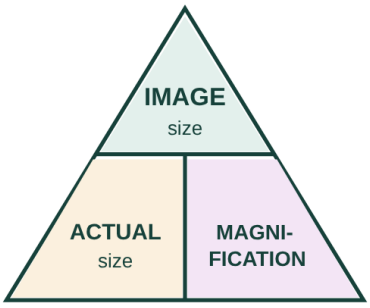
IGCSE and O Level Biology magnification and microscopes

Notes, practice questions and answers for Cambridge IGCSE Biology 0610 and O Level Biology 5090. Free from numrahedu.com, where you can also use the virtual microscope and the magnification trainer.

The magnification formula



magnification = image size ÷ actual size
actual size = image size ÷ magnification
image size = actual size × magnification

Cover what you need to find. If the other two are one above the other, divide. If they are side by side, multiply.

Five steps for every magnification question

1. Measure the image with a ruler, in mm. Measure the same part that the question gives the actual size for.
2. Check the units. Both sizes must be in the same unit before you divide, so change mm to µm, or µm to mm, if you need to.
3. Choose the form of the formula for what you are asked to find, and write it down.
4. Put in the numbers and calculate. Show your working, because there are marks for it.
5. Write the answer properly. A magnification has a times sign and no units. A size needs its unit.

Worked examples

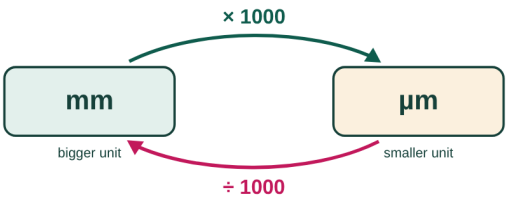
Find the magnification. A seed is 12 mm long. In a drawing, the seed is 60 mm long.
magnification = image size ÷ actual size
= 60 ÷ 12
= ×5

Find the actual size. A drawing of a cell has a magnification of ×200. In the drawing, the cell is 50 mm long.
actual size = image size ÷ magnification
= 50 ÷ 200
= 0.25 mm

Sizes in different units. A cell is 50 µm wide. In a photograph, it is 40 mm wide.
Change the image size to µm: 40 × 1000 = 40 000 µm
magnification = image size ÷ actual size = 40 000 ÷ 50
= ×800

mm and µm: changing units

Cells are too small to measure in mm, so their sizes are given in µm (micrometres). There are 1000 µm in 1 mm.



Change	Do this	Example
cm to mm	× 10	6.4 cm = 64 mm
mm to µm	× 1000	0.25 mm = 250 µm
µm to mm	÷ 1000	80 µm = 0.08 mm

Key words

Term	Meaning
Magnification	How many times bigger the image is than the real object. It is written with a times sign and has no units, for example ×40.
Image size	The size you measure with a ruler on the drawing or photograph.
Actual size	The real size of the object.
mm	Millimetres. A ruler is marked in mm, so always measure in mm, not cm.
µm	Micrometres. There are 1000 µm in 1 mm. Cells are usually measured in µm.
Eyepiece lens	The lens you look through at the top of a microscope, often ×10.
Objective lens	The lens just above the slide. A microscope has a few, such as ×4, ×10 and ×40, on a part that turns.
Total magnification	Eyepiece lens magnification × objective lens magnification. A ×10 eyepiece with a ×40 objective gives ×400.
Field of view	The circle of the slide that you can see. At a higher magnification you see a smaller part of the slide.
Stain	A dye, such as iodine solution or methylene blue, that makes parts of a cell easier to see.
Hand lens	A simple magnifying glass, often ×6 or ×10, used for larger specimens such as a leaf or a seed.

