All SaintsAcademy

GCSE Sciences Skills Workbook

Student Name

____

Teacher

____

Class ________________________

When you are preparing to answer a question, look carefully at the **command word**. The command word that is used gives a clear indication of what kind of answer is needed. If you don't give the right kind of answer, you could lose marks.

Command word	Definition
Add/Label	Requires the addition of labelling to a stimulus material given in the question, for example labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included. This can include using an equation to calculate a numerical answer.
Comment on	Requires the synthesis of a number of variables from data/information to form a judgement.
Compare	Looking for the similarities **or** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question.
Compare and contrast	Looking for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete	Requires the completion of a table/diagram.
Deduce	Draw/reach conclusion(s) from the information provided.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.
Devise	Plan or invent a procedure from existing principles/ideas.
Discuss	Identify the issue/situation/problem/argument that is being assessed within the question. Explore all aspects of an issue/situation/problem/argument. Investigate the issue/situation etc. by reasoning or argument.
Draw	Produce a diagram either using a ruler or using freehand.
Estimate	Find an approximate value, number, or quantity from a diagram/given data or through a calculation.

Command word	Definition
Evaluate	Review information (e.g. data, methods) then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer).
Measure	To determine the dimensions or angle from a diagram using an instrument such as a ruler or protractor.
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axes with important features indicated, the axes are not scaled.
State and explain	Make a point and link ideas to justify that point. An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Write	When the questions ask for an equation.

Verbs preceding a command word	
Suggest a …	Suggest an explanation or suggest a description

I can…

- interpret command words to answer questions effectively.

Some questions require you to compare things in a longer piece of writing.

What does the question mean?

These types of questions will start in one of these ways:

Compare: Point out the similarities/differences or benefits/drawbacks of two things.

Evaluate: Point out the good/bad points about things and use these points to say whether overall you think things are good or bad.

Discuss or Explain why: Use an argument in support of or against an idea.

How to think about the question

Plan your answer. Try using a table for good/bad points or similarities/differences.

For example, consider this question:

Evaluate the advantages and disadvantages of using hydrogen rather than petrol as a fuel for cars.

Advantages of hydrogen	Disadvantages of hydrogen
Lots of water to make hydrogen from	Expensive to produce (uses electricity)
Hydrogen engines only produce water	Difficult to store
Hydrogen engines don't release greenhouse gases	Fossil fuels may need to be burnt to make electricity to make hydrogen

Use a paragraph or two to compare these points. Then you need to say whether, on balance, you think hydrogen is a better fuel. Remember: grammar, punctuation and spelling are important!
For example:

A problem with petrol is that it's made from crude oil, which may run out. Hydrogen is made using water, and that won't run out! However, hydrogen is expensive to make, and fossil fuels may be used in power stations to make the electricity to make the hydrogen. Fossil fuels release greenhouse gases. At least if we all used hydrogen cars our cities would be less polluted. Hydrogen is hard to store but scientists should find a better way to store it. So, I think that hydrogen is a better fuel for cars than petrol.

I can…

- plan an answer to a question about comparing two or more things with each other.

Some questions ask you to describe things in a longer piece of writing.

What does the question mean?

These types of questions start with 'Describe' or 'Explain how'. Your answer needs to present a number of points in a logical order, clearly showing the links between them.

How to think about the question

Start your planning by writing down what you know. Use a list of short phrases. Then:

- draw lines between phrases to link them, or
- arrange them into a table with headings to show the links, or
- number the phrases in a logical order.

For example:

1 Describe how the properties of gold, iron and copper relate to their uses.

Metal	Properties	Uses
gold	shiny, doesn't tarnish	jewellery
iron	cheap, strong	bridges, car bodies
copper	good conductor	electrical wires

2 Ben boils some water in a kettle. Explain how the energy for this came from coal, and the energy in the coal originally came from the Sun.

7 heat energy in steam 1 light energy from sun

6 water turned to steam in power station

2 photosynthesis 3 chemical energy in plants 4 plants turn to fossils

5 coal 8 turbine and generator in power station 9 makes electricity

What makes a good answer?

You don't need to use all your points but make sure that those you do use are in a good order. You also need to show clearly how one point links with the next. You must use scientific words correctly, and use good grammar, punctuation and spelling.

I can…

- plan an answer to a question that involves describing something.

To convert a fraction to a decimal

Divide the top number of the fraction by the bottom number. If the top number is smaller than the bottom number, then the decimal will always start '0'.

Some fractions don't divide completely, so you end up with a **recurring** (repeating) number.

Try remembering common fractions as decimals, to save time:

$^1/_2 = 0.5$	$^1/_4 = 0.25$
$^3/_4 = 0.75$	$^1/_8 = 0.125$

For example, $^1/_3 = 0.3333\ldots$ (the '…' means the numbers continue forever). If we have numbers like this, we 'round' it to one or two decimal places. Each number after the decimal point is one decimal place. When rounding numbers, the rule is:

1. Choose the number of decimal places.
2. Look at the number in the next decimal place.
3. If it is 5 or more round up. If it is less than 5 round down.

So 0.3333… is 0.33 to 2 decimal places.

$^2/_3 = 0.66666\ldots$, which is 0.67 to 2 decimal places.

1 Convert the following fractions to decimals. (Remember to show your working.)

a $^1/_{10}$ **b** $^6/_{100}$ **c** $^3/_8$ **d** $^5/_6$

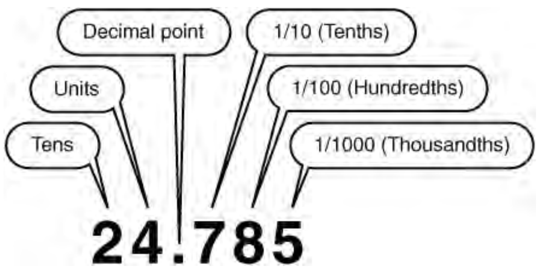
To convert a decimal to a fraction

First, find the lowest place value of your decimal.

Now write the place value under the number as a fraction. Then cancel the fraction down.

So, the lowest place value in 0.6 is tenths. As a fraction this is $^6/_{10}$ or $^3/_5$.

0.75 is $^{75}/_{100}$ or $^3/_4$ and 0.851 is $^{851}/_{1000}$



2 Convert the following decimals to fractions. (Remember to show your working.)

a 0.1 **b** 0.04 **c** 0.625 **d** 0.875

Ratios

A ratio shows how something is divided up. A statement like there are 3 blues for every 2 reds is a ratio statement. This can be written as a ratio using a colon (:) 3 : 2

In a molecule of water there are 2 hydrogen atoms and 1 oxygen atom. The atoms in a water molecule are present in the ratio 2 hydrogen to 1 oxygen, which can be written as 2 : 1.

3 Mr and Mrs Brown have five children, three boys and two girls. Write the ratio of boys to girls.

4 The formula for carbon dioxide is CO_2. This means it has 1 carbon atom and 2 oxygen atoms. What is the ratio of carbon atoms to oxygen atoms in a molecule of carbon dioxide?

5 Write down the ratio of atoms in the following molecules.

a CH_4 **b** CO_2 **c** N_2O_3

I can…

- convert between decimals and fractions
- use ratios

'Per cent' (%) means 'out of a hundred'. If 30 out of a hundred pupils in a school chose to do hockey instead of netball, you could say that $^{30}/_{100}$ or 30% chose hockey.

If there were only 50 girls, and 10 of them chose hockey, what percentage of the girls is that?

10 out 50 is $^{10}/_{50}$. To get this out of 100, we multiply the top and bottom by 2, which is $^{20}/_{100}$ or 20%.

17 out of 45 boys chose to do tennis. What is that as a percentage?

First we need to write this as a decimal.

$^{17}/_{45}$ or 17 ÷ 45 = 0.377… or 0.38 to two significant figures.

Now we convert the decimal into a fraction by writing the numbers above the lowest place value (see MS1). This is $^{38}/_{100}$ or 38%.

1 Work out the percentages for these examples.

- **a** 35 out of 50 teachers in a school are women.
- **b** 24 pupils out of a class of 30 remembered their homework.
- **c** Jane got 14 marks out of 20 in a test.
- **d** Only 100 out of 800 pupils in a school walk to school in the mornings.

Working out numbers from a percentage

You should know that 50% is $^{1}/_{2}$ and that 25% is $^{1}/_{4}$.

For more complicated ones, write out the fraction and use a calculator.

So, 32% of 70 is the same as $^{32}/_{100} \times 70$ (the × means 'of').

Work this out on a calculator: 32 ÷ 100 (= 0.32) and then 0.32 × 70 = 22.4

2 Work out the numbers for these examples.

- **a** 80% of pupils in a class of 30 passed a test.
- **b** 70% of pupils in Year 7 have a computer at home. There are 200 pupils in Year 7.
- **c** 20% of 60 cars in the school car park are red.
- **d** 40% of 500 pupils in the school have black hair.

I can…

- calculate and use percentages.

Standard form

Standard form is a version of index form. It is used when we need to represent very large numbers, such as the distances between planets, or very small numbers, such as the sizes of structures inside cells.

For example, the speed of light is about 300 000 000 metres per second (m/s). It could be easy to lose track of all those zeros! To help avoid that, and to make it quicker to write, we say that 300 000 000 is the same as $3 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$ (count the zeros). 300 000 000 is the same as 3 multiplied by 10, eight times over. We can write this as 3×10^8.

We can do the same for very small numbers. For example, a red blood cell is about 0.000 0065 metres wide. This is the same as $6.5 \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$.

$\frac{1}{10}$ can be written as 10^{-1} and so $\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$ can be written as 10^{-6}. 0.0000065 in standard form is 6.5×10^{-6}. (Note: The number part in standard form is always given as a number between 1 and 10.)

You can easily compare numbers in standard form, because the bigger the index number is, the bigger the number.

1 The circumference of the Earth is about 40 000 kilometres. Write this in standard form.

2 An average human hair is about 0.00015 m wide. Write this in standard form.

3 Write the following as an ordinary numbers.

a 6.4×10^6 **b** 4.2×10^{-3} **c** 8.926×10^5 **d** 2.129×10^{-9}

I can…

- use and interpret units in index form
- convert numbers into standard form.

Sometimes in science we try to predict what will happen based on what we already know. We might describe our prediction in numbers as a **probability**, such as the probability that the next baby born is a girl, or the probability that it will rain next Tuesday.

A probability is the likelihood of something happening. The probability is calculated as

$$\frac{\text{the number of ways an outcome can happen}}{\text{the total number of possible outcomes}}$$

For a fair 6-sided dice, there are 6 possible equally likely outcomes. So the probability of rolling a 1 is 1/6.

There are 3 even numbers on a dice (2, 4, 6) so the probability of rolling an even number is 3/6 or 1/2.

The probability of rolling a number that is not 1 is 1 – 1/6 = 5/6.

Probabilities can be written as fractions, decimals and percentages.

Fractions

When you know the number of ways an outcome can happen, and the total number of possible outcomes, you can write probability as a fraction. You do not need to write the fraction in its simplest terms.

For example, the probability of picking a King from a pack of cards is 4/52.

Decimals

A piece of toast is dropped 1000 times. It lands butter side up 510 times.

An estimate for the probability that a piece of toast will land butter side up is 510/1000 = 0.51.

Percentages

The probability that a piece of toast will land butter side up is 0.51 × 100 = 51%

Some weather forecasts give a probability of a particular weather type as part of a prediction. This is usually shown as a percentage.

The forecasters run their computer prediction models many times. The percentage shows what proportion of times the model predicted that type of weather. So, if there is a 60% change that it will rain, there is a 100 – 60 = 40% chance that it will not rain.

The probability of rolling an even number on a dice is ½ = 0.5 = 50%

1 A couple are expecting a baby. The baby is equally likely to be a girl or a boy. Show this probability as a fraction, a decimal and a percentage.

I can…

- describe what a probability is
- calculate probabilities
- present probabilities in different forms.

When you have collected data or other information in your investigation, you need to display it in a way that makes it easy to identify key differences, trends and patterns. Different kinds of data are best presented in different ways.

Method of presentation	When used …
table	• to show items in a certain order (e.g. numerical order, alphabetical order). This is useful if you want to show the best or worst thing in a list. The best thing appears at the top of the table and the worst appears at the bottom.
bar charts	• to show how things compare • normally the independent variable is discontinuous and the dependent variable is quantitative
frequency diagrams	• to compare numbers of things
histograms	• a frequency diagram where the values for the independent variable are continuous but have been grouped into ranges
line graphs	• to show how one variable changes as another (usually time) changes • used when you know that the two variables are linked
scatter graphs	• to look for a link (relationship) between two variables • both variables are quantitative
pie charts	• to show proportions of a total contributed by different items (e.g. the proportions of students who come to school by bus, car …)
Venn diagrams	• to show the amount by which groups of items are the same or different
flow diagrams	• to show a sequence of information
labelled drawings	• to describe objects and processes

I can…

- describe different ways of presenting information
- choose an appropriate way to present information.

A table is a way of showing a lot of information in a way that is easy to read.

This …

Bike	Number of pupils
ordinary bike	16
mountain bike	9
racing bike	5
no bike	4

is easier to read than this …

> Out of all the children in the class, 16 of them have an ordinary bicycle. Four of the pupils did not have a bike at all. Racing bikes were owned by five pupils, and the other nine all had mountain bikes.

Ordering the information in a table can also make it easier to see patterns.

Results tables

When you do a practical, you often need to record your results in a table. You should draw your table before you start your experiment.

This table is for an experiment to find out how long it takes to dissolve different amounts of sugar in some hot water.

The **independent variable** (what you change) always goes in the first column.

These are the amounts of sugar that will be tested.

Amount of sugar (spatulas)	Time to dissolve (minutes)
1	
2	
3	
4	
5	

The **dependent variable** (what you measure) goes in the other column.

Always put the units in.

Use a ruler to draw your table.

If you investigate more than one thing, your table will need more than one column for the results. For example:

Amount of sugar (spatulas)	Time to dissolve (minutes)	
	Hot water	Cold water
1		
2		
3		
4		
5		

This heading applies to both of the columns beneath it.

I can…

- organise data in a table to see a pattern
- justify the use of a table.

A bar chart displays data.

Make gaps between the bars for an independent variable that is:

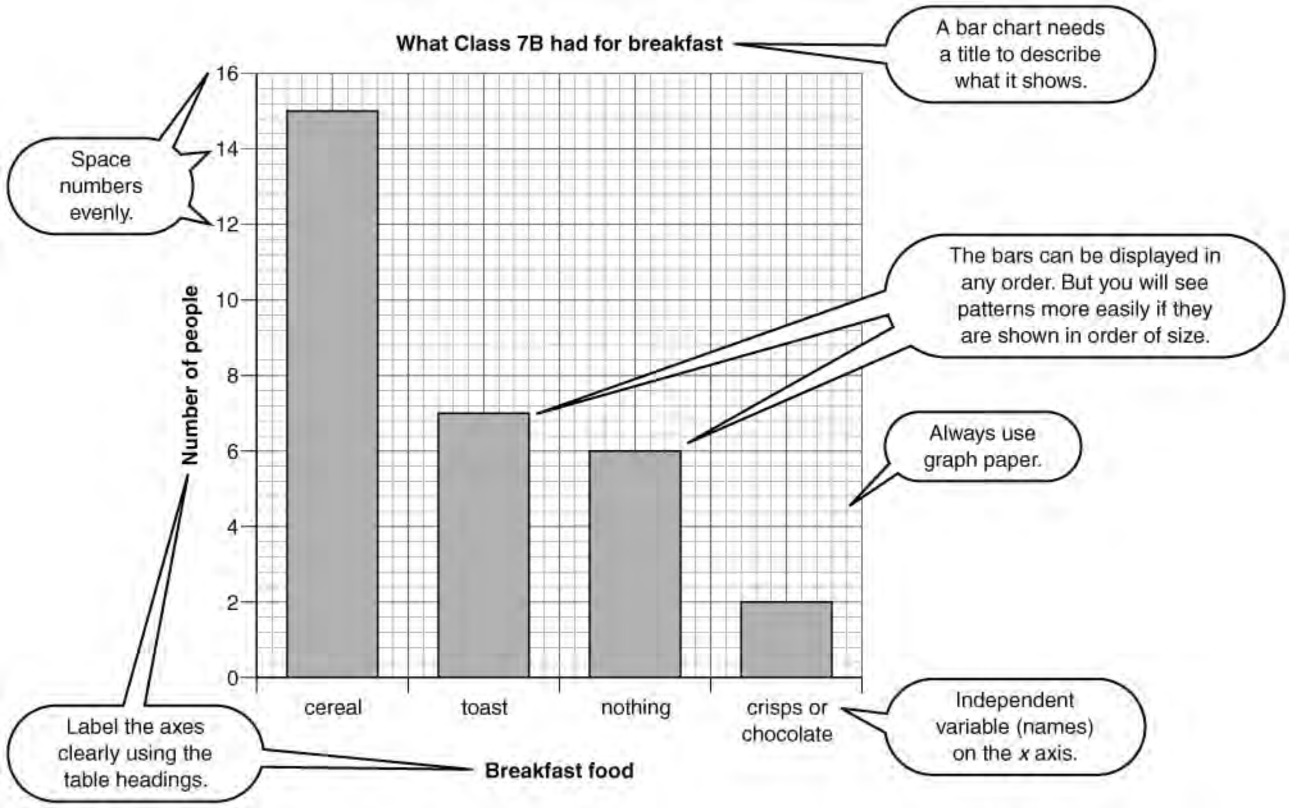
- given in words (qualitative data), such as colours Red, Blue, Green or foods
- counted and can only take certain values (discrete data), such as number of brothers or shoe size.

A bar chart is sometimes called a **column graph** (e.g. in a spreadsheet program) if the bars are displayed vertically rather than horizontally.

Drawing a good bar chart

The bar chart below has been drawn from this table of data.

Breakfast food	Number of people
cereal	15
toast	7
crisps or chocolate	2
nothing	6



Always use a ruler to draw straight lines, and draw your bar charts as neatly as possible.

1 **a** Look at the bar chart. Which was the most popular breakfast?

b Explain how you can tell from the graph which the least popular breakfast is.

c How many students had nothing for breakfast?

2 Display the following data in a bar chart. Remember to use graph paper, and use a ruler to draw straight lines.

In class 7X, there were 5 children with no brothers and sisters, 12 children with 1 brother or sister, 4 children with 2 brothers or sisters and 1 child with 3 brothers or sisters.

I can…

- identify, interpret, draw and know when to use a bar chart.

A frequency table shows the frequencies or numbers of different items or in different groups. A **frequency diagram** is like a bar chart.

Showing the data on the right on a graph, by plotting one point at a time wouldn't show anything useful. But grouping the heights into groups and scoring how many students there are in each height group can be useful. The data can be displayed on a **tally chart**.

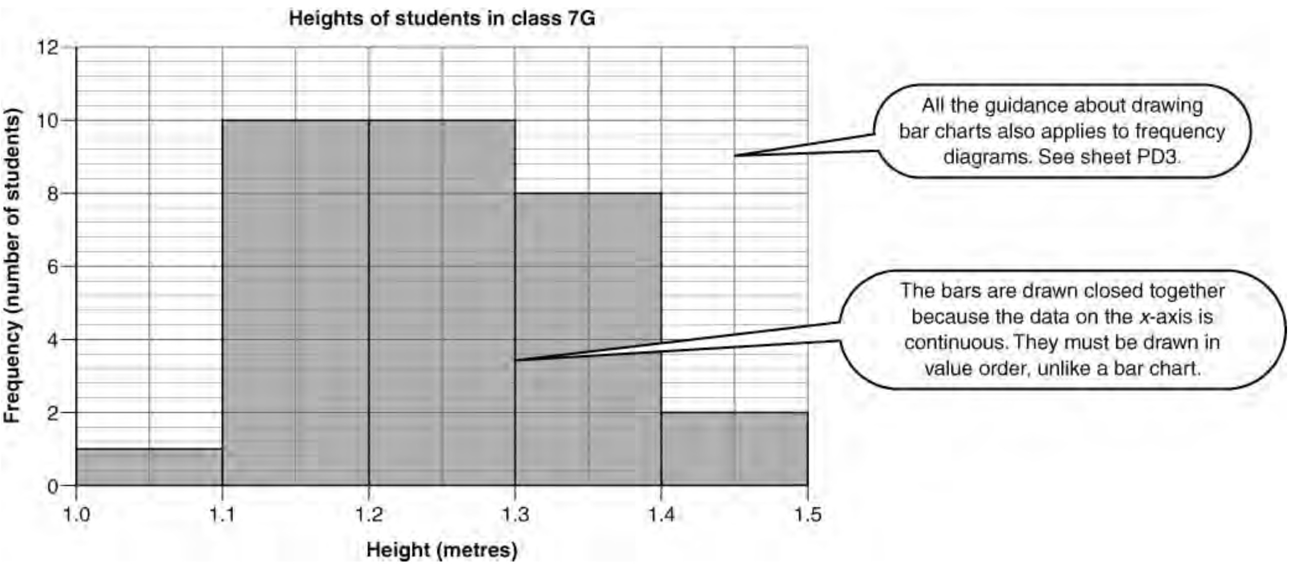
Think carefully of the best way to group the data to get a useful pattern. The groups are the same size (in this case, 0.09 m).

