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The light microscope: its parts, a real microscope and a diagram, total magnification

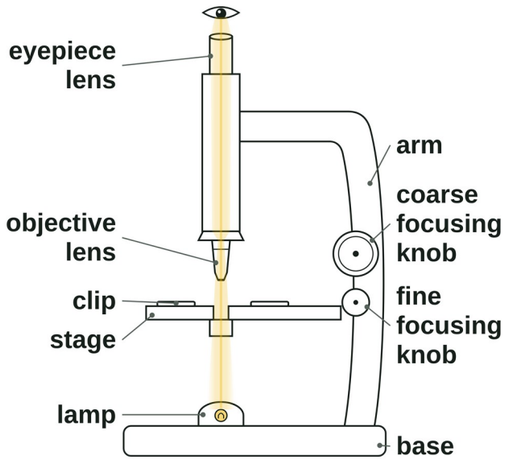
1. What a light microscope does

A **light microscope** uses light and lenses to make a magnified image. Light from the **lamp** shines up through the **specimen**, the thing you are looking at. Then two lenses magnify it: the **objective lens** and the **eyepiece lens**.

- The specimen sits on a **microscope slide**, a thin, flat piece of glass.
- The specimen must be **thin**, so that light can pass through it. A thick piece blocks the light.
- A picture of something seen through a light microscope is a **light micrograph**.

2. The parts and their jobs

Part	Job
Eyepiece lens	the lens you look through; it magnifies the image (often × 10)
Objective lens	magnifies the image; there are usually three (such as × 4, × 10 and × 40) on a turning nosepiece
Stage and clips	the stage holds the slide; the clips keep it still
Lamp	shines light up through the specimen (older microscopes use a mirror)
Coarse focusing knob	the larger knob: moves the lens and the slide a long way, to find the image
Fine focusing knob	the smaller knob: moves them a tiny distance, to make the image sharp
Arm and base	hold the microscope steady; carry it by the arm, with a hand under the base



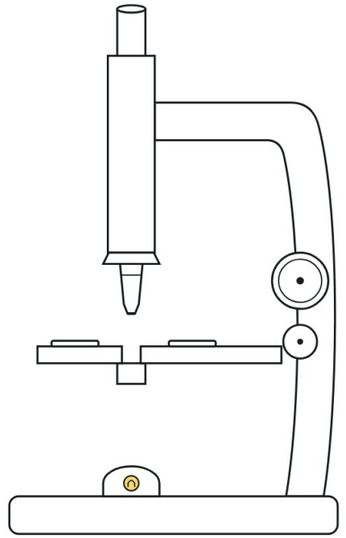
3. A real microscope and a diagram

- A real school microscope has **three objective lenses** on a turning nosepiece. A diagram usually shows one.
- On a real microscope the fine knob often sits inside the coarse knob, on both sides. A diagram draws two separate knobs.
- The parts are always in the same places, so you can name them on any microscope.

A diagram is simplified: it shows only the parts you need to name.



A real microscope



An exam diagram

4. Total magnification

total magnification = eyepiece lens magnification × objective lens magnification

Worked example: the eyepiece lens is × 10 and the objective lens is × 40.

- Numbers in: 10 × 40 = 400, so the total magnification is **× 400**. It has no unit.
- Check: the answer is bigger than either lens on its own.

The higher the magnification, the smaller the **field of view**. With a × 10 eyepiece lens:

Objective lens	Total magnification	Field of view	Onion cells across
× 4	× 40	about 4.0 mm	about 20
× 10	× 100	about 1.6 mm	about 8
× 40	× 400	about 0.4 mm	about 2

Watch out: multiply, never add. × 10 and × 40 give × 400, not × 50.