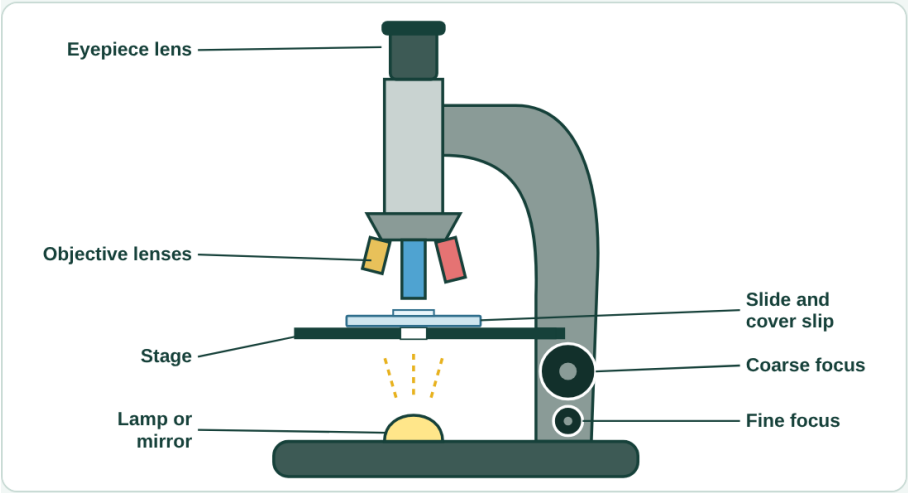
How to write your answers

Avoid	Write
Magnification = 40 mm	Magnification = ×40. A magnification has no units.
Measuring the image in cm	Measure in mm. If you did measure in cm, multiply by 10 first.
Dividing sizes in different units, such as 60 mm ÷ 30 µm	Change one so the units match: 60 mm = 60 000 µm, then 60 000 ÷ 30.
magnification = actual size ÷ image size	magnification = image size ÷ actual size. The image goes on top.
actual size = image size × magnification	actual size = image size ÷ magnification.
Giving an answer with no working	Write the formula, then the numbers, then the answer. The working earns marks.
0.3333333 mm	Round to a sensible number of figures, such as 0.33 mm, or to what the question asks for.
The cells are more magnified, so they are bigger	Magnification changes the image size. The actual size stays the same.

Measuring well

- **Measure in mm.** A ruler is marked in mm. Write 34 mm, not 3.4 cm.
- **Measure the right part.** Measure along the line you are given, or the same part that the actual size is for, such as the widest point.
- **Start from zero.** Put the 0 of the ruler on one end of the line, not the edge of the ruler.
- **Same units before dividing.** Change mm to µm, or µm to mm, so both sizes match.
- **Measure several, find a mean.** For cells, measure a few and calculate the mean, because cells are not all the same size.
- **Check the answer makes sense.** A cell is far smaller than 1 mm. A magnified drawing is bigger than the real thing.

The light microscope



Numrahedu.com: a light microscope, simplified.

Part	What it does
Eyepiece lens	The lens you look through. It magnifies the image, often by ×10.
Objective lenses	Lenses of different magnification on a part that turns. Start with the lowest power.
Stage	The flat platform that holds the slide over a hole, so light can pass up through the specimen.
Slide and cover slip	The specimen sits on a glass slide under a thin cover slip, which keeps it flat and protects the lens.
Coarse focus	The large wheel. It moves the stage or the lens a long way, to find the image on low power.
Fine focus	The small wheel. It moves by tiny amounts, to make the image sharp. On high power, use only this one.
Lamp or mirror	Sends light up through the specimen. Never use a mirror to reflect direct sunlight, because it can damage your eyes.

How to use a microscope

1. Turn the lowest power objective lens into place.
2. Put the slide on the stage, with the specimen over the hole, and switch on the lamp.
3. Look from the side and use the coarse focus to bring the lens and the slide close together, without touching.
4. Look through the eyepiece and turn the coarse focus slowly the other way until the image is clear.
5. Move the slide so the part you want is in the middle of the field of view.
6. Turn to a higher power objective lens, then use only the fine focus to make the image sharp.

Total magnification

total magnification = eyepiece lens × objective lens. With a ×10 eyepiece lens, the ×4, ×10 and ×40 objective lenses give ×40, ×100 and ×400.