Heights of students in 7G (in metres)

1.13, 1.34, 1.44, 1.15, 1.17, 1.19, 1.11, 1.24, 1.22, 1.21, 1.28, 1.14, 1.15, 1.16, 1.31, 1.20, 1.36, 1.22, 1.38, 1.23, 1.05, 1.39, 1.34, 1.29, 1.32, 1.31, 1.21, 1.45, 1.25, 1.27, 1.14

Height range (m)	No of people	Total
1.0 ≤ h < 1.1	I	1
1.1 ≤ h < 1.2	~~IIII~~ ~~IIII~~	10
1.2 ≤ h < 1.3	~~IIII~~ ~~IIII~~	10
1.3 ≤ h < 1.4	~~IIII~~ III	8
1.4 ≤ h < 1.5	II	2

The height is the **independent variable** and is continuous (because it is measured and not counted or described in words). When the independent variable is continuous you can plot the information from the tally chart as frequency diagram. There are no gaps between the bars in a frequency diagram where the independent variable is continuous.



1 These are the amounts of pocket money each person in a class gets.

£2.00, £5.00, £4.50, £4.75, £5.60, £5.40, £5.00, £5.00, £5.20, £4.50, £4.80, £8.00, £8.50, £8.50, £7.00, £7.50, £7.00, £6.50, £6.50, £6.00, £6.50, £6.25, £6.25, £6.30, £5.80, £5.20, £5.40, £4.80

a Draw a grouped frequency table.

b Tally the amounts into your frequency table.

c Draw a frequency diagram.

2 1000 people who have just passed through passport control at an airport have had different journey times. How would you display this data? Explain your reasoning.

I can…

- interpret frequency diagrams
- draw and use tally charts and frequency tables.

Line graphs are used:

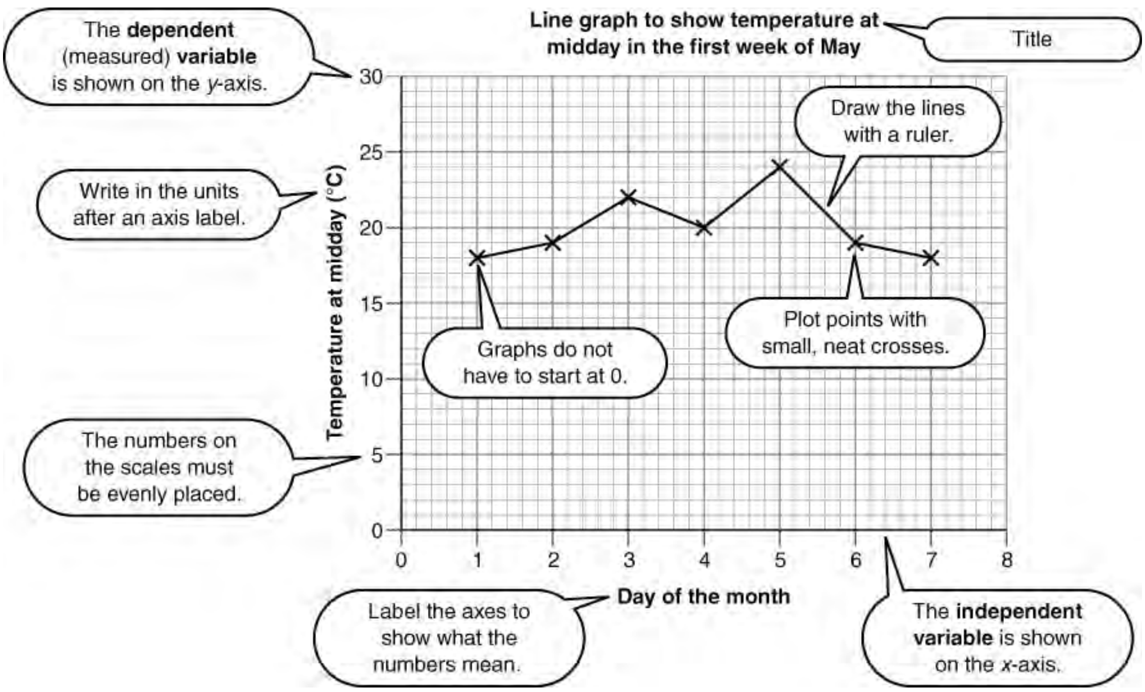
- to show how one variable changes as another (usually time) changes
- when you know that the two variables are linked.

Scatter graphs are very similar but are used when you want to show a relationship between two variables (see Skills Sheet PD6).

We want to show how the temperature changes with time, so we draw a line graph.

We join the points with straight lines to show what could have happened to the temperatures in between, and show the pattern of rises and falls. We can use the lines between days to estimate the temperature between the days, but it is only an estimate.

Day of month	Temperature at midday (°C)
1	18
2	19
3	22
4	20
5	24
6	19
7	18



Working out the scale

You need to use scales that allow your graph to fill as much of the graph paper as possible.

- First, look at the table of results and work out the largest number for each axis.
- Count the squares on your graph paper. Can you make the number of squares match the largest number? If there are not enough, try again, counting in 2 s, 5 s, 10 s, 100 s etc., until you find a scale that fits on the paper.

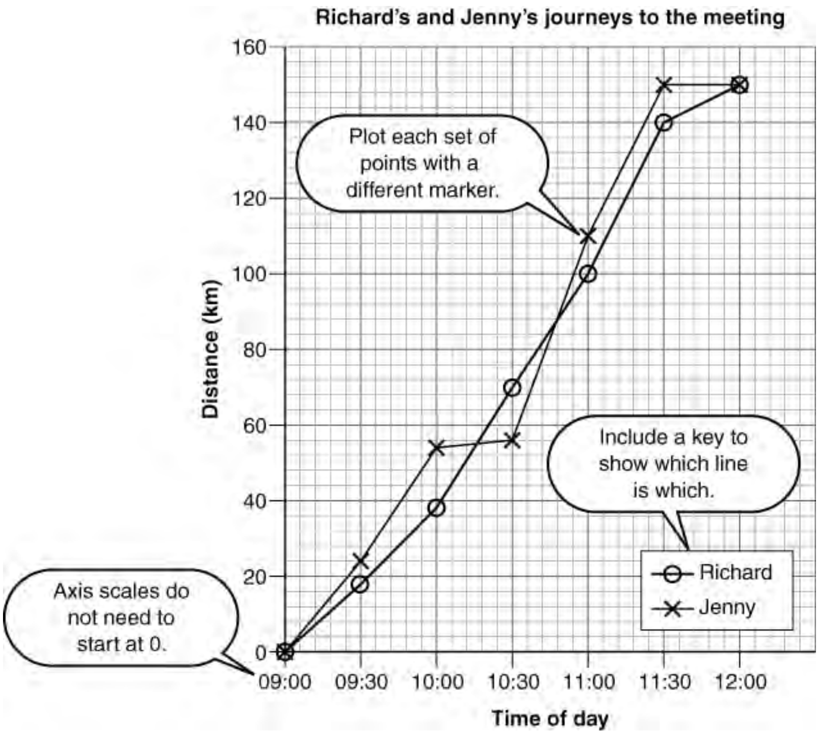
Two sets of results

Sometimes you need to put two sets of results on one graph so that you can compare them.

The table shows the distances covered by Richard and Jenny in their cars. They both need to be at a meeting by midday but decide to take different routes to cover the 150 km.

The line graph below shows the two sets of data. A graph on which distance is plotted against time is called a ‘distance–time graph’.

Time of day	Total distance covered by Richard (km)	Total distance covered by Jenny (km)
09:00	0	0
09:30	19	25
10:00	39	55
10:30	70	56
11:00	100	110
11:30	140	150
12:00	150	150



1 **a** Tim also goes to the same meeting as Richard and Jenny. He leaves at 09:30. At 10:30 he has gone 80 km and by 11:30 he has gone 150 km. Draw a line graph to show Tim’s journey.

b Why is a line graph drawn for these journeys and not a scatter graph?

2 Cal measured the volume of gas made by some pondweed every hour for a day. He noticed that more gas was made in the afternoon, when the Sun was brighter. So, he did an experiment to see if there was a link between the amount of gas and the brightness of the light. He shone different brightnesses of light at some pondweed and measured the volume of gas at each brightness. What sort of graph should Cal draw for each set of data? Explain your answer.

I can…

- decide when to use a line graph
- draw a line graph neatly and carefully.

Scatter graphs are used:

- to find out whether there is a link (relationship) between two variables
- when both variables are quantitative (written as numbers).

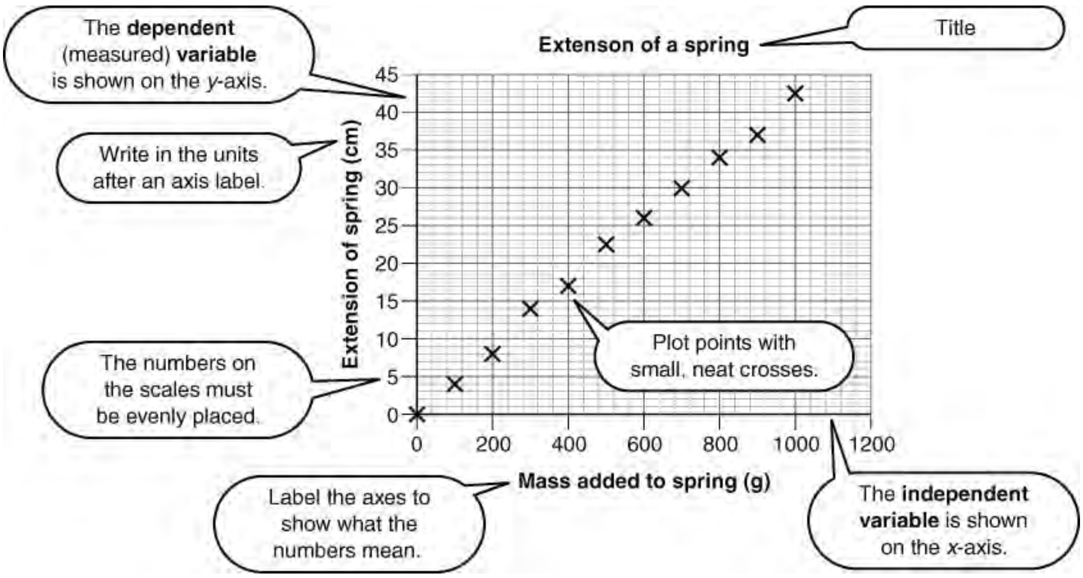
Line graphs are very similar but are used when you know there is a link between two variables and you want to show how one variable changes with another (usually time).

The table shows the results from an experiment to find out if there is a relationship between the amount of mass added to the bottom of a spring and the amount that the spring extends.

The mass has been changed (it is the independent variable) and the extension has been measured (the dependent variable). To clearly see if there is a relationship, we plot a scatter graph.

The scatter graph below shows that there is a **relationship** or **correlation**: the heavier the mass, the greater the extension. In this example both variables increase – a **positive correlation**. If one variable decreases as the other increases, it is a **negative correlation**.

Mass (g)	Extension of spring (cm)
0	0
100	4
200	8
300	14
400	17
500	22
600	26
700	30
800	34
900	37
1000	42



Working out the scale

You need to use scales that allow your graph to fill as much of the graph paper as possible.

- First, look at the table of results and work out the largest number for each axis.
- Count the squares on your graph paper. Can you make the number of squares match the largest number? If there are not enough, try again, counting in 2 s, 5 s, 10 s, 100 s etc., until you find a scale that fits on the paper.

Lines of best fit

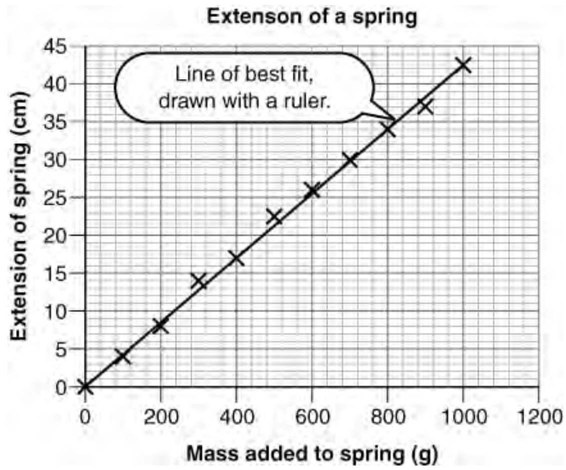
On the graph on page 1 it looks like the points should follow a straight line. However, there are some slightly inaccurate readings so the points don't exactly line up. We can still draw a line, though, to show the correlation (relationship) between the two variables. This line is called a **line of best fit** because it does not go exactly through all the points.

A line of best fit goes through the middle of your points so that about half the points are above the line and half are below it.

A line of best fit does not need to go through the origin.

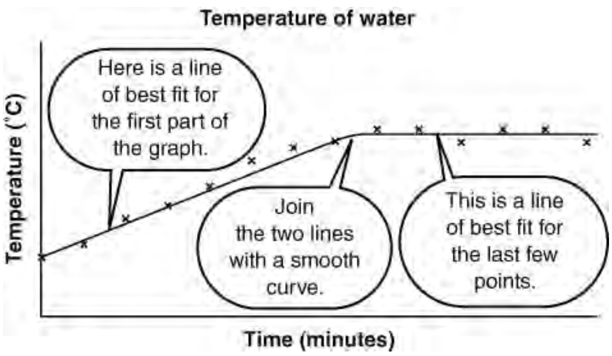
We can use the line to estimate the values between the points. We can also extend the line to estimate values beyond the range of measurements in the experiment.

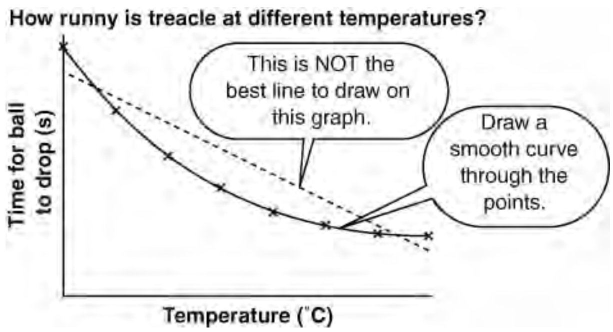
If there are any **anomalous** results, you ignore them (see Skills sheet Anomalous results and outliers).



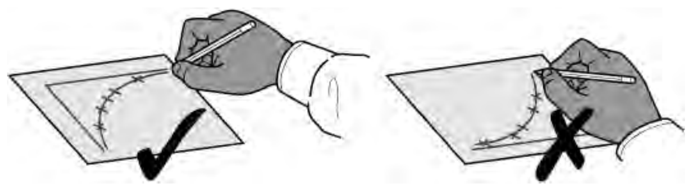
More lines and curves

Sometimes a graph will have two lines of best fit. And sometimes you will need to draw a curve of best fit instead.





If you need to draw a curve, hold the paper so that your arm is on the inside of the curve. Use your elbow as a pivot and practice drawing the curve a couple of times before putting your pencil onto the paper.



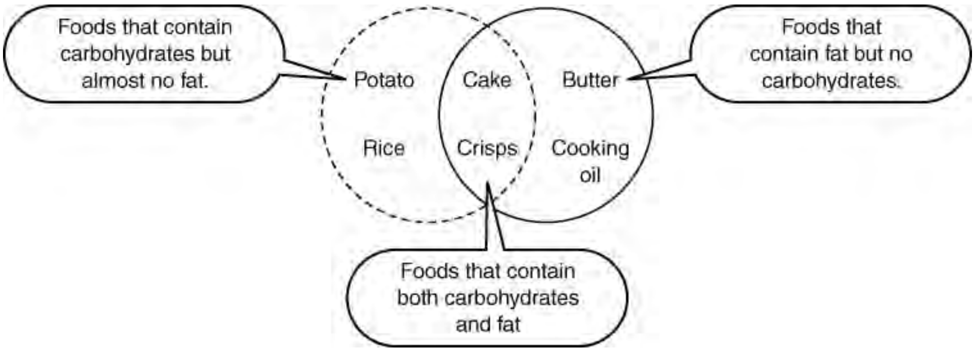
1 Plot the following data on a scatter graph and add a line of best fit.

Mass in a toy wheelbarrow (g)	50	100	150	200	250	300
Force needed to lift wheelbarrow (N)	2.4	5.1	7.5	10.2	12.3	15.1

I can…

- decide when to use a scatter graph
- draw a scatter graph neatly and carefully
- draw a line or curve of best fit.

Venn diagrams are a way of displaying some of the similarities and differences in a group of objects. This can make it easier to see and interpret patterns in data. They are particularly useful when you are thinking about more than one feature of the group at the same time.



- A Venn diagram has different areas, often drawn as overlapping circles as shown above.
- Each circle represents a different feature.
- Objects are placed in a circle if they have that feature.
- If an object has more than one feature, it is placed in the part of the Venn diagram where those circles overlap.

1 Using the Venn diagram above, name one food that contains fat but doesn't contain carbohydrates.

2 An apple contains 14 g of carbohydrate and less than 1 g fat. Where would you place it in the diagram?

Drawing a Venn diagram

Before you draw a Venn diagram, you need to identify which features the objects will be grouped into, and which objects do or don't have those features. A table can be helpful for this. Here's an example using fuels.

Source of energy	Renewable?	Can only be built in a few places?
wind	yes	no
geothermal	yes	yes
oil	no	no

The two columns on the right would make the two overlapping circles of the Venn diagram. Using yes/no statements in the table makes it easier to place the energy sources in the diagram.

3 **a** Draw a Venn diagram of two overlapping circles. Label one circle 'renewable energy' and the other 'limited building places'.

b Place the sources of energy from the table in the correct areas of your Venn diagram.

c If you have time, research other sources of energy to add to your diagram.

I can…

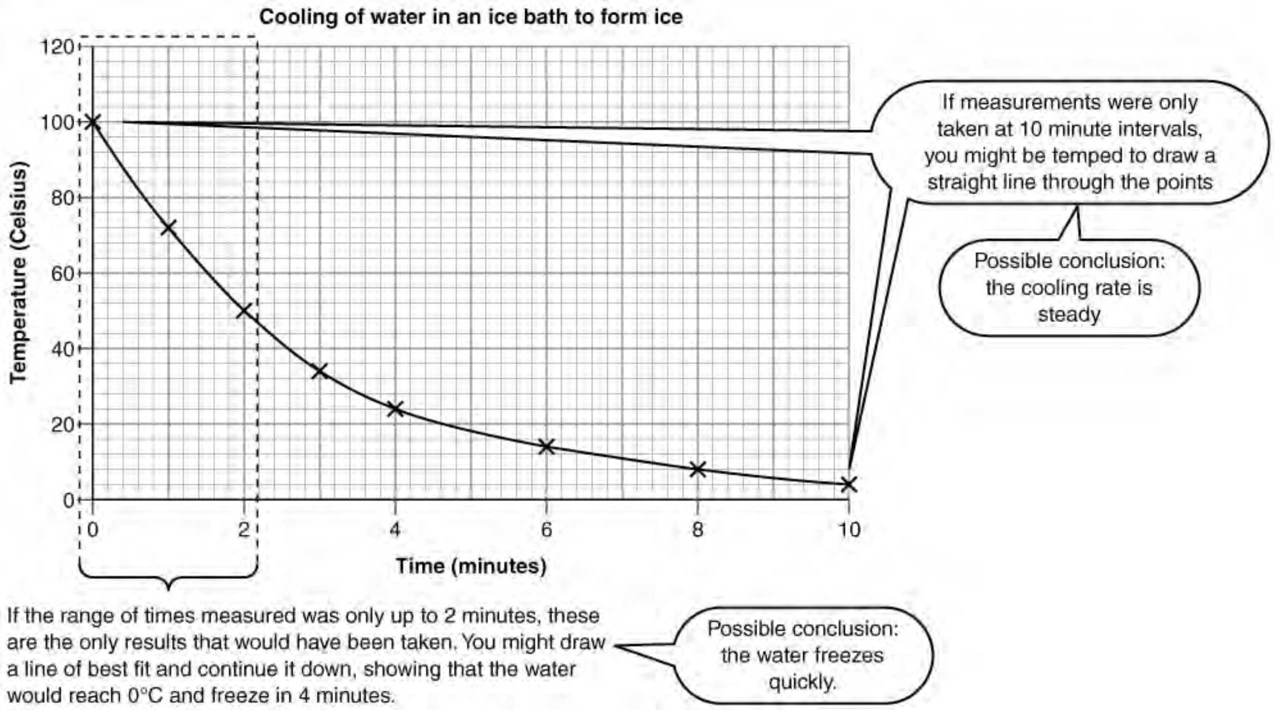
- interpret Venn diagrams
- identify when to use a Venn diagram
- present data in a Venn diagram.