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Required practical 1 (Combined Science and Biology): preparing a slide, focusing and working safely

5. Required practical 1 (Combined Science and Biology)

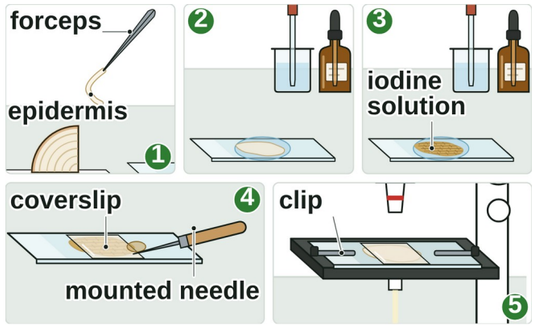
Aim: to use a light microscope to observe, draw and label plant and animal cells, with a magnification scale.

Apparatus: a light microscope, microscope slides, coverslips, an onion, forceps, a dropping pipette, water, iodine solution, a mounted needle, a paper towel, eye protection (and, for cheek cells, a clean cotton bud and methylene blue).

This practical is a skill, so it has no independent or dependent variable. To compare magnifications, you could change the objective lens (independent variable) and measure the diameter of the field of view (dependent variable), using the same slide (control variable).

6. Preparing a slide of onion cells

1. Peel a thin layer of **epidermis** (skin) from the inside of an onion layer, using **forceps**.
2. Put a drop of water on a clean **microscope slide**. Lay the epidermis flat in it, with no folds.
3. Add a drop of **iodine solution**. It is a **stain** that makes the cells, and parts such as the nucleus, easier to see. It stains the cells yellow-brown.
4. Lower a **coverslip** at an angle with a **mounted needle**, so no air bubbles are trapped. The coverslip keeps the specimen flat and stops it drying out.
5. Blot off any extra liquid with a paper towel. Clip the slide onto the stage, with the specimen over the hole.

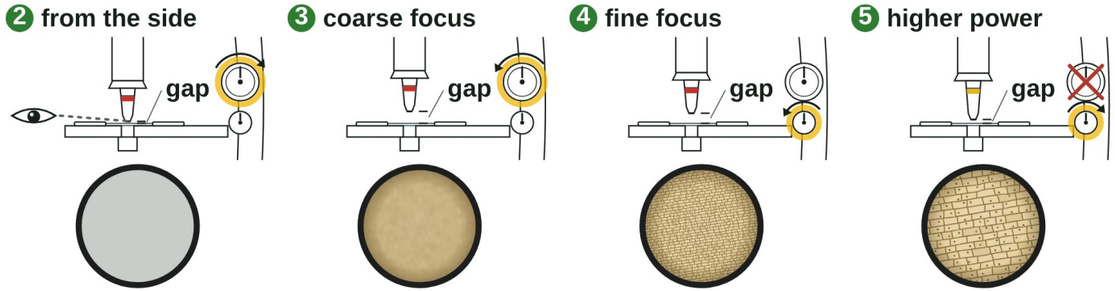


> **Watch out:** a stain makes cells easier to see. It does not make them bigger: only the lenses magnify.

7. Animal cells: cheek cells

Gently wipe the inside of your own cheek with a clean cotton bud. Smear it on a slide, add a drop of **methylene blue** and lower a coverslip. Methylene blue stains the cells blue and the nucleus dark blue. Put used cotton buds straight into disinfectant. Many schools use a prepared slide of cheek cells instead.

8. Focusing step by step



1. Start with the **lowest-power objective lens**. Its wide field of view makes the cells easy to find.
2. Watching from the side, turn the **coarse focusing knob** to bring the lens close to the slide, without touching it.
3. Look through the eyepiece lens. Turn the coarse knob to move the lens and the slide apart until the cells appear.
4. Turn the **fine focusing knob** until the image is sharp.
5. For a higher magnification, turn the nosepiece to a higher-power objective lens and refocus with the **fine knob only**.

> **Watch out:** never use the coarse knob at high power: the lens could crack the slide.
>
> **Watch out:** focusing changes the sharpness, not the size.