Making a slide and what you see

A slide of onion cells



1. A red onion.



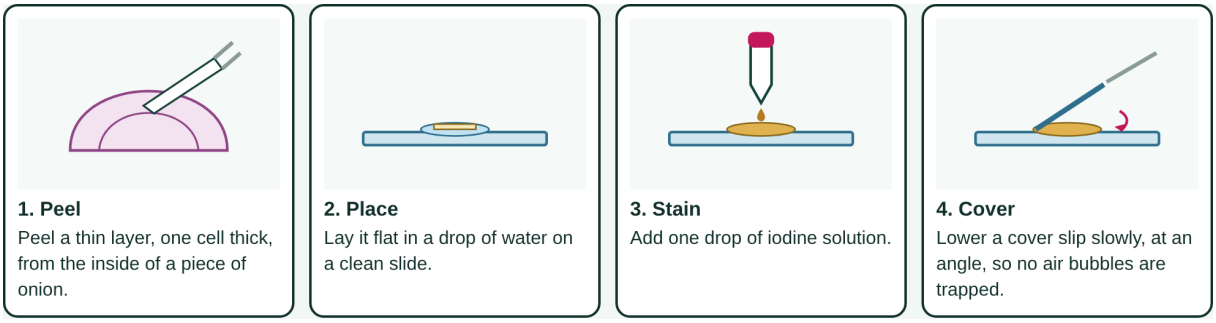
2. Cut across, the onion is made of thick, fleshy layers.



3. The thin, see-through layer peeled from a fleshy layer. This is what goes on the slide.

Real photographs taken for Numrahedu. The thin layer is almost clear, which is why a stain is added to make the cells easier to see.

1. Use forceps to peel a thin layer from the inside of a piece of onion. It must be one cell thick, so light can pass through.
2. Lay it flat in a drop of water on a clean slide.
3. Add one drop of iodine solution to stain the cells.
4. Lower a cover slip slowly, at an angle, using a mounted needle. This pushes the air out.
5. Soak up any extra liquid with paper.



1. Peel
Peel a thin layer, one cell thick, from the inside of a piece of onion.

2. Place
Lay it flat in a drop of water on a clean slide.

3. Stain
Add one drop of iodine solution.

4. Cover
Lower a cover slip slowly, at an angle, so no air bubbles are trapped.

Remember. Air bubbles look like circles with a thick dark edge. They hide the cells, so lower the cover slip slowly from one side.

A slide of cheek cells

1. Rub the inside of your cheek gently with a clean cotton bud.
2. Smear the cotton bud over the middle of a clean slide.
3. Add one drop of methylene blue to stain the cells.
4. Lower a cover slip slowly, at an angle.
5. Put the used cotton bud straight into disinfectant.

Remember. Cheek cells are animal cells. They have no cell wall, so they have an irregular shape and a thin outline, and they are much smaller than onion cells.

What the cells look like

Slide	What you see
Onion cells, iodine solution	Regular shape, like bricks. A clear cell wall. A nucleus, stained brown. No chloroplasts, because an onion bulb grows under the ground.
Cheek cells, methylene blue	Irregular shape. A thin cell membrane and no cell wall. A nucleus, stained dark blue. No chloroplasts and no large vacuole.

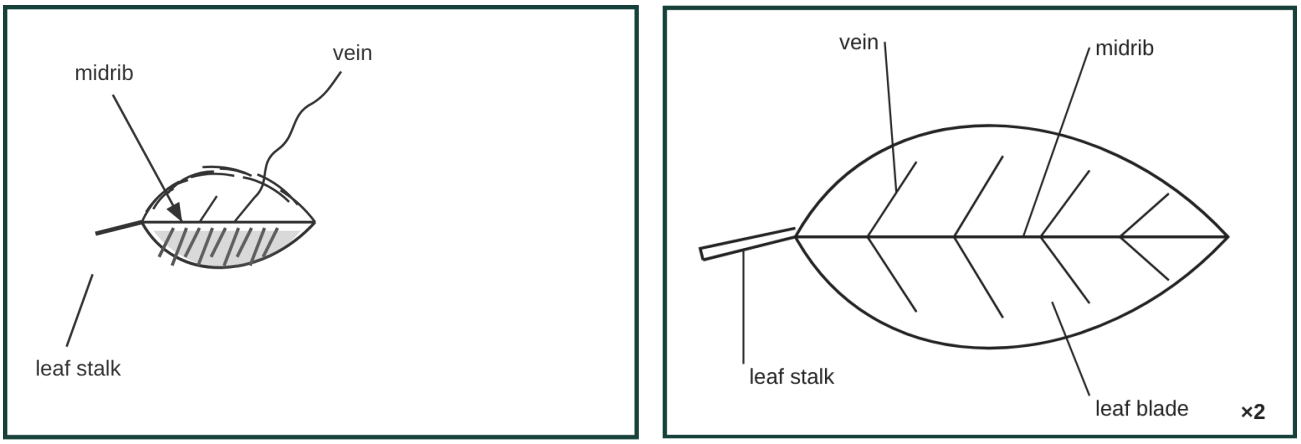
Slide	What you see
Pondweed leaf cells, no stain	Regular shape with a cell wall. Many green chloroplasts round the edge of each cell, because a large vacuole fills the middle.