You might have to plan an investigation where you have little idea what the results might be like. This can make it difficult to decide:

- what variable to measure
- how wide a range of measurements to make
- how many measurements to make
- how far apart the measurements should be (the ‘interval’ between each one).

All these factors will affect the conclusion you can draw from your results.

A **trial run** (or **preliminary** task) is when you carry out your planned experiment with a limited number of values for the independent variable. It helps you to decide how best to carry out your investigation.



In the example in the graph, a trial run that took measurements at 0, 5 and 10 minutes would have shown a rapid cooling in the first 5 minutes, and a slow cooling in the second 5 minutes. It would also have shown that the water had not turned to ice after 10 minutes. So the full experiment would need measurements at frequent intervals to show how the rate (speed) of cooling changes. The range would also need to continue beyond 10 minutes.

A trial run can also test if your method will work as you planned, if you are using the right equipment and can take measurements properly, and if the method is safe.

1 You want to investigate how the amount of gas produced changes when different masses of marble chips are added to some acid.

a What trial run you would do?

b How would the results from your trial run help you decide how to carry out your main investigation?

I can…

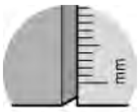
- describe what a trial run is
- explain why a trial run should be carried out.

‘Bias’ is a word commonly used to describe someone’s point of view. It means that their view doesn’t take into account all the evidence, and lacks balance. We say someone is ‘biased towards …’ something, meaning that they have chosen that in preference to something else.

Bias in primary data

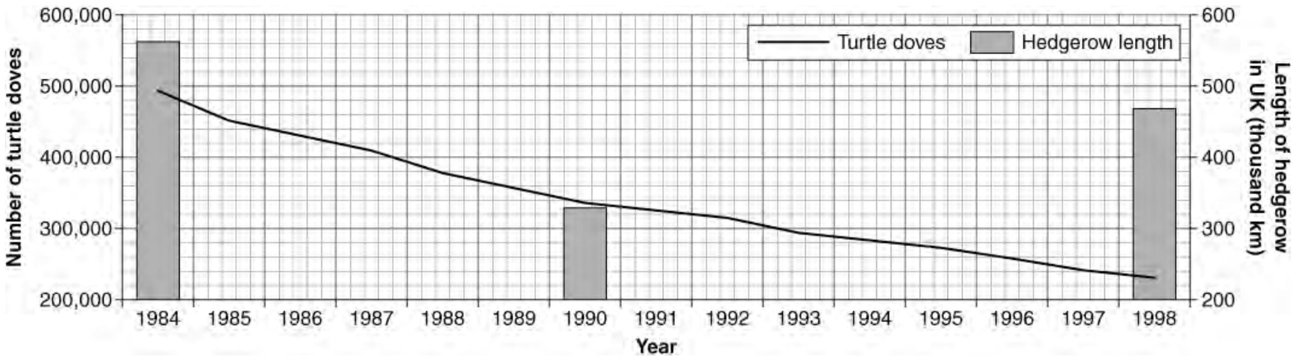
In science investigations, results can be biased if the method or equipment has a fault.

One source of bias in measurements is **systematic error**. This can happen when equipment is not used properly and all the values are changed in the same direction.

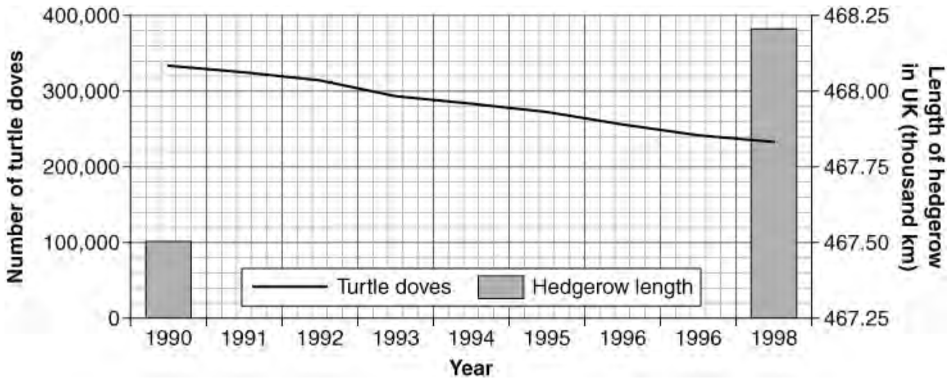


If all the measurements are taken from the end of the ruler, and not the first mark, the results will be biased towards being too short.

A conclusion can be biased if it is only based on a certain section of the results (and not all of them).



Looking at the graph, if we used the data for hedgerows from 1990 and 1998, we might conclude that the increase in hedgerows caused a decrease in the number of turtle doves.



Identifying bias in secondary data

When you are looking for secondary data, you need to look for any bias in the data you decide to use.

It is important to check the method that produced the data, to make sure that there was no chance for systematic error. You also need to check whether a sufficient range of data are included so that the conclusion is less likely to be biased.

You can refer to biased secondary data in your own work, as long as you identify how it is biased.

1 Look at the graph.

a If you only used the data for hedgerows from 1984 and 1998, what conclusion might you draw?

b If you only used the data for hedgerows from 1990 and 1998, what conclusion might you draw?

c If you used all three pieces of data for the hedgerows (1984, 1990 and 1998) what conclusion might you draw?

I can…

- explain how bias will be avoided
- suggest reasons why some people might be biased
- identify possible bias in scientific reporting.

It is important that you plan and carry out your investigations in a way that produces good quality data.

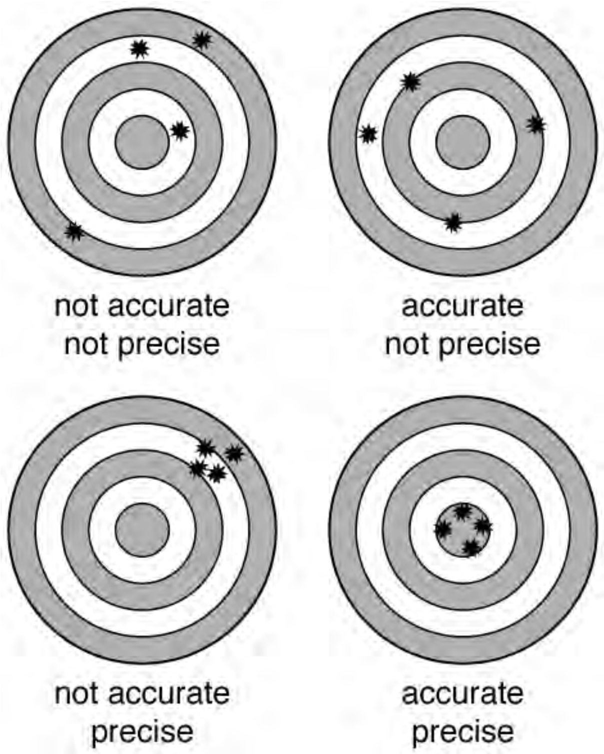
Accuracy and precision

Accuracy and precision are not the same thing, although the terms are often confused.

Precision is how close repeated measurements are.

Accuracy is how close a measurement is to its true value. Accurate measurements may or may not be precise. Similarly, precise measurements may or may not be accurate.

Of course, it doesn't make sense to measure huge distances to the nearest millimetre, so you will need to consider what is an **appropriate** level of accuracy for your data. (It might help to think about how many **significant figures** you need in your data.)



In your planning, you need to think about how to gather data that is appropriately accurate and precise.

Systematic and random errors

Different kinds of error can occur when taking measurements.

Systematic errors are where all the data are biased in the same way. For example:

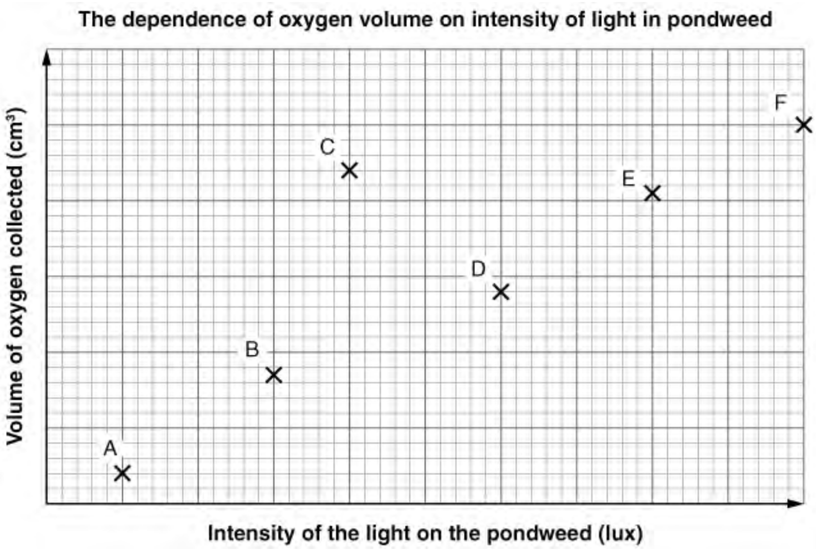
- measuring from the end of a ruler rather than from zero (see Skills sheet PI 2 Bias)
- not setting a balance to zero before measuring a range of masses.

Systematic errors can be difficult to spot in results. You need to look carefully at how the equipment was used to help you identify these errors.

Random errors occur where chance changes affect some measurements and not others. This often happens because not enough care is taken over measuring. For example:

- not allowing a thermometer time to adjust to a new temperature before taking one of your measurements.

Random errors can be easier to spot than systematic errors, particularly when the data is plotted on a graph. Random errors often stick out as **outliers** or **anomalous readings** (measurements that do not fit the overall pattern).



1 Look at the graph.

a Which point is an outlier (is an anomalous reading). Explain your answer.

b What sort of error is this caused by?

I can…

- explain what accuracy and precision mean
- state a degree of accuracy/precision required and plan to collect data to that degree
- justify a method of collecting accurate/precise data
- explain how to use apparatus so that systematic errors are avoided.

A **hazard** is something that can cause harm (to you or to others). A **risk** is the chance of a hazard causing harm. When planning and doing experiments you need to identify the hazards and plan ways in which to reduce the risks. This is called a **risk assessment**.

Follow these three steps to do a risk assessment:

1. *Identify the hazards* (e.g. spills, chemical substances used, chemical substances produced in your experiment, heavy objects, hot objects, organisms).
2. *Find out about the hazards.* Find information about the ways in which the hazards could harm you or others (e.g. you could look at information cards for different chemical substances, you could check hazard symbols).
3. *Reduce the risks.* Suggest ways to reduce the risk of harm being caused by the hazards. Concentrate on hazards that can cause the most harm and those that can harm the greatest number of people.

Reduce the risks – general

- Follow all the Lab Safety Rules.
- If you are using liquids or equipment that could break, wear eye protection.
- If you get something in your eye or cut yourself, tell your teacher immediately.

Reduce the risks – chemical substances

- If you spill a harmful substance, get it on your skin or breathe it in, tell your teacher at once.
- There may be some spilt chemical substances on the bench that you cannot see. So DO NOT put your hands in your mouth.
- DO NOT breathe chemical substances in.
- DO NOT get substances on your skin.
- DO NOT taste substances.
- DO NOT have a lighted Bunsen burner anywhere near something that will catch fire.
- DO make sure you understand any safety symbols on the container.
- DO wear safety glasses or goggles.
- DO wash your hands after doing experiments.

Reduce the risks – heating things

- Always wear safety glasses or goggles.
- Do not touch anything that has been heated. Place anything that is hot on a safety mat to remind you not to touch it. Only move a Bunsen burner by holding its base.
- If you are heating a test tube, point the open end away from you and everyone else. Never look into the open end of a hot test tube.
- If you are using a Bunsen burner, make sure any hair or loose clothing is tied back and out of the way.
- If you burn yourself, tell your teacher immediately and hold the burn under running cold water.

> ⚠ You only get one set of eyes in your life.
> Burns can permanently scar you.
> Some chemicals are poisonous and can kill.

Reduce the risks – using electricity

- Mains appliances are regularly tested for safety and a sticker is put on them. Check the sticker to make sure the testing is up to date.
- DO NOT poke things into sockets.
- DO NOT plug too many things into one socket.
- DO NOT use something that has a damaged wire.
- DO NOT try to invent your own circuits.
- DO keep electricity away from water.
- DO switch a power pack off before changing a circuit connected to it.

1 Look at the drawing.

a Identify the hazards.

b How are the students increasing the risks?

c How would you reduce the risk from each hazard you identified in part **a**?

I can…

- plan appropriate safety precautions for an experiment
- describe how to stay safe in familiar situations
- explain why a certain safety instruction has been given
- identify hazards and risks.

You need data to test a scientific hypothesis.

- **Primary data** is collected from investigations you do yourself.
- **Secondary data** comes from other people's investigations.

The advantages of using primary data include:

- You control the data you collect, so you collect only what is relevant.
- You know how well the experiment went, which makes it easier to evaluate the data (say how good it is as evidence, in support of or against a hypothesis).

The disadvantages of using primary data include:

- Experiments need time and apparatus, and you may not have enough of these to carry out the experiment you want to do. This is particularly important when you need many repeat results so that you can check the data or calculate averages.

The advantages of using secondary data include:

- It can be quicker and easier to collect, such as from books or the Internet.

The disadvantages of using secondary data include:

- You may not get enough detail about how the experiment was carried out, so you may not be able to evaluate the data well.

Understanding the difficulties and limits of collecting primary data will help you develop the skills you need to evaluate other people's data.

1 Draw a table to compare the advantages and disadvantages of primary and secondary data.

2 Suggest some sources of secondary data.

3 Write dictionary definitions for the words:

  a data

  b primary data

  c secondary data

  d evaluation

I can…

- describe the advantages and disadvantages of using primary and secondary data.

Qualitative data

Qualitative data is in words, such as colours or days of the week.

Quantitative data

Quantitative data is in numbers, such as height in centimetres.

Quantitative data can also be:

- **continuous**, where any value is possible within a certain range, such as the speed of a car in kilometres per hour
- **discrete**, where values can only be chosen from certain numbers. Discrete values are normally in whole numbers, such as the number of people who had eggs for breakfast yesterday. You can't have a quarter of a person having eggs. Sometimes discrete values include other numbers, such as UK shoe sizes. Shoes come in half sizes but there is not a continuous range of sizes available (you can't buy a size 7.23 shoe).

Sometimes a variable can be collected as either qualitative or quantitative data. For example, height could be measured by a ruler to give values in centimetres, or it could be recorded as being 'short', 'medium' or 'tall' if the actual value wasn't important for the investigation.

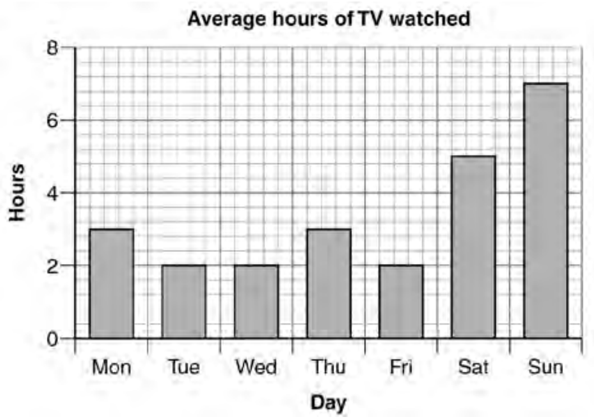
Continuous and discontinuous data

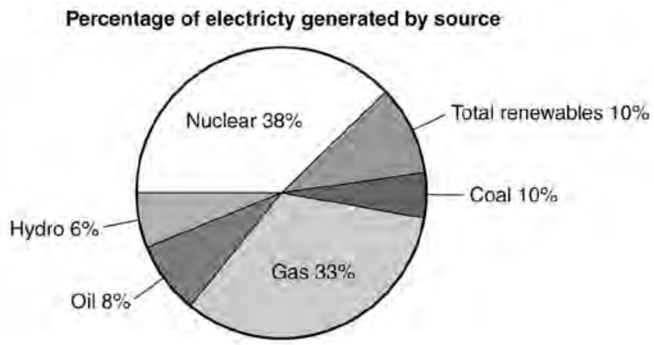
Any data that is not continuous is described as being **discontinuous**. So qualitative and discrete data are both types of discontinuous data.

Presenting data

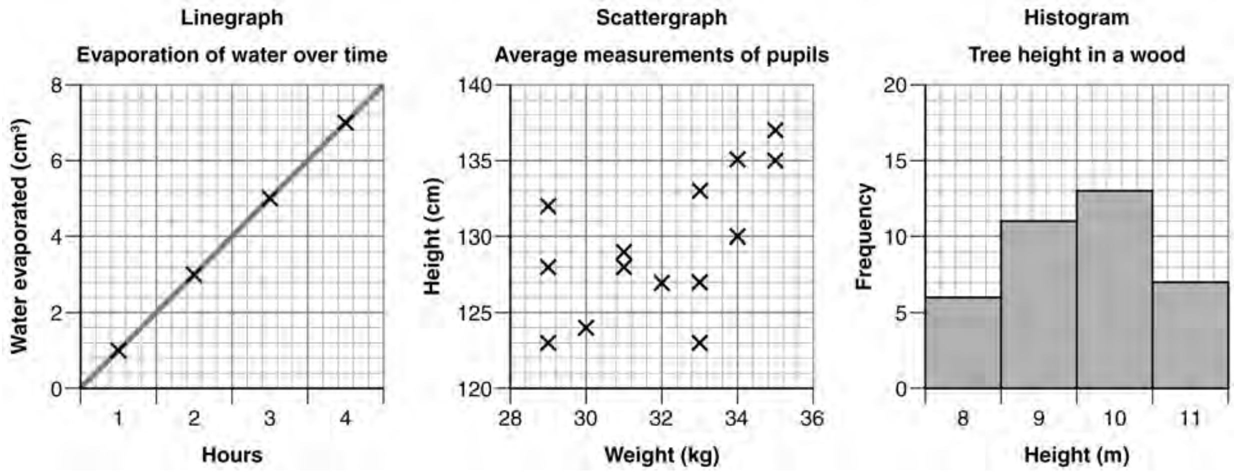
The way you record data will restrict how you can display it afterwards.

These ways of displaying data are used when one variable is qualitative:





These ways of displaying data are used when all the data is quantitative:



1 Identify the different data that is being collected in each of the following and state what kind of data it is.

a A chromatography investigation measured the distance travelled (in centimetres) in a certain time (measured in minutes) by different colours of ink.

b A survey gathered information about how many people came to school by bus, car, bike or on foot and how long it took them.

c Mrs Patel timed how long it took Mike, Ravi, Tim and Dan to run the four different lengths of races on sports day.

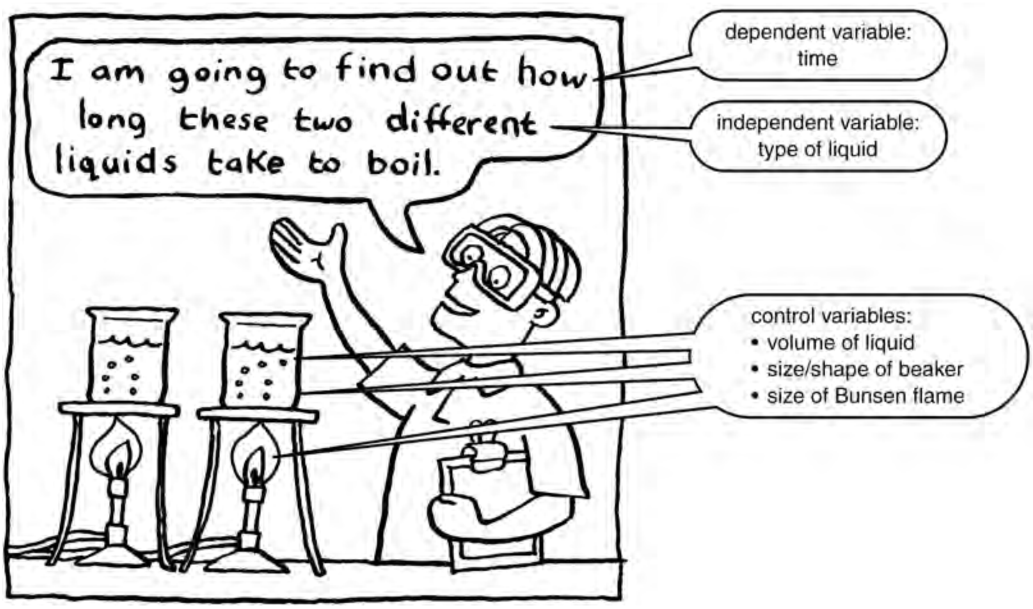
I can…

- identify qualitative, quantitative, discrete and continuous.

