The laboratory toolbox

A laboratory contains many specialised pieces of equipment. It is important to know how to use the equipment safely and accurately before attempting any practical experiments. You must also be familiar with techniques for heating, mixing, measuring and pouring before beginning. After completing an experiment, you need to record results and explain your observations.

Use this chapter as a guide to safety and laboratory techniques.

Working safely

Safety rules

Safety rules

Always…

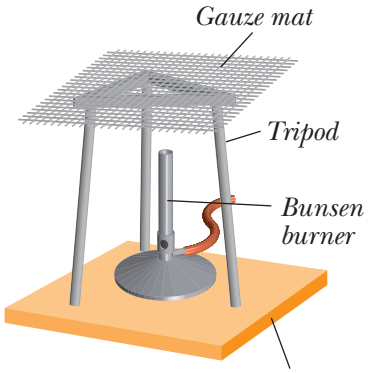
- Follow the teacher's instructions
- Push in chairs and keep walkways clear during experiments
- Tie back long hair
- Wear safety glasses and laboratory coats, unless instructed not to by the teacher
- Keep books and papers away from heating equipment and chemicals
- Inform your teacher immediately of spills or broken equipment
- Inform your teacher immediately of any cuts or burns
- Point the mouths of test tubes away from yourself and other students
- Place heating equipment and chemicals on heatproof mats
- Wait until heating equipment has cooled down before putting it away
- Clean up and wash your hands thoroughly after doing an experiment.

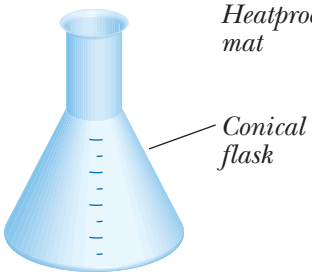
Never…

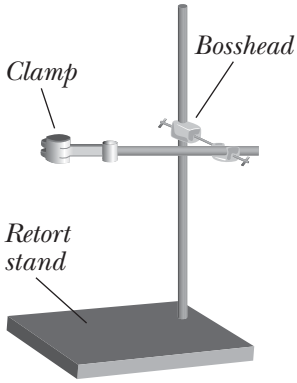
- Enter the laboratory without a teacher present
- Enter the preparation rooms
- Eat or drink in the laboratory
- Sit on the benches or tables
- Run or push in the laboratory
- Conduct experiments or touch equipment unless your teacher tells you to
- Put solid objects, like matches, in the sink
- Pour hazardous chemicals down the sink (check with your teacher)
- Smell or taste chemicals unless your teacher says it's OK
- Leave an experiment unattended
- Operate electrical switches with wet hands.

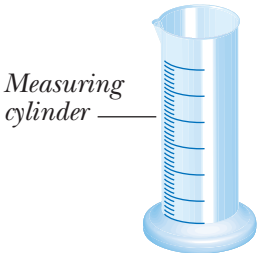
Laboratory equipment

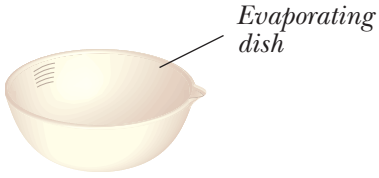
EQUIPMENT	USE
Beaker	Container for mixing or heating substances
Bosshead	Holds the clamp to a retort stand
Bunsen burner	Heats substances
Clamp	Holds objects at a required height along a retort stand
Conical flask	Container for mixing substances or collecting filtered substances
Evaporating dish	Container for evaporating small amounts of substances over a Bunsen burner
Filter funnel	Used with filter paper to filter substances
Gauze mat	Supports containers over a Bunsen burner while they are heated. Spreads heat evenly under the container
Heatproof mat	Protects benches from damage
Measuring cylinder	Used to measure volume accurately
Retort stand	Used with clamps and bossheads to hold substances at a required height
Safety glasses	Protects eyes
Spatula	Used to pick up small amounts of solid substances
Stirring rod	Used to stir mixtures
Test tube	Container for holding, heating or mixing small amounts of substances
Test-tube holder	Holds test tubes while they are being heated
Test-tube rack	Holds test tubes upright
Tongs	Used to pick up and hold small solids while they are heated
Tripod	Supports gauze mats over Bunsen burners