Hazards and precautions

What	Hazard	Precaution
Glass slide and cover slip	Break easily and can cut	Handle by the edges. Put broken glass in the glass bin, not the ordinary bin.
Iodine solution	Irritant, stains skin	Wear eye protection and wash off any spills.
Methylene blue	Stains skin and clothes	Wear gloves or wash your hands, and wipe up spills at once.
Cheek cells	May carry microorganisms	Use your own cells only, and put the cotton bud and slide in disinfectant.
Mounted needle or scalpel	Sharp	Cut away from your fingers, on a tile.
Mirror on a microscope	Reflected sunlight can damage eyes	Use a lamp, or daylight from the sky. Never reflect direct sunlight.

Biological drawings

The first drawing breaks six rules. The second is the same leaf drawn well.



Numrahedu.com: a poor drawing and a good drawing of the same leaf.

Fault in the first drawing	How to fix it
The drawing is too small	It uses less than a quarter of the box. Draw it large, to use most of the space.
Sketchy, broken lines	The top edge is made of many short strokes. Draw one clear, unbroken line with a sharp pencil.
Shading	Part of the leaf is shaded. A biological drawing has outlines only.
An arrowhead on a label line	Label lines should end cleanly on the part, with no arrowhead.
A label line that stops short	This line does not reach the leaf stalk. A label line must touch the part it names.
A label line drawn by hand	This line wanders. Label lines are drawn with a ruler.

The rules for a drawing

- **Use a sharp pencil.** Fine lines that are clear and unbroken. No sketchy or feathery lines.
- **Draw it large.** Use most of the space you are given.
- **No shading.** Outlines only. Do not shade or fill in any part.
- **Show what you see.** Draw the specimen in front of you, with the parts in the right proportions, not a textbook diagram.
- **Rule the label lines.** Use a ruler. Each line must touch the part it names.
- **No arrowheads, no crossing.** Label lines should not cross each other, and should end cleanly on the part.

Drawing sheet

Draw a specimen in the box: a leaf, a seed, a flower, or cells you can see under a microscope. Then measure your drawing and the real specimen, and calculate the magnification.

Length of my drawing: ..... mm Actual length of the specimen: ..... mm

Magnification = image size ÷ actual size = ... ÷ ..... = × .....

Check your drawing

[ ] Use a sharp pencil. Fine lines that are clear and unbroken. No sketchy or feathery lines.
[ ] Draw it large. Use most of the space you are given.
[ ] No shading. Outlines only. Do not shade or fill in any part.
[ ] Show what you see. Draw the specimen in front of you, with the parts in the right proportions, not a textbook diagram.
[ ] Rule the label lines. Use a ruler. Each line must touch the part it names.
[ ] No arrowheads, no crossing. Label lines should not cross each other, and should end cleanly on the part.
[ ] Magnification worked out and written beside the drawing, with a times sign and no units.