9. Safety

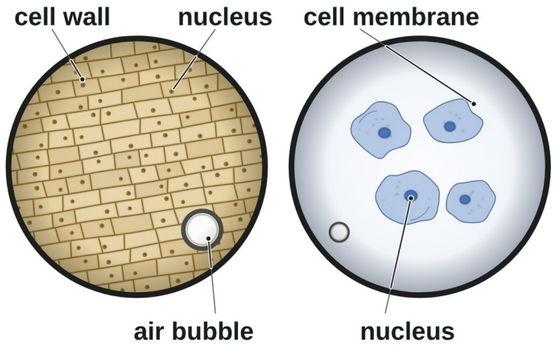
Hazard	Risk	Precaution
Iodine solution, methylene blue	irritate the eyes; stain skin and clothes	wear eye protection; use a dropper; wipe up spills
Mounted needle, glass slides and coverslips	cuts	handle with care; tell the teacher about broken glass
Cheek cells	spreading infection	use only your own cheek and a clean cotton bud; used buds into disinfectant
The microscope	dropping it; a mirror pointed at the Sun can damage your eyes	carry it with one hand on the arm and the other under the base; never point a mirror at the Sun

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Results, biological drawings, magnification and resolution, what can go wrong

10. What you see

- **Onion cells** (iodine solution): brick-shaped cells in rows, about 0.2 mm long. You can see the **cell wall**, the **cytoplasm** and a **nucleus**. The cell membrane is pressed against the wall, so you cannot see it on its own. There are **no chloroplasts**: an onion bulb grows underground.
- **Cheek cells** (methylene blue): flat, uneven cells, about 50 µm across, with a dark blue **nucleus**, a **cell membrane** and **no cell wall**.
- You cannot see **mitochondria** clearly with a school light microscope. **Ribosomes** are far too small to see at all.



onion cells, × 100
iodine solution

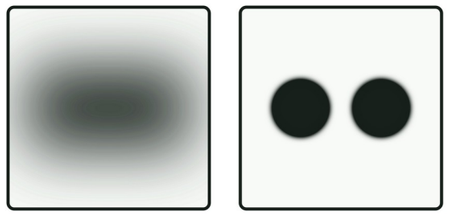
cheek cells, × 400
methylene blue

Watch out: an air bubble is round, with a thick dark edge. It is not a cell. Do not draw it.

11. Magnification and resolution

- **Magnification**: how many times bigger the image is than the real object.
- **Resolution** (resolving power): the ability to see two points that are close together as two separate points.

A light microscope can resolve points about **200 nm** (0.2 µm) apart. Points closer than that blur into one, however much you magnify them.



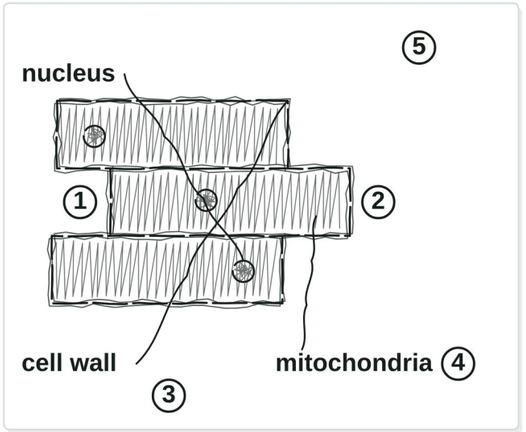
low resolution: one blur

high resolution: two points

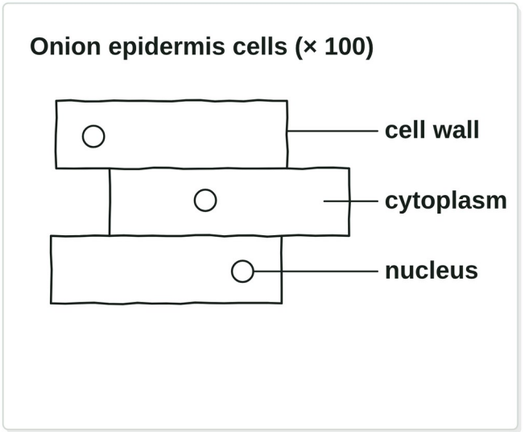
Watch out: magnifying a blurry image only gives a bigger blur. More detail needs a higher resolution.