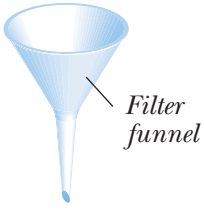


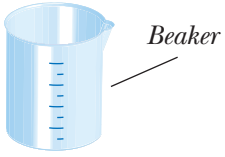


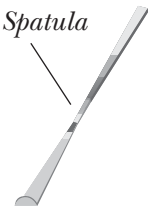


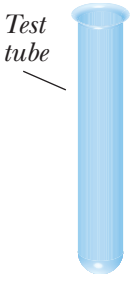


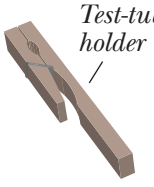


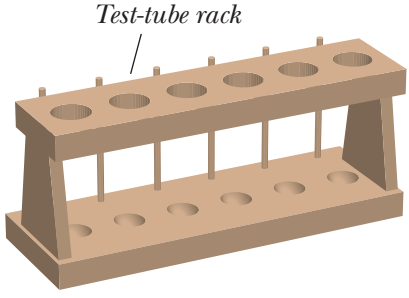






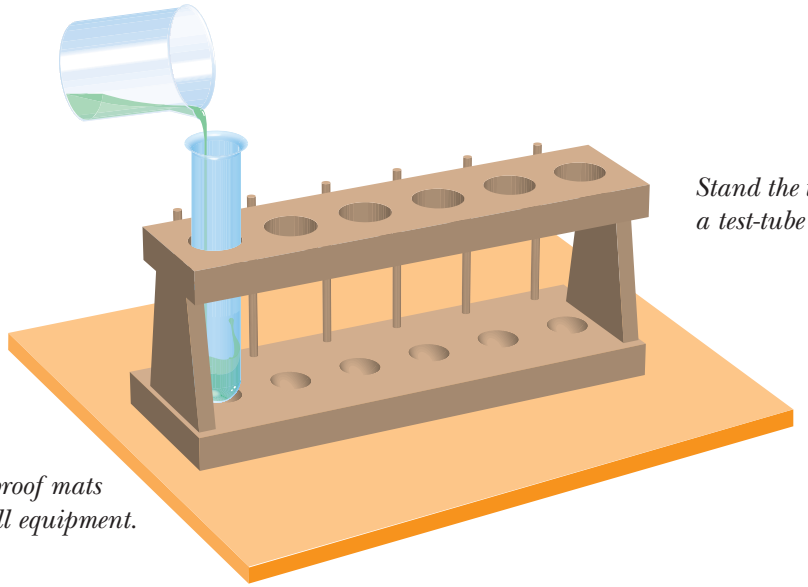






Pouring a liquid into a test tube

Pour liquids carefully into the test tube from a beaker or measuring cylinder. Use a filter funnel when pouring from bottles or containers without a lip.

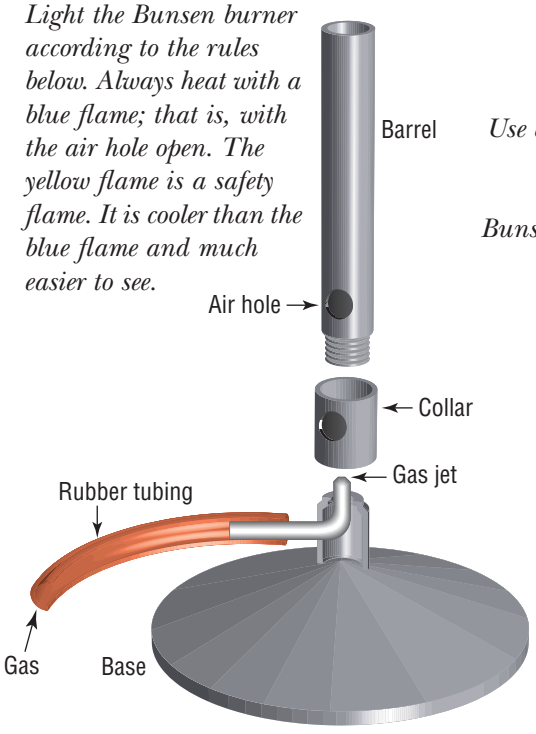


Stand the test tube in a test-tube rack.

Use heatproof mats under all equipment.

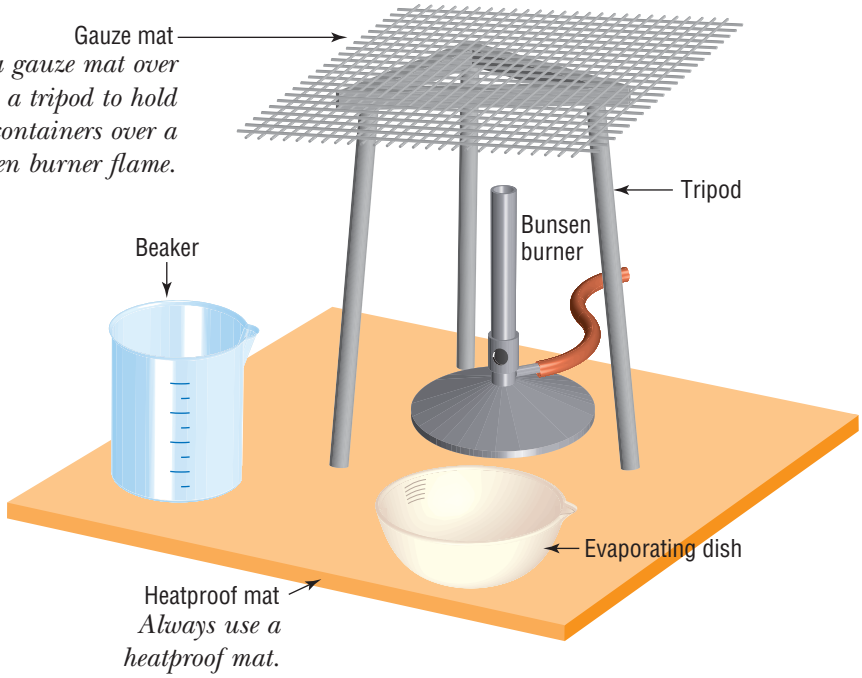
Using a Bunsen burner

Light the Bunsen burner according to the rules below. Always heat with a blue flame; that is, with the air hole open. The yellow flame is a safety flame. It is cooler than the blue flame and much easier to see.