Magnification questions

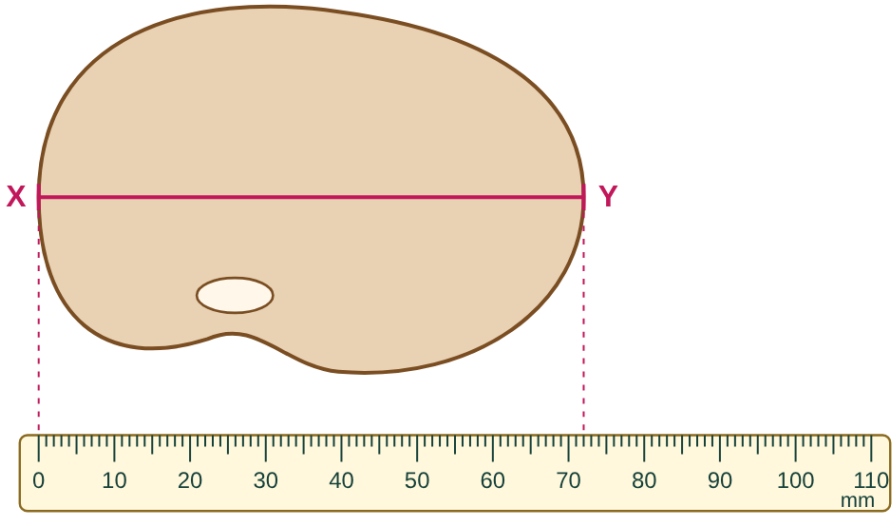
16 original questions, 51 marks. Answer on paper, then mark your work with the answers at the end.

Printed at full size (100%), each drawing is true to scale, so you can measure it with your own ruler. If your printer shrinks the page, or you are reading on a screen, read the ruler printed under the drawing instead.

Q1. The formula [2 marks]

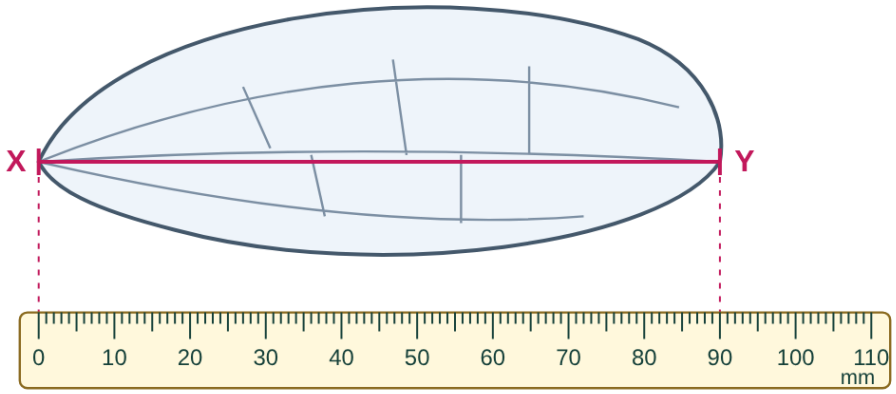
(a) State the formula for magnification. [1] (b) Rearrange the formula to give actual size. [1]

Q2. Measure, then find the magnification [3 marks]



The drawing shows a bean seed. The actual length of the seed is 18 mm. (a) Use the ruler to measure the length of line XY. [1] (b) Calculate the magnification of the drawing. [2]

Q3. Measure, then find the actual size [3 marks]



The drawing shows the wing of an insect. The magnification of the drawing is ×6. (a) Use the ruler to measure the length of line XY. [1] (b) Calculate the actual length of the wing. [2]

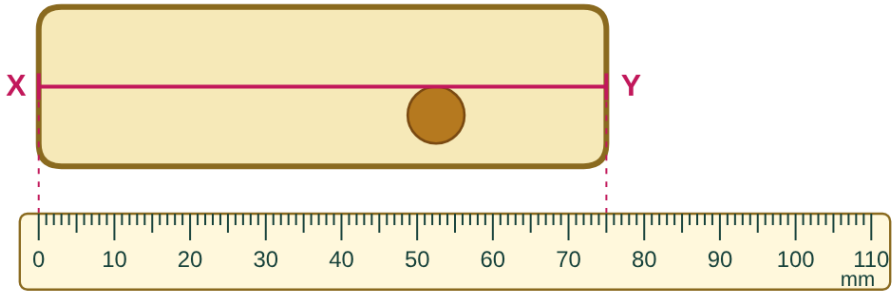
Q4. A drawing smaller than life [3 marks]