12. A biological drawing

Poor



Good



Draw large: two or three cells, not the whole field of view. Keep the sizes of the parts in proportion. The numbers match the mistakes in the poor drawing.

1. Use a **sharp pencil** and clear, single lines.
2. **No shading.**
3. Draw **label lines with a ruler**. Each line touches its part, and no two lines cross.
4. **Label only what you can see.**
5. Add a **title** and the **magnification** (eyepiece × objective, such as "× 100"), or a scale bar.

Watch out: draw what you see, not a textbook cell: no mitochondria if you cannot see them.

13. What can go wrong

Problem	Likely cause	Fix
Dark image, cells on top of each other	the layer is too thick or folded	peel a thinner layer; lay it flat
Everything dark brown	too much iodine solution	add one drop only
Only a bright circle	out of focus, or the specimen is not over the hole	move the slide; refocus on low power

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Key words, exam tips and check yourself

Key words

Coarse focusing knob: the larger knob, which moves the lens and the slide a long way apart or together to find the image.

Coverslip: a very thin square of glass laid over the specimen to keep it flat and stop it drying out.

Electron microscope: a microscope that uses a beam of electrons instead of light, giving a much higher magnification and resolution.

Eyepiece lens: the lens at the top of a microscope that you look through.

Field of view: the circle you can see when you look down a microscope.

Fine focusing knob: the smaller knob, which moves the lens and the slide a tiny distance to make the image sharp.

Light microscope: a microscope that uses light and lenses to make a magnified image.

Magnification: how many times bigger the image is than the real object.

Methylene blue: a blue stain used to make the nuclei of animal cells, such as cheek cells, easier to see.

Objective lens: a lens just above the specimen; a microscope has several, each with a different magnification.

Resolution (resolving power): the ability to see two points that are close together as two separate points.

Specimen: the thing you look at under a microscope.

Stage: the flat platform that holds the microscope slide.

Stain: a dye that colours cells, or parts of cells, so they are easier to see.

Total magnification: the magnification of the eyepiece lens multiplied by the magnification of the objective lens.

Exam tips

- Use the exam names: eyepiece lens, objective lens, stage, coarse focusing knob, fine focusing knob.
- Total magnification: multiply, never add. Write it as “× 400”. It has no unit.
- Focusing: lowest power first; coarse knob, then fine knob; fine knob only at high power.
- A stain makes cells easier to see. It does not make them bigger.
- Drawings: sharp pencil, single lines, no shading, ruled label lines, a title and the magnification.
- Magnification makes the image bigger. Resolution decides how much detail you can see.

Check yourself

Cover the answers, then check.

1. What two things does a light microscope use to make a magnified image?
2. What is the job of the stage?
3. An eyepiece lens of × 5 is used with an objective lens of × 10. What is the total magnification?
4. Why is iodine solution added to onion cells on a slide?
5. Which focusing knob do you use first, to find the image?
6. On your slide you see a round shape with a thick, dark edge. What is it?
7. What is meant by resolution?
8. Name one structure you can see with an electron microscope but not with a light microscope.

Answers

1. Light and lenses.
2. It holds the microscope slide.
3. × 50 (5 × 10 = 50).
4. To make the cells, and parts such as the nucleus, easier to see. It is a stain.
5. The coarse focusing knob.
6. An air bubble, not a cell.
7. The ability to see two points that are close together as two separate points.
8. Ribosomes (allow the inside of a mitochondrion).

14. Light and electron microscopes

	Light microscope	Electron microscope
Uses	light	a beam of electrons
Magnification	up to about × 1500	up to about × 2 000 000
Resolution	about 200 nm	about 0.2 nm
You can see	cells, nuclei, chloroplasts	ribosomes, the inside of mitochondria

An **electron microscope** has a much higher magnification and resolution, so biologists can see many more **sub-cellular structures**. **1665**: Robert Hooke names cells. **1930s**: the first electron microscopes. **1950s**: ribosomes are seen for the first time.