Beakers and evaporating dishes can be placed straight onto a gauze mat for heating. Never look directly into a container while it is being heated. Wait until the equipment has cooled properly before handling it.

Gauze mat
Use a gauze mat over a tripod to hold containers over a Bunsen burner flame.



1. Place the Bunsen burner on a heatproof mat.
2. Check that the gas tap is in the *off* position.
3. Connect the rubber hose to the gas tap.
4. Close the air hole of the Bunsen burner.
5. Light the match and hold it over the barrel of the Bunsen burner.
6. Turn on the gas tap.
7. Adjust the flame.
8. Remember to keep long hair tied back. Wear safety glasses and a laboratory coat at all times.

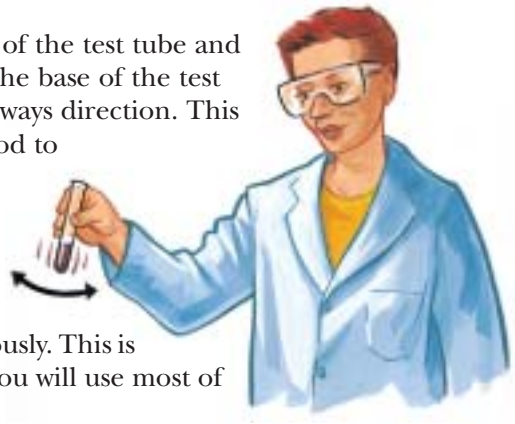
Heating a test tube

Tripods and gauze mats are not used when heating test tubes. Hold the test tube with the test-tube holder. Keep the base of the test tube above the flame. Make sure that the test tube points away from you and other students.

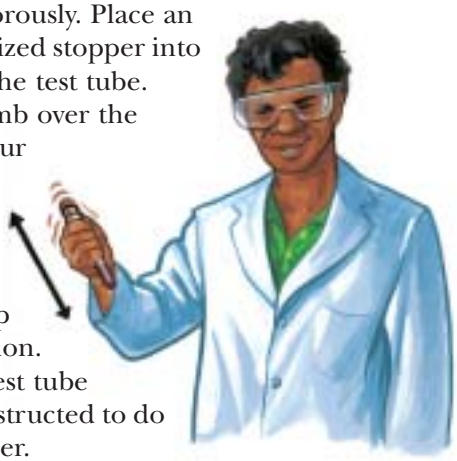
Shaking a test tube

There are two ways to shake substances in a test tube.

Method 1:
Hold the top of the test tube and gently move the base of the test tube in a sideways direction. This method is good to use with non-hazardous substances that do not need to be shaken vigorously. This is the method you will use most of the time.



Method 2:
Use a stopper when a substance needs to be mixed by shaking vigorously. Place an appropriately sized stopper into the mouth of the test tube. With your thumb over the stopper and your hand securely around the test tube, shake the test tube with an up and down motion. Only shake a test tube in this way if instructed to do so by the teacher.

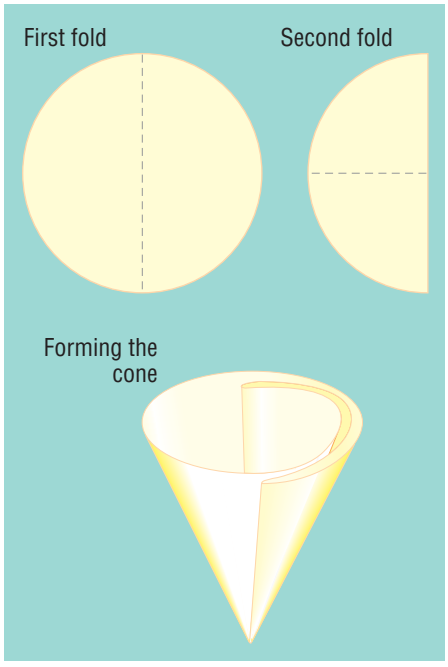


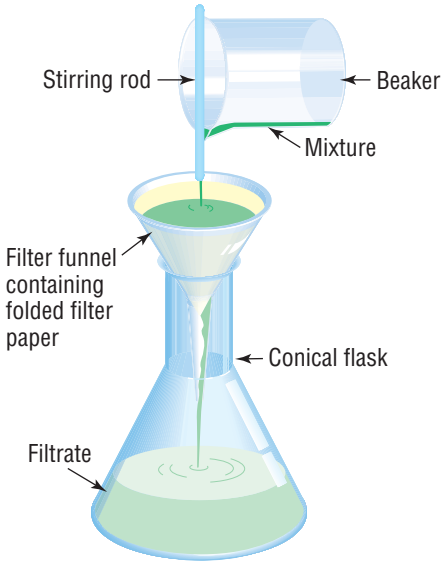
Filtering mixtures

Place the folded filter paper in the filter funnel.