A leaf is 120 mm long. A student draws it 80 mm long. (a) Calculate the magnification of the drawing. Give your answer to two decimal places. [2] (b) State what a magnification of less than 1 tells you. [1]

Q5. Changing units [4 marks]

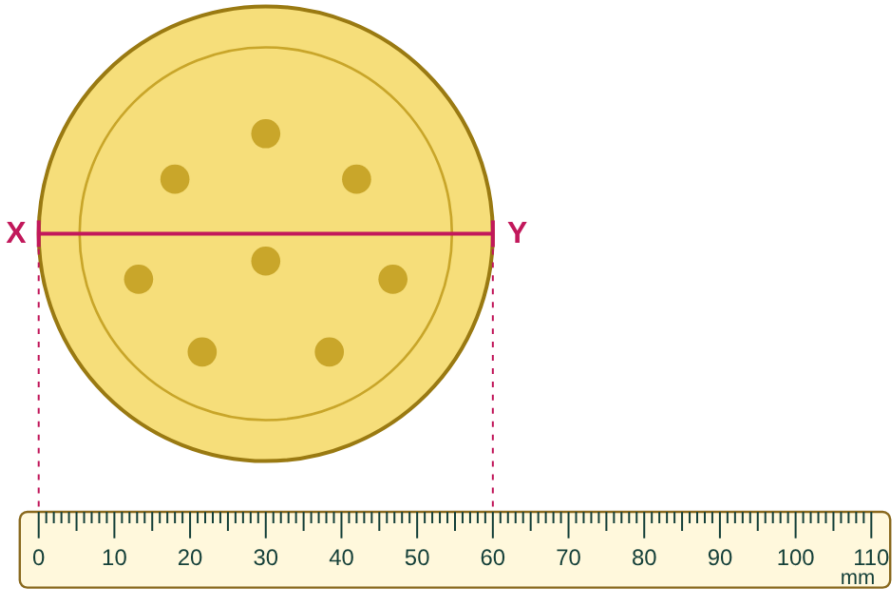
Convert: (a) 0.05 mm to µm [1] (b) 250 µm to mm [1] (c) 1.2 mm to µm [1] (d) 8 µm to mm [1]

Q6. The size of a cell [4 marks]



The drawing shows one cell from an onion. The magnification of the drawing is ×250. (a) Use the ruler to measure the length of line XY. [1] (b) Calculate the actual length of the cell in mm. [2] (c) Give the actual length in µm. [1]

Q7. Magnification with µm [3 marks]



The drawing shows a pollen grain. Line XY is its diameter. The actual diameter of the pollen grain is 40 µm. Calculate the magnification of the drawing.

Q8. How big to draw it [2 marks]

A red blood cell is 0.007 mm across. A student wants to draw it at a magnification of ×8000. Calculate how wide the drawing must be.

Q9. Total magnification [2 marks]

A microscope has a ×10 eyepiece lens, and objective lenses of ×10 and ×40. Calculate the total magnification with each objective lens.

Q10. Cells across the field of view [3 marks]

Under a microscope, the field of view is 2 mm wide. Eight cells of about the same size fit across it, end to end. (a) Calculate the mean length of one cell in mm. [1] (b) Give this length in µm. [1] (c) Suggest why this is only an estimate. [1]

Q11. Using a microscope [4 marks]

A student puts a slide on the stage and looks through the eyepiece on the highest power. The view is blurred and no cells can be found. Describe how the student should find the cells and bring them into focus.

Q12. Making a slide [5 marks]

Describe how to prepare a slide of onion cells to look at under a microscope. Include how to avoid air bubbles.