Different kinds of variables

Variables are things that might change during an experiment.

- The variable that you choose the values of is the **independent variable**.
- The variable that changes when the independent variable changes is the **dependent variable**. It depends on the independent variable. You measure the dependent variable in an experiment.
- There may be many other variables that might change and change the value of the dependent variable. You have to keep these variables constant so they don't affect the experiment. These are called **control variables**.

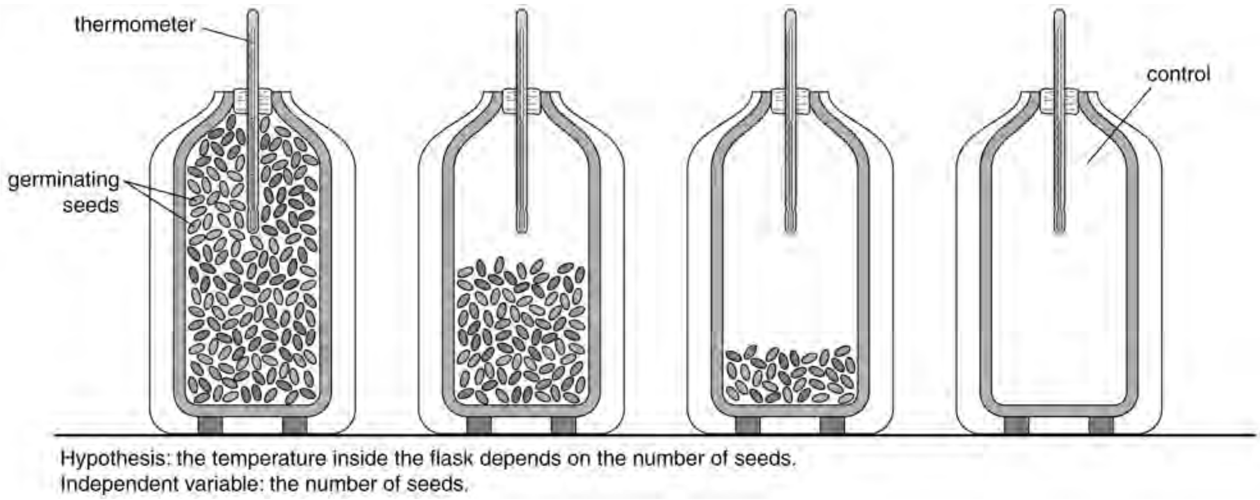


Fair tests and controls

When you stop all the control variables from changing in an experiment, you carry out a **fair test**. A fair test is an experiment in which only the independent variable can cause a change in the dependent variable.

Sometimes it is difficult to stop all the control variables changing. This is particularly true when an investigation happens over a long time. For example, the air temperature and amount of light may change during the day when an all-day experiment is done. In this kind of investigation you use a **control**.

A control is an identical set of apparatus to the set used in the experiment, but without the independent variable.



Hypothesis: The temperature inside the flask depends on the number of seeds germinating.

Independent variable: the number of seeds.

Any change in temperature in the empty flask is not caused by the seeds. So, any change in the temperature in this flask must be taken into account when looking at the changes in temperature in the other flasks.

1 In the examples below, identify the dependent and independent variables. Also, suggest some other variables that might need to be controlled during the experiment to make the test fair.

a the effect of surface type on the speed of a toy vehicle

b how the rate of fizzing changes with size of marble pieces placed in dilute acid.

2 Explain why all the variables apart from the independent variable need to be controlled during an experiment.

I can…

- identify the dependent and independent variables in an investigation
- identify variables that need to be controlled in an investigation
- explain why a test is fair.

Data is used to support a hypothesis (idea) in an investigation or show that a hypothesis is wrong. If the data is of good quality, then you can be sure that what it shows you about a hypothesis is correct. Good quality data is repeatable and valid.

Repeatability and reproducibility

If you repeat measurements and the results are the same each time, the data is 'repeatable'. Data that is repeatable is of better quality than data that is not because you can be more sure that the data is correct.

If measurements are repeated by someone else and they are the same as your measurements, the data is 'reproducible'. Again, reproducible data is of better quality than data that is not reproducible.

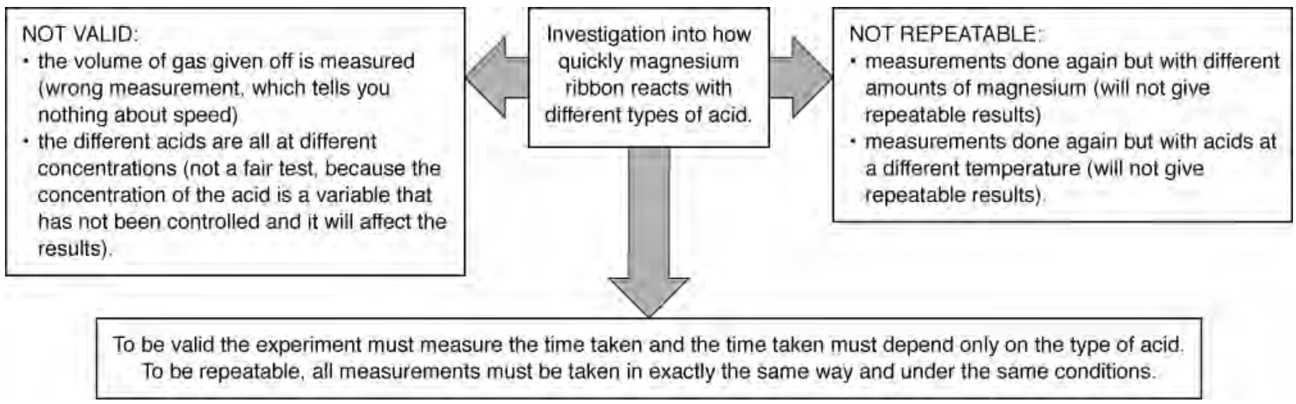
Fair tests are good at producing repeatable and reproducible results.

Sometimes, repeatable and/or reproducible data is said to be 'reliable'. You can rely on it being correct.

Validity

When something is **valid**, it does what it is meant to. So valid results are ones that measure what is needed for the investigation. A valid conclusion is one that only uses valid results.

A fair test is valid. The changes in the dependent variable (which you measure) have only been caused by the independent variable. All the other variables have been controlled and so do not affect the results.



1 Sonja's hypothesis is that the current in a circuit depends on the number of cells. She investigates this using a circuit that contains two bulbs in series and a switch. She measures the current with a voltmeter. Half way through her experiment, before she can try any of her measurements again, one bulb blows. So she replaces it and carries on.

a How valid will her results be? Explain your reasoning.

b How repeatable will her results be? Explain your reasoning.

c Suggest how Sonja can improve the quality of her data.

I can…

- explain how a method allows the collection of valid data.

You should usually repeat the measurements you make in an investigation. This allows you to:

- check that your results are correct
- identify readings that are **anomalous** (do not fit an overall pattern)
- calculate **mean** readings (useful when it is very difficult to keep all the control variables completely constant.

If measurements are the same each time they are done then the data is repeatable. Repeatable data means that you can be more sure of a conclusion.

If your measurements are not repeatable, you should check your method.

How many repeats should you do?

It is often a good idea to take three readings. This will allow you to spot any readings that are obviously wrong. If there is a reading that is obviously wrong, then you may wish to do some more repeats to double check. Look at the table below, which gives an example.

Result of test	Discussion
1st test: time = 27.1 s	One test is not enough as this could be anomalous results – there is nothing to judge it against.
2nd test: time = 30.3 s	The two tests produce very different values. One of these is possibly anomalous, but which one? We need a third test to find out.
3rd test: time = 27.4 s	This is much closer to the 1st reading so it looks like the 2nd reading is anomalous. It would be good to check with another repeat though.
4th test: time = 27.3 s	This confirms that the 2nd test gave an anomalous results.

You should plan to repeat readings when you are designing an investigation. However, you may want to do even more repeats when you are actually doing the investigation.

Carrying out large numbers of repeats

Taking repeat sets of measurements is particularly important when it is difficult to control every variable, such as when working with living organisms.

In these situations it is best to plan as many repeats as you can using the time and resources available.

I can…

- plan to repeat measurements
- explain why measurements should be repeated
- justify the number of repeat measurements in a plan.

RC1 Finding information

When you are trying to find information, or **secondary data**, the first step is to make sure you know exactly what it is you want to find out and write this down.

This is not a very good way to start, as there are lots of different things you could find out.

I want to find out about the sea.

I want to find the names of five different fish that live in the sea.

This is much better!

Using the Internet

The Internet is a great source of information, but there is so much information that it is sometimes difficult to find exactly what you need. Think carefully about the key words you will use for searching.

If you type ‘fish’ into the search box, it will find millions of websites. Use two or more search terms to focus your search. The more search terms you use, the better. The search engine will usually give you sites that include all of the terms you have asked for. Usually the sites are ordered according to how closely they match your search terms.

If you still get too much information, try searching for images instead. It is quite easy to see which images could be useful, and the images are often linked to other websites that can give you more information.

Record the addresses of or bookmark any websites you use in case you need to find them again. You will also need to quote any sources you use in any of your work. This not only means other people can check your sources, but also gives credit to the people who produced that information.

Using libraries

Books are also a good source of information. The non-fiction books in libraries are organised into different subjects. The book you want may be in the science section, but there might be useful information elsewhere in the library as well.

When you have chosen a book, you can find the information you need by:

- looking at the contents list
- using the index
- scanning the text to find key words
- looking for pictures.

A glossary in a book will explain key terms used in the text, and may also help you check if the book contains what you are looking for.

Write down the name of the book and the author, in case you need to use the book again to find more information, and also so you can credit the source of information if you use it in your work.

Libraries often have CD-ROMs as well as books. The CD-ROM will usually have a contents list or index that will help you to find information, or there might be a ‘Search’ box where you can type in key words to look for.

Evaluating information

Many sources of information are ‘biased’ – they only put one side of an argument. When you are choosing sources of information, you need to think carefully about how the source might be biased, and make sure you balance the information by presenting the other side of the argument.

I can…

- collect information efficiently from different sources
- reference sources of information.

Name ______________________________ **Class** ____________ **Date** _____________

Circle the number of stars next to each of these sentences to describe what you covered and how well you did.

Planning	I have…	
	made a simple prediction.	* * * * *
	identified one variable to control from a list given to me.	* * * * *
	made a prediction and given a reason for my prediction from my own knowledge.	* * * * *
	planned which apparatus to use.	* * * * *
	planned to change one variable and measure another.	* * * * *
	written a method as a series of steps, including saying what I will look for.	* * * * *
	identified obvious variables that need to be controlled.	* * * * *
	planned good ways of controlling variables so that I did a fair test.	* * * * *
	stated one way in which I will remain safe.	* * * * *
	made a prediction and explained it using scientific knowledge.	* * * * *
	explained why I will look for certain things happening.	* * * * *
	stated the number of measurements I will make of the dependent variable. (This might include planning a preliminary test.)	* * * * *
	stated the lowest and highest values of the independent variable to be used. (This might include planning a preliminary test.)	* * * * *
	described some ways in which I remain safe and how I will make sure others stay safe.	* * * * *
	made a prediction using my own scientific knowledge or from information obtained from secondary sources of information.	* * * * *
	explained my hypothesis, including the relationship between independent and dependent variables.	* * * * *
	explained how my chosen apparatus will allow me to collect data to appropriate degrees of accuracy and precision.	* * * * *
	identified less obvious variables that need to be controlled and planned good ways of doing this.	* * * * *
	identified hazards and described how to reduce the risks from those hazards, both to myself and to others.	* * * * *
	made up a scientific question and a hypothesis by using information from some different sources.	* * * * *
	identified how/where errors might occur and explained how my method will take account of those errors so that I collect good quality evidence.	* * * * *
	justified my choice of investigation strategy.	* * * * *
	justified my choice of method to explain how it will allow me to collect good quality evidence to draw a firm conclusion. This includes the collection of data that minimises error, that I can be sure is correct and that is valid, accurate enough and precise enough.	* * * * *

What could you do to improve? ____

____

Obtaining evidence	I have…	
	made some observations by following instructions.	* * * * *
	used apparatus properly and followed instructions carefully to make a series of observations.	* * * * *
	worked safely by following instructions.	* * * * *
	accurately recorded readings from scales.	* * * * *
	identified when measurements should be repeated and carried out those repeats.	* * * * *
	recognised a range of familiar risks and taken actions to control them.	* * * * *
	collected data in a logical order and with precision and accuracy.	* * * * *
	followed risk assessment procedures.	* * * * *
	obtained good quality data with the accuracy and precision needed in order to draw a firm conclusion.	* * * * *

What could you do to improve? ____

____

Recording results	I have…	
	recorded my results in a table which was given to me.	* * * * *
	recorded my data in a suitable way e.g. drawn a table or a labelled diagram.	* * * * *
	drawn a chart or a graph.	* * * * *
	decided on the best way of presenting my data (e.g. as a bar chart, line graph, scatter graph).	* * * * *
	drawn a neat and accurate chart or graph with scales chosen to allow the graphs to fill most of the graph paper and clearly show any pattern.	* * * * *
	decided whether to include or ignore inconsistencies and anomalies in my charts and graphs, and pointed out what I have done with the anomalies.	* * * * *
	presented graphical data using lines or curves of best fit.	* * * * *
	used simple error bars on a scatter graphs.	* * * * *

What could you do to improve? ____

____

Considering results/ conclusions	I have…	
	described what I found.	* * * * *
	drawn a straightforward conclusion, using my evidence.	* * * * *
	identified simple patterns in my data.	* * * * *
	used the patterns in my data to draw a conclusion.	* * * * *
	used correct scientific language when writing about my conclusion.	* * * * *
	drawn a conclusion, explaining how I have used my evidence.	* * * * *
	pointed out inconsistencies and anomalies in my data.	* * * * *
	used scientific and mathematical conventions (e.g. symbols, equations).	* * * * *
	drawn valid conclusions from my evidence.	* * * * *
	explained how well my conclusions support the original hypothesis.	* * * * *
	used scientific ideas in my explanations.	* * * * *
	carried out calculations to help me to draw conclusions.	* * * * *
	explained how inconsistencies or errors do/do not affect my conclusion.	* * * * *
	explained whether my evidence is good enough to draw my conclusions or whether it has limitations.	* * * * *
	decided whether to include or exclude anomalous results and explained my choice.	* * * * *

What could you do to improve? ____

____

Evaluation	I have…	
	suggested a simple improvement for my investigation.	* * * * *
	given scientific reasons for my suggestion to improve my investigation.	* * * * *
	explained how good my evidence is for supporting my conclusion.	* * * * *
	explained ways in which my method could be improved in terms of repeatability, reproducibility, accuracy and precision.	* * * * *
	identified uncontrolled variables that may have affected my results.	* * * * *
	described how to better control some variables and explained the effects of better controlling them.	* * * * *
	explained why my data is sufficient/not sufficient for my conclusions.	* * * * *
	suggested and justified improvements to my methods, using detailed scientific knowledge and understanding.	* * * * *
	pointed out further questions raised by my investigation and outlined a way of taking the investigation of a particular aspect further.	* * * * *

What could you do to improve? ____

____

You may be asked to work in a group to research information for an investigation or for a presentation. Working in a group requires planning to help make the work successful.

1 Planning

In your group:

a Decide what your research is going to focus on. Write down what you decide.

b Decide how you are going to present the information. You could make a poster or leaflet, design a website, or give a presentation. Write down what you decide.

c Decide what each member of your group will do – each person might look for the same information from different sources, or look for different information. Also think about any abilities that a member of your group has (good at maths, good at drawing, good at using the computer).

d Decide where you will look for information and agree who will look where so that you don't waste time repeating what each other has done.

e Decide how you will tell each other how well you are getting on. It’s a good idea to set up regular group meetings where you can discuss the progress you are making and how to sort out any problems you have come across.

2 Progressing

a Plan how to measure the progress of your task. Remember when the deadline is and break down the work into small steps that you can check on progress in your meetings to help you finish everything on time.

b Decide how people can help each other in their group if any one needs help.

c Consider who you can get help and advice from to help you keep on track, or to help if things don’t go as planned.

3 Evaluating

Answer these questions once you have finished:

a What do you think went well?

b What do you think went less well?

c What do the other members of your group think about what went well and what went less well?

d What did *you* do to help the group to complete the task?

e Discuss in your group ways of improving how you work as a team. Write down what you decide.

I can...

- work as a team to carry out research
- evaluate teamwork.

Good notes help you to:

- organise the information you find
- make sure you have covered all the important points
- focus on the key points and ignore unnecessary detail
- write a report or a summary in your own words.

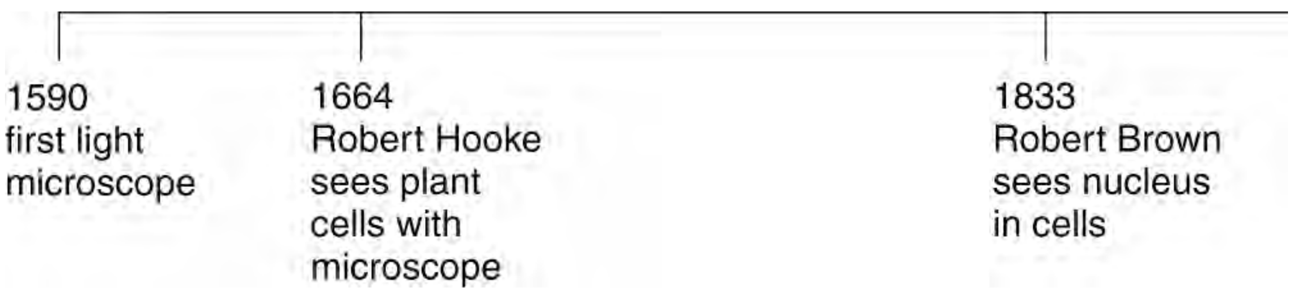
Step 1: Start by thinking about what your notes are for:

- writing a summary
- comparing things (e.g. similarities and differences, points for and against)
- showing problems and their solutions
- showing how one thing (a cause) leads to another (an effect) (e.g. when you think up a hypothesis or make a prediction).
- writing lists
- revising.

Step 2: Decide how to organise your notes. It often helps to use different colours. Here are some examples:

Timeline

If your information needs to be organised chronologically, use a timeline to note key points.



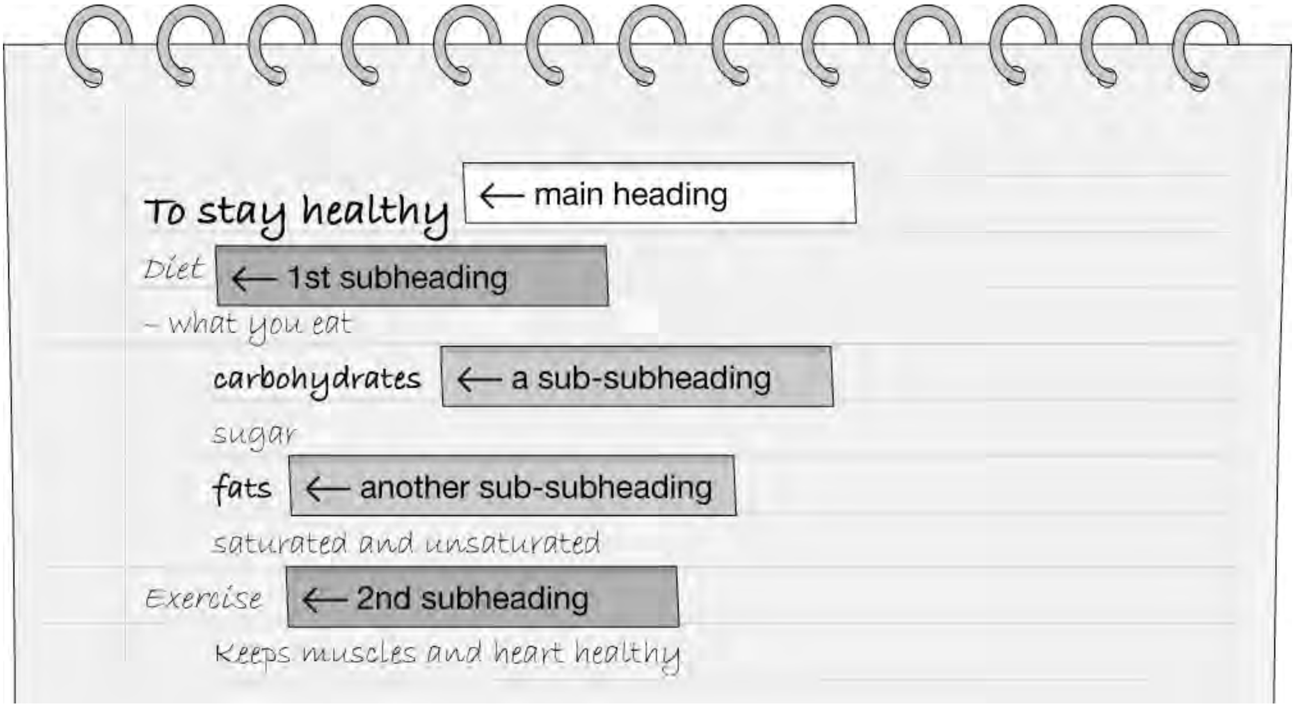
Table

If you need to organise your notes into a few categories, then a table might be more useful.