Moisten the filter paper or filter funnel with clean water, to hold it in place.

Gradually pour the mixture into the filter funnel. Be careful not to overflow the filter funnel or allow the mixture to be poured between the filter paper and the funnel.





Using electricity safely

Never:

- place heavy appliances on the edge of a bench
- allow water near electrical cords or plugs
- place objects, other than electrical plugs, into an electrical switch
- use appliances with damaged cords or exposed wires.

Disposing of chemicals safely

Always:

- follow the teacher's directions for the safe disposal of different chemicals.

Never:

- put solid materials down the sink
- put hot objects in the bin. Wait for them to cool down first.
- put broken glass in a classroom bin. The teacher will dispose of it in a separate bin using a dustpan or gloves.

Measuring things

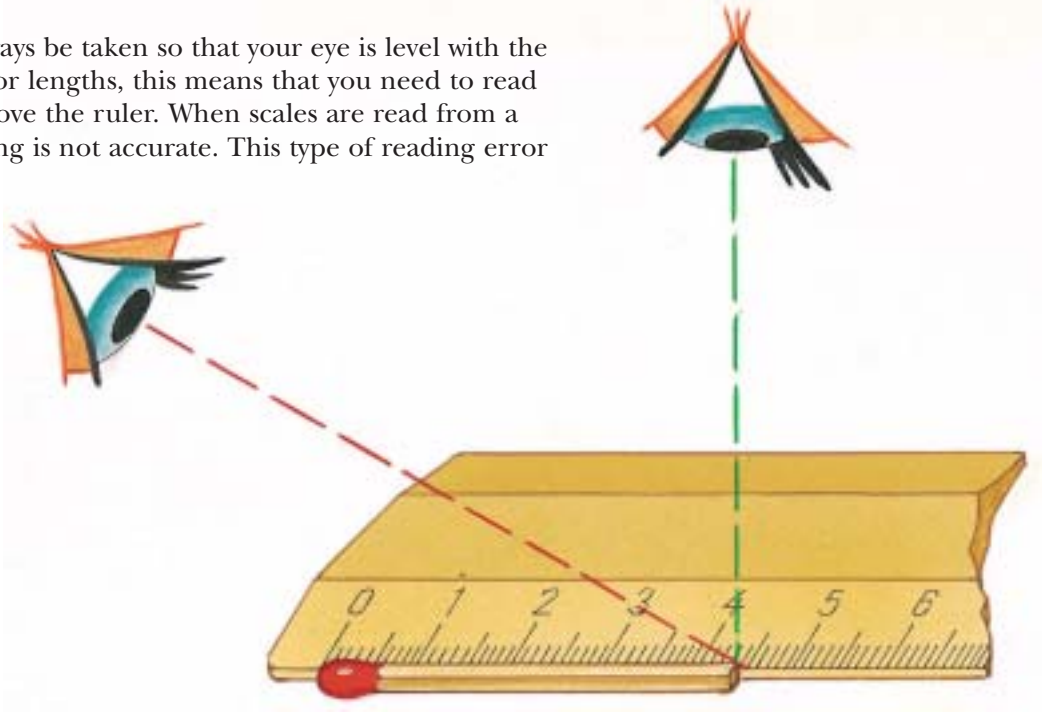
Measuring length

The standard unit for measuring length is the metre (m). But length can also be measured in millimetres (mm), centimetres (cm) or kilometres (km).

Make sure you read a ruler from directly above it.
The length of this match is 4.4 cm.

Parallax error

Measurements should always be taken so that your eye is level with the reading you are taking. For lengths, this means that you need to read the scale from directly above the ruler. When scales are read from a different angle, the reading is not accurate. This type of reading error is called **parallax error**.



Measuring temperature

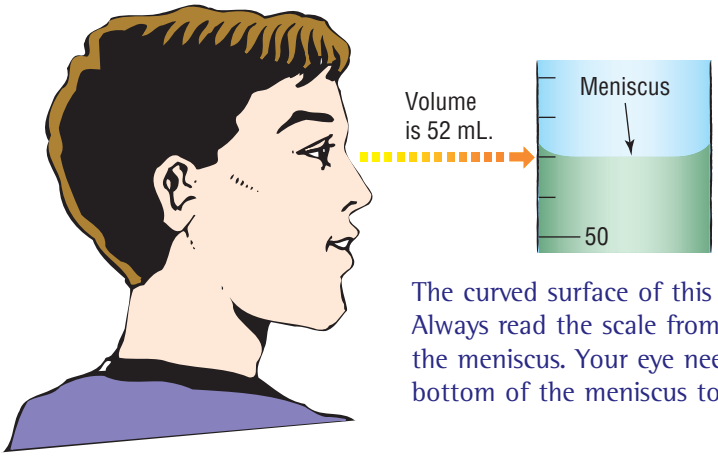
A thermometer is used to measure temperature. Temperature is often measured in degrees Celsius (°C).