Q13. Stains [3 marks]

(a) Explain why a stain is used when looking at cells. [1] (b) Name a suitable stain for onion cells and a suitable stain for cheek cells. [2]

Q14. Plant cells or animal cells? [3 marks]

A student looks at two slides. The cells on slide A have a regular shape, a thick outline and small green structures. The cells on slide B have an irregular shape and a thin outline. (a) State which slide has plant cells. [1] (b) Give two pieces of evidence for your answer. [2]

Q15. Improve the drawing [4 marks]

A student draws a seed. The drawing is small, it is shaded with pencil, the outline is sketchy, and the label lines have arrowheads that stop short of the parts. State four ways to improve the drawing.

Q16. Spot the mistakes [3 marks]

Read this working: "Image size = 6 cm. Actual size = 0.2 mm. Magnification = 6 ÷ 0.2 = ×30 mm." Give three corrections.

Answers

Q1. The formula

- (a) One mark for magnification = image size ÷ actual size.
- (b) One mark for actual size = image size ÷ magnification.

Q2. Measure, then find the magnification

- (a) One mark for 72 mm. A reading from 71 to 73 mm is fine.
- (b) One mark for 72 ÷ 18.
- (b) One mark for ×4.

Q3. Measure, then find the actual size

- (a) One mark for 90 mm. A reading from 89 to 91 mm is fine.
- (b) One mark for 90 ÷ 6.
- (b) One mark for 15 mm.

Q4. A drawing smaller than life

- (a) One mark for 80 ÷ 120.
- (a) One mark for ×0.67.
- (b) One mark for the drawing being smaller than the real leaf.

Q5. Changing units

- (a) One mark for 50 µm.
- (b) One mark for 0.25 mm.
- (c) One mark for 1200 µm.
- (d) One mark for 0.008 mm.

Q6. The size of a cell

- (a) One mark for 75 mm. A reading from 74 to 76 mm is fine.
- (b) One mark for 75 ÷ 250.
- (b) One mark for 0.3 mm.
- (c) One mark for 300 µm.

Q7. Magnification with µm

- One mark for measuring XY as 60 mm. A reading from 59 to 61 mm is fine.
- One mark for making the units the same: 60 mm = 60 000 µm, or 40 µm = 0.04 mm.
- One mark for ×1500.

Q8. How big to draw it

- One mark for 0.007 × 8000.
- One mark for 56 mm.

Q9. Total magnification

- One mark for ×100 with the ×10 objective lens.
- One mark for ×400 with the ×40 objective lens.

Q10. Cells across the field of view

- (a) One mark for 0.25 mm.
- (b) One mark for 250 µm.
- (c) One mark because the cells are not all exactly the same size, or because part cells at the edge are hard to count.

Q11. Using a microscope

- Any four of these, one mark each:
- Start with the lowest power objective lens.
- Move the slide so the specimen is over the hole in the stage, in the light.
- Use the coarse focus until the image is clear.
- Move the cells to the middle of the field of view.
- Then turn to a higher power objective lens.
- On high power, use only the fine focus.

Q12. Making a slide

- Any five of these, one mark each:
- Peel a thin layer, one cell thick, from the inside of the onion.
- Thin, so that light can pass through.
- Lay it flat in a drop of water on a slide.
- Add a drop of iodine solution as a stain.
- Lower a cover slip slowly, at an angle.
- Use a mounted needle to lower the cover slip.
- Soak up extra liquid with paper.

Q13. Stains

- (a) One mark because cells are almost clear, so a stain makes parts such as the nucleus easier to see.
- (b) One mark for iodine solution for onion cells.
- (b) One mark for methylene blue for cheek cells.

Q14. Plant cells or animal cells?

- (a) One mark for slide A.
- (b) One mark for the thick outline, which is a cell wall.
- (b) One mark for the green structures, which are chloroplasts.

Q15. Improve the drawing

- One mark for a larger drawing that uses most of the space.
- One mark for no shading.
- One mark for clear, unbroken lines drawn with a sharp pencil.
- One mark for label lines drawn with a ruler that touch the parts, with no arrowheads.

Q16. Spot the mistakes

- One mark for changing 6 cm to 60 mm, so both sizes are in mm.
- One mark for 60 ÷ 0.2 = 300.
- One mark for writing ×300 with no units.

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