Advantages	Disadvantages
brakes – allows car to slow down	car working parts – causes overheating
between road and types – allows car to grip the road	brake pads, tyres, engine parts – wears things away

Lists with headings

If you have a lot of information that can be grouped into several categories, a list with headings and subheadings can be useful. This can make writing a report easier because you already have the headings for your report.

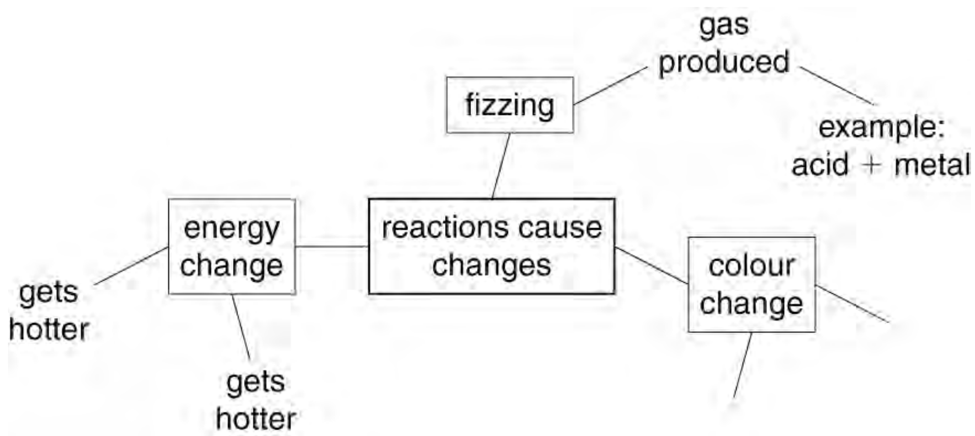


Concept maps

Some people prefer to use concept maps, rather than lists. Concept maps also makes it easier to add new groups of notes to those that you have already recorded.

Concept maps can easily get cluttered, so:

- Start with a clean sheet of A4 and write a title in the middle.
- Add ideas as branches to the map.
- Group similar ideas and link them with lines or arrows.
- Use just one or a few words for each note, to keep the map as tidy as possible.
- Highlight the most important idea in each group – these can make good headings for your writing.



Flow diagrams

Flow diagrams can show how one idea leads to another or can show a sequences of events.

water turned to steam → steam rises → turns turbine → turbine turns generator

Step 3: Skimming and scanning.

The first time you read a text, skim through it quickly. Look for:

- main ideas – these may be shown by headings
- text structure – e.g. from simple to more complex ideas, from old to new
- key words
  - key nouns (what the text is about)
  - signal words and phrases such as:
    - comparisons (e.g. alternatively, although, as well as, but, however, in contrast to, on the other hand, similar to)
    - problems and solutions (e.g. difficulty, problem, solution, question, answer, to overcome this)
    - causes and effects (e.g. as a result of, because, caused by, depends on, due to, if … then …, leads to, so that, therefore, which in turn)
    - lists (which often start with: such as, for example).

Then scan through the text more slowly to look for any specific information that you need. While you are reading, keep in mind what information you are looking for. If your text is printed out, you may be able to highlight anything useful using coloured pens or pencils.

I can...

- Make and organise notes.

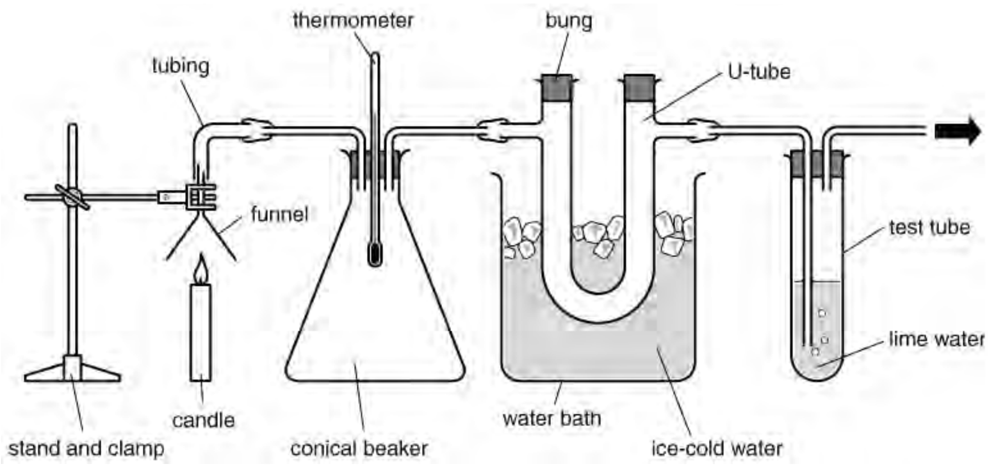
Information can be presented in different ways – the best method of presentation depends on who it is for and what they need to know.

Examples of presentation:	
written report	letter
list of instructions	poster
video	electronic presentation/slide show
article for newspaper, magazine or webpage	illustrated booklet

Choosing words vs. images

The younger the audience, the fewer words you should use. The words should be simpler too.

Other people may also find it easier to understand what you mean if you use diagrams or pictures.



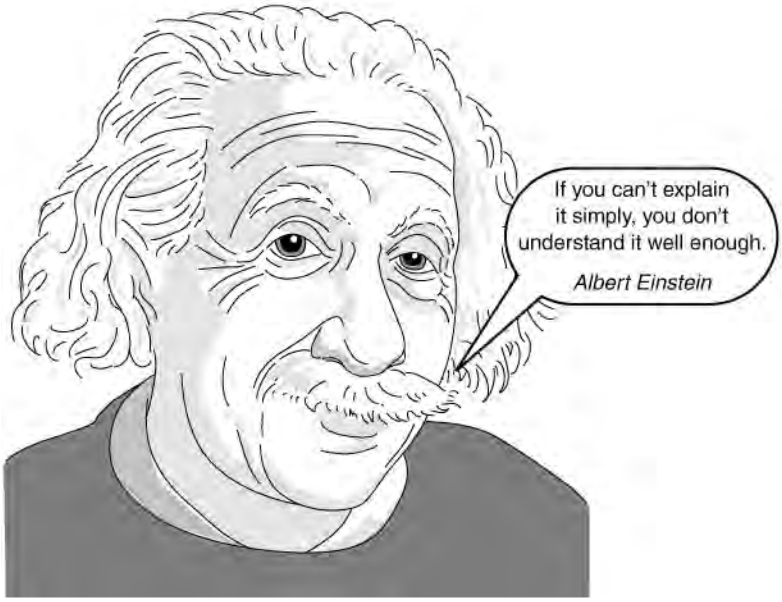
A well-labelled diagram can save a lot of writing. How long would it take you to describe this fully in words?

If you are trying to describe a process, or change over time, then a well-labelled flow chart or cartoon might be clearer than a list of instructions.

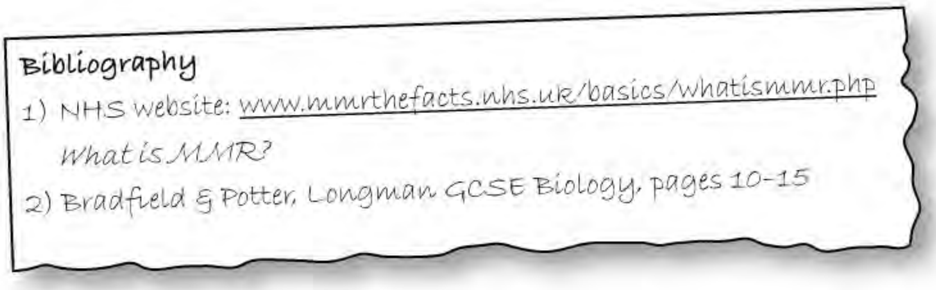
Diagrams and pictures help to make the writing less ‘heavy’ to look at. If you want your presentation to look serious then consider a written report. If you want to attract people to look at your work, then a poster might be better.

Preparing your presentation

If you have looked things up don't just copy bits out. It will be obvious that you have done it! And if you don't understand something that you are writing, it is best not to write it. Keep things simple and stick to the main points.



Remember to write down all the places where you got your information, including the names of any books, CD-ROMs, websites and the authors. These should be included at the end of your presentation as the 'Bibliography'. For example:



Try to finish your presentation a few days before the deadline. Then leave a day before looking through it again. It's much easier to spot problems with it this way. Alternatively, ask a friend to look through it and point out anywhere that the information isn't coming across clearly. This will give you time to sort out the problems before handing your work in.

Don't forget to put your name on your report!

I can…

- present information using a mixture of text, diagrams, charts and graphs
- choose a suitable method of presenting information for a given audience.

Talking about science is a good way to test how well you understand it. It is also useful for exploring different points of view on a scientific topic, especially those with no single 'right' answer.

If you are asked to prepare a speech or take part in a debate, you need to research the issue and write a good set of notes to support you while you are speaking.

For a speech, you may only need to present ideas and information from your own point of view. For a debate, you may be asked to play a character with a particular point of view. Keep checking that your notes match that point of view, to help you stay 'in character'.

Preparation

- Write down some thoughts about what you (or your character) think about the topic.
- Carry out research, using the Internet, books, magazines and newspapers. Find facts or opinions that support what you think – your 'argument'. For a debate, also find some facts or opinions that others might use. You may need to argue against these points.
- Organise your research into a clear set of notes, such as a table like this:

Use of cloning	Reasons for it	Reasons against it

- Start your speech by saying briefly what you think.
- Organise the main part of your speech under a series of subheadings, and write a few sentences for each subheading. This part of your speech will explain why you think the way you do. Don't get side-tracked! If you start talking about things that are not relevant to your main point, your message will become less clear.
- Finish your speech with a very brief summary of your main points.
- In a debate, it is a convention that speeches are addressed to the person running the debate, not people on the other side of the debate. So people often start speeches by saying 'Mr Chairperson …' or 'Madam Chairperson …'.
- Your teacher will tell you how long you have to speak for, so practise your speech and time how long it takes so that you can adjust the length before you do it for real. Also, try to learn some of the sentences of your speech so that you don't just read it out.

Running a debate

Here is one way to run a debate.

- Your teacher will put pieces of paper with the names of each person into a 'hat'. Your teacher will then draw names from the 'hat' to decide who will speak in the debate. Your teacher will be the chairperson – and time the speeches and organise the debate.
- Only one person speaks at a time. If you are asked to speak, look at the people you are talking to. Also, imagine that you have to talk to the back wall of the classroom – that way you'll make sure that everyone can hear you.
- Listen to what the speakers are saying and take notes if you agree or disagree with them. You can use your notes if you are called to speak, to argue with others or against them.
- Questions may be asked of the speakers or short statements made 'from the 'floor', at the end.
- At the end a vote is held by show of hands or secret ballot.

I can...

- express my own views clearly
- listen to and try to understand other people's points of view.

Writing up investigations – check list

Scientific reports are written in different sections, so it is easy for others to find information.

Title

Use a short title.

☐ Make sure it contains key words from your report.

Aim

State what you were trying to find out. You could use:

☐ a question

☐ a phrase such as 'My aim was to …' or 'I wanted to find out …'.

Introduction

Show your scientific understanding and ideas.

☐ Write about the science behind your investigation to show your understanding.

☐ Explain the idea (**hypothesis**) that you are going to test and why you have that idea.

☐ State your **prediction** – what you think will happen if your idea is correct.

You may want to divide this section into three parts – background, hypothesis, prediction.

Method

Describe what you did (or will do). Include:

☐ the equipment (**apparatus**) – use scientific terms

☐ step by step instructions

☐ the variables you kept the same to make it a **fair test**

☐ the variable you changed

☐ what measurements you took and how you took them

☐ how you made your experiment safe for yourself and others

☐ a diagram, if it helps you to explain something better than writing it in words.

Results

Present your data neatly. Think about:

☐ whether to present your data in a table

☐ how to order your data in a table to show any patterns

☐ whether you can draw a chart or a graph to show any patterns

☐ whether you need to do calculations to show your results more clearly

Conclusion

Analyse your data. Try to:

- ☐ describe any **relationships** (patterns) in your data
- ☐ explain your data using scientific ideas
- ☐ compare your data with your prediction to see if they match. If they do not, then say why
- ☐ explain whether your investigation has provided **evidence** to support your hypothesis.

Evaluation

Describe how sure you are of your data and conclusion. You could describe:

- ☐ problems you had or anything that went wrong
- ☐ any variables that you could not control
- ☐ how **accurate** you think your measurements were
- ☐ how **repeatable** your results were (did repeated measurements give the same results?)
- ☐ how **reproducible** your results were (were your results repeatable by other groups?)
- ☐ how you could improve your investigation and why your suggestions make it better.

☐ Are there further questions raised by your investigation ….

I can…

- report scientific investigations clearly.

When you complete an investigation, it is important to write it up. It is no use finding out something if you don't tell others about it. In your report, always try to use scientific words.

Scientific reports are written in different sections, so it is easy for others to find information.

Title

Use a short title.

Try to mention some of the key words from your report in the title (e.g. the names of the variables).

Aim

State what you were trying to find out.

You could start your aim by using a phrase like '*I wanted to find out …*' or '*My aim was …*'

Or you could use a question. Remember to put a question mark at the end of your question, e.g. *Does temperature affect how many cress seeds germinate?*

Introduction

Show your understanding and ideas.

There are often three parts to an introduction and you may want to divide your introduction into these three parts with three headings – background, hypothesis, prediction.

For 'background', describe the science that you know and how it is relevant to your investigation.

A **hypothesis** is the idea you are testing in the investigation. If you get stuck, try using the phrase 'depends on' to write your hypothesis, e.g. *I wanted to test the hypothesis that the number of cress seeds that germinate <u>depends on</u> the temperature.*

A **prediction** is what you think will happen. Start your prediction by using a phrase like '*I think that …*' or '*I predict that …*'

To write the main part of your prediction, try using the words *'If … then …'*, e.g. *I think that <u>if</u> I increase the temperature, <u>then</u> more cress seeds will germinate.*

Or try using *'… -er, … -er'*, e.g. *I think that the warm<u>er</u> the liquid, the great<u>er</u> the amount of salt that will dissolve*.

Then explain your reasoning for your prediction, including the science you used to make it.

Method

Describe of what you did (or will do). Write this out in a series of steps.

If you have done the investigation, use verbs in the past tense, e.g. *I <u>measured</u> out …, I <u>took</u> a dish …, I <u>used</u> a …*

If you have not yet done the investigation, use verbs in the future tense, e.g. *I <u>will measure</u> out …, I <u>will take</u> a dish …, I <u>will use</u> a …*

Use correct scientific terms for equipment (e.g. beaker, measuring cylinder, Bunsen burner, microscope slide, coverslip, motor, cell).

Results

Display your collected data neatly. Sometimes you'll need to do some calculations so that your conclusions are clearer.

If you are describing what happened, start or join sentences together with 'time conjunctions'.

To write about actions, try using:

first, at first, second, lastly, finally, before, after, next, then, during, until, while.

To write about what happened because of an action, try using:

since, consequently, in order to, as a result, when.

You will often use a table but make sure it has an order to it (e.g. alphabetical order, number order).

If you can, draw a chart or a graph to show patterns more clearly. Make sure your charts and graphs are very neat. Remember to choose even scales, write in a title and label the axes.

Conclusion

Analyse your data. Look for patterns in your data and then explain what your data shows. Your conclusions must only be based on the data you have presented.

If you are comparing things, start or join sentences together with 'conjunction connectives'.

Equally, in the same way, as with, similarly, like, likewise, in contrast, but, on the other hand, whereas, unlike, alternatively, instead of, otherwise.

Evaluation

Describe how sure you are of your data and conclusion. Also, say how your investigation could be improved.

Use verbs that show how certain you are.

less certain → more certain

Verb	may	might	should	could	can	would	will
Example	it *may* show that ...	I *might* need to ...	I *should* have used ...	To test my idea further I *could* ...	From this result I *can* say that ...	It *would* be better to ...	I *will* measure ...

I can…

- report scientific investigations clearly.

Name ______________________________ **Class** ____________ **Date** _____________

Do not fill in any parts of these sheets that you do not plan to do or did not do. Just leave those sections blank.

Title of investigation

____

Aim

____

____

Introduction

My idea to test is …

____

____

My scientific reasons for having this idea are …

____

____

Prediction

____

____

My scientific reasons for thinking this are …

____

____

Method

This is my apparatus list …

____

____

____

____

____

I (plan to do / did) the investigation this way …

A **variable** is anything that can change. To make it a **fair test**, these are the variables to keep the same …

This is the variable to change …

This is the variable to measure …

This is how to stay safe …

This diagram shows my apparatus …

Results

These are my results …

I (have / have not) also drawn a graph / chart.

Conclusion

My results show …

I think this happens because …

My results compare with my prediction in the following ways …

I think that my investigation (supports / does not support) my hypothesis because …

Evaluation

I think my results were (good / bad) because they (did / did not) allow me to draw a firm conclusion.

I did / did not control these variables properly …

My measurements (were / were not) accurate because …

My results (were / were not) repeatable. This means I can be (sure / less sure) about them.

If I could do this investigation again, I would change it in the following ways …

I would change these things because …

Teacher comments

Planning

Obtaining results

Conclusion

Evaluation

I can...

- report scientific investigations clearly.

RC9 Facts, opinions and arguments

In an **argument**, you try to persuade other people to agree with your point of view. A scientific argument will be much stronger if it is based on facts rather than on opinions.

- **Facts** are statements or observations that have been repeatedly shown to be correct. Facts can be supported with data and graphs.
- **Opinions** are what people believe to be true without being able to use data to show that they are correct.

1 Which of the following are facts, and which are opinions? Explain your answers.

a The Moon is the only natural satellite of the Earth.

b The Moon orbits the Earth once in every 27–28 days.

c It would be great to live on the Moon.

d The gravitational force on the Moon is much less than on the Earth.

e The view of Earth rising on the Moon is one of the most beautiful in our Solar System.

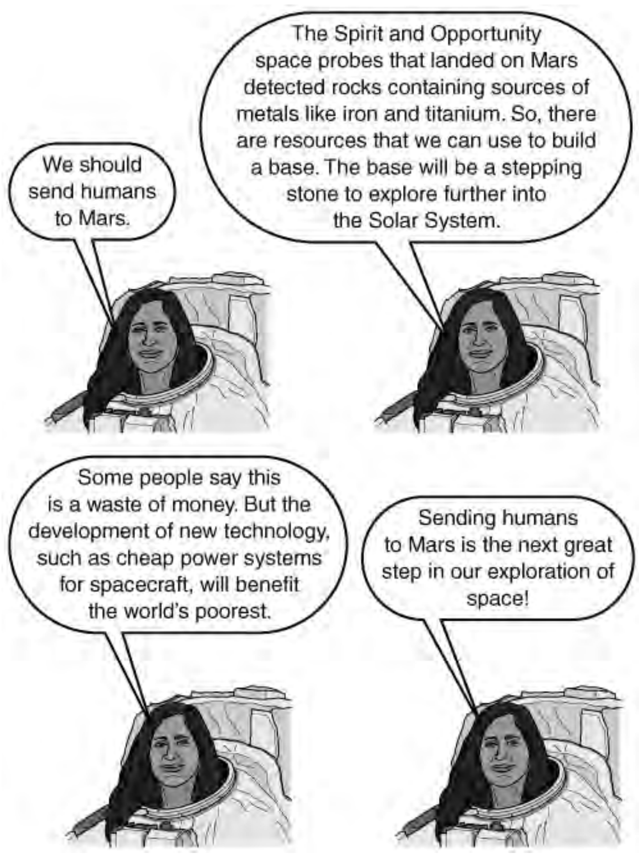
Constructing good arguments

To construct a good argument, you need to gather evidence to support your point. Your evidence may come from your own experiments or other people's.