The thermometers used in schools are filled with alcohol, dyed red so that it is easier to see. When using thermometers remember these points:

- Ensure that the bulb of the thermometer is fully covered by the substance you are taking the temperature of.
- Never rest the bulb on the bottom of a container; the bottom of a beaker being heated may be hotter than its contents.
- Never use a thermometer as a stirring rod.
- Read a thermometer as soon as the level of the alcohol stops rising or falling.
- Read the thermometer with your eye level at the top of the alcohol column. A reading taken from any other angle will result in parallax error.
- Do not rest a thermometer on a bench where it is likely to roll off.
- Immediately report any breakage of thermometers to the teacher. Broken thermometers are very sharp.

Measuring volume

Volume measures how much space a substance takes up. The standard unit for volume is litres (L), but in a laboratory, it is usually measured in millilitres (mL) with a measuring cylinder.

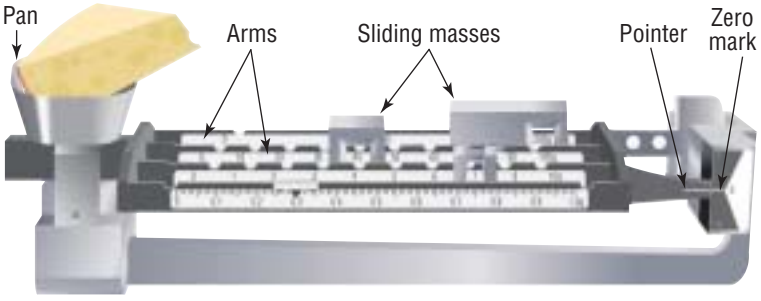


The curved surface of this liquid is called a **meniscus.** Always read the scale from the bottom, flat section of the meniscus. Your eye needs to be level with the bottom of the meniscus to avoid parallax error.

Measuring mass

Mass measures the amount of matter in a substance. The standard unit for mass is kilograms (kg), but in the laboratory, you are most likely to measure mass in grams (g). Mass is measured with a balance. It may be either an electronic balance or a beam balance. When using balances:

- Make sure that the balance is 'zeroed' before using it. An electronic balance is zeroed by pressing the zero or tare button. Zero a beam balance by sliding all of the masses to the zero notches.
- Place the object on the electronic or beam balance.
- Read the mass. If you are using an electronic balance, you can read the mass straight from the screen. If you are using a beam balance, the pointer will have moved. By 'zeroing' the pointer, the mass can be determined. Do this by moving the heaviest sliding mass towards the pointer. Slide it as far as possible without the arm overbalancing the zero, or balance, mark. Repeat this for the other arms, except the one with the smallest sliding mass. The smallest mass should balance the pointer, so that it lines up with the zero or balance mark. Add the masses on each of the arms to determine the total mass.



