the drawing a title and write the magnification

$$\text{magnification} = \text{size of image} \div \text{size of real object}$$

Total magnification of a microscope is the eyepiece lens magnification $\times$ the objective lens magnification. For a drawing, measure the image with a ruler and use the equation above. Rearranged: size of real object = size of image $\div$ magnification.

Finding the real size

A student draws a cell. The drawing is 54 mm wide and the magnification is $\times 300$. Calculate the real width of the cell in μm .

1. real size = image size $\div$ magnification
2. $54 \div 300 = 0.18 \text{ mm}$
3. $0.18 \text{ mm} \times 1000 = 180 \mu\text{m}$

Answer: 180 μm

Finding the magnification

A cell is 90 μm long in real life. In a drawing it is 45 mm long. Calculate the magnification.

1. Convert to the same unit: $45 \text{ mm} \times 1000 = 45\,000 \mu\text{m}$
2. magnification = image size $\div$ real size
3. $45\,000 \div 90 = 500$

Answer: $\times 500$

Common mistake: Do not use the coarse focus on high power, because the lens can hit and crack the slide. Handle slides and coverslips carefully and wipe up any spilt iodine, which stains skin and clothes.

Quick check

1. Why can electron microscopes show more detail than light microscopes?
2. How many nanometres are there in 1 μm ?
3. Convert 0.05 mm into μm .
4. State the equation linking magnification, image size and real size.
5. Why is a coverslip lowered at an angle?

Quick check answers

Microscopy and measuring cells

1. They have a higher magnification and higher resolution.
2. 1000 nm.
3. 50 μm (0.05×1000).
4. magnification = size of image $\div$ size of real object.
5. To avoid trapping air bubbles.