The more evidence you have for your point of view, the stronger your argument.

Your argument also needs a clear structure.

Beginning:	Start with a clear statement of your point of view.
Middle:	Give *one* reason for your point of view, with evidence.
	Give another reason for your point of view, with evidence, etc.
End:	State your point of view again, with a brief list of your reasons.



You may also need to consider other people's points of view.

- What points might others make against your argument?
- Is their point based on evidence? Or is it only based on opinions?
- Can you find some evidence to show what they think is incorrect?

You can then add a **rebuttal** into your argument after the middle section. This will make your argument stronger.

Rebuttal:	A point against your argument, with evidence to show why you think this point is wrong.

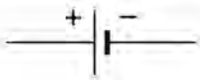
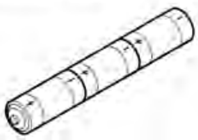
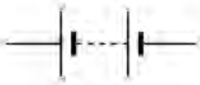
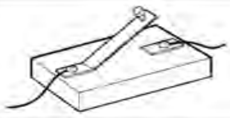
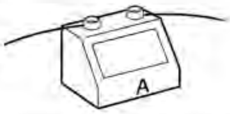
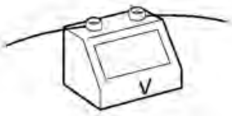
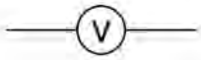
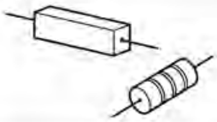
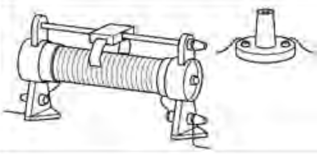
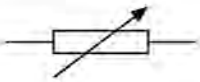
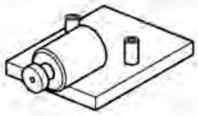
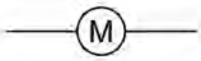
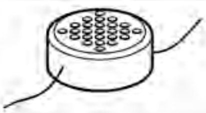
2 Identify the different parts of the argument in the drawings.

When listening to other people's arguments, watch out for **bias**.

I can…

- construct an argument.

When drawing electrical circuits, scientists use agreed symbols for each of the components. These symbols make the diagrams easier to draw and to interpret. You should use these symbols in your own circuit diagrams.

Picture	Component	Symbol	Description
	cell		A cell stores chemical energy, and transfers it into electrical energy when it is put in a circuit.
	battery		A battery is two or more cells connected together.
	switch		A switch is used to control the flow of electricity in a circuit. No current can flow when the switch is open.
	bulb		A bulb transfers electrical energy into light and heat energy.
	ammeter		An ammeter measures the current (the amount of electricity flowing). An ammeter is always connected *in series*.
	voltmeter		A voltmeter measures the voltage across a cell or component. A voltmeter is always connected *in parallel*.
	resistor		A resistor makes it difficult for current to flow. Resistors are used to control the size of the current flowing in a circuit.
	variable resistor		A variable resistor can be adjusted to control the amount of current in a circuit.
	motor		A motor transfers electrical energy into kinetic (movement) energy.
	buzzer		A buzzer transfers electrical energy into sound energy.

I can…

- give examples of scientific symbols
- explain why internationally agreed symbols and conventions are necessary in science communication.

There is an international standard system of units of measurement, called the **SI system**. All the units in the SI system have defined values. So anyone who uses these units knows that everyone else will understand exactly what the measurement is. The table on the right shows many of these units.

You may find other units for some of these quantities (e.g. inches for length). In science, we always use SI units.

Quantity measured	Name of unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
force	newton	N
area	square metres	m^2
volume	cubic metres	m^3
temperature	degrees Celsius	°C
speed	metres per second	m/s
current	ampere or amp	A
energy	joule	J
voltage	volt	V
pressure	pascal	Pa
power	watt	W
frequency	hertz	Hz

Standard prefixes

Sometimes the SI units are not a convenient size, so we use bigger or smaller versions. For instance, it is a bit awkward to measure the thickness of a leaf in metres! It is much easier to use millimetres. An extra part is added to the name of the unit and to its symbol to show we are using a bigger or smaller version. These additions are called **prefixes**.

Prefix	Symbol	Meaning	Example
mega-	M	1 000 000	1 megawatt (1 MW) = 1000 000 W
kilo-	k	1000	1 kilojoule (kJ) = 1000 J
deci-	d	1/10	1 cubic decimetre (dm^3) = 1/1000 m^3 (1/10 m × 1/10 m × 1/10 m)
centi-	c	1/100 (a hundredth)	100 centimetres (cm) = 1 m
milli-	m	1/1000 (a thousandth)	1000 millimetres (mm) = 1 m
micro-	μ	1/1 000 000 (a millionth)	1000 micrometres (μm) = 1 mm
nano-	n	1/1 000 000 000	1 000 000 nanometres (nm) = 1 mm

Other units

There are some units that are still commonly used which do not fit the standard pattern.

Quantity	Standard unit	Other units still used
time	seconds	minutes, hours, days, years
length	metres	miles
speed	m/s	kilometres per hour (km/h), miles per hour (mph)
volume	m^3	litres (1 litre = 1000 cm^3 = 1 dm^3), millilitres (1 ml = 1 cm^3)

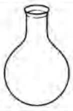
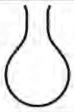
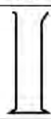
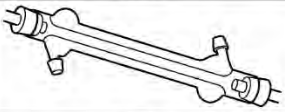
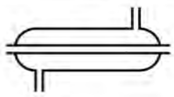
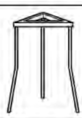
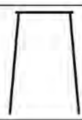
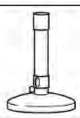
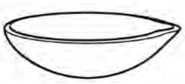
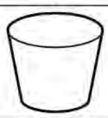
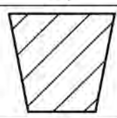
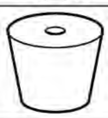
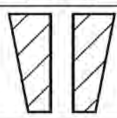
I can…

- give examples of scientific symbols
- interpret diagrams that use scientific symbols and conventions
- explain why internationally agreed symbols are useful.

Drawing apparatus

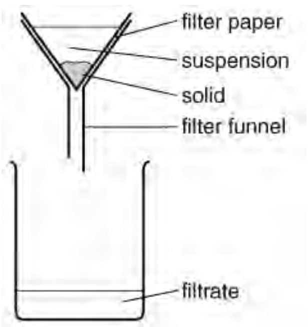
Usually in science we draw diagrams of apparatus rather than pictures. Diagrams are easier to draw, and make it easier to see how the apparatus is joined together.

Imagine the apparatus cut in half. You draw what you would see from the side – this is called a cross-section diagram. Here are some standard diagrams that you should use.

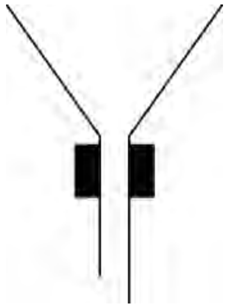
Apparatus	Name	Diagram	What it is used for
	test tube		storing or mixing solids and liquids
	boiling tube		heating solids and liquids
	beaker		holding liquids or solids
	conical flask		holding and mixing liquids
	round-bottom flask		heating liquids
	measuring cylinder		measuring volumes of liquids
	Liebig condenser		cooling a vapour and condensing it into a liquid
	tripod		heating a beaker, flask or crucible over a Bunsen burner
	gauze		supporting a beaker or flask and spreading the heat from the flame
	Bunsen burner	 HEAT	heating things
	evaporating basin		evaporating the water from a solution
	filter funnel (with paper)		separating an insoluble solid from a liquid
	rubber bung		keeping things in a tube or flask
	rubber bung with a hole		the hole is so that a tube or thermometer can be put into the liquid without any gases escaping

Scientific diagrams show how pieces of apparatus are put together to do practical work.

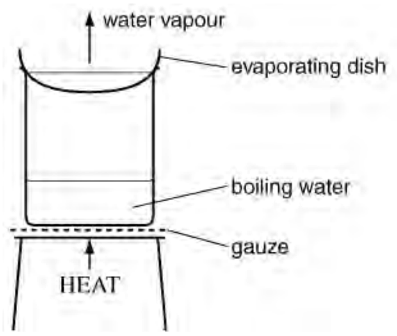
Example 1: Filtering



You don't usually need to show the clamps and stands.
You know that the filter funnel is not really floating in mid-air.
Clamps can be shown like this.

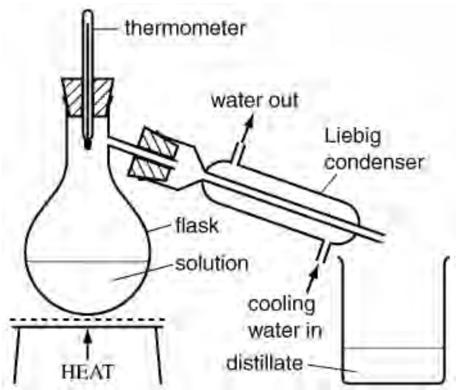


Example 2: Evaporating



Keep it simple! You can use an arrow to show heat instead of wasting time trying to draw a Bunsen burner.

Example 3: Distillation



This is a much more complicated diagram. Look carefully at the bungs. See how the diagram shows that the thermometer and tubes go through the middle of the bungs. Be careful that you don't 'block off' tubes that are really open. See how the 'water in' and 'water out' tubes are left open at the ends.

1 Draw a diagram showing a test tube half full of liquid sitting inside a beaker that is half full of water. The beaker is being heated by a Bunsen burner.

I can…

- draw and interpret diagrams that use scientific symbols and conventions.

metal
semi-metal
non-metal

mass number or nucleon number
atomic number or proton number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	[258] **Cn** copernicium 112	[284] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

lanthanoids (or lanthanides)	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[145] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
actinoids (or actinides)	232 **Th** thorium 90	231 **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103

The mass numbers show the total numbers of protons and neutrons in the nucleus of an element. Isotopes of an element can have different numbers of neutrons, so not all atoms of an element have the same mass number. This periodic table shows the mass number of the most common isotope of each element.

I can…

- describe how elements are arranged in order.

The scientific method is a series of steps that are used to answer questions about how or why things work. It often starts with **observations** about the real world. This leads to a question about how or why things happen.

Scientists then think up an idea to explain why they think something happens. This idea is called a **hypothesis**. Scientists often develop their hypotheses using their scientific knowledge, understanding and experience. A hypothesis has to be able to be tested using **investigations**.

The hypothesis is used to 'make a **prediction**'. The prediction is what you think will happen in an investigation if the hypothesis is correct.

An investigation will produce some results or **data**. Usually you look at data from your own investigations but you can look at other people's data too. You consider (carefully look at) the data to see if it matches your prediction. If it matches, then the data is **evidence** that your hypothesis is correct. We say that the evidence 'supports the hypothesis'. If the data does not match the prediction, we say that the evidence 'does not support the hypothesis'.

If a hypothesis seems to be correct then it can be tested again by using it to write more predictions. When the data from many investigations support a hypothesis, the hypothesis becomes a **theory**. A theory is a hypothesis that has been well tested.

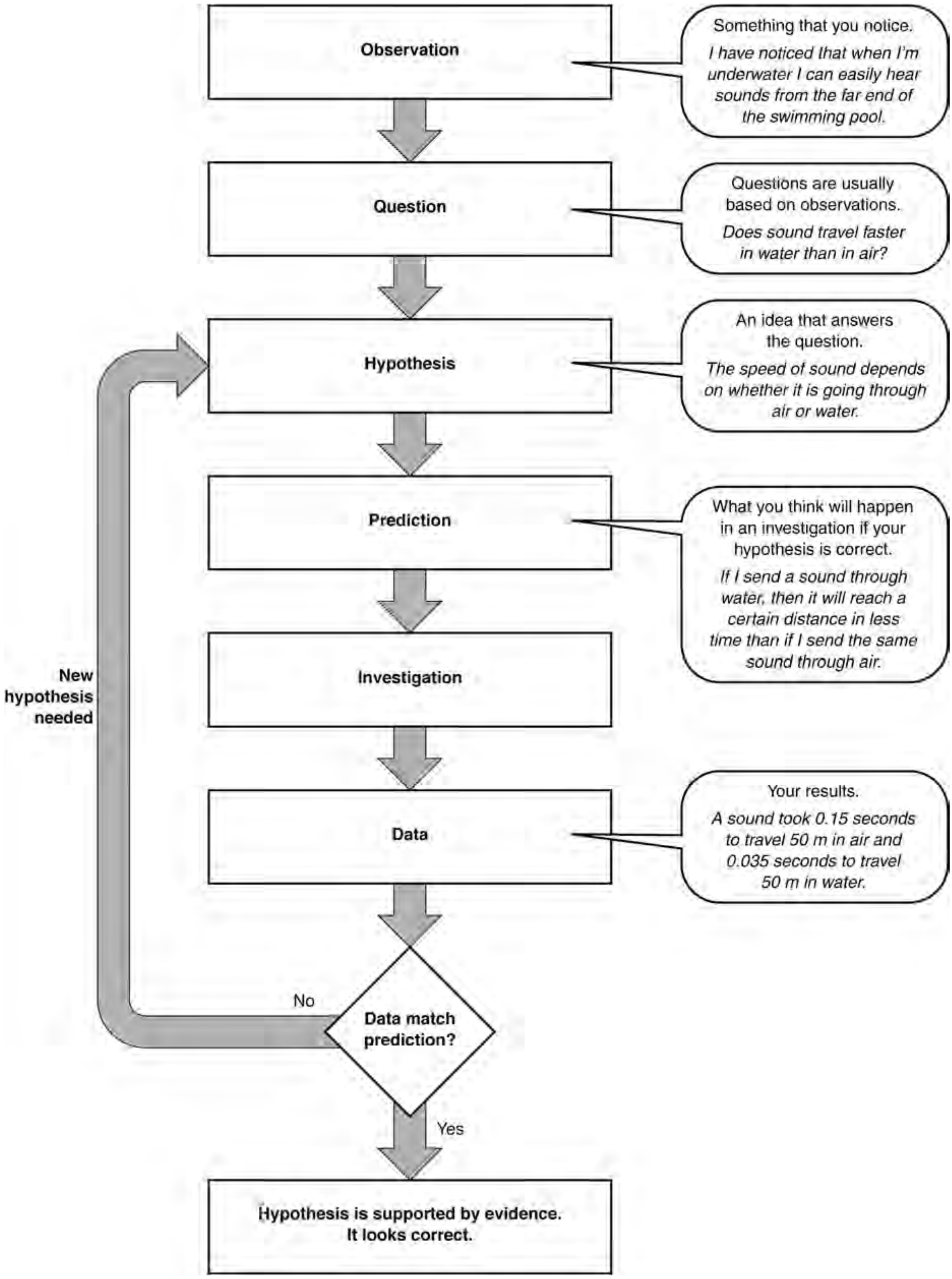
Scientists continue to test theories time and time again. As our knowledge of science changes over time, so do hypotheses and theories. You can never *prove* that a theory is *true*. Even the theories of really famous scientists have been replaced by new ideas as we have done more experiments and found out more about the world we live in.

The results of investigations often cause other questions to arise. These can then also be answered using the scientific method.

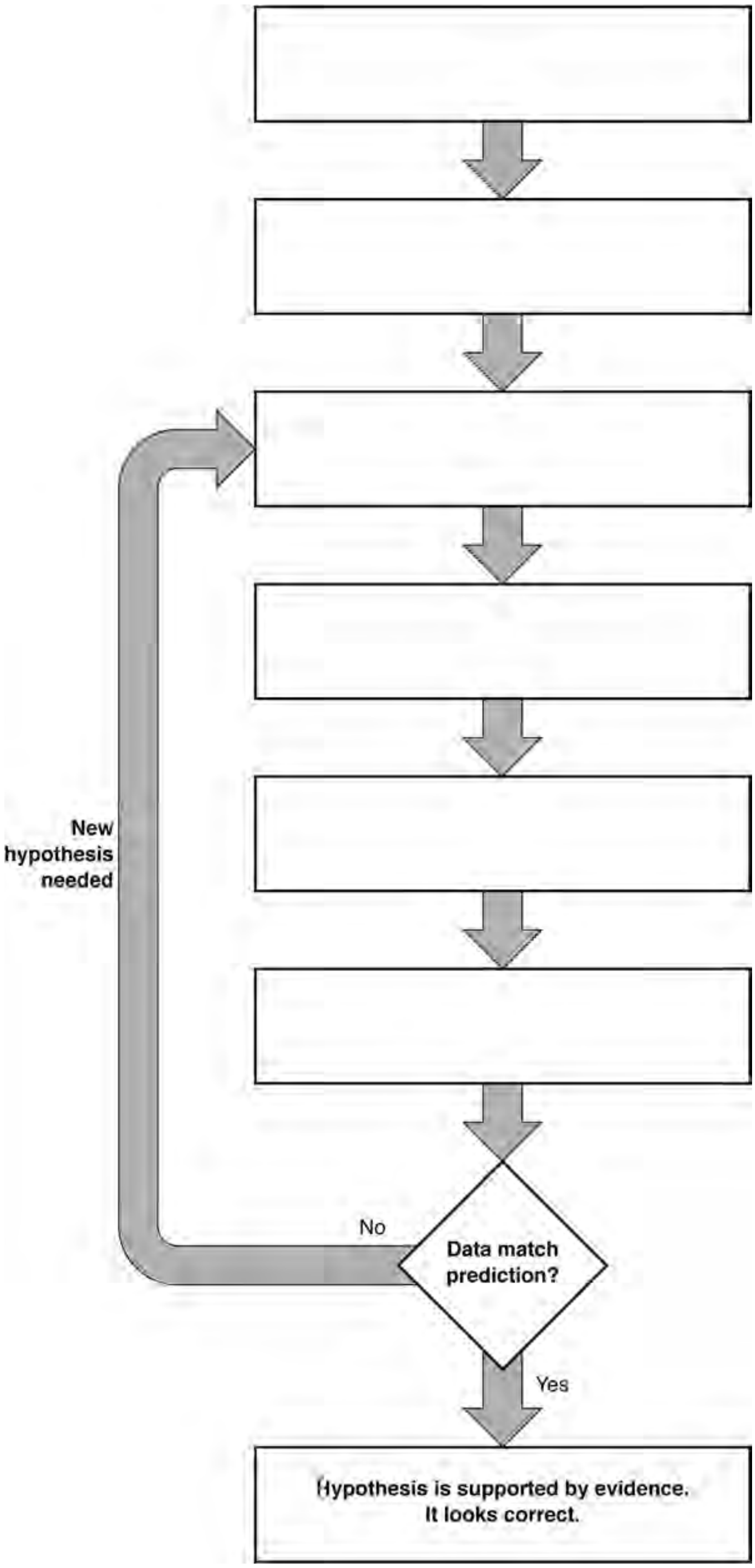
> This is the scientific meaning of the word 'theory'. The word is often used in a general way to mean 'a good idea'. Watch out for this difference!

I have noticed that more woodlice are found under damp logs than under dry stones.	An experiment is done using a 'choice chamber'. Woodlice choose were to stay in the chamber – in a damp or dry area.
More woodlice were found in the damp side of the apparatus than in the dry side, so woodlice do prefer damp places.	If I give woodlice a choice of a damp place and a dry place, then more woodlice will move to the damp place.
The number of woodlice found in an area depends on how damp the area is.	Do woodlice prefer damp places?

Do not make a double-sided copy of this sheet.


Observation
Something that you notice.
I have noticed that when I'm underwater I can easily hear sounds from the far end of the swimming pool.
Question
Questions are usually based on observations.
Does sound travel faster in water than in air?
Hypothesis
An idea that answers the question.
The speed of sound depends on whether it is going through air or water.
Prediction
What you think will happen in an investigation if your hypothesis is correct.
If I send a sound through water, then it will reach a certain distance in less time than if I send the same sound through air.
Investigation
Data
Your results.
A sound took 0.15 seconds to travel 50 m in air and 0.035 seconds to travel 50 m in water.
Data match prediction?
No
New hypothesis needed
Yes
Hypothesis is supported by evidence. It looks correct.

Cut out the boxes and stick them into the correct places on the flowchart to show how you can use the scientific method to answer this question: Which conditions do woodlice prefer to live in?



I can…

- outline the basic scientific method
- describe what a hypothesis, a prediction, evidence and a theory are
- identify an observation, a hypothesis, a prediction and results.

A hypothesis is:

- an idea about how or why something happens
- developed from observations and scientific questions
- can be tested using an investigation.

The hypothesis

Hypotheses are only ideas. Many new hypotheses are not believed when they are first suggested because they only have a little evidence to support them.

A prediction is:

- made using a hypothesis
- what you think data from an investigation will show if a hypothesis is correct.