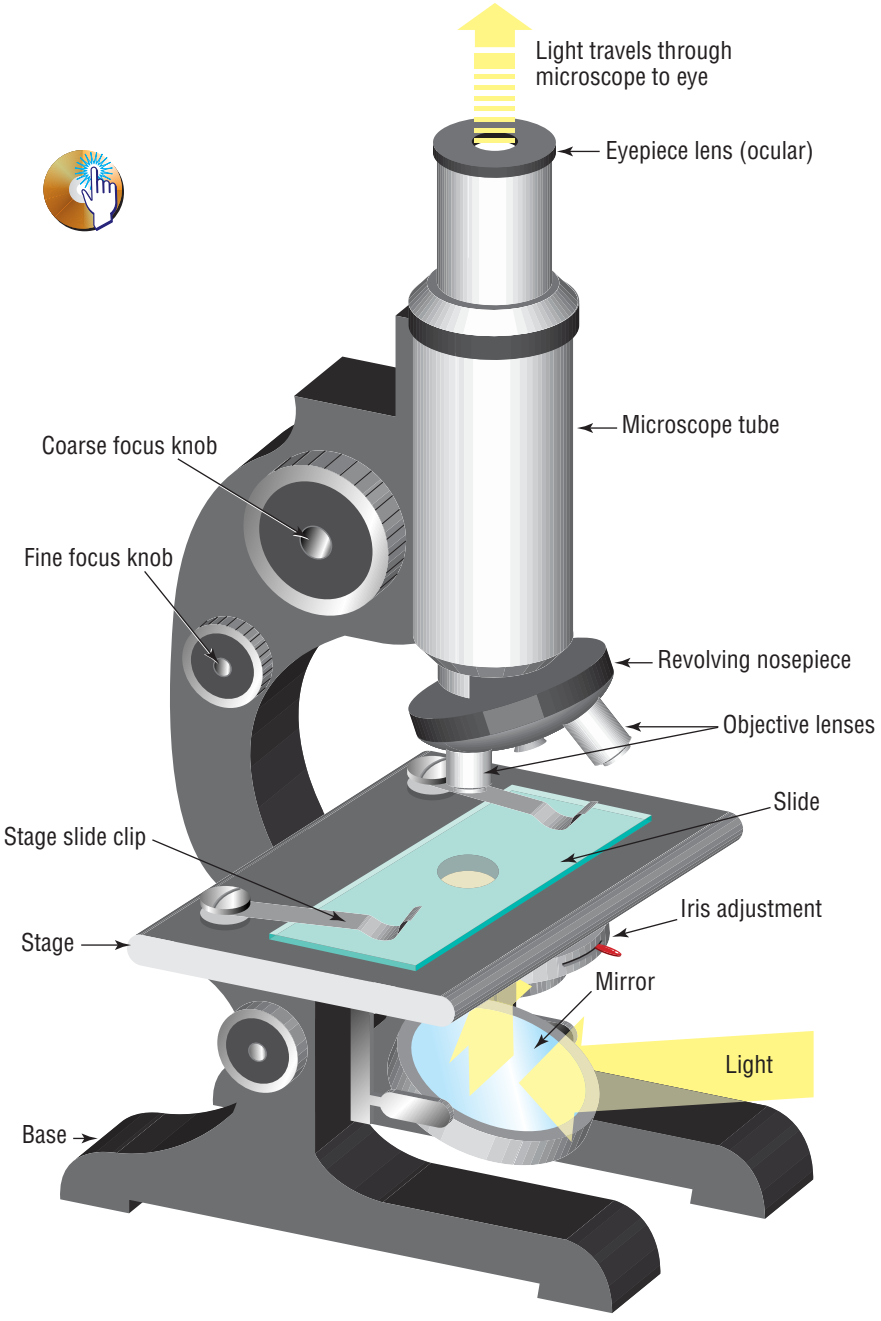
200 g + 40 g + 7 g + 0.3 g = 247.3 g

Sensitive equipment

Using a microscope

Microscopes make small objects easier to see. The microscopes commonly used in schools can magnify objects up to 400 times. The total magnification of a microscope can be calculated by multiplying the magnification of the eyepiece lens by the magnification of the objective lens. For example, a 10× eyepiece and a 20× objective lens would provide: 10 multiplied by 20 = 200 times magnification.

Microscopes are very expensive and are easily damaged if they are not handled carefully.



The microscopes at your school may look slightly different from this one. Some microscopes have a built in light. Microscopes with built in lights do not have a mirror and do not require a separate microscope lamp.

Rules for handling a microscope:

- Always use two hands when carrying a microscope: one on the arm of the microscope and the other under the base.
- Place the microscope securely on a flat surface, away from the edge.
- Never shine sunlight directly up the microscope tube. You could damage your eyes.
- Use only lens tissues to clean microscope lenses: never use your fingers.

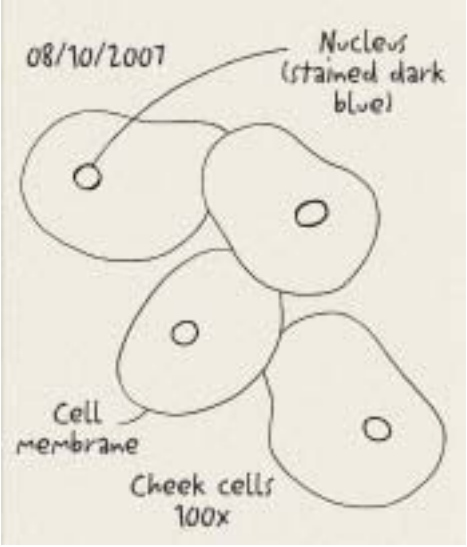
More hints for using a microscope:

- Begin focusing a microscope on the lowest magnification.
- Focus a microscope by beginning with the coarse focus. Look from the side and adjust the objective lens so that it is just above the microscope slide.
- Turn the coarse focus knob to move the tube up until the object comes into view.
- Turn the fine focus to make the image of the object as clear as possible.

Drawing what you see

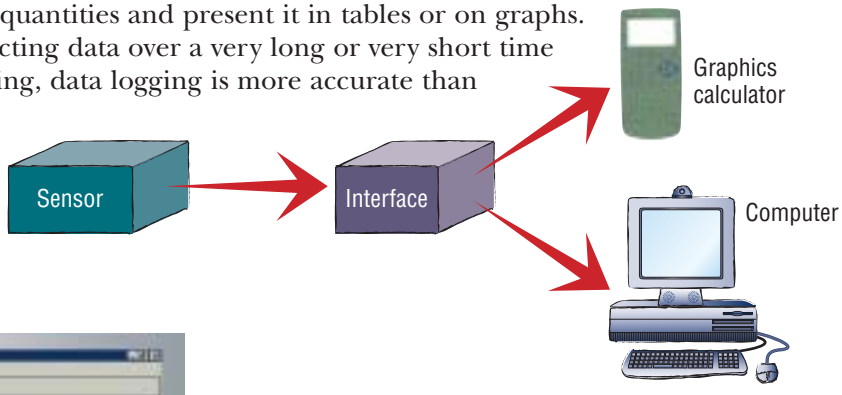
To effectively draw what you see through a microscope, follow these instructions:

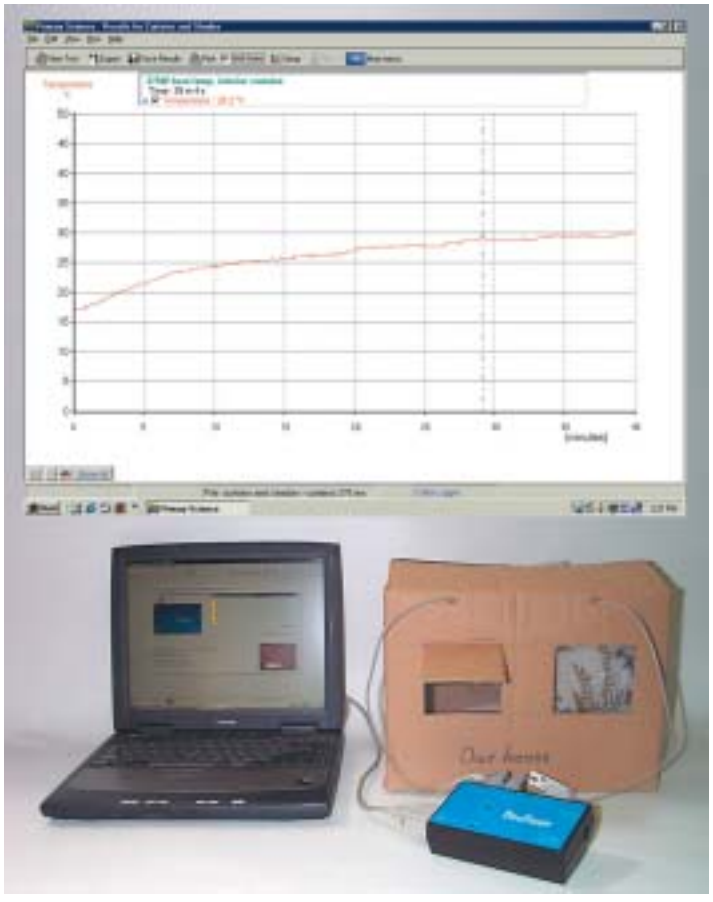
- Always use pencil.
- Keep the diagrams simple. Don't include shading or colours. Draw only the lines and shapes you see.
- Do not attempt to draw everything you see, especially if there are many cells. Draw three or four representative, or typical, cells.
- The diagram should be quite large — about a third of a page.
- Label the structures you can identify.
- Record the date, the name of the specimen and the magnification setting on the microscope.



Using data-logging equipment

Data-logging equipment is used to measure quantities and present it in tables or on graphs. Data loggers are particularly useful for collecting data over a very long or very short time span. In many cases, for example, when timing, data logging is more accurate than measuring time with a clock, watch or stopwatch. Data loggers consist of two main parts, a sensor (or probe) and an interface. The interface can be plugged into either a graphics calculator or a computer.





Data loggers can be used to measure temperature, time, distance, magnetism, force, sound level and much more. Once a data logger has collected data, it is important to analyse the data. What does the data mean? How can it be used?

Keeping a record

Constructing a table

Always include the units used.

The heading for each column is a clear label of what has been measured.

Distance (cm)	Time for ant to travel between markers (s)
0	0
2	3
4	7
6	8
8	12

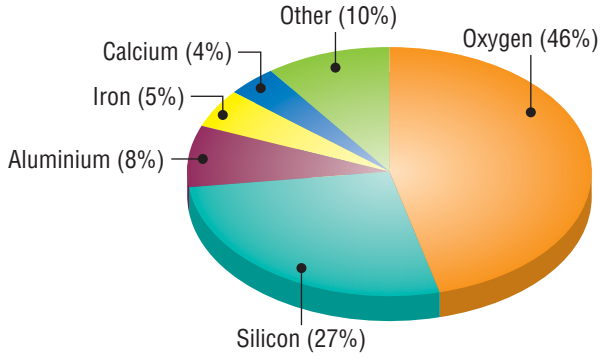
Use a ruler to draw lines for rows, columns and borders.

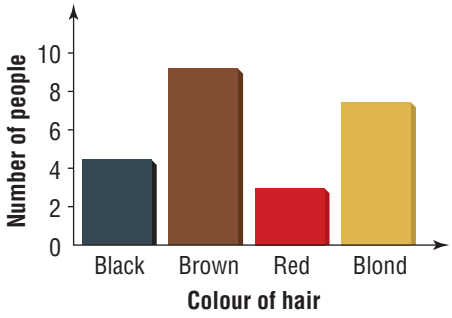
Enter the data in the body of the table. Do not use units in this part of the table.

Graphing

Graphs are used to make data easier to interpret. The type of graph used depends on the type of data to be displayed.

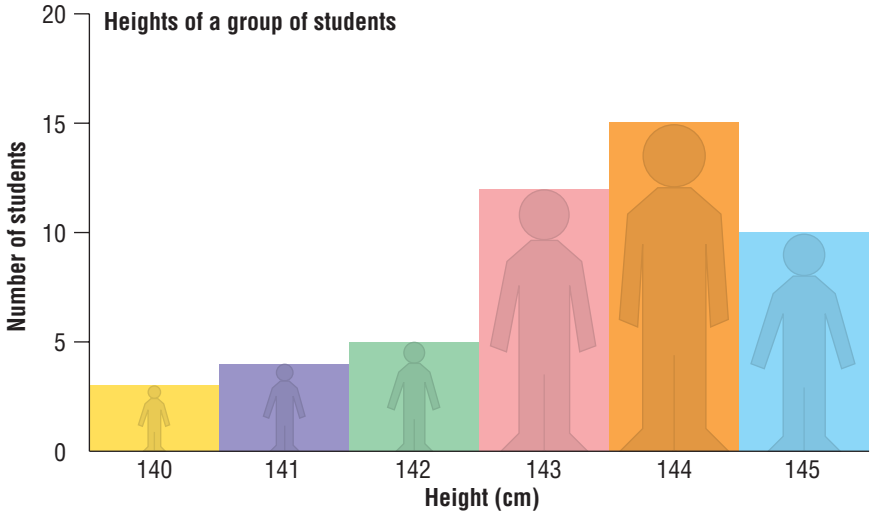
Pie charts are useful for showing the parts that make up a whole. For example, a pie chart can be used to show the percentages of different substances in the Earth's crust.