The prediction

You then do an investigation and see if the **data** matches your prediction. If it matches, then the data is **evidence** that your hypothesis is correct. We say that the evidence 'supports the hypothesis'. If the data does not match the prediction, we say that the evidence 'does not support the hypothesis'.

When results do not match a prediction, the investigation method needs to be checked. If the data from many investigations do not support a hypothesis, a new hypothesis is needed.

There are some useful phrases to help you write hypotheses and predictions:

	Example 1	**Example 2**	**Notes**
Observation	Mr Brown hits a tennis ball further than Khalid.	I breathe quickly when I run.	
Scientific question	Why does the ball go further?	Why do I breathe quickly when I run?	Start with a word like 'why', 'what', 'where', 'when' or 'how'. Use a question mark at the end.
Hypothesis	The distance the tennis ball travels *depends on* the force it is hit with.	The quickness of my breathing *depends on* how fast I go.	The phrase '*depends on*' can be useful when writing a hypothesis. It can help identify the data you need to gather to test your idea.
Prediction	*If* a tennis ball is hit with a greater force, *then* it will go further.	*If* I move faster, *then* I will breathe more quickly.	Try using '*If … then …*' to help turn a hypothesis into a prediction.

1 For each of the following:

i write a hypothesis **ii** turn your hypothesis into a prediction.

a I breathe quickly when I run.

b Why does a candle take different lengths of time to go out when put under jars of different sizes?

c I find it more difficult to pick up a glass bottle when my hands are oily.

d Do plants grow better if they are given fertiliser?

I can…

- use a hypothesis to make predictions.

A **model** is a way of representing something difficult, complicated, unusual or invisible. A model helps us to understand something more easily. Some models are used to describe and explain how things work. Some models are used to *discover* how things work.

Physical models

Physical models are models that you can touch.

- Molecules can be represented with balls joined with sticks, to help describe the shapes of molecules.
- Mice are models for testing human drugs. It is much easier to try things out on mice and there are fewer concerns about harming mice than harming humans.

Abstract models

Abstract models exist in our imaginations, inside computers or as written symbols.

- The flow of electrical current through a circuit can be described more easily by thinking about water flowing through pipes.

- In the particle theory we imagine that everything is made up of particles that behave like tiny balls, whizzing around and bouncing off one another.
- Mathematical formulae are also abstract models (e.g. speed = distance / time).
- Computer models use complex maths to explain and predict what happens in complicated systems, such as weather forecasting.
- Chemical equations model what happens during chemical reactions. For example:

methane + oxygen → carbon dioxide + water

or

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

- Food chains and food webs are also abstract models.

Analogies

Some abstract models are analogies. An analogy is a comparison to an everyday item. Thinking about electricity as being like water in a pipe and thinking about particles as being like bouncing balls are both analogies.

The limits of models

Models are always simpler than what they are describing. This means that they may not be able to describe or explain all of an idea.

For example:

- Electrical current flows along a wire like water in a pipe. If the pipe is narrow at one point, this is like a resistor and the current slows. *But*, if a water pipe breaks, the water leaks out. This does not happen in an electrical circuit.

- Electrical current flows along a wire like a rope being pulled through another person's fingers. If the second person squeezes, the resistance increases. *But*, when you try out this physical model, the person pulling tends to pull harder as the resistance increases and a cell does not do this.

When you use a model it is important that you understand the ways in which the model is good and the ways in which it is not so good. This will allow you to compare models and decide which is best for a particular purpose.

1 State an advantage and a disadvantage of each model of electrical current above.

I can…

- explain why models are used.

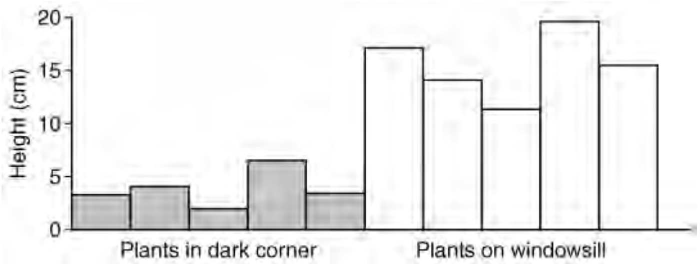
Your **conclusion** is what you found out in your investigation. The conclusion needs to be drawn from the evidence and data you have collected and considered, and should describe any **relationship** you found between the independent and dependent variables.

A good conclusion:

- describes the relationship between variables as fully as possible
- relates the conclusion back to the original hypothesis
- is explained using your science knowledge and understanding.

Simple conclusion about plant growth:

The results show that plants grown on the windowsill grow taller than those grown in the dark corner.



If you have worked out a numerical relationship between the variables, then include this in your conclusion.

Better conclusion from graph:
The results show that the plants grown on the windowsill grow at least twice as tall as those grown in the dark corner.

This conclusion would be even better if it compared the mean growth for plants on the windowsill and the mean growth of plants in the dark corner.

Relating the conclusion to the hypothesis

If you wrote a hypothesis at the start of your investigation, then remember to compare your conclusion with your hypothesis. For example:

- My conclusion supports my hypothesis because it shows that …
- My conclusion shows that my hypothesis was wrong because it shows that …

You will need to give a reason for your statement.

Explaining your conclusion

Try to explain your conclusion using what you have learnt in science. This can help you extend your conclusion beyond your investigation to suggest what would happen in a similar investigation.

Example:
Plants need light to make food for growth. So plants growing in light should make more food than plants growing in a dark corner.

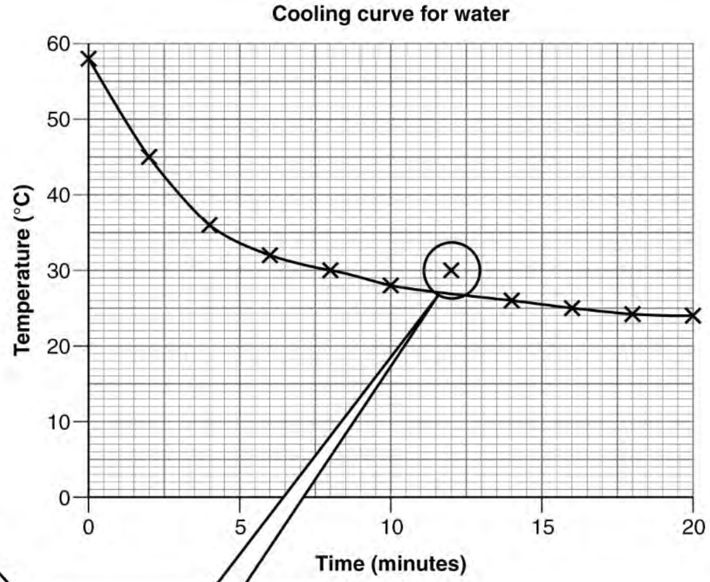
I can…

- draw a valid conclusion from evidence.

Anomalous results and outliers

An **anomalous result** or **outlier** is a number in a series that lies outside the expected values.
You may be able to spot an anomalous result in a table, but it is often easier to see them on a graph.

Time (mins)	Temperature (°C)
0	58
2	45
4	36
6	32
8	30
10	28
12	30
14	26
16	25
18	24
20	24



This value is higher than expected compared with the rest of the results – an anomaly

If you find an anomalous result you need to decide:

- What caused it?
  Anomalous results are often caused by random error. Did anything particular change or go wrong when you took that measurement?
- What to do about it?
  If you are certain that the anomaly was the result of a random error, then don't include it in the rest of your data analysis.

Remember to justify in the evaluation of your investigation why you excluded any anomalous values.

When calculating a mean from a series of repeat tests, remember to ignore any anomalies.

For this data, ignore the result from Test 2 as it does not fit the pattern of the other test values.

Repeat test	Distance (cm)
1	35
2	15
3	38
4	33

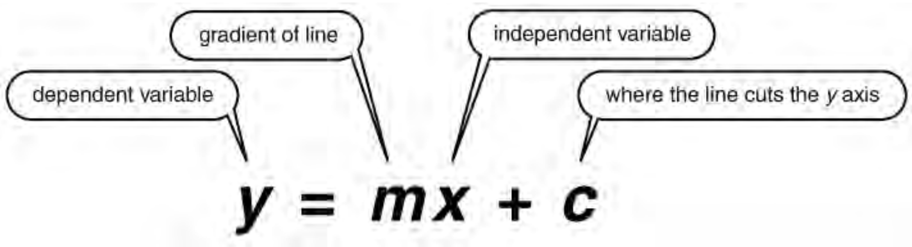
I can…

- identify and explain anomalous results or outliers.

When a graph plotted for two quantities or variables is a straight line, we say that the two variables have a linear relationship.

You can find a formula to represent a linear relationship from a straight line graph.

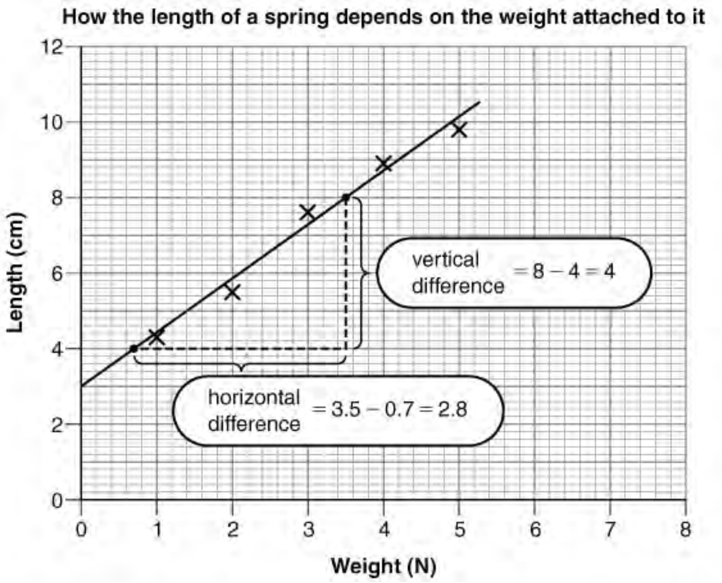
The equation of any straight line is



m is the gradient or steepness of the line. It is the amount the dependent variable (*y*) increases every time the independent variable increases by 1.

c is the point where the line cuts the vertical (*y*) axis.

Finding the gradient



A Choose *two* points on the line, where it is easy to read off the values.

B Work out the vertical difference and horizontal difference between the points.

C Divide the vertical difference by the horizontal difference:

4/2.8 = 1.43.

Gradient m = 1.43.

Writing the formula

In the graph above the line crosses the *y*-axis at 3.

Write $y = mx + c$

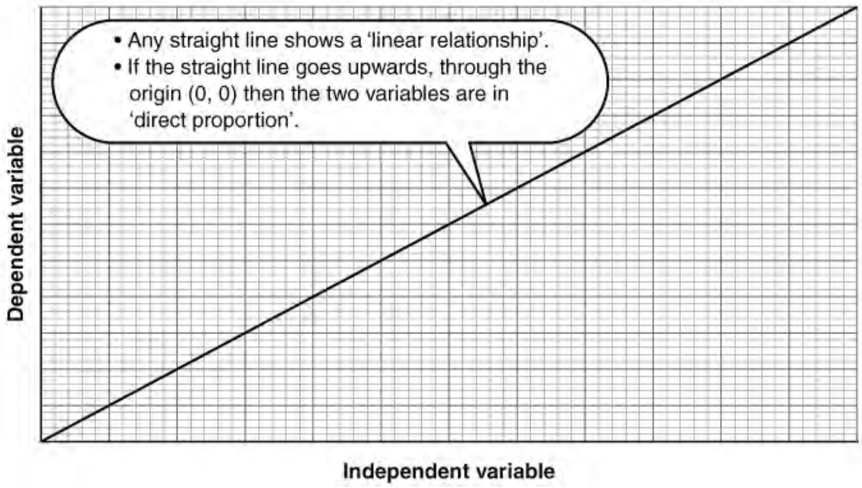
Substitute the values for m and c:

$y = 1.43x + 3$

Rewrite with the dependent variable for *y* and the independent variable for *x*:

length = 1.43 × weight + 3.

Linear graphs



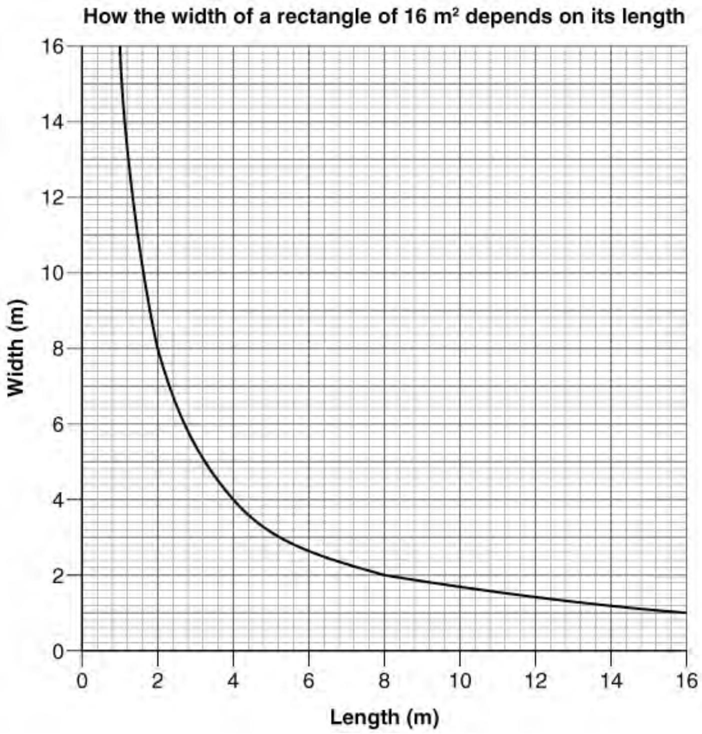
A straight line graph through (0, 0) shows that the two variables are in **direct proportion**.
This means that:

- When one variable is zero, so is the other.
- The variables increase or decrease in the same ratio. For example, if one doubles, so does the other and if one halves, so does the other.

When two variables are in **indirect proportion**,

- if one doubles, the other halves
- if one halves, the other doubles.

An indirect proportion graph looks like this:



I can…

- identify (direct, indirect) proportionality using graphs
- use data to create a mathematical formula.

At the end of an investigation, you need to **evaluate** the evidence to show how good your conclusion is.

There are different ways to evaluate a practical investigation.

Evaluating a method

- Is your method valid? Does it produce results that allow you to answer the aim?
- Did you carry out a fair test? Were there any variables you could not control?
- Were your measuring instruments accurate enough?
- Did anyone else in the class use a different method? Was their method better or worse? Why?

Evaluating a set of results

- How repeatable are your results? How precise are your repeated results?
- Are the results accurate enough to draw a firm conclusion?
- Have you got enough results? Do the results cover a large enough range to see the pattern clearly? Does the interval between the readings allow you to see the pattern clearly? You need enough results to give a clear pattern, or to be certain that there is no pattern.
- Have you identified any anomalous values and stated whether you included them in the analysis of results?

Evaluating a conclusion

- Is your conclusion valid? Is it only drawn from the data from the investigation?
- Does your conclusion describe any relationship in your results as fully as possible?
  Your conclusion should be based on all your results, except those that are anomalous.
- Have you compared your conclusion with your prediction? What does this tell you about your original hypothesis?
- Have you tried to explain your conclusion using your science knowledge and understanding?

If you identify any weaknesses during your evaluation, you should say what you would do to improve the investigation if you were to do it again.

I can…

- evaluate methods, results and conclusions.

KWL stands for 'Know, Want to know, Learned'. You can use this strategy to help you keep track of what you already know, what you want to know and then, after the lesson, what you have learned.

This strategy is very useful when watching videos in class. Suppose you are going to watch a video about the Solar System. You should never just watch the video without attempting to make notes.

However, if you make too many notes you might miss something interesting or important. By using KWL, you can write down a few facts about the Solar System before watching the video. You can also write down a few things that you want to learn from the video. While you are watching the video you can add new information in the 'Learned' column as this is the new stuff that you have just learned. It's a great way to learn and a great way to increase your confidence about your own learning.

The example below shows how to lay out your page when doing a KWL exercise. It shows the 'Know' column filled in because that is the information that you already know. You should also fill in the 'Want to know' column before you watch the video. Remember that these are only examples. You might write some quite different things, and they would still be correct.

You would fill in the last column while you were watching the video.

Know	Want to know	Learned
I know the Solar System has eight planets.	Which planet is the biggest?	
I know the planets orbit the Sun.	Which planet takes longest to go around the Sun?	
I know that Earth has one moon.	How many moons does Saturn have?	
I know that Neil Armstrong was the first man on the Moon.	How big is the Sun compared to the Earth?	
I know that there are asteroids between Mars and Jupiter.	How far is it to the Moon?	

Name ______________________________ Class ____________ Date _____________

Know	Want to know	Learned

Self- and peer- assessment

Assessments tell you how you are doing, but they don't always have to involve a teacher.

Self assessment is all about *you* assessing your work for yourself. This is a good idea because it gets you thinking about what you understand, what you may need help on, and where you could do with some feedback and improvement.

Peer assessment is all about *students* assessing the work of other students. This is a good idea because there is always something you can learn from the success (and the mistakes!) and the comments of others. Now pair up to assess and to be assessed ...

1 Complete Part 1 of the following form:

Part 1: You and your work:

The piece of work I would like assessed is: ____________________

____

The parts I would particularly like feedback on are: ____________________

____

Things to consider when answering where you would like feedback include:

Did you plan as well as you could? Did you show what you know? Did you make yourself clear? Were you accurate? Were you relevant? In which parts of the work are you most or least confident?

2 Pass your completed Part 1 to your student assessor, for them to complete Part 2:

Part 2: Your feedback from your student assessor:

Here's what I thought were the strengths of your work: ____________________

____

Here's what I found a bit confusing or unclear: ____________________

____

Here's what I thought about the parts you particularly wanted feedback on: ____________________

____

Three things you *must* do when answering the above are:

- Back up all your comments with examples or evidence, e.g. don't just write 'Some of your sentences were too long, which made them difficult to understand'. Back it up with 'For example, the second sentence of the third paragraph.'
- Focus on things that can actually be addressed and improve the piece of work.
- Be mature and considerate – give your feedback sensitively!

3 Pass the completed Part 2 back to the student being assessed, for them to complete Part 3:

Part 3: You, your feedback and where you can improve:

What did the feedback confirm that you already knew (or suspected!)? ____________________

____

What responses surprised you? ____________________

____

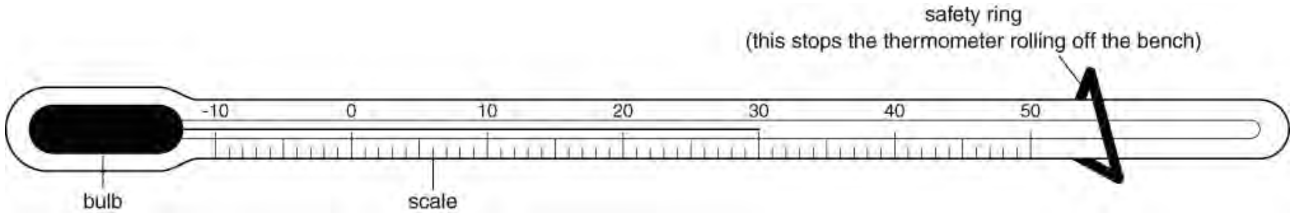
What have you learnt from the feedback? ____________________

____

What will you act on to improve? (List at least one thing) ____________________

____

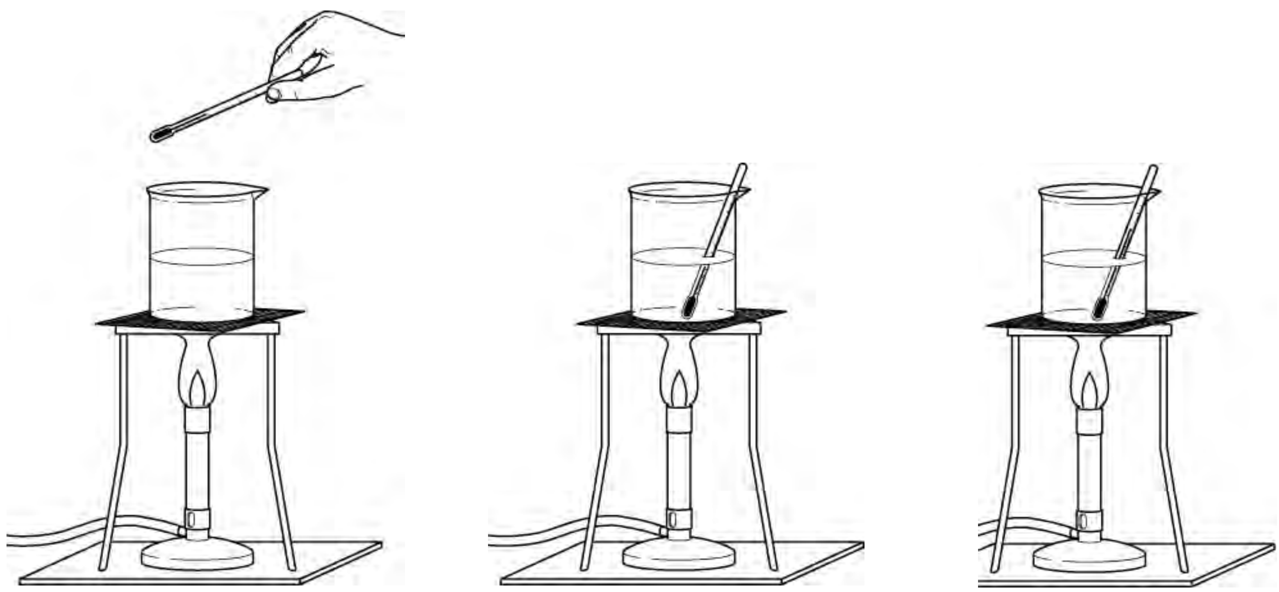
Thermometers contain a liquid that expands (gets bigger) when it gets hotter. The expanding liquid moves up a narrow tube. We use the **scale** to see how far the liquid has moved, and this tells us the temperature.



The thermometer measures the temperature of the liquid in the **bulb**. If a thermometer is lying on a bench in the lab, it will be reading the temperature of the room.

> ⚠ Thermometers are made of glass, and are easily broken.
>
> Some thermometers have a red or green liquid in them. This is alcohol, dyed so that you can see it. Thermometers with a silvery liquid contain mercury. Mercury is dangerous, and if you break a thermometer you must never touch the mercury.
>
> ## Safety rules
>
> - Never put a thermometer down where someone can knock it off the bench.
> - Make sure your thermometer has a safety ring fitted.
> - If you break a thermometer, *always* tell your teacher. Do not try to clear it up yourself.

When a thermometer is moved to a place that has a different temperature, you need to allow time for it to adjust to the new temperature before you take measurements.



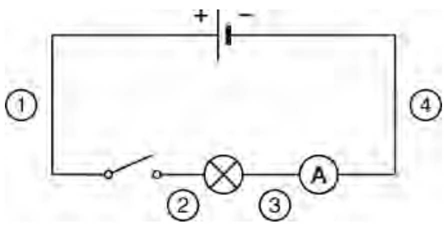
I can…

- use simple apparatus in the best way.

Series circuits

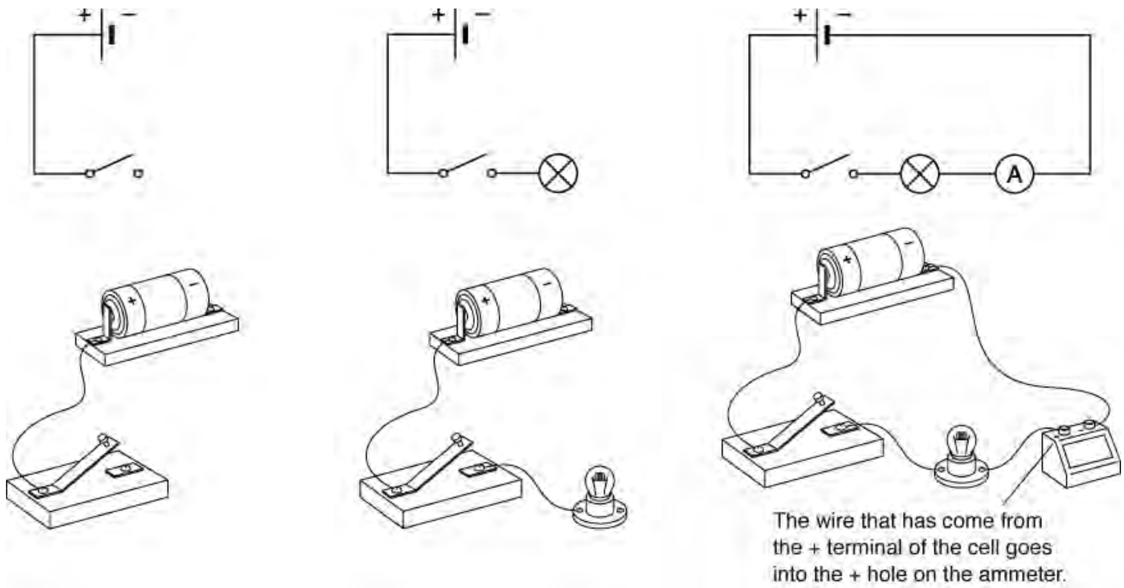
Building circuits is always easier if you use a **circuit diagram** to help you.

First, collect all the **components** you need. You can work out how many wires you need by counting up the number of pieces of wire between each component.



This circuit needs four wires

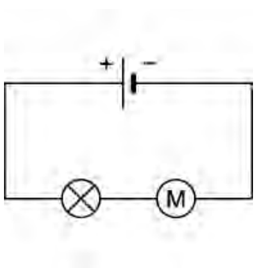
Even complicated circuits are quite easy to put together if you follow the circuit round and put in one component at a time, like this.



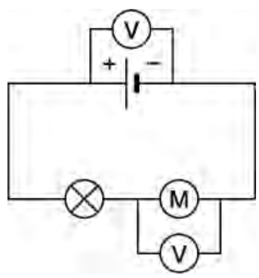
Voltmeters in series circuits

When you are building a circuit with voltmeters, it is easier if you ignore the voltmeters to start with.

Build this first.

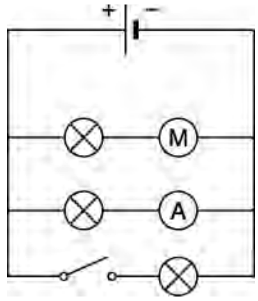


Then add the voltmeters.



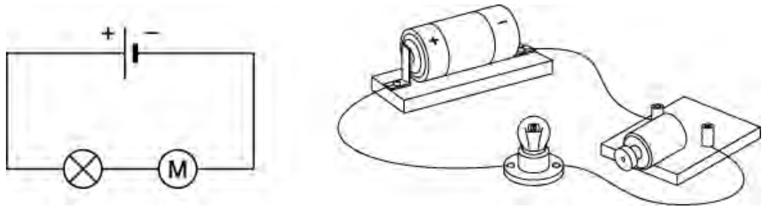
Parallel circuits

Building parallel circuits is easy if you look at one branch of the circuit at a time.

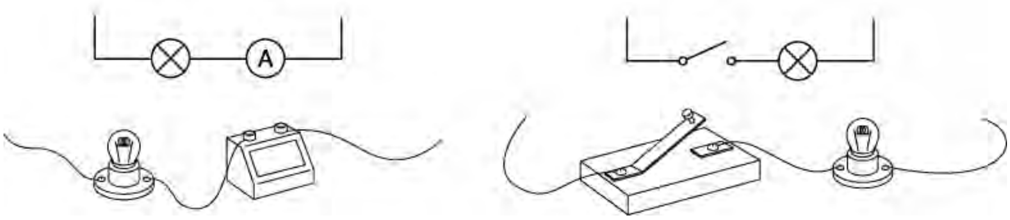


Instead of trying to build this circuit all in one go, take one piece at a time.

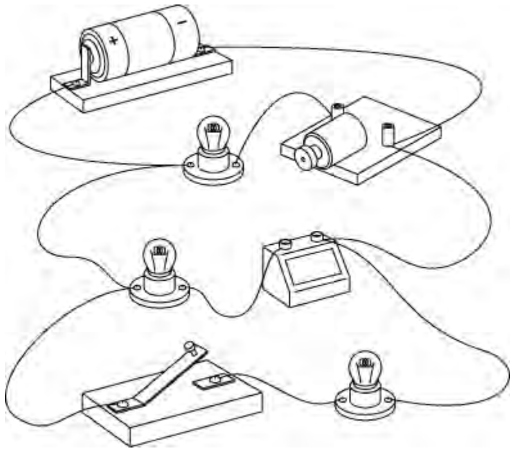
First, build the top part, like this.



Then make the branches.



Then put them all together.



Voltmeters in parallel circuits

If you need to use voltmeters in your circuit, put them in last.

I can…

- explain how different pieces of apparatus work together
- interpret diagrams that use scientific symbols and conventions
- follow instructions with one or more steps.

Commonly used stains

methylene blue: stains cell nuclei.

iodine/potassium iodide solution: stains nuclei, cell walls and starch in chloroplasts.

toluidine blue: stains nuclei.

eosin Y: stains cytoplasm, red cell walls.

⚠ Check the safety information for the stain you are using, and follow the instructions carefully.

Wear eye protection.

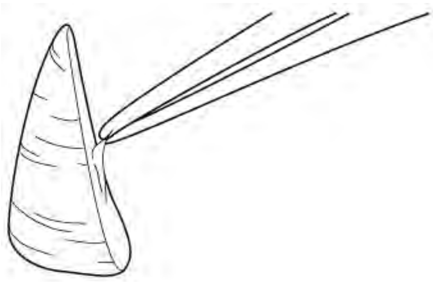
If you need to look at material closely, then you will need to prepare a slide of the material so that it can be viewed using a **microscope**.

Material from plants and animals may be colourless. A coloured **stain** added to the sample material may help you see some structures in the material more clearly.

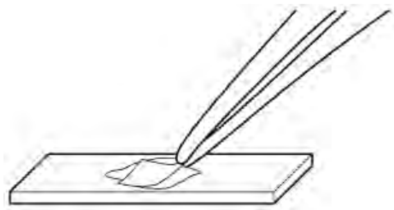
A coverslip placed over the sample will stop the material drying out, and will prevent water from clouding the objective lens.

A Place a drop of water in the centre of a microscope slide. The water may contain a **stain** to make the cells show up better. (Alternatively, the stain may be added later.)

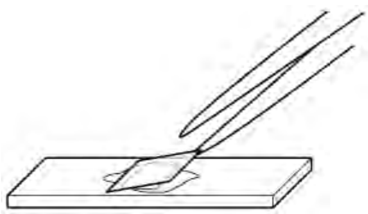
B Using some forceps, or your fingernails, peel off, cut or scrape a small sample of what you want to look at. Remember: the sample needs to be thin, otherwise light will not go through it and you will not see anything.



C Place your sample (your **specimen**) onto the drop of water on your slide.



D Using the forceps, lower a coverslip onto your specimen. If you do this carefully and slowly you will avoid trapping air bubbles under the coverslip. Air bubbles will make it more difficult to look at the specimen clearly.



1 What does a stain do?

2 Why do we use coverslips?

3 Why is the coverslip lowered gently over the sample?

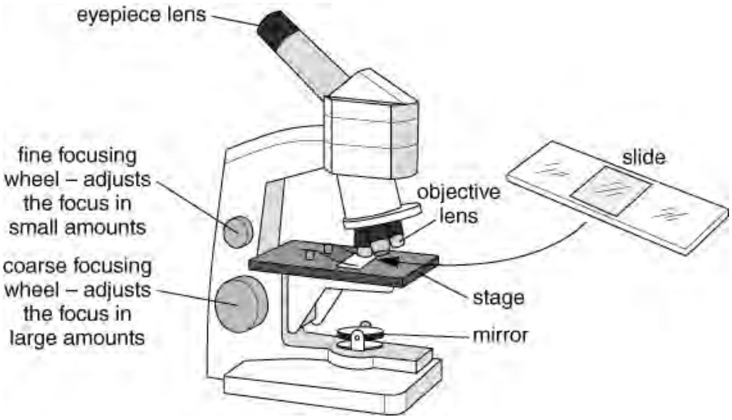
4 What things should you do to stay safe while preparing a slide?

I can…

- use simple apparatus in the best way.

A microscope needs to be set up carefully and safely, to avoid damaging it or the slides.

⚠ Wear eye protection.



A Turn the **objective lenses** so that the lowest power lens is over the hole in the **stage**.

B Turn the large **coarse focusing wheel** to make the gap between the **stage** and the **objective lens** as small as possible.

C Place a **slide** on the **stage**. Use the clips to hold the slide in place.

D Adjust the **light source**. Either turn on the lamp or turn your mirror so that light is reflected up into the hole in the stage.

⚠ Never point the mirror directly at the Sun. This can permanently damage your eyesight.

E Look into the **eyepiece lens**. It is best to look down a microscope with both eyes open. If you do this, your eyes will not get tired and you will see more.

F Turn the **coarse focusing wheel** slowly so that the gap between the **stage** and the **objective lens** gets bigger. Keep turning until what you see is clear (**in focus**).

G To see a bigger image, place the next most powerful **objective lens** over the **specimen**. Only use the **fine focusing wheel** to adjust the focus.

⚠ Do not use the coarse focusing wheel with higher power objectives. If you can't see anything, go back to a lower power objective and focus the slide again before returning to the higher power objective.

Calculating the magnification

To calculate the magnification of a microscope, you multiply the power of the eyepiece lens with the power of the objective lens:

$$\text{magnification} = \text{eyepiece power} \times \text{objective power}$$

For example, if a $\times 5$ eyepiece and $\times 10$ objective were used, the image seen through the microscope would be $5 \times 10 = 50$ times larger than the real size of the sample on the slide.

Looking after the microscope

- Always cover it up once you have used it. The glass in the lenses scratches easily – even dust will scratch them!
- Always use the 'fine focusing wheel' with the larger objective lenses, otherwise you may break your slide and damage the objective lens.
- Always place the smallest objective lens over the hole in the stage when changing slides.

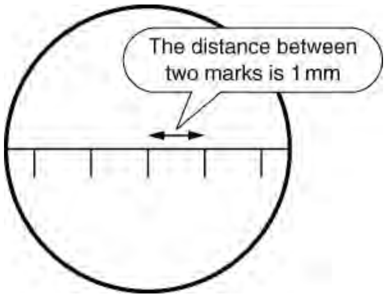
I can…

- explain what a microscope does
- describe how to use simple apparatus in the best way.

If you want to measure the size of something in a specimen that you are looking at through a microscope, you will need to calculate the field of view.

The **field of view** is the area that you can see when you look down a microscope. To calculate the field of view:

A Set up your microscope on its lowest magnification and place a transparent ruler under the clips so that the millimetre scale is over the hole in the stage.



B Focus your microscope so that you can see the millimetre scale. Count the number of millimetre markings you can see across the field of view. This gives you the width of the field of view in millimetres.

C Now remove the ruler and place a slide under the clips and look at it through the microscope. Focus the microscope and get a clear image.

D Knowing the width of the field of view, you should be able to estimate the size of what you are looking at. For example, if the field of view is 6 mm wide, and the object you are looking at covers 1/6 of the field of view:

$$\text{real size of object} = \text{field of view} \times \text{proportion of field of view covered by object}$$
$$= 6 \times 1/6 = 1 \text{ mm}$$

1 What is the field of view?

2 How do you measure a field of view?

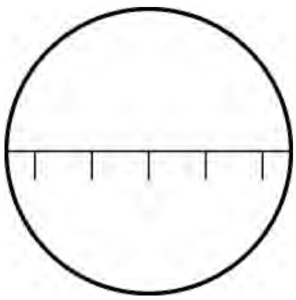
3 In the drawing higher up the page, the millimetre scale from a transparent ruler can be seen.

a What magnification is the microscope set to?

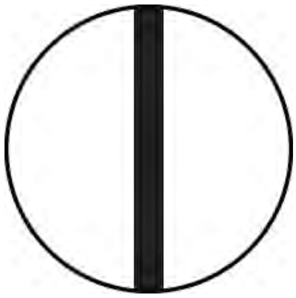
b What is the width of the field of view?

4 Drawing W, below, shows the mm scale of a ruler under a microscope. Drawing X shows a hair under the same microscope. Estimate the width of the hair.

W

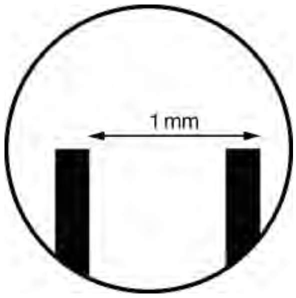


X

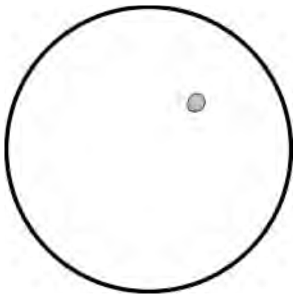


Drawing Y, below, shows the mm scale of a ruler under a microscope. Drawing Z shows a grain of sand under the same microscope. Estimate the width of the grain.

Y



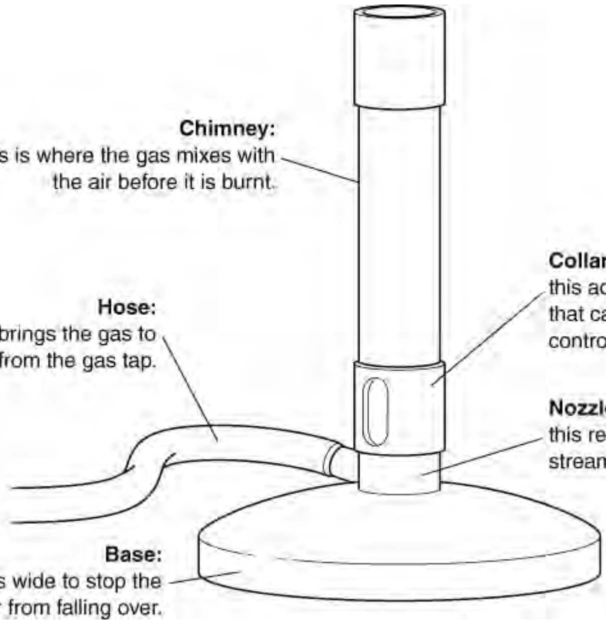
Z



I can…

- estimate using a scale.

The Bunsen burner is used to heat things in the laboratory. The diagram below shows the different parts of the Bunsen burner and explains what each part does.



⚠ If your Bunsen burner goes out, turn off the gas at the gas tap straight away.

Always let a Bunsen burner cool down before you put it away.

Remember that a Bunsen burner will get hot when it is used, so never take one apart unless you are told to do so by your teacher.

Wear eye protection.

How to light a Bunsen burner

Every time you use a Bunsen burner, you should follow these steps:

A Check the hose for breaks and holes. If it is damaged, return the burner and tubing to your teacher.

B Connect the hose to the gas tap but do not turn it on yet.

C Check that the air hole in the collar of the Bunsen burner is closed.

D Hold a lit splint a little distance (about 2 cm) above the top of the chimney of the Bunsen burner.

E Turn on the gas at the gas tap.

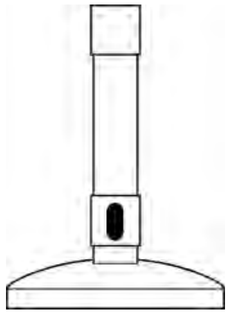
F The Bunsen burner will now light and give you a yellow flame.

G Turn down the gas supply at the gas tap until you have the size of flame needed for your experiment.

H When you have finished close the air hole, so that the flame is yellow, then switch off the gas.

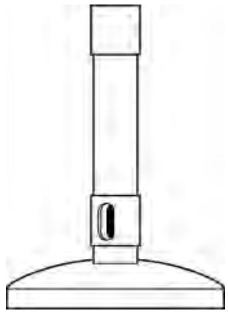
Bunsen burner flames

The Bunsen burner will give different types of flame.



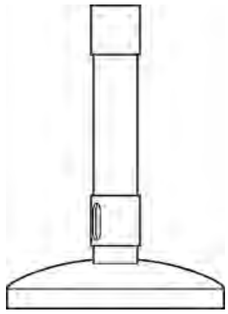
Roaring flame:

- air hole open, so lots of air mixes with the gas
- noisy, blue flame
- very hot flame
- used for heating things quickly.



Medium flame:

- air hole half-open, so some air mixes with the gas
- light blue flame, which is quieter than the roaring flame
- flame is quite hot
- used for heating liquids, especially if you are using a boiling tube.



Safety flame:

- air hole closed, so hardly any air mixes with the gas
- quiet, bright yellow flame
- flame is not as hot as the medium flame
- not used for heating, because the flame leaves a layer of soot on things.

⚠ If you are not using your Bunsen burner, you should either turn it off, or close the air hole so that people can see the flame.

When you have practised lighting your Bunsen burner, copy and complete the table below and draw the three flames you have seen. Use this sheet to help you.

Type of flame	Safety	Medium	Roarer
type of air hole		half open	
amount of air mixing with gas			
amount of noise			
main colour of flame			
diagram of flame			

I can…

- explain how to use a Bunsen burner
- use simple apparatus in the best way