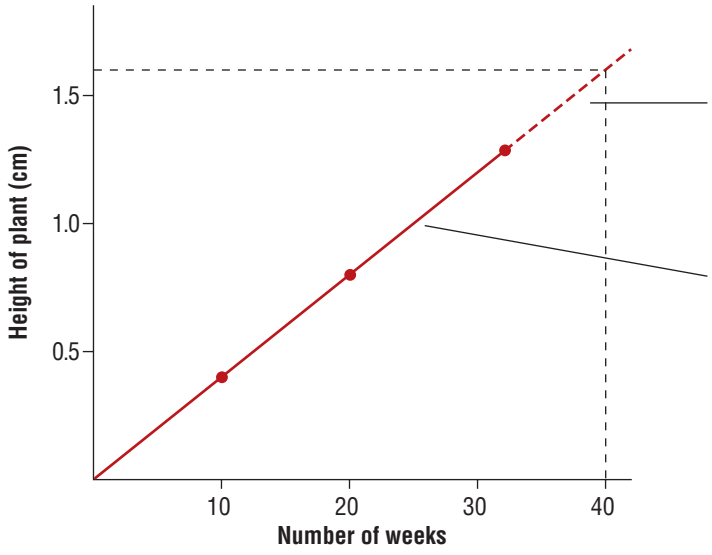


Bar and column graphs are used to display data that is not **continuous**; one piece of data does not relate exactly to the next. For example, a bar graph can be used to show the number of students in a class with each hair colour.

Histograms are bar graphs with the bars touching. They are often used to display the results of a survey. The heights of a group of students could be represented this way. Notice that the heights are recorded along the axis and in the middle of the bar.



Lines graphs have a horizontal *x*-axis and a vertical *y*-axis. They are often used to represent data gathered in laboratory experiments that are continuous. A line graph is used to show how something *changes*. For example, line graphs could be used to show how quickly a plant grows.



A line graph can be used to predict what might happen in the future.

Line graphs are useful for working out values between those that you actually observed.

Reporting your findings

Writing a laboratory report

All practical reports should include your name, your partners' names, the date and the title of the experiment. Each of the following must also be included in the report.

Aim

One or two short sentences that describe the reason for doing the experiment. The aim can also include an **hypothesis —** a guess about the results of an experiment. The aim may begin something like:

To find out . . .

To investigate . . .

To compare . . .

To make . . .

Materials

A list of the equipment and chemicals used

Method

The set of steps you followed to do the experiment. Scientific diagrams are used to describe how equipment was set up. The method needs to be clear enough so that anyone reading the report would be able to repeat your experiment.

Results

Measurements and observations made during the experiment. Measurements can be recorded in a table or on a graph.

Discussion

What the results show and a possible explanation of your results. Any difficulties you had or ideas for improving the experiment are also written in this section.

Conclusion

A short statement describing what you found out. The conclusion needs to relate back to the aim.

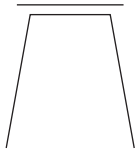
Drawing laboratory equipment

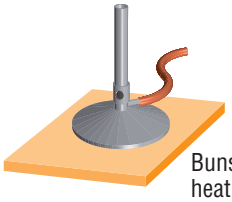
Scientific drawings can be used in laboratory reports to show how equipment was set up. It is important for the drawings to be clear and easy to understand. When drawing scientific diagrams, you should:

- Always draw in pencil.
- Use a ruler to draw straight lines.
- Label the equipment drawn.
- Draw only a cross-section of the equipment.
- Do not put lines across the top of glassware.

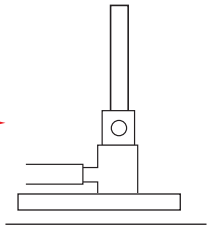
Here are some ideas for simplifying scientific diagrams.

Tripod and gauze mat

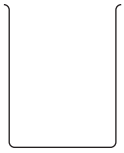




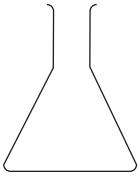
Bunsen burner and heatproof mat



Beaker

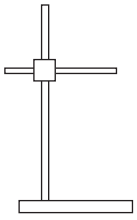


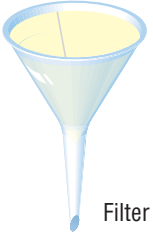
Conical flask



Test tube

Retort stand, bosshead and clamp





Filter funnel and filter paper